GE

Grid Solutions

DS Agile C26x

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Technical Manual

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CONTENTS

INTRODUCTION	C26x/IT EN/E72
SAFETY AND HANDLING	C26x/SA EN/E72
FUNCTIONAL DESCRIPTION	C26x/FT EN/E72
HARDWARE	C26x/HW EN/E72
CONNECTION	C26x/CO EN/E72
COMMUNICATIONS	C26x/CT EN/E72
NETWORK MONITORING	C26x/NM EN/E72
INSTALLATION	C26x/IN EN/E72
APPLICATION	C26x/AP EN/E72
SETTINGS	C26x/ST EN/E72
HUMAN INTERFACE	C26x/HI EN/E72
COMMISSIONING	C26x/CM EN/E72
MAINTENANCE AND FAULT FINDING	C26x/MF EN/E72
RECORD SHEET	C26x/RS EN/E72
SECURE DEPLOYMENT GUIDE	C26x/SD EN/E72
TECHNICAL DATA	C26x/TD EN/E72
GLOSSARY	C26x/LX EN/E72

INTRODUCTION

C26X/EN IT/E72

Contents

1	**TECHNICAL MANUAL OVERVIEW**	**3**
1.1	Chapter description	3
2	**FOREWORD**	**5**
2.1	Target Audience	5
2.2	Typographical conventions	5
2.3	Nomenclature	6
2.4	Compliance	6
3	**INTRODUCTION TO DS AGILE**	**7**
4	**PRODUCT SCOPE**	**8**
4.1	DS Agile Control Units	8
4.2	Applications and Scope	8
5	**OPERATING SYSTEM COMPATIBILITY**	**11**

1 TECHNICAL MANUAL OVERVIEW

This manual provides some general information about the technical manual and an introduction to the DS Agile C26x units described in this technical document.

1.1 CHAPTER DESCRIPTION

Introduction Chapter (IT)

This is this document containing the description of each chapter of the DS Agile C26x guides. It is a brief introduction to DS Agile C26x controller's capabilities.

Safety Chapter (SA)

This chapter contains the safety instructions, handling and reception of electronic equipment, packing and unpacking parts, Copyrights and Trademarks.

Functional Description Chapter (FT)

This chapter contains a description of the product. It describes functions of the C26x.

Hardware Description Chapter (HW)

This chapter contains the hardware product description (product identification, case, electronic boards, operator interface, etc.).

Connection Chapter (CO)

This chapter contains the external wiring connections to the DS Agile C26x.

Communications Chapter (CT)

This chapter provides the companion standard of all supported protocols toward SCADA (Telecontrol BUS) and IED on LBUS. This is the list of protocol functions that the C26x uses.

Network Monitoring Chapter (NM)

This chapter contains instructions on how to set the networks for SNMP protocol.

Installation Chapter (IN)

This chapter contains the installation procedures.

Applications Chapter (AP)

This chapter contains instructions on how to configure the features of the DS Agile C26x using SCE, ISaGRAF ….

Settings Chapter (ST)

This chapter contains the list of the user functions on-line settings with default values and range.

Human Interface (HI)

This chapter contains the operator interface description, Menu tree organisation and navigation, LEDs description, Setting/configuration software.

Commissioning Chapter (CM)

This chapter contains instructions on how to download onto the sub-system the databag describing the configuration.

Maintenance Chapter, Fault finding and repairs (MF)

This chapter helps identify failure modes, fault codes and describes the recommended repair actions.

Record Sheet Chapter (RS)

This chapter contains record sheet to follow the maintenance of the C26x.

Technical Data Chapter (TD)

This chapter contains the technical data including, accuracy limits, recommended operating conditions, ratings and performance data.

It also describes environment specification, compliance with technical standards.

Current Transformer Technical Data (CD)

This chapter contains information on the current transformers used for protection applications.

Glossary Chapter (LX)

This chapter contains lexical description of acronyms and definitions.

2 FOREWORD

This technical manual provides a functional and technical description of General Electric's DS Agile C26x controller, as well as a comprehensive set of instructions for using the device. The level at which this manual is written assumes that you are already familiar with substation control, monitoring, protection, automation and have experience in this discipline.

We have attempted to make this manual as accurate and comprehensive as possible. However, we cannot guarantee that it is free from errors. Nor can we state that it cannot be improved. We would therefore be very pleased to hear from you if you discover any errors or have any suggestions for improvement. Our policy is to provide the information necessary to help you safely specify, engineer, install, commission, maintain, and eventually dispose of this product. We consider that this manual provides the necessary information, but if you consider that more details are needed, please contact us.

All feedback should be sent to our contact centre via the following URL: www.gegridsolutions.com/contact

2.1 TARGET AUDIENCE

This manual is aimed towards all professionals charged with installing, commissioning, maintaining, troubleshooting, or operating any of the products within the specified product range. This includes installation and commissioning personnel as well as engineers who will be responsible for operating the product.

The level at which this manual is written assumes that installation and commissioning engineers have knowledge of handling electronic equipment. Also, system and protection engineers have a thorough knowledge of protection systems and associated equipment.

2.2 TYPOGRAPHICAL CONVENTIONS

The following typographical conventions are used throughout this manual.

- The names for special keys appear in capital letters.

  For example: ENTER

- When describing software applications, menu items, buttons, labels etc as they appear on the screen are written in bold type.

  For example: Select **Save** from the file menu.

- Filenames and paths use the courier font

  For example: `Example\File.text`

- Special terminology is written with leading capitals

  For example: Sensitive Earth Fault

2.3 NOMENCLATURE

Due to the technical nature of this manual, many special terms, abbreviations and acronyms are used throughout the manual. Some of these terms are well-known industry-specific terms while others may be special product specific terms used by General Electric. The first instance of any acronym or term used in a particular chapter is explained. In addition, a glossary is available at the end of this manual.

We would like to highlight the following changes of nomenclature however:

- The range of C264 substation and bay computers is being widened to encompass new applications such as the process bus Ethernet network. On this occasion, the name of the range becomes DS Agile. Because new models will soon be available, the name C264 is replaced by C26x in the manuals. Please note that this is a phased evolution, and where the text in the manual refers to software labels, there may still some references to the previous names until the software update is completed.
- The word 'relay' is no longer used to describe the device itself. Instead, the device is referred to as the 'IED' (Intelligent Electronic Device), the 'device', or the 'product'. The word 'relay' is used purely to describe the electromechanical components within the device, i.e. the output relays.
- The C26x units will now be referred to as "controllers" rather than "computers" in order to avoid any confusion with the PC-type computers used in other DS Agile sub-systems.
- The British term 'Earth' is used in favour of the American term 'Ground'.

2.4 COMPLIANCE

The device has undergone a range of extensive testing and certification processes to ensure and prove compatibility with all target markets. A detailed description of these criteria can be found in the Technical Data chapter.

3 INTRODUCTION TO DS AGILE

DS Agile is a comprehensive solution capable of meeting all electricity supply requirements. It comprises a range of components, systems and services from GE Grid Solutions.

Central to their concept is flexibility.

DS Agile provides the ability to define an application solution and, through extensive communication capabilities, to integrate it with your power supply control system.

The DS Agile ranges provide:

- A range: Industrial PCs
- C range: Control units
- H range: Ethernet switches
- M range: Measurement products for accurate metering and monitoring
- P range: Protection devices
- S range: Versatile PC support and substation control packages

DS Agile products include extensive facilities for recording information on the state and behaviour of the power system using disturbance and fault records. They can also provide measurements of the system at regular intervals to a control centre enabling remote monitoring and control to take place.

The DS Agile range will continue to be expanded. The general features will also be enhanced, as we are able to adopt new technology solutions.

For up-to-date information on any DS Agile product, visit our website: http://www.gegridsolutions.com/.

4 PRODUCT SCOPE

GE Grid Solutions' philosophy is to provide a range of control units, gateways and IEDs products. Each of these products can be used independently or be integrated to form a DS Agile system, a Digital Control System (DCS) or a SCADA system.

4.1 DS AGILE CONTROL UNITS

Driven by the requirements around the world for advanced applications in SCADA, Digital Control Systems, Automation, control and monitoring, GE Grid Solutions has designed and developed a complete range of DS Agile C26x control unit products, specifically for the power process environment and electric utility industry. It allows building a customised solution for Control, Monitoring, Measurement and Automation of electrical processes.

The DS Agile C26x range is designed to address the needs of a wide variety of installations, from small to large and customer applications. Emphasis has been placed on strong compliance to standards, scalability, modularity and openness architecture. These facilitate use in a range of applications from the most basic to the most demanding. They also ensure interoperability with existing components and, by providing building control units, PLC or IEDs approach, provide a comprehensive upgrade path, which allows DS Agile capabilities to meet customer requirements.

The key features of this control unit family result from it being based on an Ethernet client/server architecture, it Is a modular control unit that offers a wide variety of applications such as Bay Controller, Remote Terminal Unit, Sequence of Event Recorder, Data Concentrator and Programmable Logic Controller.

4.2 APPLICATIONS AND SCOPE

The DS Agile C26x substation controller is a sophisticated solution supporting multiple applications and functions for substation control, communication, monitoring, protection, and automation.

The DS Agile C26x modular bay control unit is used to control and monitor switch bays. The information capacity of the DS Agile C26x is designed for controlling operated switchgear units equipped with electrical check-back signalling located in medium-voltage or high-voltage substations.

External auxiliary devices are largely obviated by the integration of binary inputs and power outputs that are independent of auxiliary voltages, by the direct connection option for current and voltage transformers, and by the comprehensive interlocking capability.

This simplifies handling of bay protection and control technology from planning to station commissioning. During operation, the user-friendly interface makes it easy to set the unit and allows safe operation of the substation by preventing non-permissible switching operations.

Continuous self-monitoring reduces maintenance costs for protection and control systems.

A built-in liquid crystal display (optional front face with LCD) shows not only switchgear settings but also measured data and monitoring signals or indications.

The bay is controlled interactively by using the control keys and the display.

Adjustment to the quantity of information required is made via the DS Agile System Configurator Editor (DS Agile SCE).

The DS Agile C26x can be connected to a higher control level, local control level or lower levels by way of a built-in communications interface.

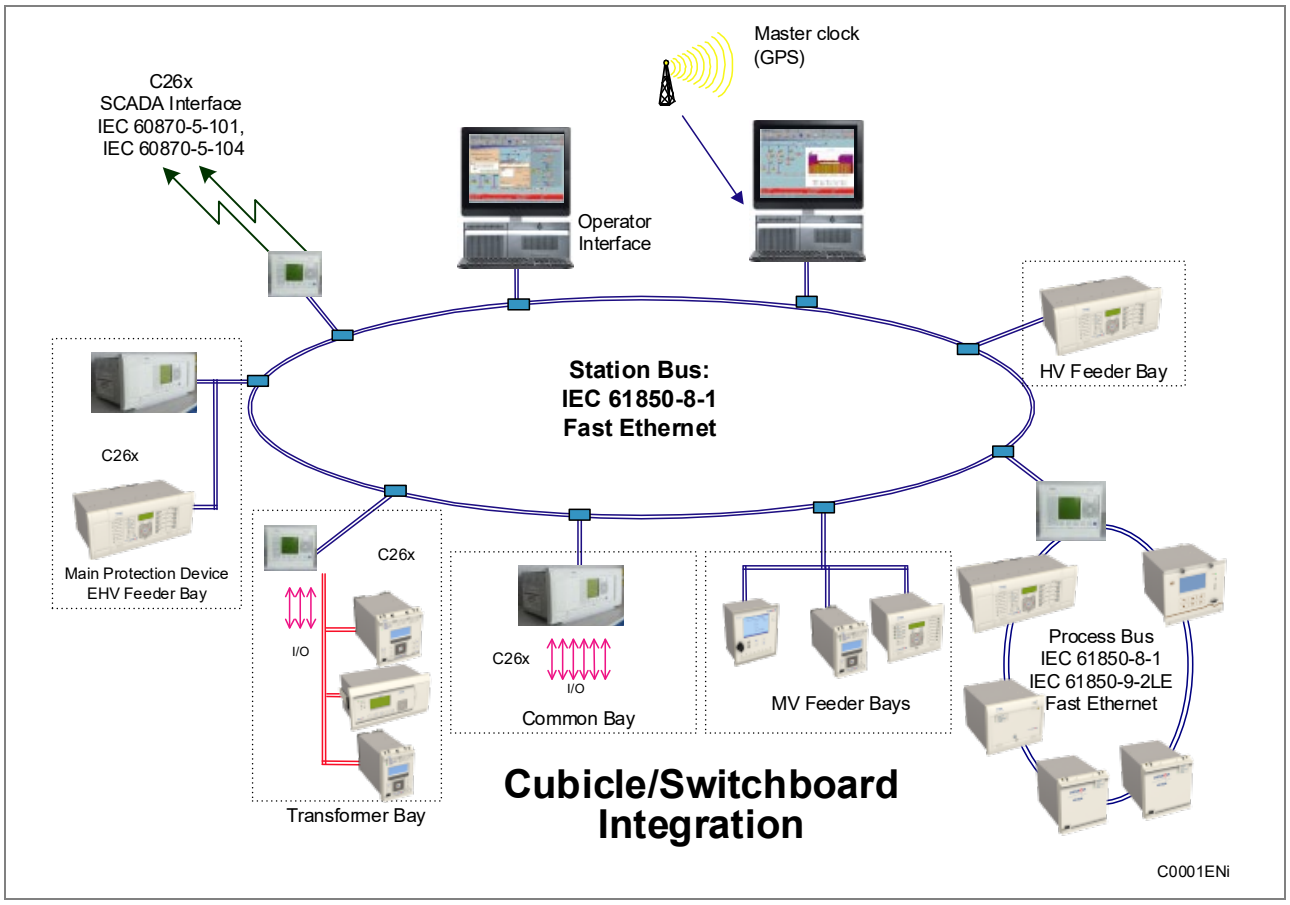


Figure 1: Typical use of a DS Agile C26x – Bay Controller

At a glance the C26x acquisition and control process is like this, based on a set of boards:

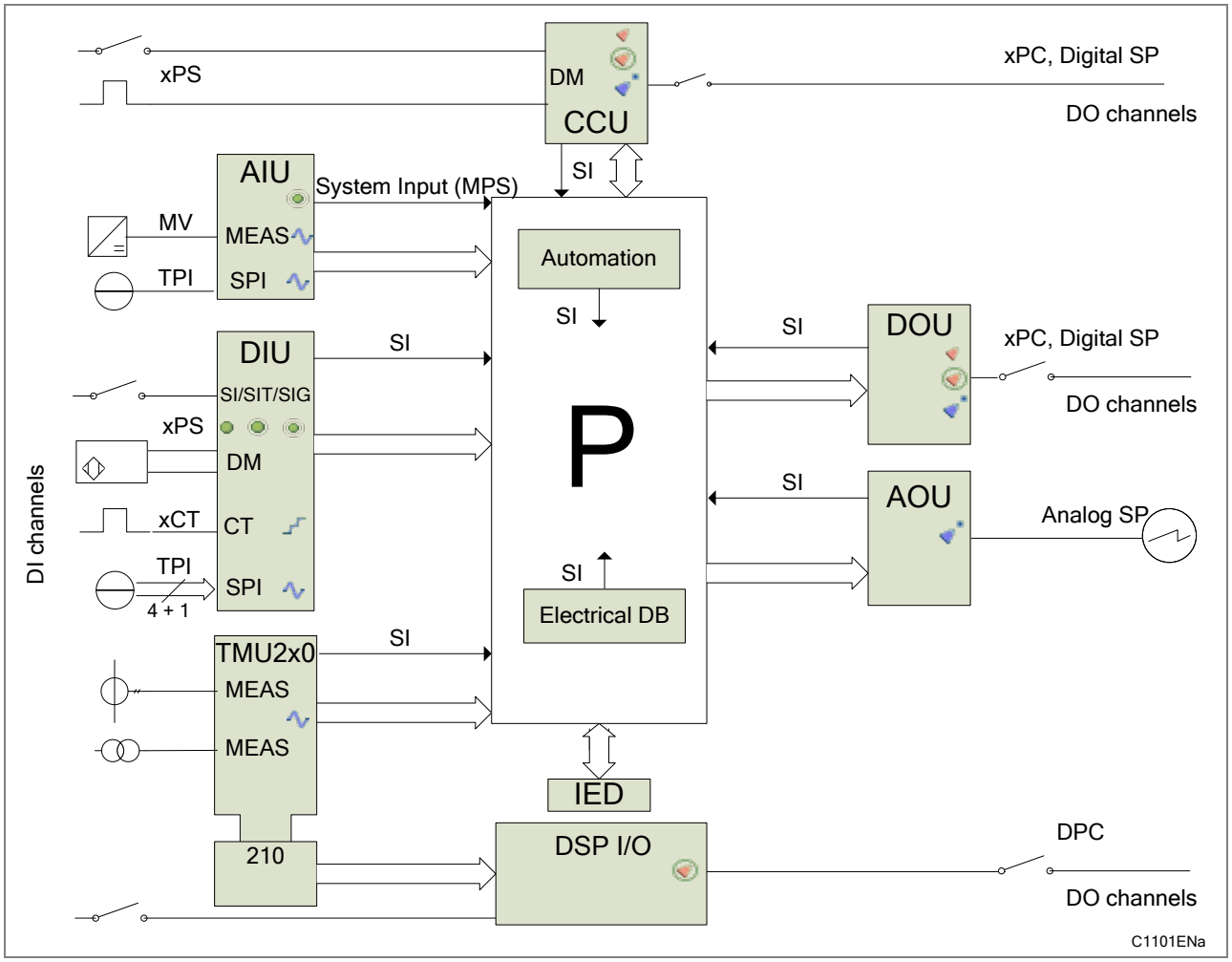


Figure 2 : Typical acquisition and control process of a DS Agile C26x

Find details on

- Boards in chapters C26x/EN HW and CO
- Processing in chapter C26x/EN FT
- Configuration in chapter C26x/EN AP

5 OPERATING SYSTEM COMPATIBILITY

Several applications may be used to configure the DS Agile C26x:

- the Computer Management Tool (DS Agile CMT)
- the setting software MiCOM S1

They are approved to run with **Windows 10 LTSC 2019 for Enterprise 64-bits edition**, with the following parameters:

Software tool	Run as administrator?	Run in XP compatibility mode?
DS Agile CMT	No	No
MiCOM S1	No	No

SAFETY INFORMATION

C26X/EN SA/E72A

Contents

1	CHAPTER OVERVIEW	3
2	HEALTH AND SAFETY	4
3	SYMBOLS	5
4	INSTALLATION, COMMISSIONING AND SERVICING	6
4.1	Lifting Hazards	6
4.2	Electrical Hazards	6
5	WIRING	8
5.1	General Wiring	8
5.2	Protective Earth Wiring	8
5.3	USB Port	8
6	DECOMMISSIONING AND DISPOSAL	9
7	WARRANTY	10
8	COPYRIGHTS & TRADEMARKS	11
8.1	Copyrights	11
8.2	Trademarks	11
9	WARNINGS REGARDING USE OF GE GRID SOLUTIONS PRODUCTS	12
10	MANUFACTURER	13

1 CHAPTER OVERVIEW

This chapter provides information about the safe handling of the equipment. The equipment must be properly installed and handled in order to maintain it in a safe condition and to keep personnel safe at all times. You must be familiar with information contained in this chapter before unpacking, installing, commissioning, or servicing the equipment.

2 HEALTH AND SAFETY

Personnel associated with the equipment must be familiar with the contents of this Safety Information.

When electrical equipment is in operation, dangerous voltages are present in certain parts of the equipment. Improper use of the equipment and failure to observe warning notices will endanger personnel.

Only qualified personnel may work on or operate the equipment. Qualified personnel are individuals who are:

- familiar with the installation, commissioning, and operation of the equipment and the system to which it is being connected.
- familiar with accepted safety engineering practises and are authorised to energise and de-energise equipment in the correct manner.
- trained in the care and use of safety apparatus in accordance with safety engineering practises
- trained in emergency procedures (first aid).

The documentation provides instructions for installing, commissioning and operating the equipment. It cannot, however cover all conceivable circumstances. In the event of questions or problems, do not take any action without proper authorisation. Please contact your local sales office and request the necessary information.

3 SYMBOLS

Throughout this manual you will come across the following symbols. You will also see these symbols on parts of the equipment.



Caution:
Refer to equipment documentation. Failure to do so could result in damage to the equipment



Warning:
Risk of electric shock



Earth terminal



Protective Earth terminal

Note:

The term 'Earth' used in this manual is the direct equivalent of the North American term 'Ground'.

4 INSTALLATION, COMMISSIONING AND SERVICING

4.1 LIFTING HAZARDS

Many injuries are caused by:

- Lifting heavy objects
- Lifting things incorrectly
- Pushing or pulling heavy objects
- Using the same muscles repetitively

Plan carefully, identify any possible hazards and determine whether the load needs to be moved at all. Look at other ways of moving the load to avoid manual handling. Use the correct lifting techniques and Personal Protective Equipment (PPE) to reduce the risk of injury.

4.2 ELECTRICAL HAZARDS



Caution:
All personnel involved in installing, commissioning, or servicing this equipment must be familiar with the correct working procedures.



Caution:
Consult the equipment documentation before installing, commissioning, or servicing the equipment.



Caution:
Always use the equipment as specified. Failure to do so will jeopardise the protection provided by the equipment.



Warning:
Removal of equipment panels or covers may expose hazardous live parts. Do not touch until the electrical power is removed. Take extra care when there is unlocked access to the rear of the equipment.



Warning:
Isolate the equipment before working on the terminal strips.



Warning:
Use a suitable protective barrier for areas with restricted space, where there is a risk of electric shock due to exposed terminals.



Caution:
Disconnect power before disassembling. Disassembly of the equipment may expose sensitive electronic circuitry. Take suitable precautions against electrostatic voltage discharge (ESD) to avoid damage to the equipment.



Caution:
NEVER look into optical fibres. Always use optical power meters to determine operation or signal level.



Caution:
Insulation testing may leave capacitors charged up to a hazardous voltage. At the end of each part of the test, discharge the capacitors by reducing the voltage to zero, before disconnecting the test leads.



Caution:
Operate the equipment within the specified electrical and environmental limits.



Caution:
Before cleaning the equipment, ensure that no connections are energised. Use a lint free cloth dampened with clean water.

5 WIRING

5.1 GENERAL WIRING

Only two wires can be screwed together on any one connector. The AC and DC signal and communication wires should use separate shielded cable.



Caution:
A high rupture capacity (HRC) fuse must be used for auxiliary supplies (for example Red Spot type NIT or TIA) with the following characteristics:

- Current rating: 16 Amps
- Minimum dc rating: 220 Vdc
- gG operating class in accordance with IEC 60269

The fuses must be connected in series with the positive auxiliary supply input connections for both primary (Pin 23) and secondary (Pin 1) BIU261D inputs

Wires should be connected with the power supply connectors unplugged. Each wired signal has to be tested before plugging and fixing the connectors. The connectors have to be fixed on the C26x case with the screws available at each extremity of the connector.

For connection of the protective (earth) conductor, see *Connection* chapter (*C26x/EN CO*).

5.2 PROTECTIVE EARTH WIRING

This equipment requires a protective conductor (earth) to ensure user safety according to the definition in the standard IEC 60255-27: 2005 Insulation Class 1. See *Connection* chapter (*C26x/EN CO*).

5.3 USB PORT

The front panel includes a B-Type USB port intended for maintenance purposes only.

Warning:
The front serial USB port is intended for maintenance purpose only. It is isolated to ELV level and is not intended for user connection. ESD precautions should also be taken when accessing it.

6 DECOMMISSIONING AND DISPOSAL



Caution:
Before decommissioning, completely isolate the equipment power supplies (both poles of any dc supply). The auxiliary supply input may have capacitors in parallel, which may still be charged. To avoid electric shock, discharge the capacitors using the external terminals before to decommissioning.



Caution:
Avoid incineration or disposal to water courses. Dispose of the equipment in a safe, responsible an environmentally friendly manner, and if applicable, in accordance with country-specific regulations.

7 WARRANTY

The media on which you receive GE Grid Solutions' software are warranted not to fail to execute programming instructions, due to defects in materials and workmanship, for a period of 90 days from date of shipment, as evidenced by receipts or other documentation. GE Grid Solutions will, at its option, repair or replace software media that do not execute programming instructions if GE Grid Solutions receives notice of such defects during the warranty period. GE Grid Solutions does not warrant that the operation of the software shall be uninterrupted or error free.

A Return Material Authorization (RMA) number must be obtained from the factory and clearly marked on the package before any equipment will be accepted for warranty work. GE Grid Solutions will pay the shipping costs of returning to the owner parts which are covered by warranty.

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GE Grid Solutions products are not designed with components and testing for a level of reliability suitable for use in or in connection with surgical implants or as critical components in any life support systems whose failure to perform can reasonably be expected to cause significant injuries to a human.

In any application, including the above reliability of operation of the software products can be impaired by adverse factors, including -but not limited- to fluctuations in electrical power supply, computer hardware malfunctions, computer operating system, software fitness, fitness of compilers and development software used to develop an application, installation errors, software and hardware compatibility problems, malfunctions or failures of electronic monitoring or control devices, transient failures of electronic systems (hardware and/or software), unanticipated uses or misuses, or errors from the user or applications designer (adverse factors such as these are collectively termed "System failures").

Any application where a system failure would create a risk of harm to property or persons (including the risk of bodily injuries and death) should not be reliant solely upon one form of electronic system due to the risk of system failure to avoid damage, injury or death, the user or application designer must take reasonably steps to protect against system failure, including -but not limited- to back-up or shut-down mechanisms, not because end-user system is customised and differs from GE Grid Solutions testing platforms but also a user or application designer may use GE Grid Solutions products in combination with other products.

These actions cannot be evaluated or contemplated by GE Grid Solutions; thus, the user or application designer is ultimately responsible for verifying and validating the suitability of GE Grid Solutions products whenever they are incorporated in a system or application, even without limitation of the appropriate design, process and safety levels of such system or application.

10 MANUFACTURER

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FUNCTIONAL DESCRIPTION

C26X/EN FT/E72C

Contents

1	**CHAPTER OVERVIEW**	**9**
2	**SOFTWARE FEATURES**	**10**
3	**C26X BCU IMPLEMENTATION**	**11**
3.1	**SBUS - C26x**	**11**
3.2	**SBUS – Two redundant C26x BCUs**	**11**
4	**DS AGILE C26X MANAGEMENT**	**12**
4.1	**Operating Mode Management**	**12**
4.1.1	BCU Internal Operating modes	12
4.1.2	IEC 61850 Operating Modes	16
4.1.3	BCU Redundancy Mode management	21
4.1.4	SCU Redundancy Mode management	23
4.2	**Database management**	**28**
4.2.1	General	28
4.2.2	How to download a database through the Ethernet	30
4.2.3	How to switch the databases	31
4.2.4	How to perform a check of the database	31
4.2.5	How to modify the database	31
4.2.6	How to modify a parameter setting in the current DB	32
4.2.7	How to read out a parameter setting	32
4.3	**Self-tests**	**32**
4.4	**Time management**	**33**
4.4.1	External clock	34
4.4.2	Clock synchronisation message from a SCADA gateway	35
4.4.3	SNTP Client and Servers	35
4.4.4	PTP synchronisation	36
4.4.5	Time set by an operator	37
4.4.6	Local clock update	37
4.4.7	Management of loss of external time reference	38
4.4.8	Update method	38
4.4.9	Limits and performance	39
4.5	**Cyber-Security**	**39**
4.5.1	User Accounts Roles and Permissions	39
4.5.2	Authentication	46
4.5.3	Security Log	49
4.5.4	Syslog Events	50
4.5.5	Secure Communications	52
4.5.6	Certificates	52
5	**COMMUNICATIONS**	**53**
5.1	**Telecontrol Bus - TBUS**	**53**
5.2	**Legacy Bus - LBUS**	**54**
5.2.1	Modbus TCP/IP Protocol	55
5.3	**Station Bus - SBUS**	**58**

5.3.1 Exchanges 58
5.3.2 Supported Common Data Classes 59
5.3.3 Controls 59
5.3.4 GOOSE Supervision 59
5.4 Process Bus - PBUS 63
5.4.1 Feature availability 63
5.4.2 Station Bus/Process Bus communications availability via redundant C26x BCU 63
5.4.3 IEC 61850-8-1 GOOSE communications 64
5.4.4 IEC 61850-9-2 LE communications (Sampled Values) 69

6 DIRECT PROCESS ACCESS 85

6.1 Input Check 85
6.2 Output check 85
6.3 Time tagging 85
6.4 Digital input acquisition (DI) 85
6.4.1 Acquisition 85
6.4.2 Debouncing and filtering 86
6.4.3 Toggling 86
6.5 Counters acquisition (CT) 87
6.5.1 Single counter (SCT) 87
6.5.2 Double counter (DCT) 87
6.6 Digital measurement (DM) 88
6.6.1 Acquisition without Read Inhibit signal 88
6.6.2 Acquisition with Read Inhibit signal 90
6.6.3 Encoding 90
6.7 Analogue input acquisition (AI) 91
6.7.1 Input ranges 91
6.7.2 Acquisition cycle 91
6.7.3 Self-checks 91
6.7.4 Time tagging 91
6.8 Digital outputs (DO) 92
6.9 Digital Setpoints 92
6.9.1 Encoding 92
6.9.2 Read Inhibit 93
6.9.3 Open / Close Select Order 93
6.10 Analog Setpoints 94
6.10.1 Output ranges 94
6.10.2 Output management 94
6.10.3 AOU Watchdog management 95

7 DATA PROCESSING 96

7.1 Binary Input Processing 96
7.1.1 Binary Input Definition 96
7.1.2 Processing of Single Point Status 97
7.1.3 Processing of Double Point Status 99
7.1.4 Processing of Multiple Point Status 102
7.1.5 Counting 104
7.1.6 System Inputs (SI) 107
7.1.7 IED inputs 108

7.1.8	Group processing	108
7.1.9	SBMC Mode Processing	109
7.1.10	BI sent to automatism features	109
7.2	**Measurement Input Processing**	**109**
7.2.1	Measurement Input Processing - Focus	110
7.2.2	Focus 1: Analogue measurement processing up to threshold detection	111
7.2.3	Focus 2: Digital Measurement Processing up to Threshold Detection	114
7.2.4	Focus 3: TMU2XX - CT/VT measurement processing up to Threshold Detection	115
7.2.5	Focus 4: All Measurement Values: Threshold Detection through Transmission	117
7.2.6	TMU2XX - CT / VT Calculations - General	119
7.2.7	TMU2XX - Frequency Network Channel selection	122
7.2.8	TMU220: CT / VT Calculations – Inputs	124
7.2.9	TMU220: CT / VT Calculations – Outputs	125
7.2.10	TMU210: CT / VT Calculations – Inputs	133
7.2.11	TMU210: CT / VT Calculations – Outputs	135
7.3	**Manual operations on datapoints**	**138**
7.3.1	suppression	138
7.3.2	Substitution	138
7.3.3	Forcing an invalid measurement	138
7.4	**Measurement resulting states**	**138**
7.4.1	Transmission	139
7.5	**Tap Position Indication (TPI) measurement processing**	**146**
7.5.1	Acquisition from Digital Inputs	146
7.5.2	Acquisition from Analogue Inputs	146
7.5.3	Manual suppression	146
7.5.4	Substitution	147
7.5.5	Forcing an invalid TPI	147
7.5.6	TPI resulting states	147
7.5.7	Scaling	147
7.5.8	Transmission	147
7.6	**Accumulator Input Processing**	**148**
7.7	**Energy counting**	**148**
7.7.1	Acquisition process	151
7.7.2	Energy Counter Processing	153
7.7.3	Scaling factor	154
7.7.4	Energy Counter Transmission	154
7.7.5	Limitations	154
7.8	**Basic Data Handling**	**155**
7.8.1	Test Mode	155
7.8.2	Device order running	156
7.8.3	Current execution status SPS for Open/Close control commands	156
7.8.4	Open/close command state SPS datapoints for C26x output contacts	156
7.8.5	Controls management from PSL	157
7.8.6	Caveat: PSL (FBD) and Redundant Operation	157
8	**CONDITION MONITORING FUNCTIONS**	**159**
8.1	**Generalities**	**159**
8.1.1	Behaviour in case of external requests	159
8.1.2	Function Blocking	159
8.1.3	Default modes	159

8.1.4	Measurement and counter	160
8.1.5	Warning & alarm management	160
8.2	**Circuit Beaker Monitoring**	**161**
8.2.1	General description	161
8.2.2	Included features	161
8.2.3	Function scope	161
8.2.4	Limitations	162
8.2.5	Current broken and contact abrasion	162
8.2.6	Operation counter	170
8.3	**Switchgear Monitoring**	**172**
8.3.1	Input Data points	172
8.3.2	Output data points	172
8.3.3	Operations and time management	173
8.3.4	Limitations	173
8.4	**Diverter Switch Monitoring**	**174**
8.4.1	Input Data points	174
8.4.2	Output data points	174
8.4.3	Diverter switch abrasion calculation	175
8.4.4	Limitations	176
8.5	**Tap Changer Monitoring**	**177**
8.5.1	Input datapoints	177
8.5.2	Output datapoints	178
8.5.3	Operations and time management	178
8.5.4	Limitations	179
8.6	**Motor Monitoring**	**180**
8.6.1	Wiring scenarios	180
8.6.2	Input datapoints	181
8.6.3	Output datapoints	182
8.6.4	Default operation values	182
8.6.5	Operations	182
8.6.6	Alarms and Warnings	183
8.6.7	Behaviour upon compter reboot	183
8.6.8	Limitations	183
8.7	**Residual Lifetime Monitoring**	**184**
8.7.1	Input datapoints	184
8.7.2	Output datapoints	184
8.7.3	Operations and time management	184
8.7.4	Alarms and Warnings	184
8.7.5	Limitations	184
9	**PROTECTION FUNCTIONS**	**185**
9.1	**Directional Element**	**185**
9.2	**Curve Element**	**186**
9.3	**Overcurrent Protection (50/51)**	**190**
9.3.1	Phase Overcurrent Protection implementation	190
9.4	**Earth Fault protection (50N/50G/51N/51G/67N)**	**194**
9.4.1	Earth Fault Protection implementation	194
9.5	**Circuit Breaker Failure (50BF)**	**199**
9.5.1	Circuit Breaker Protection implementation	199

10	**CONTROL SEQUENCES**	**205**
10.1	**Description**	**205**
10.1.1	General	205
10.1.2	Control sequence phase management	206
10.1.3	Direct Execute mode	209
10.1.4	SBO once mode	210
10.1.5	SBO many mode	213
10.1.6	Generic selection checks	215
10.1.7	Selection behaviour	219
10.1.8	Generic execution checks	222
10.1.9	Execution behaviour	223
10.1.10	Controls time sequencing	224
10.1.11	How an xPS starts a control sequence	227
10.2	**Control of non synchronised breakers**	**228**
10.2.1	Non-synchronised circuit-breaker features	228
10.2.2	Control sequence of non-synchronised circuit-breakers	228
10.3	**Control of synchronised breakers**	**229**
10.3.1	Synchronised circuit-breaker features	229
10.3.2	Circuit-breakers with external synchrocheck	230
10.3.3	Circuit-breakers with internal synchrocheck	236
10.4	**Control of disconnectors (Switchgear)**	**240**
10.4.1	Disconnector features	240
10.4.2	Control sequence of disconnectors	240
10.5	**Control of transformers**	**240**
10.5.1	Transformer features	240
10.5.2	Control sequence of transformers	240
10.6	**Control of ancillary devices**	**245**
10.7	**Control of Intelligent Electronic Devices (IED)**	**245**
10.7.1	Control to IEDs by xPC	245
10.7.2	Control to IEDs by Digital setting point (SPC)	246
10.8	**System controls**	**246**
10.9	**Types of control sequences**	**246**
10.10	**Control sequences checks**	**246**
10.10.1	Mode Management	247
10.10.2	IED connected	247
10.10.3	Control mode	247
10.10.4	Uniqueness of control	247
10.10.5	Inter-control delay	247
10.10.6	Status of the device	248
10.10.7	Lock device	248
10.10.8	Running Automation	248
10.10.9	Interlocking	248
10.11	**HV Control Sequences**	**248**
10.11.1	Circuit-breaker	248
10.11.2	Disconnector	248
10.11.3	Transformer	248
11	**AUTOMATIONS**	**249**
11.1	**Built-in Automation functions**	**249**

11.1.1	Auto-Recloser (AR)	249
11.1.2	Trip Circuit Supervision (TCS)	266
11.1.3	Automatic Voltage Regulation–AVR	269
11.2	**Synchrocheck**	**306**
11.2.1	General	306
11.2.2	Functional Description	308
11.2.3	Synchrocheck Computation	318
11.2.4	Synchrocheck Type 1	322
11.2.5	Synchrocheck Type 4	333
11.2.6	Configuration and settings	343
11.2.7	Digital Output (DO) of the circuit-breaker	347
11.2.8	Synchrocheck Type 5	347
11.3	**Interlocking: logical equations**	**379**
11.3.1	Inputs	380
11.3.2	Outputs	380
11.3.3	Control	380
11.3.4	Behaviour	380
11.3.5	Interlocking and Synchrocheck	384
11.4	**Slow automation: Programmable Logic Control (PLC)**	**385**
11.4.1	Inputs	386
11.4.2	Outputs	386
11.4.3	Control	387
11.4.4	Behaviour	387
11.4.5	Limits and specifications	387
11.5	**Fast automation: Programmable Scheme Logic (PSL)**	**388**
11.5.1	General	388
11.5.2	Timers	389
11.5.3	Boolean	390
11.5.4	RS flip-flop	390
12	**RECORDS & LOCAL ARCHIVING**	**393**
12.1	**Permanent records storage**	**393**
12.1.1	Events	393
12.2	**Waveform Recording**	**393**
12.2.1	Fast Waveform	394
12.2.2	Slow Waveform	397
12.2.3	Recording Mechanism	400
12.3	**Non-permanent data storage**	**401**
12.3.1	Alarms	401

1 CHAPTER OVERVIEW

This document is a chapter of the DS Agile C26x documentation. This chapter contains the functional description of this device.

The hardware description can be found in the Hardware Description (HW) chapter.

All the connection diagrams are shown in the Connection Diagrams (CO) chapter.

The capabilities, performance and environmental limits of this device can be found in the Technical Data chapter (TD).

2 SOFTWARE FEATURES

The C26x is a modular product at the hardware, software and functional levels. All its functions are fully configurable in accordance with the customer's needs and requirements. The C26x offers the following features:

- Direct processing interface through Digital Inputs (DI), Digital Outputs (DO), Analogue Inputs (AI), Analogue Outputs (AO) and Current Transformer (CT)/Voltage Transformer (VT) boards
- Direct Operator Interface (aView)
- Embedded parameters to control all common plants or devices
- High communication abilities to IED, Ethernet, and SCADA
- Settable automation modules
- Events, alarms, measurement display, printing and archiving
- Enhanced inner management with database management, self-test controls and the capability to synchronise all the devices.

The components of the software management include:

- Input/Output boards: DI, DO, AI, AO
- Analogue Inputs: AI, and from the optional CT/VT board
- Communications with the Tele control Bus (TBUS), Station Bus (SBUS)). Please refer to the Communication chapter of this manual.

Communication with peripherals such as:

- Local Operator Interface: LCD, front panel

There are three ways to perform automation functions:

- Programmable Scheme Logic (PSL) for all C26x units
- Programmable Logic Control (PLC) for all C26x units
- Built-in automation functions, such as:
  - Auto-Recloser (AR)
  - xPS/xPC Association
  - Pole Discrepancy
  - Automatic Voltage Regulation (AVR)
  - Synchrocheck
- Phase-to-Phase Synchrocheck with the TMU210

Depending on whether the C26x unit is redundant or not, the software features are different for a redundant C26x unit and for a non-redundant C26x unit.

3 C26X BCU IMPLEMENTATION

The DS Agile C26x is the base module of the DS Agile architectures.

Each C26x includes an internal rack. The control unit's boards are mounted on this rack. "Rack" is the general technical name, but there can be different functional names.

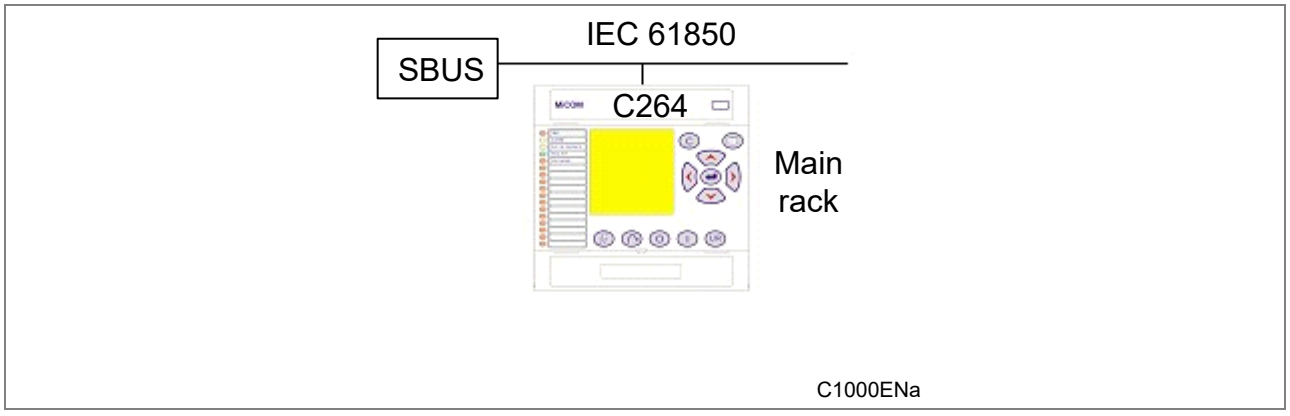
The functional name depends on the C26x's location in a system. The functional names for the rack are as follows:

- Main rack: In a standalone system, the first (and only) unit
- Main rack: In a redundant system, the default active unit
- Backup rack: In a redundant system, the default standby unit
- Redundant system: A system that includes an active unit and a standby unit

The family of C26x units discussed in this chapter includes the following devices and configurations:

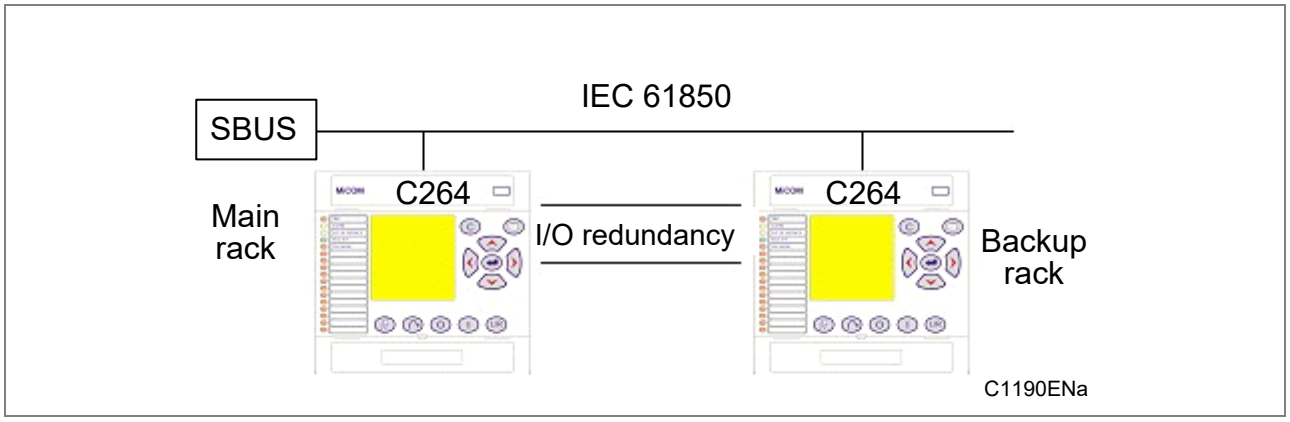
3.1 SBUS - C26X

The C26x is connected to the SBUS through an Ethernet Port and uses the IEC 61850 protocol.



3.2 SBUS – TWO REDUNDANT C26X BCUS

Each C26x is connected to the SBUS through an Ethernet Port and uses the IEC 61850 protocol.



4 DS AGILE C26X MANAGEMENT

The C26x manages its own operating mode, configuration (databases), and time.

4.1 OPERATING MODE MANAGEMENT

4.1.1 BCU INTERNAL OPERATING MODES

4.1.1.1 DEFINITIONS

C26x internal modes

The C26x operates in the following modes:

- Initialisation mode (0)
- Operational mode
  - Normal (active) mode (2)
  - Downgraded (standby) mode (3)
- Maintenance mode (4)
- Faulty mode (5)
- Halt mode (6)

C26x faults include

- **Anomaly**: a fault that causes a downgrade in the behaviour of the C26x. There are hardware and/or software anomalies, as follows:
  - Board failure
  - Loss of synchronisation
  - Loss of communications
- **Software fault**: a major software error causes a software fault, which causes the C26x to go into the **Faulty** mode.
- **Vital hardware fault**: a fault that causes a software halt which causes the C26x to stop the application software. Vital hardware faults include:
  - CPU fault
  - Power supply fault
  - Bus fault
  - Permanent interruption fault

4.1.1.2 INITIALIZATION MODE

After a power on or a manual reset event occurs, the C26x goes into the initialization mode. The initialization mode does not exceed one minute. The C26x performs different types of tests and checks, as follows:

Vital hardware tests

Flash memory test: in the event of a problem, the C26x tries to repair this flash memory. If a vital hardware test fails, the C26x exits the initialization mode and enters the Halt mode.

Non-vital hardware tests

The C26x performs non-vital hardware tests only on the boards installed in the C26x, and on the peripheral devices connected to the C26x:

- Input and output boards:
  - To determine the number and the type of the installed input and output boards
  - To check for the presence of previously installed input and output boards and to determine whether a board is absent
  - To check the serviceability of the installed input and output boards and to determine whether a board is unserviceable
- Communication boards: the C26x performs this test using the communication protocol
- Displays, such as the LCD screen and the LEDs: the C26x performs a single test for the presence of the HMI board
- Peripheral devices, such as the external clock, and so on: the C26x uses timeouts to check for the presence of the peripheral devices.

If one of these non-vital hardware tests fails, the C26x goes into the relevant **downgraded** mode.

- **Software tests (database consistency tests)**

  Upon each restart, the C26x performs database consistency tests. These tests ensure that the database is compatible with the hardware and software of the C26x, and that the database does not contain inconsistent configuration data. The database consistency tests include:

- **Check for the presence of a database**
- **Check of the DB/ software compatibility**

  This check ensures that the C26x's software and the database are consistent and compatible. The C26x contains in its static data a database version number and a revision number that indicate which version of the database it can interpret. The database must have the same version and revision numbers for the C26x to accept it.

- **Check of the DB/ equipment compatibility**

  This check ensures that the database is compatible with the device into which it was downloaded. The C26x compares the type and the number of the device contained in the heading of the database with the type and the number of the device contained in the static data of the software.

- **Check of the validity of the database's data**

  This check ensures that the configured inputs and outputs are present and that the number of devices and signals, such as bays, digital inputs, and so on, remains within acceptable limits.

If any one of these checks fails, the C26x enters the **Maintenance** mode.

4.1.1.3 OPERATIONAL MODE

This mode includes two sub-modes: **Normal** mode and **Downgraded** mode.

4.1.1.3.1 Normal mode

This is the nominal operating mode of the active C26x. In this mode the C26x energises the watchdog relay and all the C26x's functions are available. Depending on the cause and severity of the failure, an error detection can cause the C26x to enter the relevant **Downgraded** mode, **Faulty** mode or **Halt** mode.

In Normal mode, you can use the local Human Machine Interface (HMI) or an upper level maintenance request to order a transition into **Maintenance** mode.

In Normal mode, you can use the local (HMI) or an upper level simulation request to order a transition into **Test** mode.

In Normal mode, you can perform the following database operations:

- Download a standby database
- Swap the databases: the C26x automatically restarts
- Modify a database
- Display database information.

The C26x transmits the results of the Test mode to the local HMI and to the upper level remote control point (RCP).

4.1.1.3.2 Downgraded mode

In the event of an anomaly, the C26x enters **Downgraded** mode. In this mode, the C26x's operation is not very disturbed because only a few functions are downgraded. The C26x energises the watchdog relay.

The type of downgraded mode depends on the C26x's hardware configuration. The various events that cause a downgraded mode include:

- Operation without DO on a board
- Operation without DI on a board
- Operation without AI on a board
- Operation without communications with some relays
- Operation without communications with some plant devices
- A combination of two or more of these events.

When you or the C26x resolve the cause of the transition into **Downgraded** mode, the C26x returns to **Normal** mode.

In a redundancy configuration, if the main C26x switches to downgraded mode, the backup C26x becomes the active BCU if it is healthier and the main C26x the standby BCU. See section BCU Redundancy Mode management for details.

4.1.1.4 MAINTENANCE MODE

In **Maintenance** mode, the station bus (SBUS) operates: you can communicate on the SBUS to manage the database. The Maintenance mode is shown on the local HMI (LED and LCD) and on the upper level.

The C26x deenergizes the watchdog relay.

In this mode, you can manage the database:

- Download a database
- Swap the databases
- Modify a database
- Show database information

In Maintenance mode, you can use the local Human Machine Interface (HMI) or an upper level active request to request a transition into **Operational** mode. The **Operational** mode includes the Normal mode and the Downgraded mode.

4.1.1.5 FAULTY MODE

In any mode, when a fault occurs to prevent the proper operation of the software, the C26x goes into the **Faulty** mode.

When the C26x detects a failure on the DO boards, and if the configuration allows it, the C26x enters Faulty mode. Each time the C26x switches to Faulty mode, an internal counter is incremented.

There are only two ways to exit the Faulty mode:

- A transition to **Initialisation** mode and an automatic reset of the counter
- A transition to **Halt** mode.

If the value of the internal counter remains lower than the Max_Fault parameter defined during the configuration stage, the C26x switches to **Initialisation** mode. When the elapsed time since the last increment of the internal counter equals the value Fault_Detection_Lasting parameter defined during the configuration stage, the value of the counter automatically resets.

When the value of the internal counter reaches Max_Fault, the C26x goes into the **Halt** mode.

4.1.1.6 HALT MODE

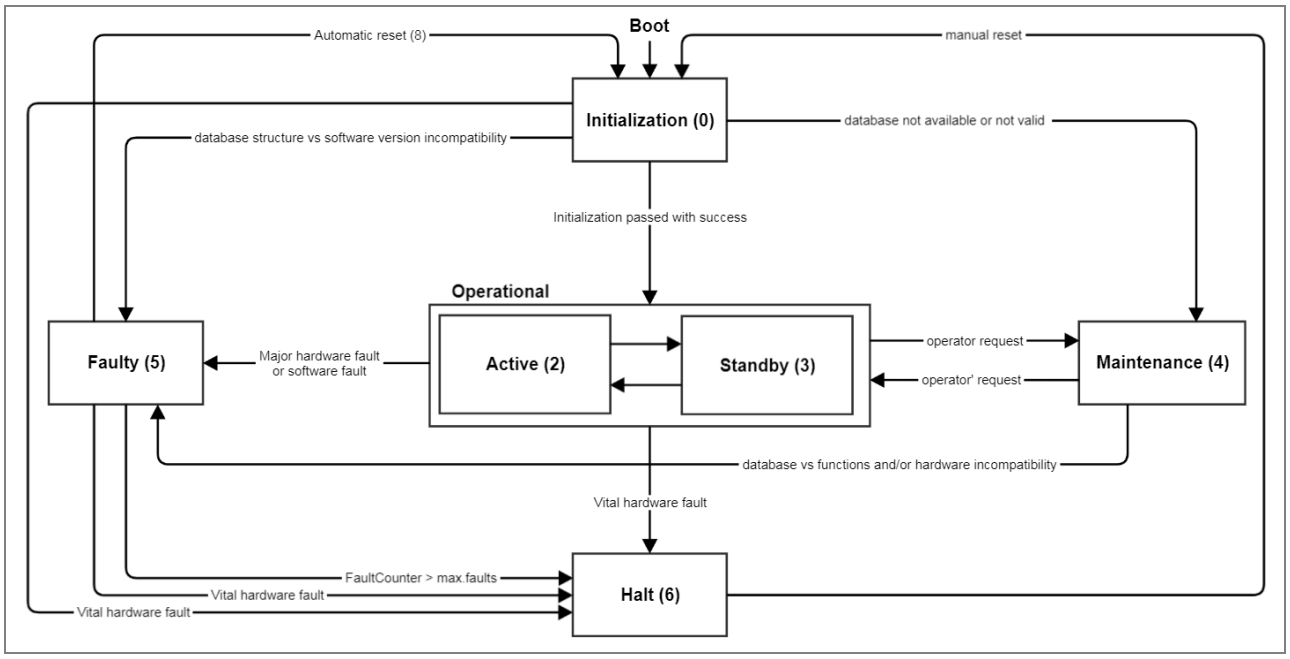
In this mode, the C26x de-energises the watchdog relay and all the output relays. The C26x does not operate anymore. The only way to exit this mode is to perform a manual reset.

4.1.1.7 SUMMARY OF MODES, TESTS, TRANSITIONS, AND FAULTS

The internal modes are summed up in the table below.

Operating mode	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Bay Controller Unit mode (C264)	Initialisation	N/A	Active	Standby	Maintenance	Faulty	Halt	Suspend	Boot

The tests and transitions are shown in the figure below.



4.1.2 IEC 61850 OPERATING MODES

Caution:
Do not change the operating mode of a redundant C26x: The standby BCU keeps its current mode even when the active BCU's mode changes.

There are four IEC 61850-compliant operating modes available for the C26x when it is operational:

- Mode "**ON**": Normal operating mode variant.
  - The output contacts are *operational*.
  - In the transmitted messages the "test" bit associated with the value is set to *FALSE*, and their content represents the actual state of the process.
  - Received messages are only taken into account if their "test" quality attribute is also set to *FALSE*.
- Mode "**ON-BLOCKED**": Normal operating mode variant.
  - The output contacts are *blocked*.
  - In the transmitted messages the "test" bit associated with the value is set to FALSE.
  - Received messages are only taken into account if their "test" quality attribute is also set to *FALSE*.

- Mode "**TEST**": Test mode variant.
  - The device runs normally
  - The output contacts are *operational*.
  - In the transmitted messages the "test" bit associated with the value is set to *TRUE*.
  - Received messages are only taken into account if their "test" quality attribute is also set to *TRUE*.
- Mode "**TEST/BLOCKED**": Test mode variant.
  - The device runs normally
  - The output contacts are *blocked*.
  - In the transmitted messages the "test" bit associated with the value is set to *TRUE*.
  - Received messages are only considered if their "test" quality attribute is also set to *TRUE*.

Note: all values sent by legacy IEDs connected through Legacy bus (LBUS) to the C26x will not be tagged in **TEST** mode if the C26x is not in **TEST** mode.

The fifth mode, “OFF”, is set when the C26x’s internal mode is the Maintenance mode, the LLNO Operating mode is OFF.

When the C26x’s internal mode is the Initialisation, Faulty, Halt, Suspend or Boot mode, IEC 61850 communication is disabled. Therefore, no operating mode can be transmitted.

The C26x **operating mode** of the logical node zero (**LLNO**) is given in the table below (in compliance with the **IEC 61850-7-4 Edition 2.1 Draft** standard):

DS Agile mode	Operational	Blocked	Test	Test-Blocked	Maintenance
Operating mode (LLNO.Mod)	ON	ON-BLOCKED	TEST	TEST-BLOCKED	OFF
Operating mode (MPS value)	1	2	3	4	5

In order to simulate the operation of distributed automatic events, such as interlocks, the C26x must be switched to Test or Test/blocked mode. In that mode, it will accept commands tagged in any mode.

Management of received datapoints

If the C26x is in Test-Blocked or Test mode:

- all incoming data (GOOSE, SV, reports) will be accepted, even if they are tagged TEST or NOT.
- all IEC61850 controls must be done with TEST set to TRUE to be accepted.

If the C26x is in Operational or On-Blocked mode:

- all incoming data (GOOSE, SV, reports) have not to be tagged in TEST to be accepted.
- all IEC61850 controls must be done with TEST set to FALSE to be accepted.

Limitation for STATION BUS only

If the C26x switches from **ON** mode to **TEST** mode or inversely:

- GOOSE input data will be considered only if the "state" changes inside the GOOSE. For instance, if a publisher IED switches to **TEST** mode and publishes new states, the C26x will ignore GOOSE flagged with **TEST** as the C26x is not in **TEST** mode. Later, if the C26x switches to **TEST** mode, any GOOSE received without new state information will be considered as repetition GOOSE, even if the C26x is in **TEST** mode as the publisher IED.
- GOOSE repetition is ignored

Nominal operation

The list below describes how C26x manages switches operating modes in steady-state (orders transmitted to C26X in steady-state operating mode).

C26X Operating modes	Operational	Maintenance	On-blocked	Test	Test-blocked
Select order	OK	Blocked by operating mode	Blocked by operating mode	Blocked by operating mode	Blocked by operating mode
Execute order	OK	Blocked by operating mode	Blocked by operating mode	Blocked by operating mode	Blocked by operating mode
Cancel order	OK	Blocked by operating mode	Blocked by operating mode	Blocked by operating mode	Blocked by operating mode(*)
xPS profile "test = yes"	q = good / test = false	q = invalid / test = false	q = good / test = true	q = good / test = true	q = good / test = true
xPS profile "test = no"	q = good / test = false	q = invalid / test = false	q = invalid / test = false	q = invalid / test = false	q = good / test = true

(*) the control button is accessible, but the C26x does not respond C26x

Error modes

The list below describes how C26x manages switches operating modes in transient state. The orders are transmitted to the C26X while an operating mode changeover (materialized by an -->: from an original operating mode to another one).

The control is a transmitted by an xPC datapoint, and the control feedback is transmitted by an xPS datapoint

The datapoint' profiles details are described hereafter for each order sent:

C26X Operating Mode	Datapoint' profiles: "TEST = yes / maintenance bay = no"			Datapoint' profiles: "TEST = no / maintenance bay = yes"	
Control mode	Direct Execute (DE)	Select Before Operate (SBO)		Select Before Operate (SBO)	
Control sent	Execute	Select	Execute	Select	Execute
Operational mode (ON) to Maintenance mode switchover	Operational mode (ON) switchover: immediate feedback after switchover: "OK" Maintenance mode switchover: variable delay from 10s to 45s feedback before switchover: "OK"	Operational mode (ON) switchover: immediate feedback after switchover: "OK" Maintenance mode switchover: variable delay from 10s to 45s feedback before switchover: "OK"	Operational mode switchover: immediate feedback after switchover: "OK" Maintenance mode switchover: variable delay from 10s to 45s feedback before switchover: "OK"	Operational mode switchover: immediate feedback after switchover: "KO - Blocked by Operating mode" Maintenance mode switchover: variable delay from 10s to 45s feedback before switchover: "OK"	Operational mode switchover: immediate feedback after switchover: "KO - Blocked by Operating mode" Maintenance mode switchover: variable delay from 10s to 45s feedback before switchover: "OK"
Maintenance mode to Operational mode switchover	Operational mode switchover: immediate feedback after switchover: "OK"	Operational mode switchover: immediate feedback after switchover: "OK"	Operational mode switchover: immediate feedback after switchover: "OK"	Operational mode switchover: immediate feedback after switchover: "OK"	Operational mode switchover: immediate feedback after switchover: "OK"
Operational mode to Test-blocked mode switchover	Operational mode switchover: immediate feedback after switchover: "OK" feedback after switchover: "operate NOK position invalid"	Operational mode switchover: immediate feedback after switchover: "OK" feedback after switchover: "KO - Blocked by Operating mode"	Operational mode switchover: immediate feedback after switchover: "OK" feedback after switchover: "operate NOK position invalid"	Operational mode switchover: immediate feedback after switchover: "OK" feedback after switchover: "KO - Blocked by Operating mode"	Operational mode switchover: immediate feedback after switchover: "OK" feedback after switchover: "operate NOK position invalid"

C26X Operating Mode	Datapoint' profiles: "TEST = yes / maintenance bay = no"			Datapoint' profiles: "TEST = no / maintenance bay = yes"	
Test-blocked mode to Operational mode switchover	Operational mode switchover: immediate feedback after switchover: "OK"	Operational mode switchover: immediate feedback after switchover: "OK"	Operational mode switchover: immediate feedback after switchover: "OK"	Operational mode switchover: immediate feedback after switchover: "OK"	Operational mode switchover: immediate feedback after switchover: "OK"

Note:
The "test" quality associated with operating mode indications is never set so that they are always accepted by operational devices.

Communications with DS Agile system HMI (aView)

When the C26x is in *test/blocked* mode, DS Agile aView displays it as being in operational mode.

Because the DS Agile aView is always in operational mode, a C26x is in *test/blocked* mode always refuses commands sent from aView with a "KO-mode" negative acknowledgement.

However, messages sent by a C26x while in *test/blocked* mode are displayed by the DS Agile aView. It is possible, via the IEC61850 agency on the aView PC, to block test-tagged frames so that aView does not display them: manually add the "Test mode" parameter to the Agency.cfg file. See SBUS/EN AP.

GOOSE exchanges with IEDs

A C26x in *test* or *test/blocked* mode:

- sets the "test" quality in the GOOSE control blocks that it publishes, except for system datapoints ("LDIA1" brick),
- filters received GOOSE control blocks:

  It only processes GOOSE frames with the "test" quality and discard any other frames.

When in operational mode, the C26x processes all the GOOSE frames without the "test" quality, i.e. untagged frames and frames in which the "test" quality is not set.

Note:
When the C26x switches from operational *mode to* test-blocked *mode and vice-versa, GOOSE input data will be considered only when a data state changes inside the GOOSE (GOOSE repetition is ignored).*
For example, if, while the C26x is in operational *mode, an IED publisher switches to* test *mode and publishes a data state change, the C26x will ignore it because it is not itself in test mode. Then if the C26x switches to* test/blocked*, all the GOOSE frames received without any data state change will be considered as repeated frames and the C26x will thus ignore the data state because the change was first published while the IED and C26x were in opposite modes.*

Report exchanges with other C26x units

A C26x in *test* or *test/blocked* mode sets the "test" quality in the Reports that it transmits, except for system datapoints ("LDIA1" brick).

4.1.3 BCU REDUNDANCY MODE MANAGEMENT

Two identical control units with the same hardware and the same database versions are used in redundancy management.

For the C26x System

The two redundant control units are the main C26x BCU and the backup C26x BCU. The C26x that manages the bay(s) is the **active** C26x; the other one is the **standby** C26x. In this configuration, the redundant C26x BCU can be:

- Main C26x BCU in active mode
- Main C26x BCU in standby mode
- Backup C26x BCU in active mode
- Backup C26x BCU in standby mode.

During the boot time, and if both control units are in operation, the **main** C26x is the **active** BCU.

The two control units perform the same functions simultaneously: inputs acquisition and processing, archiving and automation, but at any given time, only the active C26x sends controls to the electrical process or on the SBUS. A DS Agile IEC 61850 client receives data from the two control units: This client processes only the data it receives from the C26x in **active** mode. Only the C26x in **active** mode manages the communications with the IEDs or the SCADA.

This switch from **active** mode to **standby** mode, as well as from **standby** mode to **active** mode, is performed automatically as follows:

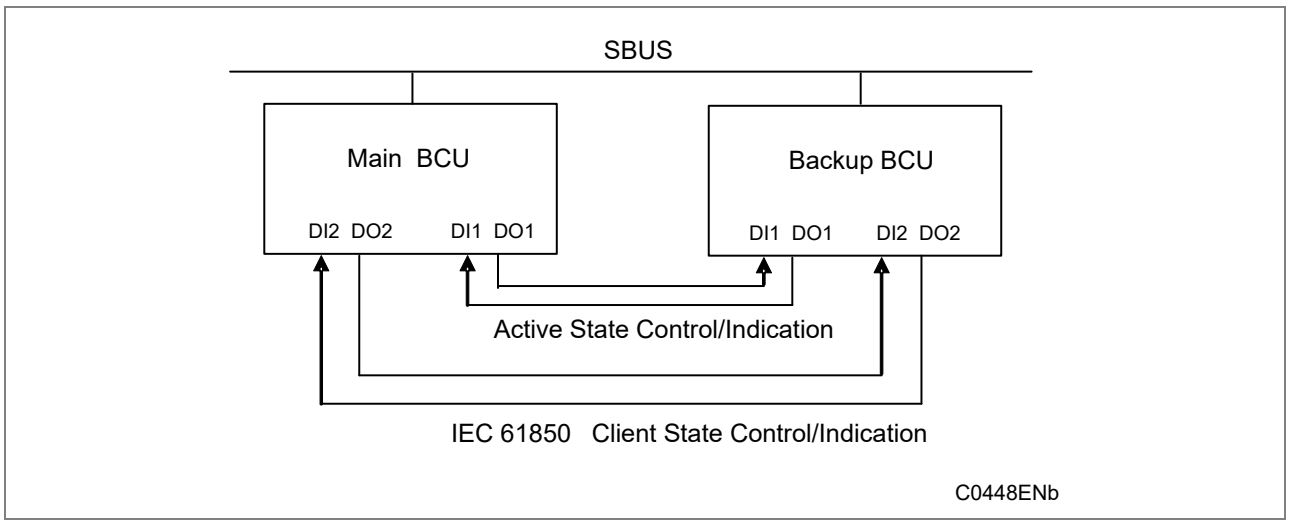


Figure 1: Redundancy management

The two control units exchange data with:

- The SBUS, to provide their internal status (IS)
- 2 pairs of DI/DO of the BIU board:
  - DI1/DO1 to indicate the Active Status: DO1 is closed if the C26x is Active
  - DI2/DO2 to indicate a Station Bus failure: DO2 is open in the event of a failure

Note:
In order for the standby C26x to become active when the active C26x loses it communications with the station bus, it is necessary that there is at least one MMS client connected or that GOOSE frames are exchanged with the two C26x.

A value is assigned to each type of C26x board failure: the control unit's IS is the sum of all the failure values. The healthiest C26x is the one with the lowest internal status value. The healthiest C26x becomes the active C26x.

Board type	Failure value for each type of board
AIU	0x01
BIU	0x02
DIU	0x04
CT/VT	0x08
AOU	0x10
CCU	0x20
DOU or HBU	0x40

The initial state is "Initialisation" (state 0) and the "DI1≠1" event is generated.

"L_IS" is the internal status of the C26x, "R_IS" is the internal status of the redundant one.

The "confirmed DI2 ≠ 1" event is the detection of a Station Bus failure by the other C26x (DI2 = 0) which has been **confirmed during 20 seconds**.

T1 is the timer of the Active status confirmation during the C26x initialisation (default value: 5 seconds for the Main 1 C26x, defined during the configuration process, 30 seconds for the Main 2 C26x). T2 is the timer of the master election (default value: 5 seconds).

The switching time is less than 30 seconds.

	State 0: Initialisation	State 1: Awaiting end of initialisation / T1 timer running	State 2: Standby	State 3: Standby / T2 timer running	State 4: Active	State 5: Standby mode selected
DI1≠1	≠ T1 timer launching ≠ go to state 1	/	≠ close DO1 ≠ go to state 4	≠ stop T2 timer ≠ go to state 4	/	/
DI1=1	go to state 2	≠ stop T1 timer ≠ go to state 2	/	≠ open DO1 ≠ stop T2 timer ≠ go to state 2	go to state 5	/
"confirmed" DI2≠1	/	/	≠ T2 timer launching ≠ close DO1 ≠ go to state 3	/	/	/
Remote IS	/	/	If (L_IS<R_IS) then ≠ T2 timer launching ≠ close DO1 ≠ go to state 3	If (L_IS>R_IS) then ≠ stop T2 timer ≠ open DO1 ≠ go to state 2	/	/
End of T1 timer	/	If DI1≠1 then: ≠ T2 timer launching ≠ close DO1 ≠ go to state 3 else: ≠ go to state 2	/	not possible	not possible	/

	State 0: Initialisation	State 1: Awaiting end of initialisation / T1 timer running	State 2: Standby	State 3: Standby / T2 timer running	State 4: Active	State 5: Standby mode selected
End of T2 timer	/	/	/	go to state 4	/	/
End of standby mode going-on	/	not possible	not possible	not possible	not possible	open DO1 if conditions to enter standby mode are not true anymore then ≠ T2 timer launching ≠ go to state 3 else ≠ go to state 2

4.1.4 SCU REDUNDANCY MODE MANAGEMENT

The SCU uses a “twin” (or “hot-hot”) redundancy mode: both units run at the same time, acquiring and controlling data, as well as providing automatic responses when required.

Only **1** running mode is available for the SCU: *Active* (equivalent to "hot").

The SCU are the twins, identical in terms of hardware and software functions, automation, protocols... They run in parallel. The BCU chooses which fast GOOSE (see section *5.4.3.6 Fast GOOSE Mechanism* for details) to take into account based on either:

- the state of a main/backup selection datapoint (**Goose red. sel.**), or
- a redundancy controller using the internal status (IS) of the SCUs

In this section, the first SCU configured in the SCE is called "SCU main", and the SCU created by the "create backup" command is called "SCU backup".

Note:
The redundancy management described here refers to how the BCU processes the GOOSE it receives. The GOOSE sent by the BCU are received and processed by both SCUs in parallel.

4.1.4.1 RUNNING MODE MANAGEMENT

Redundancy status management

The System redundancy mode is not managed at SCU level. The **Redundancy mode (RedSt)** system datapoint of the SCU is not used, it is INVALID by default.

SCU in halt mode (booting)

- the SCU is always reset on **Active** running mode
- during this reset, all automations (FBD, IsaGRAF, built-in functions) are run again

SCU in operational mode (ON)

The twin SCUs run simultaneously, performing the same functions:

- physical inputs acquisition
- post-processing
- datapoints transmission on PBUS and SBUS (only physical DI / AI / groups / mapping ...)
- archiving, logging ...

DS Agile clients (GTW, AVIEW, BCU) send controls (SPC, DPC, SETPOINT) to the twin SCUs. Both SCUs subscribe to the BCU's GOOSE, and they concurrently execute the controls.

Software components

Due to the hot/hot redundancy, software components are running on both twin SCUs.

Software components are not restarted upon a redundancy switchover.

Software component(s)	SCU #1	SCU #2
Serial Modbus master	Running	Stopped
DI/DO acquisition	Running	Running
Measurements	Running	Running
IEC 61850 Agency server	Running	Running
FBD	Running	Running

Station Bus

Both SCUs transmit data (reports) over the Station Bus.

GOOSE identification

The GOOSE transmitted by the redundant SCUs are distinguished by their **GOCBref**, which is different for each SCU.

Reports identification

Reports transmitted by the SCUs have different **IEC 61850** addresses. At client side, supervision HMI level (aView), the Reports are received as emanating from 2 different IEDs and can be animated separately.

Legacy IEDs

The SCU polls the legacy IEDs connected to it through a Legacy Bus (LBUS).

For the Modbus-RTU protocol, if a slave IED is connected to the SCU main RS485 port, and the SCU backup port RS485 in daisy-chained, a specific datapoint, **Modbus activity**, is managed by the **Redundancy Controller**, in order to allow only one RS485 port as connection master.

- If **Modbus activity** is SET, the SCU RS485 port to which the legacy IED Modbus-RTU (the slave) is connected is declared "master".
- If **Modbus activity** is RESET, the SCU RS485 port to which the legacy IED Modbus-RTU (the slave) is connected is declared "not connected".

4.1.4.2 SCU MAIN/BACKUP SELECTION USING A "SELECTOR" DATAPOINT

The BCU managing the bay selects which, among the GOOSE published by the main SCU and those published by the backup SCU, is best able to reflect the correct field information (contact position, coil state...). To this effect, it can use the optional SPS datapoint **Goose red. sel.** (Goose redundancy selector):

- **Goose red. sel.** is RESET: the GOOSE published by the main SCU is used by the BCU
- **Goose red. sel.** is SET: the GOOSE published by the backup SCU is used by the BCU

This datapoint can be managed by an internal automation (FBD or IsaGRAF) or by an external automation (according to IEC 61131-3).

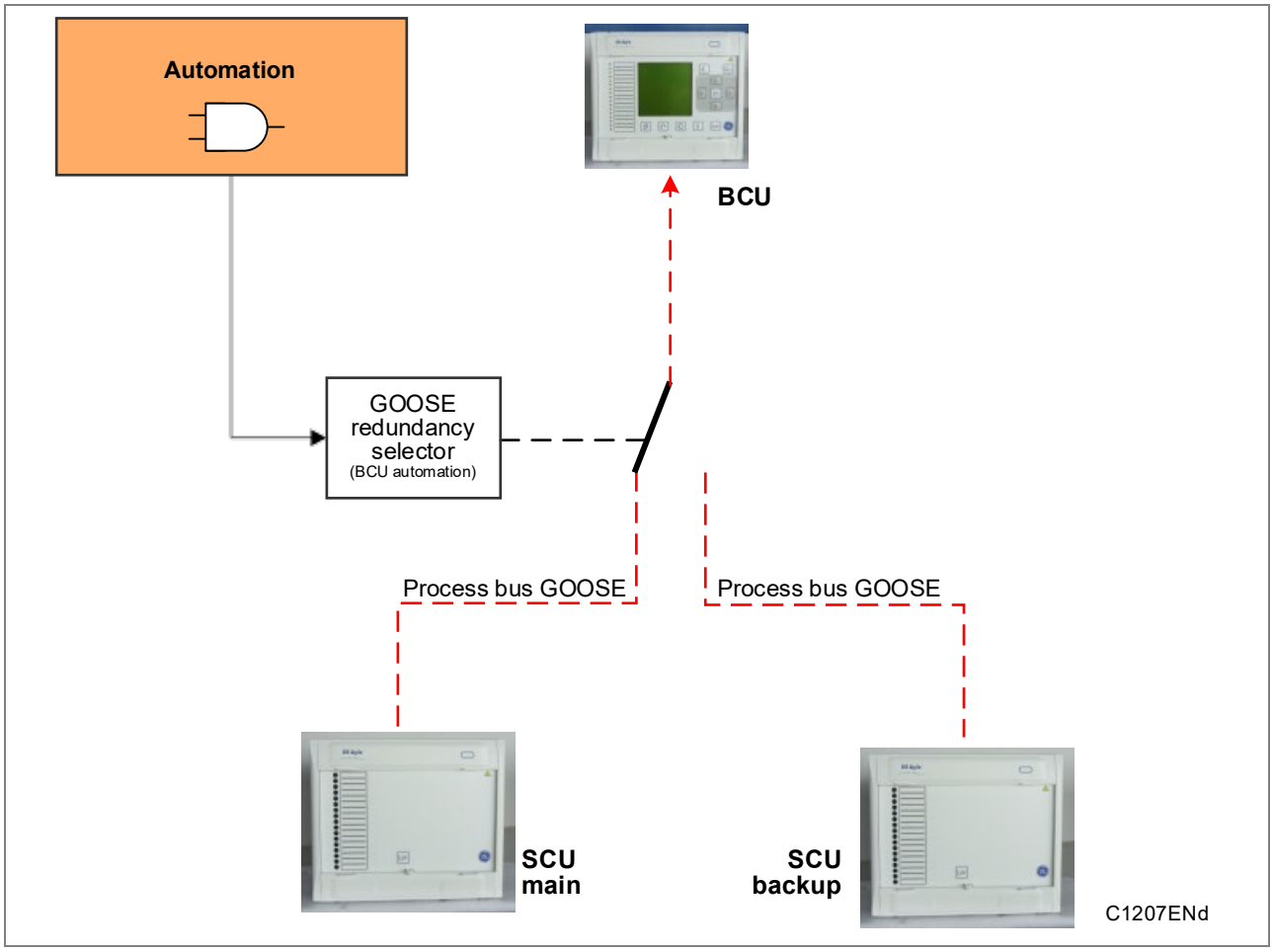


Figure 2: SCU redundancy switchover

4.1.4.2.1 Process bus (fast) GOOSE selection monitoring

For each subscribed GOOSE, 2 datapoints can be used to indicate which SCU publishes the GOOSE used by the BCU: The datapoints **Goose sel. x** (x = 1 to 8) and **Goose bck sel. x** (x = 1 to 8) are updated according to the SCU main/backup selection.

For instance, in a DCS architecture with 1 BCU managing a bay, and 2 redundant SCUs (main and backup):

- if the main SCU is selected:
  - the **Goose sel. 1**, relative to the main SCU, is SET
  - the **Goose bck sel. 1**, relative to the SCU "backup", is RESET
- if the backup SCU is selected:
  - the **Goose sel. 1**, relative to the main SCU, is RESET
  - the **Goose bck sel. 1**, relative to the backup SCU, is SET

4.1.4.2.2 Process bus (fast) GOOSE connection monitoring

For each subscribed GOOSE, 2 datapoints can be used to indicate the state of the network connections carrying the GOOSE exchanges between the BCU and the SCU.

The state of the network connection carrying the GOOSE exchanges between the BCU and the SCU is monitored using 2 datapoints updated by the Fast GOOSE unit of the BCU's firmware: **Goose con. x** (x = 1 to 8) and **Goose bck con. x** (x = 1 to 8). They are present under the BCU's System info node (DIAG brick).

These datapoints are updated according to the states of the redundant SCU connections (GOOSE received by the BCU and processed by the fast GOOSE unit).

Their states are independent from the GOOSE selection: they are indicated by the **Goose sel. x** and **Goose bck sel. x** datapoints.

Examples

In a DCS architecture with 1 BCU managing a bay and 2 redundant SCUs (main and backup):

- If the Fast GOOSE of the main SCU is received and correctly processed by the Fast GOOSE unit at BCU level:

  The **Goose con. 1** relative to the main SCU is SET

- If the Fast GOOSE of the backup SCU is received and correctly processed by the Fast GOOSE unit at BCU level:

  The **Goose bck con. 1** relative to the backup SCU is SET

- If the Fast GOOSE of the main SCU is NOT received, or NOT correctly processed by the Fast GOOSE unit at BCU level:

  The **Goose con. 1** relative to the main SCU is RESET

- If the Fast GOOSE of the backup SCU is NOT received, or NOT correctly processed by the Fast GOOSE unit at BCU level:

  The **Goose bck con. 1** relative to the backup SCU is RESET

4.1.4.3 SCU MAIN/BACKUP SELECTION WITHOUT A "SELECTOR" DATAPOINT

4.1.4.3.1 Selector datapoint state invalid ("downgraded" mode)

If the optional SPS datapoint **Goose red. sel.** is configured, but its status is INVALID in the GOOSE is received by the BCU,

- switchover is not possible, and
- only the main SCU can be selected

4.1.4.3.2 Switchover upon connection loss

In the absence of a GOOSE redundancy selection mechanism at BCU level, the following automatic behaviour is adopted:

- If the Ethernet connection (PBUS) is lost between the BCU and the main SCU:

  The BCU switches automatically, and subscribes to the GOOSE published by the backup SCU
- If the Ethernet connection (PBUS) is lost between the BCU and the backup SCU:

  The BCU switches automatically, and subscribes to the GOOSE published by the main SCU
- If the Ethernet connection (PBUS) recovers after having been previously lost (main or backup):

  The BCU does not switch automatically: it continues to subscribe to the GOOSE published by the SCU currently declared as publisher.

4.1.4.3.3 Selector datapoint not configured

If the optional SPS datapoint **Goose red. sel.** is not configured, redundancy is controlled according to the "health" state of each SCU.

The SCUs calculate their internal status (IS) according to a dedicated algorithm.

A value is assigned to each type of board failure: the control unit's IS is the sum of all the failure values.

Board type	Failure value for each type of board
AIU	0x01
BIU	0x02
DIU	0x04
AOU	0x10
CCU	0x20
DOU or HBU	0x40

The internal status of each SCU (IS) is transmitted to the BCU, which compares these values every time a change occurs. The BCU declares healthiest - and therefore preferred - the SCU with the lowest internal status value. Hereafter the failure weight values for all the types of C26X boards.

Switchover based on internal status

SCU switchover is software-controlled, i.e. it does not use DI/DOs like BCUs do. The internal states of the SCUs are transmitted to a "redundancy controller", which can be an automation on a BCU or a third-party device. The redundancy controller analyses the internal states of the SCUs, as well as any other information required by the specific application, to automatically switchover the redundant SCUs.

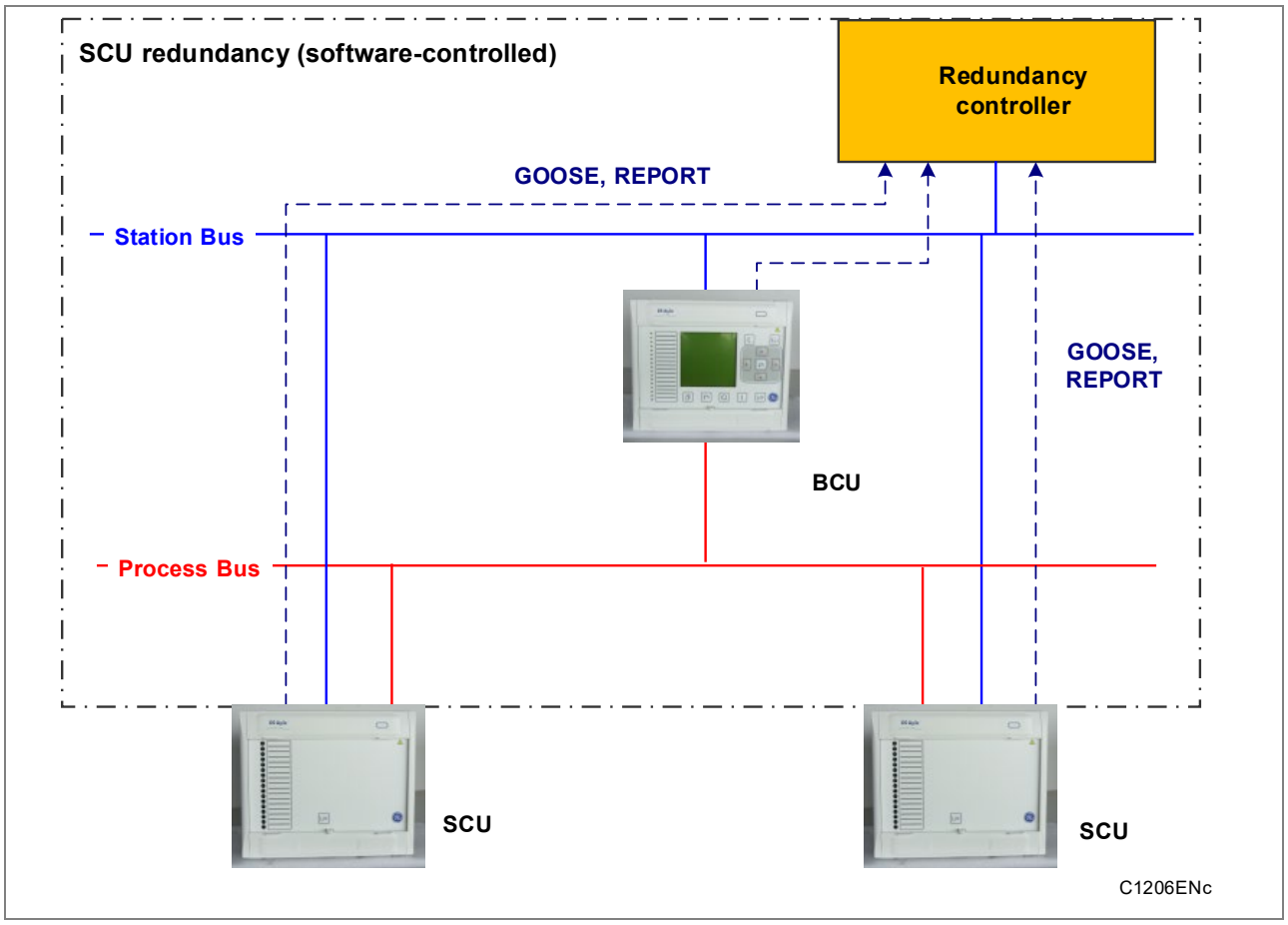


Figure 3: SCU Redundancy

4.2 DATABASE MANAGEMENT

4.2.1 GENERAL

The C26x uses structured databases to manage data. The main principle is that the C26x will only function with other DS Agile devices if their database versions are identical.

A database (DB) is a file that includes the description of the whole electrical process, and of all the devices that the C26x is likely to communicate with: IEDs, HMI, and so on. The database also includes some parameter settings for the software and for the transmission protocols. Use a separate DS Agile tool, the System Configuration Editor (SCE), to create and version the databases. Each database has a related VDBS (System Baseline Version).

You can download a standby database even if the C26x is in operation: use the filename. adb format.

You can download a database into the flash memory of the C26x in two ways:

- Use the DS Agile tool, the System Management Tool (SMT) to download the database through the IEC 61850-8-1 station bus (SBUS).
- Use GE Grid Solutions' DS Agile tool, the Computer Maintenance Tool (CMT), to download the database directly over the Ethernet network. Operators generally use the CMT only to download the first database. During the download, the CMT sends the database to all the other racks.
  This database becomes the new Standby database. Upon receipt of the Switch command, the C26x cascades the switch operation to the other racks.

The main 1 rack checks the compatibility between its database and the databases installed in the main 2 racks and in the extension racks. It the databases are different; the main 1 rack has the most recent version and deletes the databases on the other racks.

If the main database on the main 1 rack is compatible with the standby database on the other rack(s), the C26x switches the database.

At any moment, the C26x stores as many as two DBs in its flash memory. The two DBs and their related VDBS have the labels DB1, VDBS1; and DB2, VDBS2.

Each database in the C26x, DB1 and DB2, has one of the following states:

- **Missing**: the DB is not present in the controller's flash memory
- **Standby**: the DB was downloaded into the controller's non-volatile memory of, but the software does not acknowledge this version
- **Current**: the software acknowledges the downloaded DB
- **Current Modified**: a parameter setting was changed in the DB and the software currently acknowledges the DB
- **Standby Modified**: a parameter setting was changed in the DB and the software does not acknowledge the DB.

In the unit, the life cycle of the DBs is shown in the figure below:

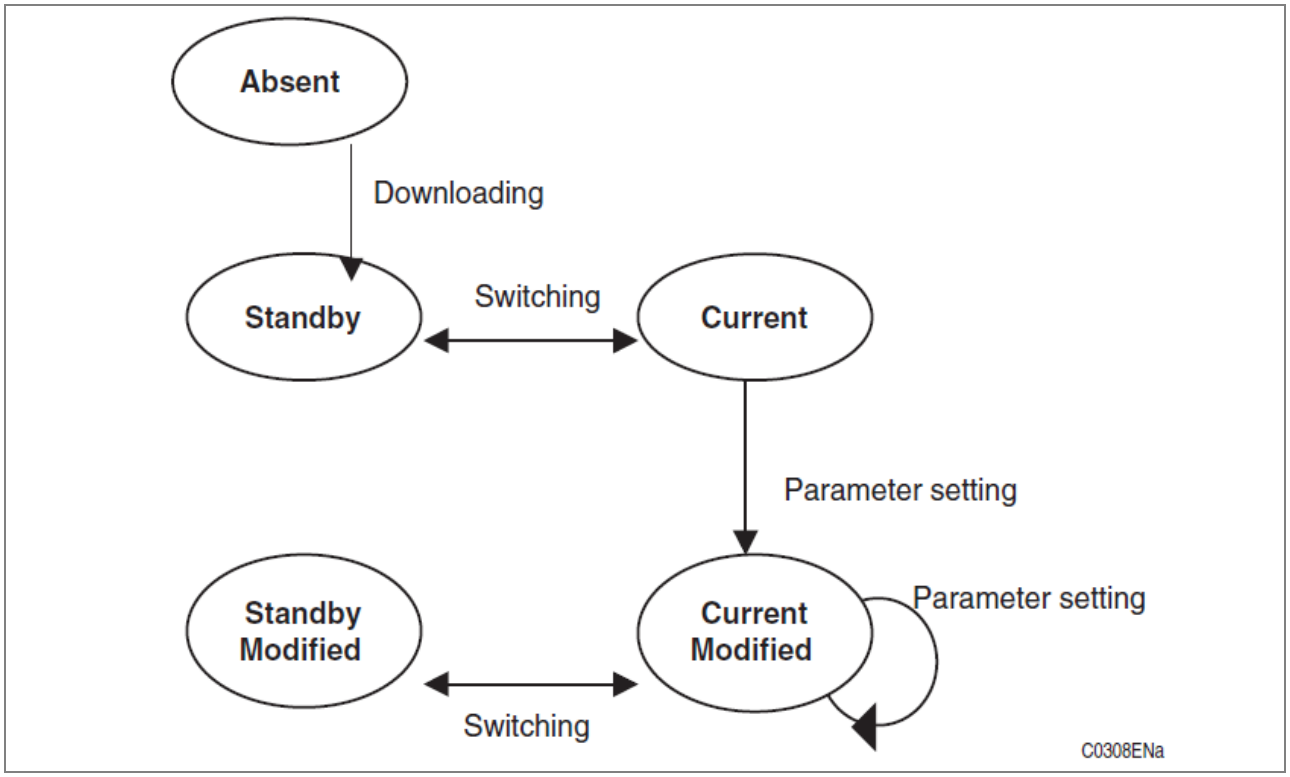


Figure 4: The different states of a database

At any moment, there is only one DB either in **Current** state or in **Current Modified** state. Similarly, there is only one DB either in **Standby** state or in **Standby Modified** state.

For the two downloaded DBs, DB 1 and DB 2, the four possible states are shown in the table below:

Database	State 1	State 2	State 3	State 4
DB1 and VDBS1	Current	Current Modified	Current	Current Modified
DB2 and VDBS2	Standby	Standby	Standby Modified	Standby Modified

A file descriptor with the label DB context, stored in the flash memory of the C26x, includes the configuration of the DB installed on the device. This file descriptor, that includes the state of each of the two databases and their related VDBS (for example, DB1 and VDBS1; DB2 and VDBS2), indicates the configuration of the databases when the C26x boots up (initialisation mode), and to start again with the **Current** database, if it exists. To update the file descriptor DB Context, use these functions:

- Download a database
- Switch the databases
- Check a database
- Modify a Database.

4.2.2 HOW TO DOWNLOAD A DATABASE THROUGH THE ETHERNET

Connect the C26x to the station bus (SBUS). Use the SMT tool to download the first DB.

The first time that you download the DB and the related Vdbs, make sure that the C26x is in maintenance mode.

Once the C26x is running with the first DB, and it is either in operational mode or in maintenance mode, you can download the standby DB and its related Vdbs.

The sequence to download the DB is as follows:

1 Use the DS Agile SMT tool to send a request to start the database transfer.

2 The receiver, the PC, returns a positive response.

3 Transmit the response to the calling device. If another request on the same DB is already in progress, the device will refuse your request.

4 Download the DB file and the related Vdbs. The C26x checks the integrity of the files: it calculates the checksum and control of the DB.

5 In the event of a fault, the C26x sends a signal to inform the calling device of the transfer.

6 After a successful transfer of the DB, the C26x checks the DB's compatibility

7 In case of an invalid DB, the C26x sends a signal to inform the calling device of the DB installation failure.

8 In case of a valid DB, the C26x:

   a Removes any **standby** DB and related Vdbs already installed in the C26x

   b Assigns the **standby** state to the downloaded DB and related Vdbs installed with it in the C26x

   c Sends a signal to inform the calling device of the success of the DB installation.

9 The C26x updates the file descriptor, Context DB, in flash memory.

4.2.3 HOW TO SWITCH THE DATABASES

The SBUS sends a request to switch the DB. **This request specifies the Version of the standby DB and related Vdbs** which are to become **current**. Please refer to *Figure 4: Database download* and to *Figure 5: Database Switch*.

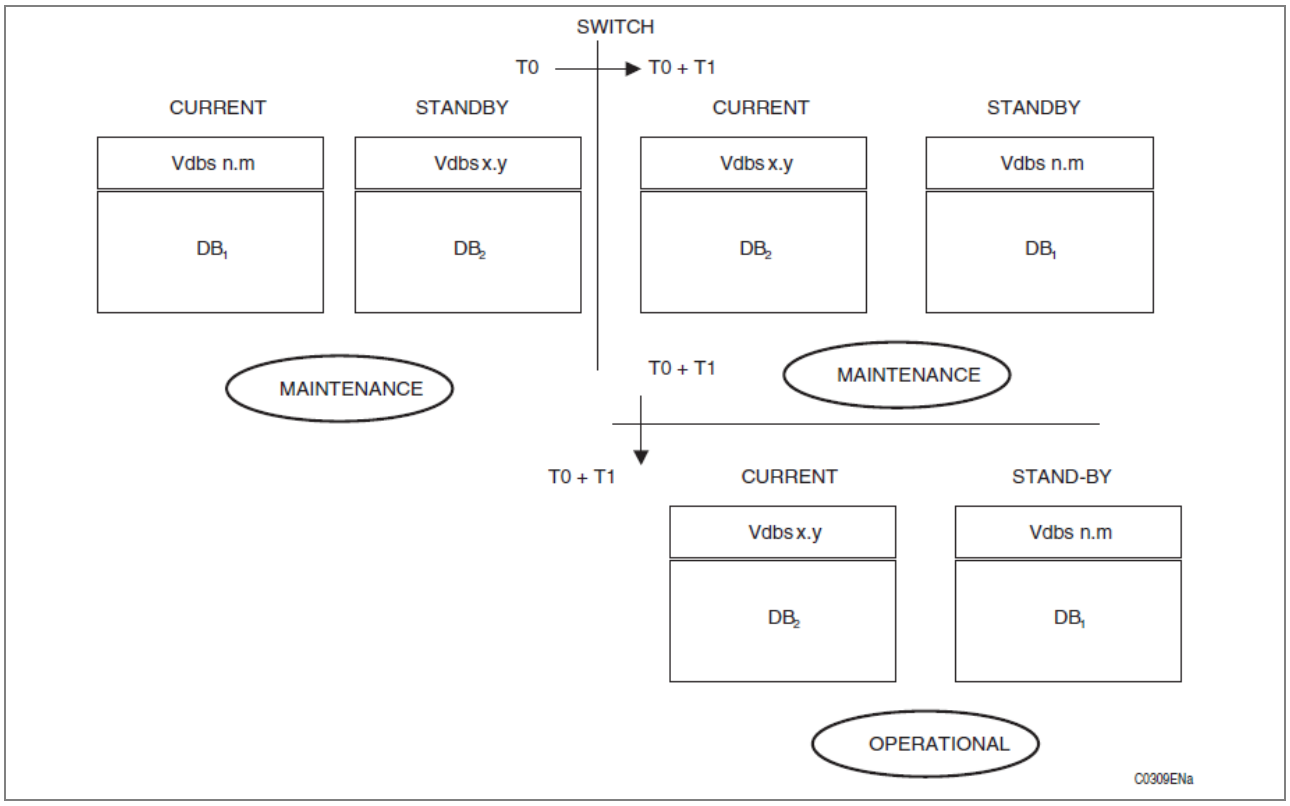


Figure 5: Switching databases

When this series of downloads is successful, the C26x switches the databases in all the racks.

After a DB switch, and if the DB is consistent with the software, the C26x automatically reboots and switches to Operational Mode.

4.2.4 HOW TO PERFORM A CHECK OF THE DATABASE

Upon each reboot, the C26x checks the DB.

4.2.5 HOW TO MODIFY THE DATABASE

With the local HMI, you can only modify a parameter setting in the current DB, i.e., the *Current* or *Current Modified* DB. You can only modify some data parameters. In order to be able to modify the parameters in the settings file, they need to be defined in the DB as “editable”. The modified DB stores the new parameter settings. The C26x increments the internal version number of the parameter setting file and calculates again the checksum of the file. The database takes the *Current Modified* state.

4.2.6 HOW TO MODIFY A PARAMETER SETTING IN THE CURRENT DB

To modify the parameter setting in the current DB, use the C26x to:

1 Check the consistency of the request:
   a Is the object known to the C26x, i.e., is the object really present in the database?
   b Can the C26x set the data?
   c Is the value of the parameter setting compatible with the type of data conveyed: is the value within the range of acceptable variations?
2 Return a negative report to the device that sent the request if it is inconsistent.
3 Write the current value of the data in the DB
4 Write the date at which you modified the data in the DB
5 Compute the checksum and to write it in the DB
6 Assign the state *Current Modified* to the DB
7 Send a positive report to the device that sent the request
8 Update the file descriptor, that is the Context database, in the flash memory

4.2.7 HOW TO READ OUT A PARAMETER SETTING

To effect a request to read out a parameter setting in the current DB from the Operator Station, use the C26x to:

1 Check the consistency of the request:
   a Is the object known to the C26x, i.e., is the object really present in the database?
   b Can the C26x set the data?
   c Is the value of the parameter setting compatible with the type of data conveyed: Is the value within the range of acceptable variations?
2 Return a negative report to the device that sent the request if it is inconsistent.:
3 Expand the response to include the parameter setting and send it to the device that sent the request

4.3 SELF-TESTS

The C26x performs the following self-tests:

- Hardware (hardware fault) at start-up and cyclically.
- Software (software fault) cyclically to ensure that software tasks are active and do not take up all the CPU time
- Database consistency at start-up
- Acquisition and output at start-up and cyclically.

4.4 TIME MANAGEMENT

The main purposes of time management are:

- To synchronise the internal clock of the C26x (referred to as the local clock) with:
  - The external clock (via SBUS) for all C26x devices
  - SCADA for all C26xdevices
  - Operator for all C26x devices
- To update the local clock
- To synchronise other devices through the SBUS with the local clock (in case of external clock failure)

You can synchronise the local clock with an external time reference from 4 sources:

- PTP synchronization through external master clock through process bus
- The SCADA sends a clock message through the TBUS and the gateway
- The system's master clock sends a clock message through the SBUS - SNTP
- An operator sets the time

of 2 possible formats:

- PTP, or
- SNTP

For the SNTP time synchronisation, there is a priority rule for these three external time references. If the external clock operates, it locks out changes from the three other sources: you cannot make modifications to the local clock in these cases:

- Locked out: The SCADA sends a clock message through the TBUS and the gateway
- Locked out: The system master clock sends a clock message through the SBUS
- Locked out: An operator sets the time

In case an external clock disconnects or does not operate, there is a priority order for the three external time references that remain:

- The SCADA sends a clock message through the TBUS and the gateway

  or

- The system master clock sends a clock message through the SBUS

  have priority over

- An operator who sets the time

Just after the local clock is synchronised, and if it is the master system clock of the LBUS, the controller synchronises the Intelligent Electronic Devices (IEDs) in accordance with the synchronisation procedure of the protocol. If the local clock is not synchronised, the controller synchronises periodically the IED all together.

When the local clock is synchronised, all events and measurements include a time tag with a synchronised attribute. If the synchronisation is lost, or was never achieved, the attributes indicate that the time tag is not synchronised.

Using the SNTP protocol, the DS Agile architecture can synchronise as many as 120 devices, such as the C26x, aView, gateways, and third-party IEDs.

Time management is organised as follows:

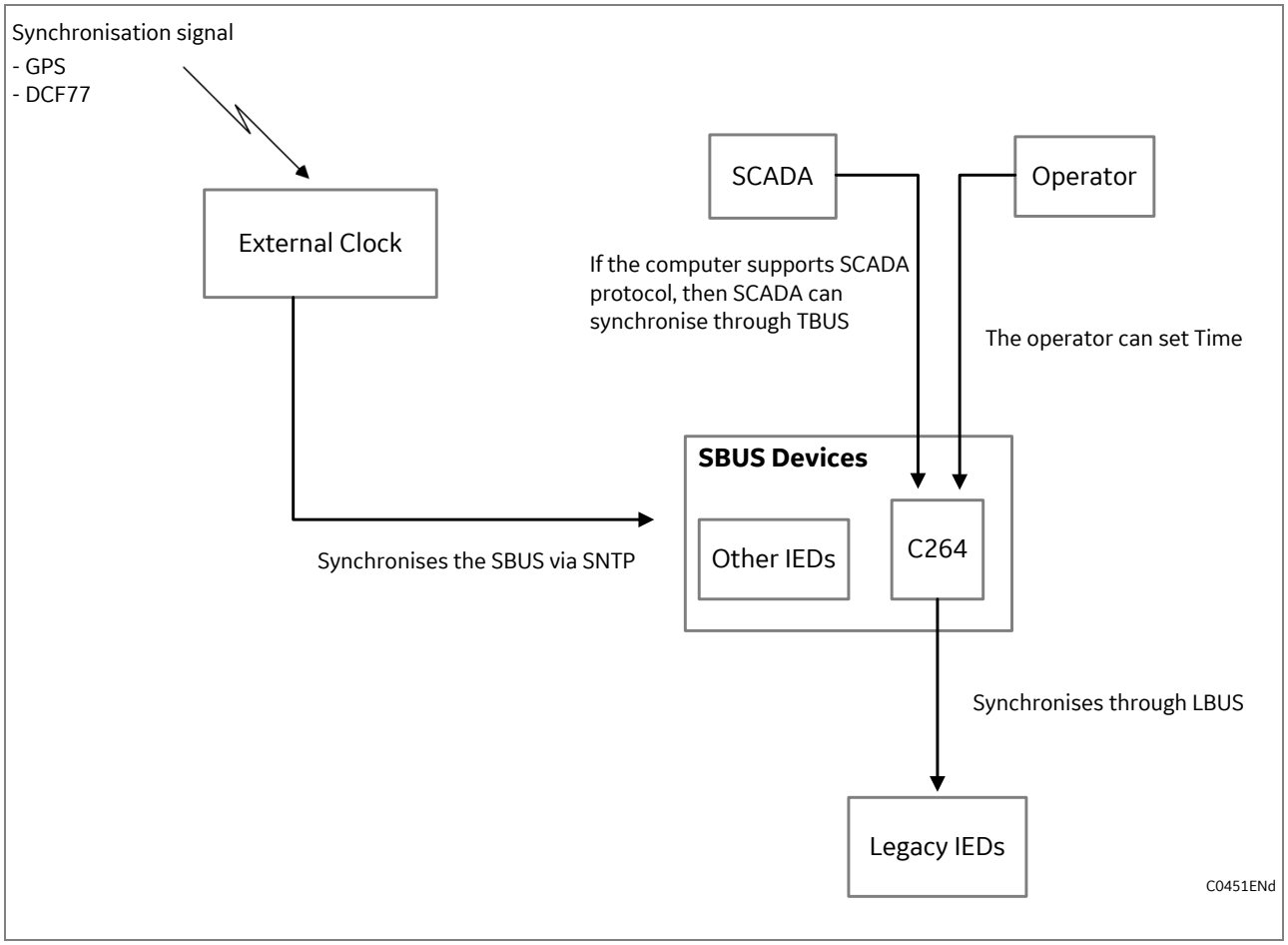


Figure 6: Time management through SNTP (SBUS)

Using the PTP protocol, the number of synchronised devices is limited by the system's architecture: a device should be separated from the master clock by a maximum of 16 network hops. Not all devices are PTP-compatible.

4.4.1 EXTERNAL CLOCK

The external clock receives the synchronisation signal through one of several protocols: GPS, DCF77, and so on. Periodically, the external clock sends the synchronisation signal, which includes the time and date, to SBUS IEDs.

Each control unit has its own local clock. The local clock synchronises with the signal from the external clock. In this system architecture, the local clock operates as the System Master Clock.

In the event of the loss of the radio signal from the external clock, two events can occur:

1 Some external clocks include a very accurate oscillator. After a loss of radio signal, these external clocks can synchronise the control unit for 8 hours. The external clock sends two messages through the protocol. The text of the messages complies with the manufacturer's specifications. For example:

- no radio received
- radio signal lost for more than 8 hours

2 The local clock remains synchronised with the external clock until the message **radio signal lost for more than 8 hours** is issued. The status of the local clock now shows as **not-synchronised**.

3 Some external clocks do not have the internal accuracy to support the radio signal. In this event, when the confirmation of a **lost radio signal** occurs in a few minutes, the status of the local clock shows as **not-synchronised**

If the control unit operates as the system's master clock for the other devices in the substation, then it continues to send the clock synchronisation message to the other devices, even if the local clock, or system master clock, is not synchronised with an external time reference. A binary input is dedicated to monitoring the status of the external clock.

4.4.2 CLOCK SYNCHRONISATION MESSAGE FROM A SCADA GATEWAY

The acquisition of a SCADA clock synchronisation message is a SCADA gateway specification.

The SCADA clock synchronisation depends on the protocol. The clock synchronisation message goes directly through the SCADA link to the C26x.

The clock synchronisation message from the SCADA gateway is in Universal Time Coordinated (UTC) time.

From the SCADA, the clock synchronisation message goes to the "local clock update" function in the control unit. The control unit checks the frame of the clock synchronisation message, removes the control fields, and transmits the clock synchronisation message.

When the SCADA gateway operates as the external time reference according to the priority, the control unit receives the clock synchronisation messages from the SCADA. An interruption relates to the arrival of the frame: the control unit can acquire the clock synchronisation message from the SCADA gateway. The delay in the transmission from the SCADA gateway is compensated.

The clock synchronisation message from the SCADA gateway must contain:

Day / month / year / hour / minutes / seconds / milliseconds

To update the control unit local clock, please refer to *4.4.6 Local clock update*.

4.4.3 SNTP CLIENT AND SERVERS

On an IEC 61850 network, the clock synchronisation uses the Simple Network Time Protocol (SNTP). In a DS Agile system, you can define as many as two control units as the System Master Clock: they become SNTP servers. All other devices installed on the IEC 61850-8-1 become SNTP clients. In event that one SNTP server fails, for example a control unit is unserviceable, or an external clock fails, the SNTP clients automatically connect to the second SNTP server.

Use the DS Agile tool, the System Configuration Editor (SCE), to configure a C26x as an SNTP server; to have redundancy, define two IP addresses. These IP addresses must be in the same range as the C26x Ethernet addresses.

In this event, no C26x is the Master Clock: all C26x devices are SNTP clients.

The synchronisation performance of the system depends on the accuracy of the third-party SNTP server.

You can connect one C26x, which is configured as an SNTP server, to a second C26x SNTP server to make a C26x redundant system.

4.4.4 PTP SYNCHRONISATION

DS Agile C26x supports real-time clock synchronisation for the timestamp of logs or events through Precision Time Protocol (PTP in accordance with IEEE/IEC 61588 (2009)).

PTP synchronises all clocks within a network by adjusting distributed clocks to a grandmaster clock. PTP enables distributed clocks to be synchronised and maintained to sub-microsecond accuracy.

4.4.4.1 PTP GRANDMASTER CLOCK

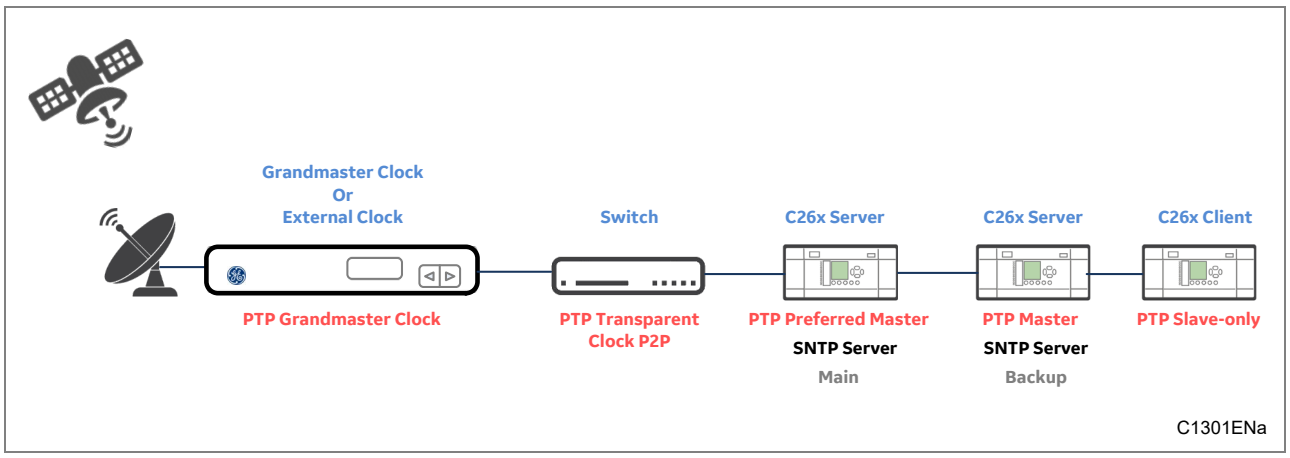
DS Agile system can be synchronised through a PTP Grandmaster clock and up to two C26x computers acting like system SNTP time servers (main and backup).

The C26x computers can be configured to communicate with only one PTP-enabled External synchronisation source. They can be setup either as a Preferred PTP Master clock or as a PTP Slave-Only clock. All C26x will then be synchronised via the PTP external synchronisation source.

Depending on your architecture, there may be:

- Up to two SNTP time servers (System Master clocks), one **Main** SNTP time server and one **Backup** SNTP time server (Optional);
- One or more Grandmaster Clock on the same network, but only one will be in active mode;
- One or more **Preferred** PTP Master(s) depending on PTP priorities.

Any other C26x in the system are configured as PTP Slave-Only clocks and all other devices as SNTP or PTP Only-Slave clock.



4.4.4.2 PTP GRANDMASTER CLOCK FAULT

Only one Grandmaster is active over a network and seen as the **Best Master clock** in the System.

If this Grandmaster clock fails and no backup Grandmaster clock is available then, the fallback Best Master Clock can be a C26x that you have previously defined as the **Preferred PTP Master clock**.

4.4.4.3 CONFIGURING THE PREFERRED PTP MASTER CLOCK

To configure a C26x as a **Preferred PTP Master clock**, refer to the **Time Synchronization** section in the **Application** chapter of the **DS Agile C26X** user manual.

4.4.5 TIME SET BY AN OPERATOR

If an external time reference operates, such as the external clock, the SCADA clock or the system master clock, you the operator cannot set the time.

If the system master clock synchronises any other device in a DS Agile system architecture, you cannot set the time for that device. However, in event the system master clock is unserviceable, or the connection fails, you can set the time for the device.

If the control unit does not receive the clock synchronisation messages from the external clock, from the SCADA gateway, or from the system master clock, you are allowed to set the time manually.

Normally, you must manually set only the system master clock. You must use the correct tool for the specific system master clock.

With the C26x local HMI on the front panel or with the maintenance laptop control unit and the Maintenance Tool (CMT), you can set the time and date.

You use two commands:

- One to modify the time: hour/minutes/seconds
- One to modify the date: year/month/day

You can reserve a third command to do a check on the date and hour values.

You must raise a manual time-set-indication. The control unit makes a record of all operator actions.

4.4.6 LOCAL CLOCK UPDATE

Each control unit has its own local clock. Each local clock has its own quartz shift: a deviation of the internal oscillator of the control unit. You must synchronise the local clock periodically to agree with an external time reference.

The time data includes:

- Loss of the external clock; loss of SCADA gateway clock synchronisation message; or loss of the system master clock
- An indication that the local clock was roughly synchronised. This indication shows any time difference, between the local clock and the clock synchronisation message that is greater than the fixed value: Δthreshold = 20 milliseconds. The control unit sends a message about the discrepancy, prints the message, and archives the event.
- Indication that the operator performed a manual time set. This “manual time set” indication is required to time-tag the events that occur.

The internal time format for the local clock is Universal Time Coordinate (UTC). The time difference between UTC and the local time is set during configuration.

The local clock operates automatically:

- For all dates including leap years up to 2037.
- For seasonal time changes: it uses the values for Daylight Savings Time (DST) as shown in the Time Zone Adjustment Table (TZTAB) file. The TZTAB file shows the differences between UTC and local time.

If the DST rules change, you can set the new rules in the control unit.

The control unit manages the milliseconds with its own quartz.

The Local Clock Update function manages the synchronisation status of the control unit as follows:

- Not synchronised: this is the status at initialization, the control unit has never been synchronised since booting or rebooting. **Date and time are invalid**.
- Synchronised: the control unit receives periodically the date and time. **Date and time are valid**. Or the control unit is master clock on the Ethernet network for other equipment.

At initialisation, the control unit shows the external clock as not-synchronised with the local clock. This status remains the same until you send a control message to the initialisation driver to receive synchronisation frames from an external time reference. When the control is OK and at the reception of the first external clock message, the synchronisation upon external clock is declared valid and the external clock is considered connected.

This synchronisation with the external clock could fall back to invalid: for example, in event the control unit did not receive an external synchronisation message for N minute(s). This can indicate an external clock failure, such as a disconnection or a message that contains invalid data. The value of this timing is 300 seconds.

In the event of an external clock failure, the local clock maintains the frequency in effect before the external clock failed. The control unit generates an internal signal or alarm and declares the system master clock invalid. When this occurs, the control unit makes a non-synchronisation mark against each event, for as long as the synchronisation with the external clock remains invalid.

When a device on the SBUS does not receive a clock synchronisation message in 180 seconds, it raises an alarm. The events processed by this device are tagged with a special mark and with the time, and the device stops the transmission of the synchronisation frame to the IEDs.

4.4.7 MANAGEMENT OF LOSS OF EXTERNAL TIME REFERENCE

As the local clock update function receives the external time reference, it manages a loss of the external time reference as follows:

- If the external clock is lost, then the local clock update shows the loss of the external clock
- If the clock message from the SCADA gateway is lost, then the local clock update shows the loss of the SCADA gateway clock message
- If the system master clock is lost, then the local clock update shows the loss of the system master clock

4.4.8 UPDATE METHOD

When the control unit validates the external clock acquisition, the control unit manages the synchronisation of the internal system master clock to the external time reference as follows:

If a difference between the local clock value and the external time reference value transmitted exists, [C Local – C External] $\neq 0$:

- If [C Local – C External] < 1 ms, the local clock is not modified
- If [C Local – C External] > 1ms, two different events are processed:

1 If [C Local – C External] $\leq \Delta$ Threshold (20 ms), the value of the local clock is progressively corrected (reduced or increased). This compensation is performed in a set time (t_1=60 s).

2 If [C Local – C External] $\geq \Delta$ Threshold (20 ms), the hour in the local clock is updated roughly.

If an operator gets the external clock time, the operator must update the local clock.

4.4.9 LIMITS AND PERFORMANCE

The control unit local clock has a small shift per day. This quartz shift, that is the deviation of the internal oscillator of the control unit, is less than 0.5 s/day (that is, $\leq$ 5.8 µs/s). This quartz shift is the same through the entire operating temperature range of the control unit. The operator must set the time periodically or synchronise the local clock with a master clock.

4.5 CYBER-SECURITY

Note:
In remote authentication all parameters, user profiles and roles are same as local authentication.

Access to the C26x is protected by several mechanisms:

- Operators use individual, password-protected login accounts, which have different access permissions depending on their functional roles.
- Sessions have a time-out to prevent unattended open sessions.
- A password policy can be implemented to ensure that strong passwords are always used.
- Security-relevant operations such as user connection attempts and disconnections, account modifications, database switch, etc. are logged in a secure file. The log file can be transmitted to a central repository (“Syslog” server). For details, see section **Security Log**.

4.5.1 USER ACCOUNTS ROLES AND PERMISSIONS

The C26x supports and stores two lists of roles and permissions.

- **Default role list**:
  - VIEWER *(Decimal value: 1, Hexa value: 0x01)*
  - OPERATOR *(Decimal value: 2, Hexa value: 0x02)*
  - ENGINEER *(Decimal value: 4, Hexa value: 0x04)*
  - RBACMNT *(Decimal value: 8, Hexa value: 0x08)*
  - SECADM *(Decimal value: 16, Hexa value: 0x10)*
- **IEC 62351-8 roles list**:
  - VIEWER *(Decimal value: 1, Hexa value: 0x01)*
  - OPERATOR *(Decimal value: 2, Hexa value: 0x02)*
  - ENGINEER *(Decimal value: 4, Hexa value: 0x04)*
  - RBACMNT *(Decimal value: 8, Hexa value: 0x08)*
  - SECADM *(Decimal value: 16, Hexa value: 0x10)*
  - SECAUD *(Decimal value: 32, Hexa value: 0x20)*
  - INSTALLER *(Decimal value: 64, Hexa value: 0x40)*

The choice of this list is decided in the CMT in the **Security** view (**Administration** tab).

Available permissions depend both on the roles associated with the user account and on the tool being used to access the C26x.

Both lists of roles and permissions are detailed hereafter:

Default Role List

Functional Role	Associated rights	Access to CMT button view
VIEWER	The VIEWER role only allows displaying data (i.e. read information). The VIEWER role does not allow changing any password other than the user's own password or viewing the security log.	Only access to: • Available Computers view, • Computer version view, • Security view (restricted, can only change his/her own password), • Event log storage view, • Monitor view, • Boards IEDs state view, • Statements view, • Disturbance view.
OPERATOR	The OPERATOR role only allows accessing data useful to run the system. This user works in the substation and can act on switchgear and plant items. The OPERATOR role encompasses the VIEWER's rights, plus additional rights required to run control commands. It does not allow changing any password other than his/her own or viewing the security log.	Access to all views, with some restrictions on the Security view (can only change his/her own password), except: • Database view, • File explorer view, • Bootinstall view.
ENGINEER	The ENGINEER is a software specialist: this role allows performing software maintenance for version upgrades. This role allows displaying data, loading a configuration database and changing the operating mode of a subsystem. It does not allow changing any password other than his/her own or viewing the security log.	Access to all views, with some restrictions on the **Security** view (can only change his/her own password).
RBACMNT	The security administrator cannot display any operational data from the DS Agile system. He/she cannot load a configuration database nor change the operating mode of a subsystem. This user is responsible for the security policy. This user can only change passwords, define account security policy and display security logs. This user does not give access to the unit's front panel LHMI.	Access to the Available Computers view. Full access to the Security view.
SECADM	The SECADM role contains all the above privileges, plus: opens an SSH port and launch a terminal to send commands via the SSH link.	Access to all views.

Default Role Permissions

Permissions	VIEWER	OPERATOR	ENGINEER	RBACMNT	SECADM
CMT login	X	X	X	X	X
Steal Session (force a connection)				X	X
Computer version (version of the Cx66 and its components, database name and version, running mode)	X	X	X		X
Get parameters (IP address, boot mode, …)		X	X		X
Set parameters			X		X
Boot Mode			X		X
Database management (clean, load, switch)			X		X
Download a file			X		X
Upload a file			X		X
Date & Time read		X	X		X
Date & Time write			X		X
System error display (read, print, save as file)		X	X		X
File Explorer (ramdev, read flash memory)			X		X
File explorer (Flash format)			X		X
Install (bootrom)			X		X
Install (bootinstall)			X		X
Start SSH session (open port)				X	X
Get system log	X	X	X		X
Set system log (archive state, etc.)			X		X
Get printer info	X	X	X		X
Set printer info		X	X		X
Stop computer		X	X		X
Reboot computer		X	X		X
Display board status	X	X	X		X
Display IED status	X	X	X		X
Get statements	X	X	X		X
Get disturbance	X	X	X		X
Change Comtrade directory		X	X		X
Erase flash disturbance		X	X		X
CB Commissioning Tool		X	X		X
CMT - account management (display first tab)	X	X	X	X	X
CMT - account management (display admin tab)				X	X
CMT - account management (display log tab)				X	X
Change an account role				X	X
Add or delete an account				X	X
Unlock account - change period time & attempts				X	X
Change own password	X	X	X	X	X
Reset the password of another account				X	X
Visualize Security log				X	X
MiCOM S1 settings		X	X		X
MiCOM S1 open port		X	X		X
MiCOM S1 download and read Settings		X	X		X

Permissions	VIEWER	OPERATOR	ENGINEER	RBACMNT	SECADM
MiCOM S1 change and upload Settings		X	X		X
LHMI login	X	X	X		X
LHMI read settings	X	X	X		X
LHMI change settings	X	X	X		X
LHMI read data	X	X	X		X
LHMI send command		X	X		X
Access Cyber Log File				X	X
Shell login			X		X
Enable/disable LHMI Login				X	X
Enable/Disable SNMP				X	X
Switch rights IEC matrix					X

IEC 62351-8 Role List

Functional Role	Associated rights	Access to CMT button view
VIEWER	A "Viewer" can only display data or read information. A "Viewer" is not authorized to change other passwords, nor to visualize the security logs.	Access only in read mode to: • Available Computers view, • Computer version view, • Date & time view, • Security view (restricted, can only change his/her own password), • Event log storage view, • Monitor view, • Boards IEDs state view, • Statements view, • Disturbance view.
OPERATOR	An "Operator" can only access data useful to run the system. This user works in the substation and can act on a subsystem. He/she has observer rights plus specific rights to trigger commands. The "Operator" is not authorized to change other passwords, nor to visualize the security logs.	Access to: • Available Computers view, • Computer version view, • Date & time view (restricted, can only read information), • Errors view, • Security view (restricted, can only change his/her own password and can launch MiCOM S1 interface), • Event log storage view, • Monitor view, • Boards IEDs state view, • Statements view, • Disturbance view.

Functional Role	Associated rights	Access to CMT button view
ENGINEER	The "Engineer" is a sub-system software user with limited rights on maintenance. The "Engineer" can display data, load a database and change a sub-system operating mode. The "Engineer" is not authorized to change other passwords, nor to visualize the security logs.	Access to all views, with some restrictions on the **Security** view (can only change his/her own password and can launch MicomS1 interface), except: • Bootinstall view.
RBACMNT	The "RBACMNT" user is responsible for Security policy. He/she is ONLY allowed to reset passwords, define the security parameters and visualize the security logs. The "RBACMNT" is not allowed to display any data of DSAgile system, load a database nor change a subsystem operating mode.	Access to: • Available Computers view, • Computer version view, • Date & time view (restricted, can only read information), • Security view (full access excepted "Disable LHMI Authentication" button and "Security Log" tab)
SECADM	The "System Administrator" can access all functionalities and views. He/she has all possible rights and can change user rights and passwords. He/she can load a database, change a sub-system operating mode or visualize the security logs, plus: Opens an SSH port and launch a terminal to send commands via the SSH link.	Access to: • Available Computers view, • Computer version view, • Date & time view (restricted, can only read information), • Security view (full access excepted "Connect MicomS1 interface" button)
SECAUD	The "Security Auditor" can display data or read information and visualize the security logs. The "Security Auditor" is not authorized to change other passwords.	Access to: • Available Computers view, • Computer version view, • Date & time view (restricted, can only read information), • Security view (restricted, can only change his/her own password and can access to "Security Log" tab)
INSTALLER	The "Installer" is a software specialist able to do software maintenance for new versions. He/she can display data, load a database and change a subsystem operating mode. The "Installer" is not authorized to change other passwords, nor to visualize the security logs.	Access to: • Available Computers view, • Computer version view, • Parameters view, • Database view, • Date & time view, • Errors view, • File explorer view, • Bootinstall view, • Security view (restricted, can only change his/her own password and can launch MicomS1 interface), • Stop computer view, • Reboot computer view

IEC 62351-8 Role Permissions

Permissions	VIEWER	OPERATOR	ENGINEER	RBACMNT	SECADM	SECAUD	INSTALLER
CMT login	X	X	X	X	X	X	X
Steal Session (force a connection)					X		
Computer version (version of the Cx66 and its components, database name and version, running mode)	X	X	X	X	X	X	X
Get parameters (IP address, boot mode, …)			X				X
Set parameters			X				X
Boot Mode			X				X
Database management (clean, load, switch)			X				X
Download a file			X				X
Upload a file			X				X
Date & Time read	X	X	X	X	X	X	X
Date & Time write			X				X
System error display (read, print, save as file)		X	X				X
File Explorer (ramdev, read flash memory)			X				X
File explorer (Flash format)			X				X
Install (bootrom)							X
Install (bootinstall)							X
Start SSH session (open port)					X		
Get system log	X	X	X				
Set system log (archive state, etc.)			X				
Get printer info	X	X	X				
Set printer info			X				
Stop computer			X				X
Reboot computer			X				X
Display board status	X	X	X				
Display IED status	X	X	X				
Get statements	X	X	X				
Get disturbance	X	X	X				
Change Comtrade directory		X	X				
Erase flash disturbance		X	X				
CMT - account management (display first tab)	X	X	X	X	X	X	X
CMT - account management (display admin tab)				X	X		
CMT - account management (display log tab)					X	X	
Change an account role				X	X		
Add or delete an account				X	X		
Unlock account - change period time & attempts				X	X		
Change own password	X	X	X	X	X	X	X

Permissions	VIEWER	OPERATOR	ENGINEER	RBACMNT	SECADM	SECAUD	INSTALLER
Reset the password of another account				X	X		
Visualize Security log					X	X	
MiCOM S1 settings		X	X				X
MiCOM S1 open port		X	X				X
MiCOM S1 download and read Settings		X	X				X
MiCOM S1 change and upload Settings			X				X
LHMI login	X	X	X				
LHMI read settings	X	X	X				
LHMI change settings			X				
LHMI read data	X	X	X				
LHMI send command		X	X				
Access Cyber Log File					X	X	
Shell login			X				
Enable/disable LHMI Login					X		
Enable/Disable SNMP					X		
Switch rights IEC matrix					X		

4.5.2 AUTHENTICATION

There are two types of Authentication for the CMT:

- Local Authentication

  Local authentication is used when the user profiles and roles are configured on the local device.

- Remote Authentication

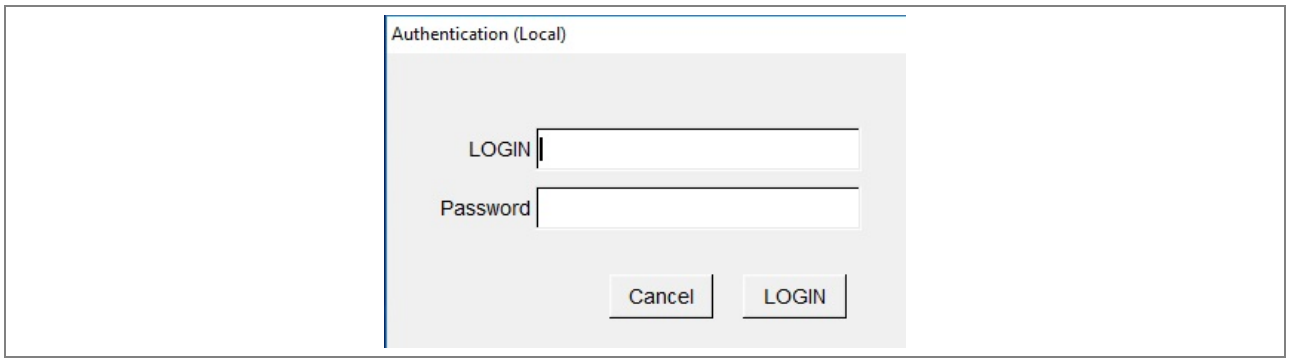
  Remote authentication is used when the user profiles and roles are configured centrally using RADIUS Server.

  If the RADIUS Server is not connected to the Station Bus network or is offline, the CMT switches to local authentication.

Note:
Login priority will be given to local / server as displayed on CMT login window.

4.5.2.1 LOCAL AUTHENTICATION

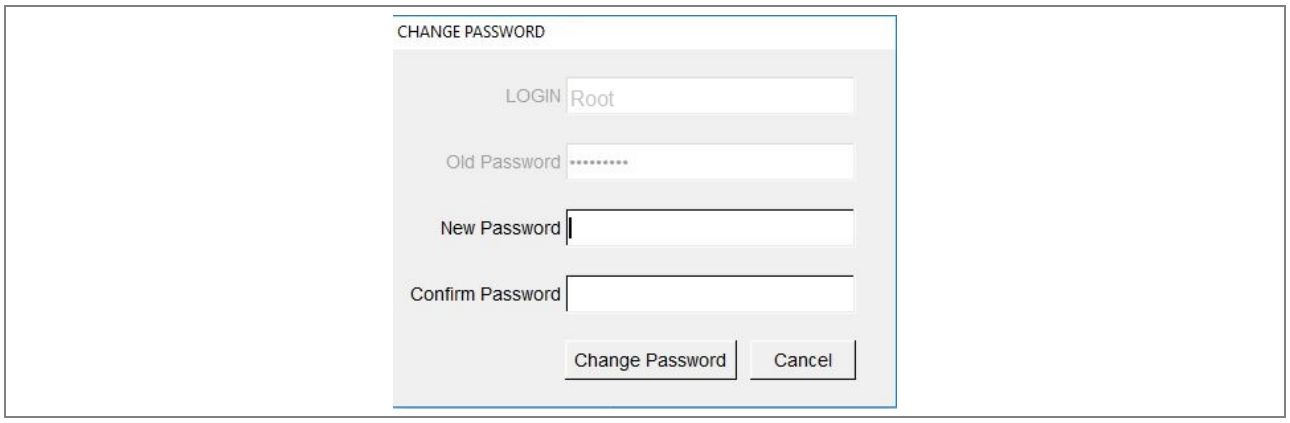
When the user starts the CMT a login popup is displayed.



The installer automatically created an administrator user account:

User Accounts	Default Password	Roles
Root	Root1234#	VIEWER OPERATOR ENGINEER RBACMNT SECADM (default role)

The first time a user attempts to log on to the CMT after its installation, a pop-up is displayed prompting to change the password.



4.5.2.1.1 Local Authentication Parameters

The local user account database and the security settings are managed using the CMT. However, they are stored locally in each C26x unit in a hidden file.

The local user account database and the security settings are common for all access points (CMT, front panel LHMI, MiCOM S1).

They are stored in non-volatile flash memory, are separate from the configuration database, and therefore are not lost after a reboot.

Inactivity Timer

A timer can be configured in the CMT to automatically close a session when the user is inactive. Depending on the user interface, the definition of "inactive" can vary:

- CMT: Only effective actions, such as clicking a button or selecting a field are considered activity. Cursor movements are not.
- MiCOM S1: Only communications with the C26x unit, i.e. upload and download of settings, are considered activity. Actions that do not involve communicating with the C26x unit, including changing settings in MiCOM S1 are not considered activity.
- LHMI: Pressing any key is considered activity.

The user is disconnected when the timer elapses.

Disclaimer

A legal disclaimer can be automatically displayed after every successful login. Its activation state and text are configured using the SCE and included in the configuration database.

In **boot** or **maintenance** mode (no active database), the CMT displays the following disclaimer, regardless of any database configuration:

"Access to this system is limited to specifically authorized users having received all trainings required by applicable laws, regulations, and by policies and procedures implemented by the legal entity hosting this system. Unauthorized users may face criminal or civil liabilities and/or penalties. The use of this system may be recorded and monitored for system operations, security policy and intellectual property compliance related purposes and any information related to the use of this system may further be disclosed to third parties or law enforcement officials as necessary. Disconnect now if you are not an authorized user or do not agree with the above terms."

Login

Login to the C26x is password-protected for all access points: CMT, front panel LHMI and MiCOM S1.

The password is not displayed.

When a user logs out from a C26x in the CMT, he is also disconnected from the connected C264 in MiCOM S1. Logging out in the CMT does not end an SSH connection (root account only).

Session

The C26x supports only one user session at a time. However, on the maintenance PC, the same user can be connected to the C26x from both the CMT and MiCOM S1 (and also the SSH terminal for the Root account).

When a local session expires, the front panel LHMI reverts to the default start panel. On the maintenance PC, there is no disconnection warning when a session expires: The user is informed of the disconnection when he/she tries to perform an action and the login popup is displayed.

4.5.2.2 REMOTE AUTHENTICATION

Remote authentication to the C26x is done through a RADIUS server.

RADIUS supports 3 communication protocols:

- PAP (insecure, but used for compatibility reasons)
- PEAPv0 (EAP-MSCHAPv2)
- EAP-TTLS (server certification verification)

Note:
The PAP protocol is insecure, it is an old standard (RFC 1334 was published in 1992). PAP protocol is available for compatibility reasons but, when possible, it should not be used.

Note:
Remote Authentication user profile rights are the same as Local Authentication user profile rights.

Note 1:

When the Active Directory Server PC is not connected to the station bus network, or if it is offline, CMT login automatically ***switches to local authentication****.*

Note 2:

User accounts with C264 profiles should also be added to DSA_LocalUser group to allow them opening a windows session. This will allow them to change their passwords, as there is no password change interface in CMT for users centrally managed.

See Secure Deployment chapter for details for how to configure the RADIUS server to authenticate C26x users.

The RADIUS server or backup RADIUS server are configured in the Cyber Security tab of the SCE.

If the device is configured to use RADIUS, the device will use RADIUS authentication instead of local authentication.

RAIDUS authentication is used to authenticate login through CMT and front panel. SSH and serial port use only local authentication.

When the user login is successfully authenticated through remote authentication, the roles of the connected user will be provided by the RADIUS server.

While establishing the user connection, if the RADIUS server is unavailable and the backup RADIUS server is configured then the device will use the backup RADIUS server. Backup RADIUS server is optional.

If both RADIUS server and the backup RADIUS server are down, authentication will fall back to the local authentication and the message will be displayed on the tool “The RADIUS server cannot be reached, switching to local authentication”. Login window will automatically be changed from Authentication (Central) to Authentication (Local).

Once the authentication falls back to the local authentication, the device will check the availability of the RADIUS server every minute. If the RADIUS server or backup RADIUS server are up again, then the authentication will switch back to the central authentication.

4.5.3 SECURITY LOG

The C26x logs the following user-related operations:

- Start/Stop/Reboot
- Login attempts (successful and failed: wrong password, account locked, existing session)
- Logout
- Add/Remove a user account
- Modify a user account password
- Lock/Unlock a user account
- Add/Remove a role to/from a user account
- Database switch
- Firmware update
- Syslog server down
- Certificate expiration
- Bootloader updated
- Enable/Disable SSH port
- Syslog message lost (buffer full)
- MiCOM S1 Settings updated

The security log is displayed in the CMT and can be sent to a central repository (Syslog server) if it is defined in the configuration database.

Whether logs occurring during a communications loss are received depends on the communications protocol:

- **UDP**: The C26x is not informed of the communications loss, therefore it continues to send the logs during the downtime. These logs are stored locally but are not received by the Syslog server.
- **TLS/TCP**: The C26x is informed of the communications loss. It stores its date and time and sends the intervening logs when the communications are restored.

4.5.4 SYSLOG EVENTS

The list of Syslog event logs available for the C26x is detailed in the tables below.

4.5.4.1 AUTHENTICATION EVENT LOGS

Category	Messages	Severity
Authentication	Login successful	Informational (6)
	Login failed > Invalid user account	Warning (4)
	Login failed > Wrong password *(consecutive Number)*	Warning (4)
	Login failed > Account locked	Notice (5)
	Login failed > Session already active	Notice (5)
	Logout > User disconnection	Informational (6)
	Logout > Timeout	Informational (6)

4.5.4.2 LOCAL SECURITY (USER MANAGEMENT & SETTINGS) EVENT LOGS

Category	Messages	Severity
Security	The user account @login was created	Notice (5)
	The user account @login was removed	Notice (5)
	The user account @login was locked	Notice (5)
	The user account @login was unlocked	Notice (5)
	The role @role was added to the user account @login	Notice (5)
	The role @role was removed from the user account @login	Notice (5)
	The password of the user account @login was changed	Notice (5)
	Security settings modified	Notice (5)

4.5.4.3 SYSTEM EVENT LOGS

Category	Messages	Severity
System	System @sysVersion started	Notice (5)
	System stopped	Warning (4)
	System rebooted	Warning (4)
	Client started (can be optional)	Informational (6)
	Client stopped (can be optional)	Informational (6)
	System updated > @sysVersion to @newSysVersion	Notice (5)
	System could not be updated > @sysVersion to @newSysVersion	Error (3)
	Database switched > @dbVersion to @newDbVersion	Notice (5)
	Database could not be switched > @dbVersion to @newDbVersion	Error (3)
	Date & time modified	Informational (6)
	System settings modified	Informational (6)
	Database settings modified	Informational (6)
	Bootroom updated	Informational (6)
	Enable SSH port	Informational (6)
	Disable SSH port	Informational (6)
	Syslog message lost (buffer is full)	Warning (4)
	MiCOM S1 Settings updated	Informational (6)
	Firmware updated > @firmVersion to @newFirmVersion	Notice (5)
	Firmware update failed > @firmVersion to @newFirmVersion > (optional) @FailureExplanation	Error (3)
	User @login accessed log file	Informational (6)
	Application software integrity failure	Error (3)
	Bootroom software integrity failure	Error (3)
	C264 Network boot	Warning (4)
	RAM corruption detected	Warning (4)
	Bitstream update	Informational (6)
	Bitstream software integrity failure	Error (3)
	Configuration changed	Informational (6)
	User @login successful login with ssh	Notice (5)

4.5.4.4 CENTRAL SECURITY (LOG, AD, SECURE COM.) EVENT LOGS

Category	Messages	Severity
Security	The Active Directory server cannot be reached	Warning (4)
	The Syslog server cannot be reached	Warning (4)
	The certificate @certificateName will expire in @remainingMonths months	Notice (5)
	The certificate @certificateName will expire in @remainingDays days	Warning (4)
	The certificate @certificateName is expired	Error (3)

4.5.5 SECURE COMMUNICATIONS

The C26x supports the SSH protocol for communications with a terminal emulator.

4.5.6 CERTIFICATES

To guaranty firmware integrity, all firmware uploaded into the C26x is digitally signed.

The C26x verifies the integrity of new firmware upon download. It also checks its firmware periodically, at intervals of less than 10 minutes to verify its integrity.

5 COMMUNICATIONS

The C26x includes different types of communications:

- Telecontrol Bus (TBUS)
- Legacy Bus (LBUS)
- Station Bus (SBUS)
- Process Bus (PBUS)

5.1 TELECONTROL BUS - TBUS

You can connect a C26x through the TBUS to the SCADA. The TBUS can use a maximum of two of these protocols:

Protocol	Protocol Type	C26x behaves as	C26x BCU	
MODBUS	Master-slave	Slave	Serial	
T101 (balanced/unbalanced)	Master-slave	Slave	Serial	
T104	Client-server	Server	Over IP	

The C26x connects directly or through a modem with SCADA.

On the C26x, you can configure up to 4 different SCADA systems, including up to 2 serial protocols + up to 2 ethernet protocols.

Each T104 protocol supports up to 4 independent client channels (SCADA front end ports), but these clients cannot simultaneously communicate with the C26x: while one channel is active, the other channels of the same T104 protocol can only perform TESTFR (no control).

Caution:
When you use the serial ports on the CPU board, make sure that the baudrate is the same for both CPU serial ports: com3 and com4.

Redundancy is not available for MODBUS.

Arbitration in a multi-SCADA architecture

If, for instance, a C26x is connected to a SCADA in T101, but also to another one in T101 or T104 (or to one of each type).

Other conditions

- substation and bay in remote mode
- control uniqueness

When the C26x is executing a command (selection or direct execution) issued by one of them, the C26x raises an internal alarm to any SCADA that places another command. Exception: if the second SCADA switches for any reason to a redundant C26x, this alarm is not sent.

5.2 LEGACY BUS - LBUS

C264behaves as a master.

Protocols

- IEC 60870-5-103 (T103)
- IEC 60870-5-101 (T101)
- MODBUS

Devices connected to

- IEDs

Physical layer

- RS232, RS422, RS485, Optical fibre

Caution:
If the main rack is redundant, there is no LBUS connected to the main rack
Caution:
There is no redundancy for the LBUS

On the C26x, two serial ports are available to make four networks with as many as two different protocols.

5.2.1 MODBUS TCP/IP PROTOCOL

MODBUS is a legacy bus master/slave protocol that is used by many devices such as relays, controllers or monitoring devices.

MODBUS has a lot of protocol options supported by the C264.

The two most commonly used are MODBUS RTU (Remote Terminal Unit) and MODBUS (TCP/IP) Transmission Control Protocol and Internet Protocol.

- MODBUS RTU relies on a master/slave architecture with only one master per network
- MODBUS TCP/IP relies on a client/server architecture with multi-client capability.

A C264 (BCU/SCU) can either be a MODBUS TCP/IP Client or MODBUS TCP/IP Server.

5.2.1.1 ARCHITECTURE

A communication system over MODBUS TCP/IP may include different types of devices:

- A MODBUS TCP/IP Client and Server devices connected to a TCP/IP network.
- Routers or gateways for interconnection between the TCP/IP network and a serial line sub-network to connect MODBUS Serial line Client and Server end devices.

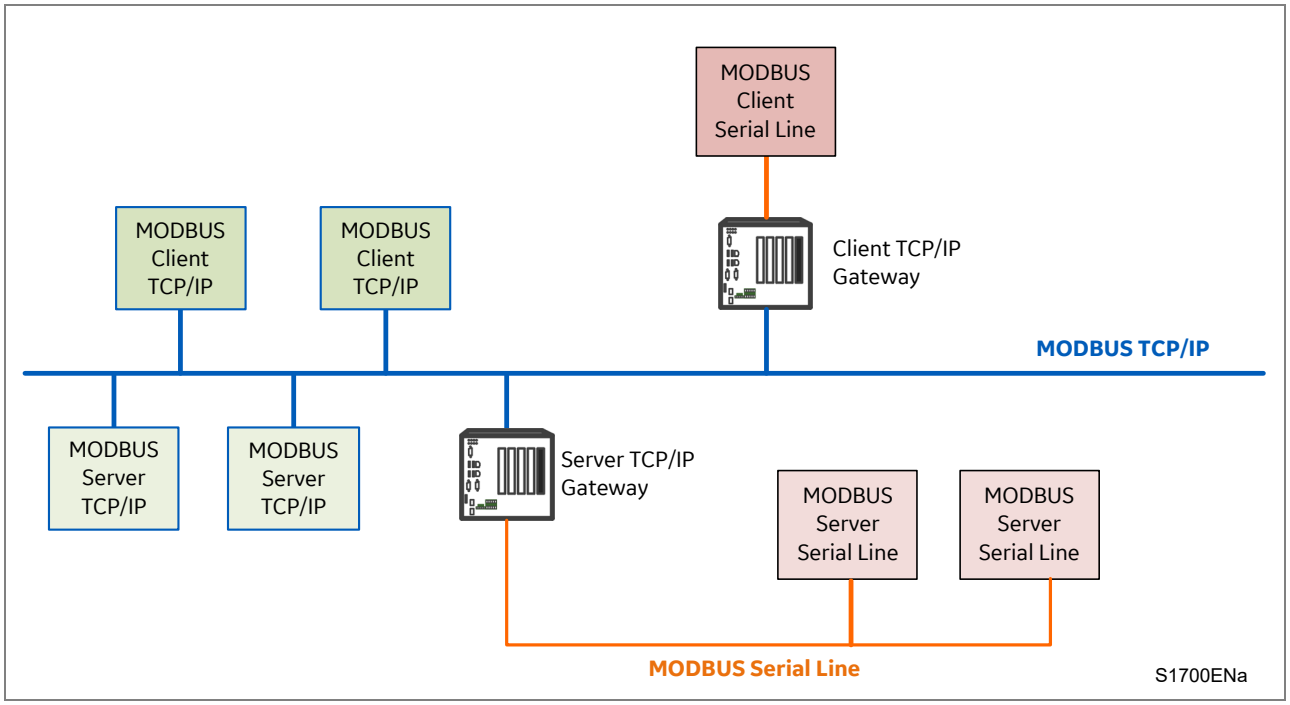


Figure 7: General communication architecture

5.2.1.2 CLIENT/SERVER MODEL

The MODBUS messaging service provides a Client/Server communication between devices connected on an Ethernet TCP/IP network.

This client / server model is based on four types of messages:

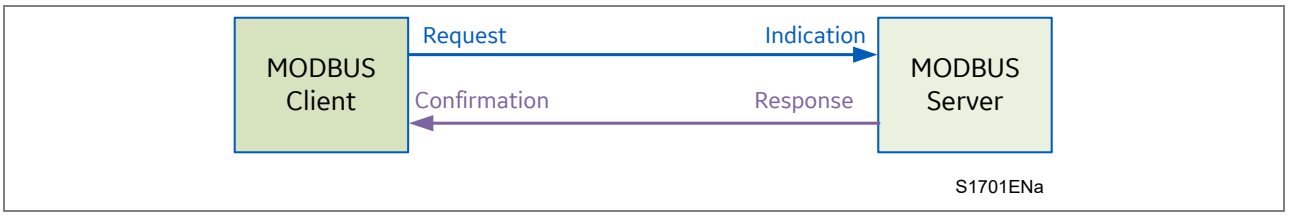


Figure 8: Modbus messaging service

Type	Description
MODBUS Request	Message sent on the network by the Client to initiate a transaction
MODBUS Confirmation	Response Message received on the Client side
MODBUS Indication	Request message received on the Server side
MODBUS Response	Response message sent by the Server

The MODBUS messaging services (Client / Server Model) are used for real-time information exchange between Clients and servers as per criticality level described in the table below:

Criticality level	Description
High	information exchange between a BCU (Client) and IEDs (Servers) from third-party provider, connected on the same MODBUS TCP/IP network segment.
High	information exchange between a SCU (Client) and IEDs (Servers) from third-party provider, connected on the same MODBUS TCP/IP network segment.
Medium	information exchange between a BCU (Client) and routers. A "router" device joins several networks segments. It means a "router" can join dissimilar networks but use the IP addressing. For example, the interconnection between the Client and Server devices connected on different MODBUS TCP/IP network segments.
Medium	information exchange between a SCU (Client) and routers. A "router" device joins several networks segments. It means a "router" can join dissimilar networks but use the IP addressing. For example, the interconnection between the Client and Server devices connected on different MODBUS TCP/IP network segments.
Low	information exchange between a BCU (Client) and SCUs (Servers) connected on the same MODBUS TCP/IP network segment, the SCU will become as a "bridge". A "bridge" device joins similar types of network so that they look like one network. The word "transparent" is often used with bridges because network clients do not know the bridge is even in place.
Low	information exchange between a BCU (Client) and gateways. A "gateway" device joins dissimilar networks. Often the "gateway" needs to be configured on client systems where communications are directed to the gateway and some address mapping is provided to get message to the recipient on the other side. For instance, the interconnection between the TCP/IP network and a Serial Line sub-network which permit connections of MODBUS Serial line Client and Server end devices.
Low	information exchange between a SCU (Client) and gateways. A "gateway" device joins dissimilar networks. Often the "gateway" needs to be configured on client systems where communications are directed to the gateway and some address mapping is provided to get message to the recipient on the other side. For instance, the interconnection between the TCP/IP network and a Serial Line sub-network which permit connections of MODBUS Serial line Client and Server end devices.

5.2.1.3 MODBUS FUNCTIONS

The functions codes from the MODBUS RTU protocol are also supported by the MODBUS TCP/IP protocol.

5.2.1.3.1 Exception codes

Once the request has been processed, the MODBUS server builds the response using the adequate MODBUS server transaction and sends it to the TCP management component.

Depending on the result of the processing two types of response can be built:

- A positive MODBUS response
- A MODBUS Exception response. The objective is to provide to the client relevant information concerning the error detected during the processing. The exception code is provided to indicate the reason of the error. This means that an IED may answer with an exception frame if it does not understand the request

Different exception codes are used:

Exception code	MODBUS Description	Interpretation and processing
01	Illegal Function Code	The function code transmitted is unknown. Sends a "Configuration error" message to the application and continues.
02	Illegal Data Address	The start data address in the request is not an allowable value. Sends a "Configuration error" message to the application and continues.
03	Illegal Value	A value referenced in the data field transmitted is not within range. Sends a "Configuration error" message to the application and continues.
04	Server failure	The server failed during the execution. Sends an "IED error" message to the application.
05	Acknowledge	The server accepted the service invocation, but the service requires a relatively long time to execute. Retries after a defined delay.
06	Server busy	The server was unable to accept the request. Retries after a defined delay.
07	Gateway problem	Gateway paths not available. Sends an "IED error" message to the application.
08	Gateway problem	The targeted device failed to respond. The gateway generates this exception.

5.2.1.4 LIMITATIONS

- A DS agile system can consist of 4 MODBUS TCP/IP Clients and between 2 and 32 MODBUS TCP/IP Servers.
- A C264 can manage up to 32 MODBUS TCP/IP IEDs.

5.3 STATION BUS - SBUS

The SBUS Protocol is used for communications between GE Grid Solutions' DS Agile subsystems but it is also available for other devices.

A C26x behaves mainly as a server but it can be also a client of other C26x devices (distributed automations) or IEC 61850-8-1 IED.

Protocol

- IEC 61850

Devices connected to

- DS Agile devices (DS Agile aView, SMT, Gateway)
- Other C26x devices
- IEC 61850-8-1 IEDs

Link layer

Ethernet 10 or 100 Mb/s

Physical support

- Copper twisted pair (RJ45 connector)
- Optical fibre (single/multi-mode)

5.3.1 EXCHANGES

The C26x acquires and sends data on an IEC 61850 network using REPORT/GOOSE.

The GOOSE is a short message (data value and quality) sent in multicast to all the IEDs on the SBUS; it is faster than the REPORT.

The REPORT is sent by a server to one client.

By default, reports are of URCB class, hence lost in the event of a communications loss.

For details on BRCB, refer to DS Agile/EN FT.

Each memory buffer is circular (FIFO). In the following example, the oldest event has been overwritten due to overflow:

96	97	98	99	100	101	2	3	
				END	↥ START	↥		

When the buffer capacity (100) is overrun, a Buffer overflow SPS is raised and is signalled when the communication is recovered.

C26x behaviour in abnormal modes

- Initialization: all the buffered data are lost
- Maintenance: all the buffered data prior to switching to maintenance mode are retained
- Test: data are buffered on as in operational mode

5.3.2 SUPPORTED COMMON DATA CLASSES

The C26x exchanges data using Common Data Classes. The table below lists the implemented classes:

Common Data Class	Description	Client support	Server support
Status			
SPS	Single input status	Yes	Yes
DPS	Double input status	Yes	Yes
INS	Integer input status	Yes	Yes
ACT	Protection activation information	Yes	Yes
ACD	Directional protection activation information	Yes	Yes
Measurement			
MV	Measurement value	Yes	Yes
CMV	Complex measurement value	Yes	Yes
WYE	3 phases + N measurement	Yes	Yes
DELTA	Phase to phase measurement	Yes	Yes
Counter			
BCR	Binary counter reading	Yes	Yes
Control			
SPC	Single point control	Yes	Yes
DPC	Double control output	Yes	Yes
BSC	Binary step control	Yes	Yes
APC	Analogue setpoint	Yes	Yes
INC	Integer control output	Yes	Yes
ISC	Integer step control output	Yes	Yes
Description			
LPL	Logical node name plate	Yes	Yes
DPL	Device name plate	Yes	Yes
Report Control Block			
URCB	Unbuffered report control block	Yes	Yes
BRCB	Buffered report control block	No	Yes

Table 1: Data management

5.3.3 CONTROLS

The C26x supports Common Data Classes control expressed with SPC, DPC, INC and APC configured as *Direct Execute* or *SBO*.

5.3.4 GOOSE SUPERVISION

DS Agile system makes it possible to monitor SBUS and PBUS GOOSE.

Supervising GOOSE allows a subscriber IED to get the real-time status of GOOSE reception. Each GOOSE subscribed by one IED can be monitored through specific datapoints.

The IEC GOOSE supervision process is as follows.

5.3.4.1 DURING ACCEPTANCE SEQUENCE

When a subscriber IED receives a valid GOOSE message (with stNum = a and sqNum = b), GOOSE messages with higher state number (stNum > a and sqNum = any) is accepted and processed.

Note: the last state number (stNum) is set at 0 when no GOOSE has been received or when detection loss occurred.

GOOSE messages with the following characteristics are accepted by the detection loss algorithm only (their values are not processed):

- stNum **=** a and sqNum **>** b
- stNum **=** a and sqNum **> 0** (if b was > 4 294 967 000)

Any other GOOSE message is ignored. When a GOOSE is accepted with a new state or during a retransmission, the GOOSE GoCB connection state is updated.

5.3.4.2 OUT OF DETECTION SEQUENCE

If a subscriber IED has already received a valid GOOSE message (**stNum** = a and **sqNum** = b), any GOOSE message with a lower state number or with the following characteristics will trigger an alarm:

- stNum < a and sqNum = any
- stNum > a + 1 and sqNum = any if a != 0
- stNum = a and sqNum <= b when b < 4 294 967 294
- stNum = a and sqNum > b + 2
- stNum = a and sqNum = 0
- stNum = a and sqNum > 1 when b was 4 294 967 294
- stNum = a and sqNum > 2 when b was 4 294 967 295

Note: the last state number (stNum) is set at 0 when no GOOSE has been received or when detection loss occurred.

5.3.4.3 DUPLICATED GOOSE DETECTION PROCESS

Management of duplicated GOOSE is based on the source MAC address contained in the GOOSE frame.

If a subscriber IED receives GOOSE with two different MAC addresses, an alarm is raised.

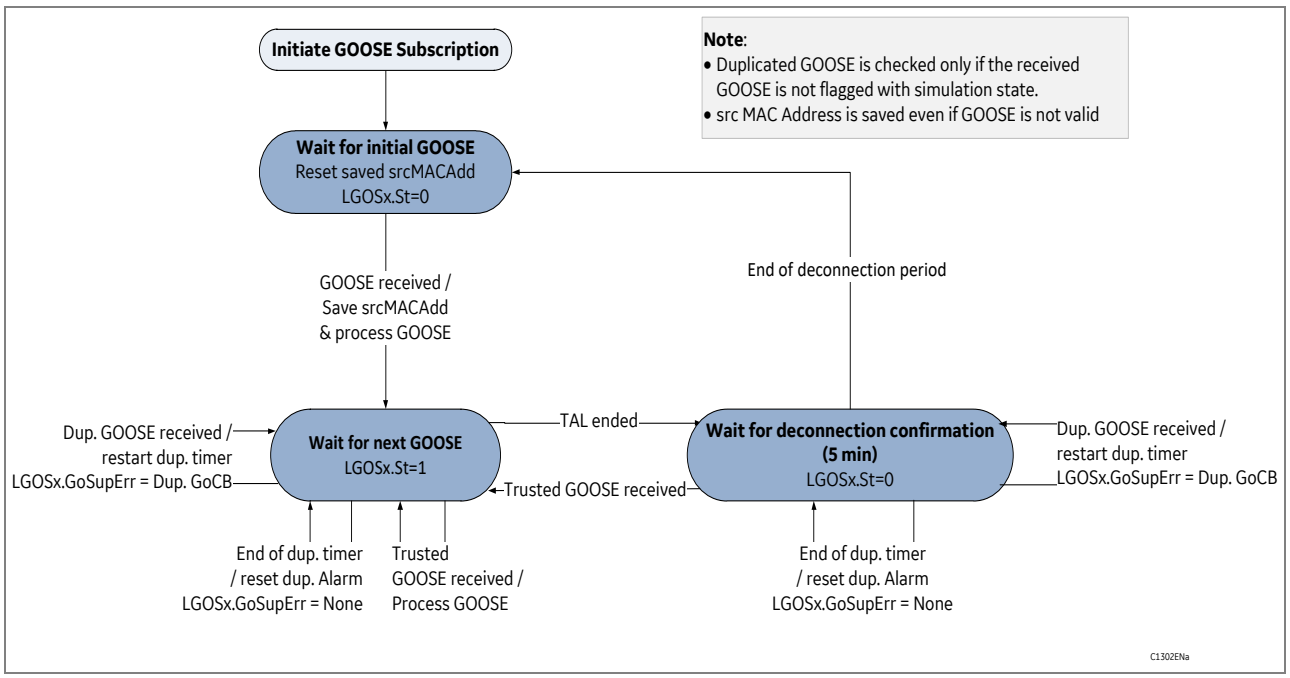


Figure 9: Duplicated GOOSE process

5.3.4.3.1 During active subscription

Every GOOSE frame has a TAL field (**Time Allowed to Live** value) which shows how long the frame is valid. By default, the TAL value is 2000 ms. It is not configurable.

When a subscription to a GoCB is active, the MAC Address of this GoCB is saved. Only GoCB with this same MAC Address is accepted.

When the connection with the publisher is lost, the recorded MAC address is reset. In the case of simulated GOOSE, the source MAC address is not checked.

5.3.4.3.2 Duplicated GOOSE detection alarm

If a duplicated GOOSE is detected (another MAC address has been stored), the GOOSE is ignored. The GOOSE communication state remains active with the trusted GOOSE and an alarm is raised.

If a duplicated GOOSE is received with another MAC address and no MAC address is selected yet, the GOOSE communication with the two publishers is disabled until only one valid GOOSE is received.

If several changes occur, only the last change is taken into account (other events are lost).

5.3.4.3.3 Loss of publisher

If a communication loss is detected when a subscriber IED receives a valid GOOSE message, a timer - based on the TAL contained in the GOOSE frame - is launched (2000 ms) to make sure that the network issue has not been recovered.

On TAL expiration, this GoCB data is updated with the quality old data and failure. In addition, an alarm state is raised. The connection state is set at 0.

5.3.4.4 GOOSE SUPERVISION STATES

For each subscribed GoCB, several datapoints can be implemented at configuration level to supervise GOOSE. For configuration details, refer to section **GOOSE Supervision** in the **Application** chapter of the **DS Agile C26x** user manual.

5.4 PROCESS BUS - PBUS

The Process Bus is used for communications between the DS Agile C26x BCU and primary devices physically connected to local signal conversion units, such as switchgear control units for circuit-breakers and merging units for conventional or non-conventional instrument transformers.

To this effect, the Process Bus supports 2 parts of the IEC 61850 protocol:

- IEC 61850-8-1 for GOOSE messages to exchange state signals and commands with the circuit-breaker's associated switchgear control unit,
- IEC 61850-9-2 LE to retrieve sampled measurements from conventional and non-conventional instrument transformers via merging units.

The DS Agile C26x BCU can manage one or two electrical bays using the Process Bus.

5.4.1 FEATURE AVAILABILITY

Not all of DS Agile's standard functions are available yet using Process Bus communications:

At this time, the following functions are available using Process Bus communications:

- Interlocking equations
- Fast Automation (FBD programmable logic)
- Slow Automation (ISaGRAF)
- Autoreclosing (with and without synchrocheck)
- Synchrocheck (types 1 and 4): If it manages two electrical bays, the BCU can manage two synchrocheck functions of the same type, either type 1 or type 4. Mixes are not supported.
- Automatic Voltage Regulation (AVR) with Digital Tap Position indication
- Disturbance recording (Fast Waveform)

The following automation and reporting functions can only be used with standard wired inputs and outputs and are not available using Process Bus communications at this time:

- Analogue Tap Position Indication
- Trip Circuit Supervision

Note:
At the time of your tender/project, please check function availability with GE Grid Solutions' Marketing Department.

5.4.2 STATION BUS/PROCESS BUS COMMUNICATIONS AVAILABILITY VIA REDUNDANT C26X BCU

If a communications link between the Process Bus and the BCU is lost, several cases are possible:

- Sampled values (IEC 61850-9-2LE)
  - If the communications link is lost between the merging unit(s) and either C26x (standby or active) BCU, sample value information will continue to be normally forwarded from the Process Bus to the Station Bus.

- GOOSE data (IEC 61850-8-1)
  - If the communications link is lost between the SCU and the standby C26x BCU, IEC 61850-8-1 information will continue to transit normally between the Process Bus and the Station Bus, in both directions via the active C26x.
  - IF THE COMMUNICATIONS LINK IS LOST BETWEEN THE SCU AND THE ACTIVE C26X BCU, IEC 61850-8-1 INFORMATION CAN ONLY BE TRANSMITTED FROM THE PROCESS BUS TO THE STATION BUS, I.E. NO COMMANDS CAN BE SENT FROM THE STATION BUS TO DEVICES ON THE PROCESS BUS.

5.4.3 IEC 61850-8-1 GOOSE COMMUNICATIONS

The C26x BCU sends and receives signals to and from switchgear control units through the Process Bus Ethernet network: Its CPU4 boards processes the SCU's digital input states and sends commands to the SCU.

5.4.3.1 SUPPORTED COMMON DATA CLASSES FOR GOOSE MESSAGES

The C26x and the remote switchgear control unit(s) exchange only binary data with their quality (bit string).

Note:
In the GOOSE messages, double datapoints are transmitted as two consecutive "single datapoints".

5.4.3.2 CONTROLS

The C26x supports commands configured as Direct Execute and Select Before Operate (SBO).

5.4.3.3 PROCESSES MANAGED BY THE CPU4 BOARD

5.4.3.3.1 Ethernet link redundancy

Communications with the process bus use two optical Ethernet links according to the IEC 62439-3 standard (PRP: Parallel Redundant Protocol).

5.4.3.3.2 Ethernet link alarm

The CPU4 board supervises the state of each communications port and indicates it by means of LEDs. For each link, the following information is provided:

- Off = No link
- On = Healthy link
- Blinking = activity

Refer to the *Hardware chapter* of this manual (ref. *C26x/EN HW*) for further details.

5.4.3.3.3 PTP synchronisation

Precision time < 1ms for a maximum of 5 hops between GE Grid Solutions-approved devices.

Note:
If the BCU is used to broadcast the PTP time over the Process Bus Ethernet network, it uses an extra hop.

C26x BCU

Depending on its synchronisation mode, the C26x BCU can either receive the time synchronisation from the process bus's PTP time server or act as time server and synchronise the devices connected to the process bus using IEEE 1588 v2 PTP.

Case 1 – Client mode (default) – The C26x BCU is synchronised by a Process Bus's PTP time server:

- The C26x BCU is synchronised via a PTP time server as long as there is one available.
- If all the available PTP time servers are lost, the C26x BCU continues to update its internal clock with the status "not synchronised".

Note:
The PTP time server can be of different types: a Grandmaster clock, another C26x BCU on the Process Bus, etc...

Case 2 – Server mode – The C26x BCU is synchronised by a Station Bus's PTP or SNTP time server:

- If there is no PTP time server available on the Process Bus network, it is possible to set the C26x BCU so that it is synchronised by a Station Bus master clock. The C26x BCU is then the PTP time server for Process Bus.
- If the C26x BCU's signal is lost, the C26x BCU continues to update its internal clock with the status "not synchronised".

The C26x BCU operates in the BC (Boundary Clock device) or OC (Ordinary Clock device) modes.

Note:
The switches used in the Process Bus network core should comply with the IEEE1588 v2 standard.

C26x SCU

The C26x SCU is synchronised through its Ethernet interface using either:

- the PTP standard: IEEE 1588 v2 in OC (Ordinary Clock) operating mode (*one-step* or *two-step*).
- the SNTP v4 standard in *Client*, *Server*, or *Client-Server* mode.

If synchronisation is lost, the C26x SCU continues to update its internal clock with the status "not synchronised".

5.4.3.4 GOOSE FRAME RECEPTION

The C26x BCU reads IEC 61850-8-1-compliant GOOSE frames on the process bus network.

The C26x BCU selects the GOOSE messages from a configured IED and its optional backup, such as for instance:

- a main C26x SCU/Generic IED
- a backup C26x SCU/Generic IED (optional)

5.4.3.4.1 Incoming GOOSE source selection

Priority is given to GOOSE frames from the main C26x SCU/Generic IED if it is configured.

Switching to the configured backup source of GOOSE frames occurs if:

- The backup source is considered better than the main one with regards to:
  - Data validity transmitted in the GOOSE frame
  - Synchronisation state of the source

  In steady state conditions:

	Main	Synchronised		Not Synchronised	
Backup		valid data	invalid data	valid data	invalid data
Synchronised	valid data	Main	Backup	Backup	Backup
	invalid data	Main	Main	Main	Backup
Not Synchronised	valid data	Main	Backup	Main	Backup
	invalid data	Main	Main	Main	Main

- GOOSE messages are being received from the backup source and not from the main source (loss of GOOSE reception from main source)

5.4.3.4.2 GOOSE filtering

GOOSE messages are accepted if the GOOSE tag (Test/Simulation) matches the C26x's operating mode:

- GOOSE tag for Test or Test/blocked mode and C26x in Test or Test/blocked mode
- GOOSE tag for On or On-blocked mode and C26x in On or On-blocked mode

A C26x in ON or On-blocked mode ignores any incoming GOOSE message that has its header field "test" is set to "True" (test mode). Conversely, a C26x in Test or Test/blocked mode ignores any incoming GOOSE message that has its header field "test" is set to "False" (on mode).

See section 4.1.2 IEC 61850 Operating Mode for information on GOOSE processing with regard to ON/TEST modes.

Note:
If a GOOSE tag from the main IED does not match the C26x's operating mode, it is discarded whatever the tag in the GOOSE published by the backup IED.

5.4.3.4.3 Data acquisition from received GOOSE messages

The C26x can receive a total of up to 477 datapoints in the incoming GOOSE frames (maximum 32) and can transmit a maximum of 16 GOOSE frames.

The GOOSE messages considered by the C26x only contain single and/or double datapoints.

If the C26x does not receive a valid GOOSE message, all the single/double datapoints are assumed "invalid".

5.4.3.5 GOOSE FRAME TRANSMISSION

5.4.3.5.1 Control commands sent in GOOSE messages

Each time the C26x generates a command, it publishes a GOOSE message.

That message is a global IEC 61850-8-1 GOOSE message that contains the current state and validity of all the datapoints.

The transmitted GOOSE messages are time-stamped with the UTC time of the command. The expected accuracy of the timestamp is better than 1 ms when the C26x is synchronised.

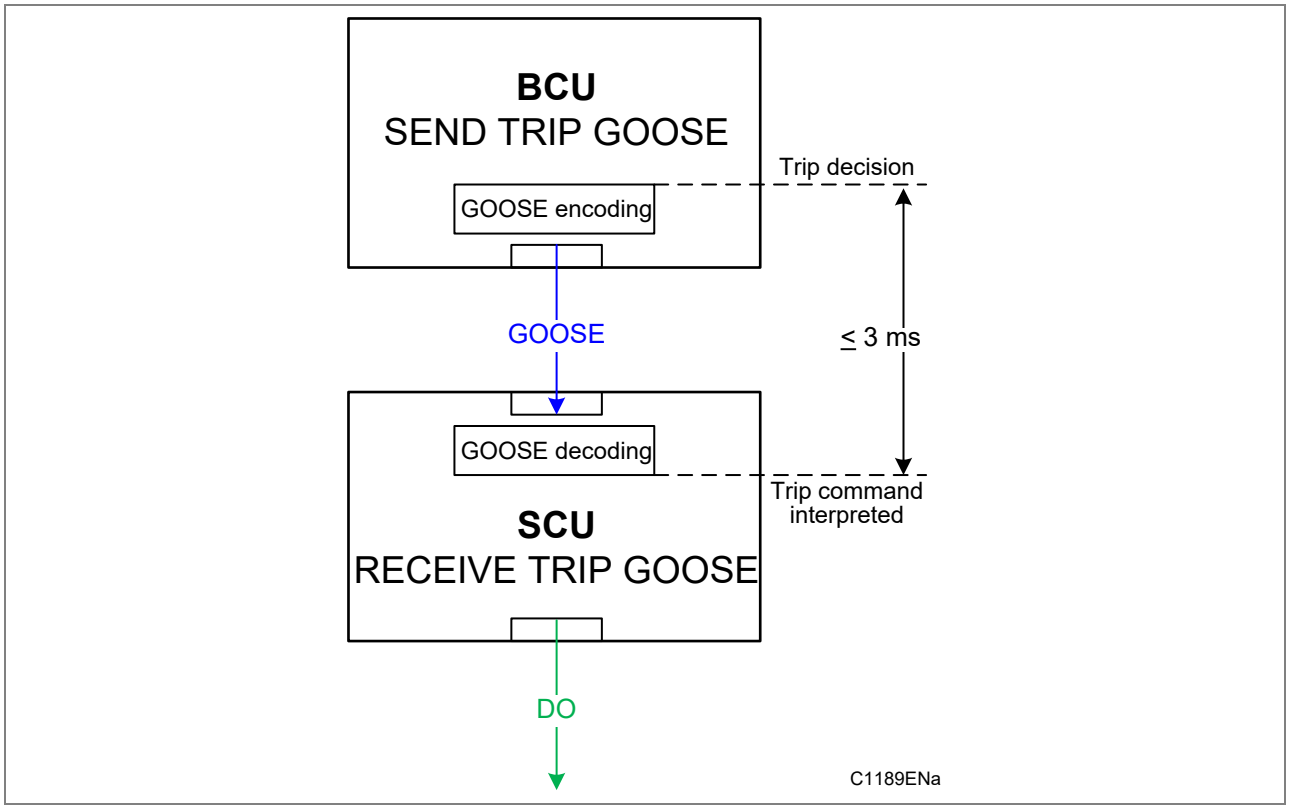
5.4.3.5.2 Data stored in the transmitted GOOSE messages

Data is sent in the GOOSE message as IEC 61850-8-1 single or “double” datapoints (i.e. two adjacent single datapoints), depending on the configuration (multiple datapoints are not supported).

If an invalid control command (non-complementarity) is generated, it is ignored, and no GOOSE message is generated.

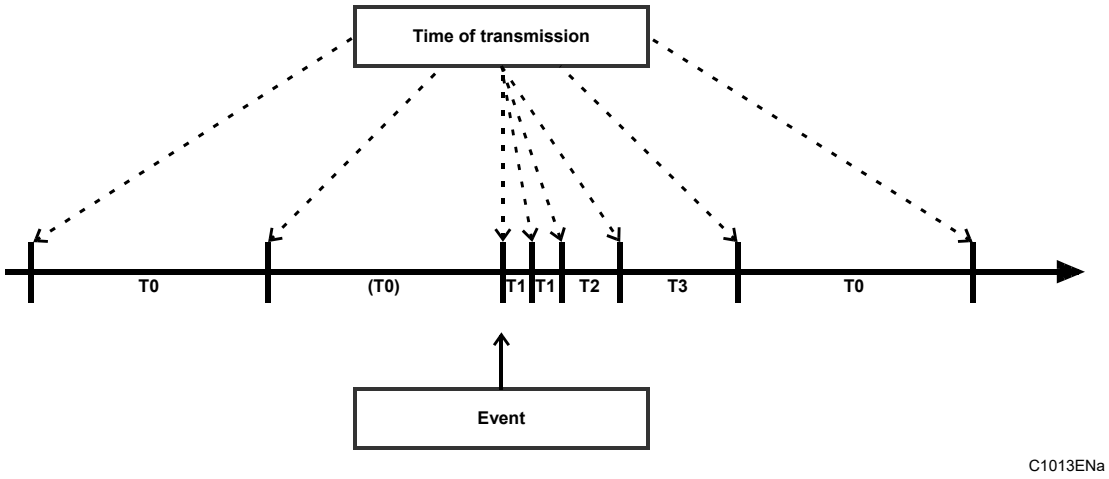
5.4.3.6 FAST GOOSE MECHANISM

The GOOSE frames exchanged by the C26x BCU and the C26x SCU on the Process Bus are processed separately from the MMS reports and the GOOSE frames exchanged by Station Bus devices. While the latter are processed by the IEC 61850 agency embedded in the BCU firmware, the Process Bus GOOSE frames are processed by a dedicated FAST GOOSE UNIT and bypass the IEC 61850 agency altogether. This guarantees that the combined transmission and processing times at both ends does not exceed 3 ms, in accordance with the IEC 61850-5 standard (type 1A “Trip” performance class).



5.4.3.7 REPETITION OF GOOSE MESSAGE TRANSMISSION

The GOOSE messages are transmitted according to the sequence described in the figure below:



T0 (2000 ms): retransmission in stable conditions (no event for a long time).
T1 (10 ms): shortest retransmission time after the event.
T2 (50 ms), T3 (500 ms): retransmission times until achieving the stable conditions time

Figure 10: GOOSE transmission time

5.4.4 IEC 61850-9-2 LE COMMUNICATIONS (SAMPLED VALUES)

Where a CT&VT board (TMU2xx) would acquire analogue values received via conventional instrument transformers, the C26x BCU's CPU4 board receives via merging units already digitised values from conventional and/or non-conventional instrument transformers (IEC 61850-9-2 LE data) over the Process Bus Ethernet network. The merging units transmit the sampled values in specific Ethernet frames called “Sampled Value Control Blocks” (SVCB) at set intervals. They can deliver several SVCBs.

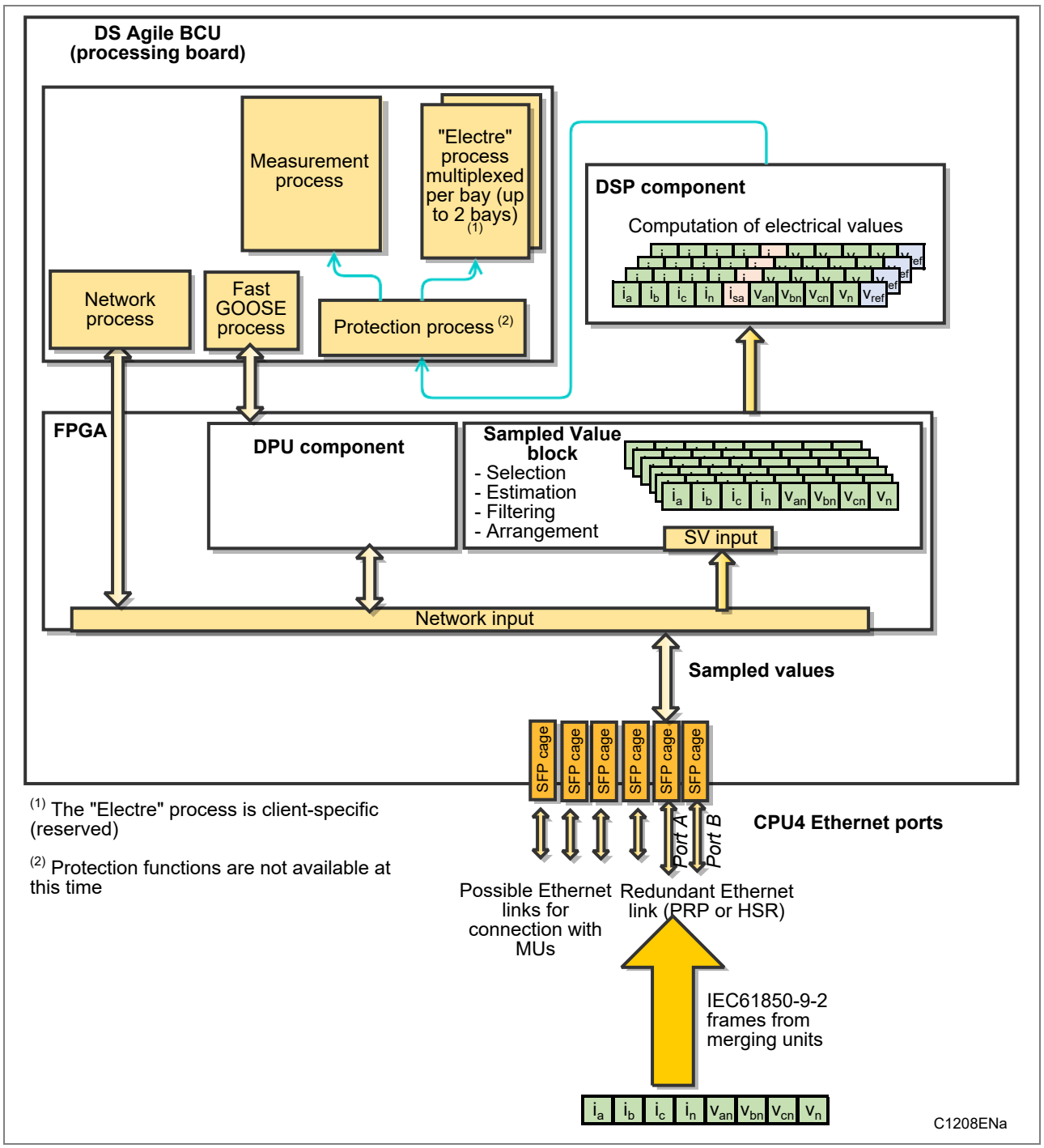


Figure 11 Sampled value process architecture in BCU

5.4.4.1 SIGNAL RECEPTION

The C26x BCU can manage up to 2 digitally-connected electrical bays. A bay can be linked to a maximum of 2 “Sample Value Groups” (a measurement group and a protection group). A **Sample Value Group** is a DS Agile customisable object that contains sample values received from different IEC61850-9.2LE Logical Devices (Merging Units). The number of sample value groups is limited to 2. This means that if the C26x BCU manages 2 electrical bays, each bay can be linked to only one SV group, summarised below:

Possible options

- **1** SampleValueGroup (protection+measurement OR measurement) per bay => up to 2 bays per BCU
- **2** SampleValueGroups (protection+measurement AND measurement) per bay => 1 bay maximum per BCU

defined by:

- max. number of electrical bays managed by BCU: **2**
- max. number of SampleValueGroups managed by BCU: **2**
- max. number of SampleValueGroups configurable per electrical bay: **2**

Note:
Both bays must be digitally connected. It is not possible to have one bay hard-wired through a TMU2xx board and the other bay connected through merging units.

Each **SampleValueGroup** is associated with a type of instrument transformer (measurement or protection class) and contains a fixed number of **10** channels: 5 current channels and 5 voltage channels which can be acquired through up to 6 merging units:

- the three phase currents I_A, I_B, I_C on the line side,
- a fourth current, usually I_N,
- a fifth, customisable, current, I_{SA},
- three-line voltages V_A, V_B, V_C,
- a fourth voltage, usually V_{BB1} or V_N,
- a fifth voltage, usually V_{BB2} or V_{BB}

All the merging units linked to the same sample value group must have:

- the same precision class (“protection+measurement” or “measurement")
- the same VT and CT primary/secondary ratios

Two sample value arrangements can be defined under each sample value group: the Main arrangement (compulsory) and the Backup arrangement (optional, used for merging unit redundancy or reference voltage switching). Arrangements may contain sampled values transmitted by different merging units.

The CPU4 board supports the IEC 61850-9-2LE sampled value acquisition process in the C26x architecture.

The primary values are received from the Process Bus in IEC 61850-9-2LE-compliant Ethernet frames. The IEC 61850-9-2LE standard recommends that frames are received from a maximum of 8 Logical Nodes (i.e. merging units) on a single 100BaseFx with LC Ethernet link in order to ensure that the network's performance is not impaired by an excessive number of frames (one every 250 µs for each LN). The CPU4 board can acquire sampled values from up to 6 LNs.

The IEC 61850-9-2LE standard allows support for two sample rates, at both 50 Hz and 60 Hz power system frequencies: 80 samples/cycle or 256 samples/cycle. The rate of 256 samples/cycle is not used in this application as it is mostly only relevant for power quality metering/analysis applications.

The power system frequency is set in the merging unit. The sampling rate should be configured in the Merging Unit (MU): the BCU only uses a rate of 80 samples per power system cycle. Merging units do not perform frequency tracking; therefore, this rate does not vary with network conditions. A SVCB is transmitted by Merging Unit every **250 µs** at 50 Hz and every **208 µs** at 60 Hz.

The CPU4 board filters the incoming IEC 61850-9-2LE frames according to their internal svID and will only process the frames containing the svIDs that it is configured to take into account.

The BCU assigns a timestamp to the sample values every 4 samples, i.e. once per millisecond at 50 Hz.

It processes protection and measurement class sampled values at the same rate:

Power system frequency	Theoretical samples per power system cycle	Sample Value transmission interval	Sampling rate
50 Hz	80	250 µs	4000 Hz (4000 frames/s)
60 Hz	80	208 µs	4800 Hz (4800 frames/s)

5.4.4.2 SIGNAL PROCESSING

5.4.4.2.1 Sample value (“SV”) processing

The C26x sampling rate compatibility is 80 samples/cycle on each channel. A frequency tracking principle would normally be applied to maintain a constant number of samples per cycle even when the signal's frequency fluctuates. Up to 3 "missing" (invalid or not received) values can be calculated (interpolated) to reach the required total number of samples.

The samples are then filtered for each selected channel, including any calculated values, using an anti-aliasing filter.

The CPU4 board selects the required SV channels according to the set channel arrangement.

The channel arrangement defines which SVs are to be mapped to the analogue signals managed by the CPU4 board.

Analogue signals:

- I_A
- I_B
- I_C
- I_N
- I_{SA} (customer-specific)
- V_A
- V_B
- V_C
- V_{BB1}
- V_{BB2} or V_N

An IEC 61850-9-2LE frame contains 8 SV channels: 4 currents and 4 voltages.

A typical static channel value arrangement could for instance be configured as follows:

First SV group

Signal	Origin	SV channel	Default position in the SV Group
I_A	Merging unit 1	1	0
I_B	Merging unit 1	2	1
I_C	Merging unit 1	3	2
I_N	Merging unit 1	4	3
V_A	Merging unit 1	5	5
V_B	Merging unit 1	6	6
V_C	Merging unit 1	7	7
V_{BB1}	Merging unit 2	5	8
V_{BB2}	Merging unit 3	5	9
I_{SA}	Merging unit 4	4	4

Second SV group

Signal	Origin	SV channel	Default position in the SV Group
I_A	Merging unit 1	1	0
I_B	Merging unit 1	2	1
I_C	Merging unit 1	3	2
I_N	Merging unit 1	4	3
V_A	Merging unit 1	5	5
V_B	Merging unit 1	6	6
V_C	Merging unit 1	7	7
V_N	Merging unit 1	8	8
V_{BB}	Merging unit 2	5	9

Validity of output channels:

In addition to the re-sampled values, the CPU4 board processes the validity of each output channel.

The validity of an output channel depends on:

- The synchronisation flag in the received SV frame: If the input frame of a selected channel is not synchronised, the corresponding output channel is invalid, and the analogue value is forced to zero.
- The quality flag of the SV channel in the received frames (defined by IEC 61850-9-2):

  If the input frame of the selected channel is synchronised and if all the SVs used for re-sampling have a good quality (including the interpolated SVs), the output channel validity is set to good and the analogue value is computed (re-sampled). Otherwise, the output channel validity is set to invalid and the analogue value is forced to zero.

- The test mode flag of the received frame depends on the test setting:
  - TestBlocked:
    If an SV used for re-sampling is in test mode, its output channel is invalid, and the analogue value is forced to zero.
  - TestIgnored:
    If an SV used for re-sampling is in test mode, its output channel validity depends on the input channel validity received in the input frame and the analogue data is computed (re-sampled).
  - TestOnly:
    - If an SV used for re-sampling is in test mode, the validity of its output channel depends on the validity of its input channel and the analogue data is computed (re-sampled).
    - If an SV used for re-sampling is not in test mode, its output channel is invalid and the analogue value is forced to zero.
- The frame loss rate:

  If the frame loss level for data received from a Logical Node is above the set threshold, the output channel is invalid, and the analogue value is forced to zero.
- The number of consecutive missing values

  If there are more than 3 consecutive missing values, the following values will be considered as definitively missing until a valid sampled value is received again.

5.4.4.2.2 DSP processing

The samples received by the DSP processor on the CPU4 board are converted to transformer secondary values for processing using the set CT/VT ratios.

The DSP software only processes valid RMS sampled values, i.e. all the sampled values of the corresponding time window must be valid, otherwise the computed RMS value is considered as invalid.

All the computed measurements are directly dependent on the validity of the sampled values received for each channel. There is therefore no need to check minimum or maximum thresholds as would normally be the case with direct analogue measurements.

Because the data transmitted in an IEC 61850-9-2 frame can only be single-phase voltages or currents (phase-to-phase values are forbidden), the wiring type is always considered as a star connection.

Note:
There is no frequency tracking. Therefore, the current and voltage values may be considered valid even if the power system frequency is out of range.

5.4.4.2.3 SampleValuesGroup constitution

A BCU can manage up to **5** current inputs and **5** voltage inputs in the same **SampleValueGroup**.

Each **SampleValueGroup** is made up of

- currents and voltages from the FEEDER side,
- an optional high accuracy current,
- and a custom voltage reference, from BUSBAR side.

Only the fifth voltage input (channel 9) can be automatically replaced with another sample value, for instance to dynamically switch the reference voltage in a synchrocheck application.

Channel	Ch. 0	Ch. 1	Ch. 2	Ch. 3	Ch. 4	Ch. 5	Ch. 6	Ch. 7	Ch. 8	Ch. 9
Label	CI#1	CI#2	CI#3	CI#4	CI#5	VI#1	VI#2	VI#3	VI#4	VI#5

5.4.4.2.4 Static arrangements block definition

Up to **2** static arrangements can be configured for each **SampleValueGroup**:

- 1 static arrangement named **MAIN**
- 1 static arrangement named **BACKUP**

The MAIN and the BACKUP arrangements must be configured for the same usage (protection or measurement).

The BACKUP arrangement is optional and configured in case of presence of MU backup in the DCS system

The example given below illustrates a possible configuration in a bay fitted with 5 merging units:

- Merging Unit #1 connected on BAY#1 FEEDER side, with a protection class TC
- Merging Unit #2 connected on BAY#1 FEEDER side, with a protection class TC
- Merging Unit #3 connected on BAY#1 FEEDER side, with a measurement class TC
- Merging Unit #7 connected on BUSBAR#2 FEEDER side, with a measurement class TC
- Merging Unit #9 connected on BUSBAR#1 FEEDER side, with a measurement class TC

Dynamic arrangement channels	**Arrangement MAIN (default)**		**Arrangement BACKUP**	
	Sampled value id	**Data entry index**	**Sampled value id**	**Data entry index**
0	svID_name_of_MU1	1 (I_A)	svID_name_of_MU2	1 (I_A)
1	svID_name_of_MU1	2 (I_B)	svID_name_of_MU2	2 (I_B)
2	svID_name_of_MU1	3 (I_C)	svID_name_of_MU2	3 (I_C)
3	svID_name_of_MU1	4 (I_N)	svID_name_of_MU2	4 (I_N)
4	svID_name_of_MU3	1 (I_A)*	svID_name_of_MU3	1 (I_A)*
5	svID_name_of_MU1	5 (V_{AN})	svID_name_of_MU2	5 (V_{AN})
6	svID_name_of_MU1	6 (V_{BN})	svID_name_of_MU2	6 (V_{BN})
7	svID_name_of_MU1	7 (V_{CN})	svID_name_of_MU2	7 (V_{CN})
8	svID_name_of_MU1	8 (V_N)	svID_name_of_MU2	8 (V_N)
9	svID_name_of_MU9	5 (V_{AN})**	svID_name_of_MU7	5 (V_{AN})**

Notes

- **data entry index** is the position of the sample value in the IEC 61850-9-2LE Ethernet frame, itself called **Sampled value id**.
- The IEC 61850-9-2LE frame contains only phase-neutral voltages as the merging units are always “star”-wired to voltage transformers.
- (*): the I_{SA} current can be any phase current. In this example, the I_{SA} is configured with the I_A Sample Value. This optional value is only for measurement use requiring high precision.
- (**): the sample value configured for BUSBAR voltage (VI #5) CANNOT be the same as a FEEDER side sample value in a static arrangement. This sample value can be replaced by another sample value in case of **dynamic arrangement** (see section *5.4.4.3 Dynamic Channel Arrangements*).

5.4.4.2.5 Fallback mode: Invalid Sample Values

IEC 61850-9-2LE frames from Merging Units may be transmitted with the quality INVALID, or not transmitted at all.

The following list describes the invalidity causes, and the BCU’s resulting behaviour.

Invalidity	Result
All MU disconnected	All measurements are invalid
One MU disconnected OR MU not synchronised	All measurements coming from the missing MU are invalid
Samples with temporarily invalid flag (< 4 samples)	Valid measurements
Samples with permanent invalid flag (> 4 samples) OR Missing frames	All measurements coming from the missing samples are invalid
No voltage, no current injected and quality valid provide by MU SV= 0	0.0 value and valid measurements
No voltage, no current injected and quality valid provided by MU SV=noise	All measurements coming from the missing samples are invalid
No voltage, no current injected and quality invalid provide by MU	All measurements coming from the missing samples are invalid
Samples tagged with TEST mode	Compare to BCU mode, if different and measurement dependent on TEST mode, the measurement is ignored. (TEST mode policy)
Checksum errors	If 5 consecutive checksum errors occur, the measurements are invalid
No interrupt reception	After 100ms (5 periods @50Hz), all the measurements are invalid
Frequency out of range (45-55Hz / 54-66Hz)	All measurements are invalid

5.4.4.3 DYNAMIC CHANNEL ARRANGEMENTS

Dynamic arrangements can be used to manage merging unit redundancy or voltage reference changes for synchrocheck applications, through internal automations or external IEC 61161-3-compliant IEDs:

- **Bay SV Arrangement**: part of an automation called **Redundancy Controller**, used to switch between the MAIN and BACKUP static arrangements to create a redundancy of Merging Units.
- **Reference Voltage Selection**: automation used to select a specific Sample Value using an index from a list of sampled vales, the PBUS SV list: this sampled value is meant to be used as reference voltage in synchrocheck applications.

2 sets of SV channel configurations, Main and Backup "arrangements", can be defined in each sample value group. Channels from up to 6 merging units can be configured in each arrangement. Channels can be included in both arrangements but may be present only once in an arrangement.

The Main arrangement is compulsory; it is always defined in the configuration. Processing always starts with that set.

Switching to the backup arrangement is done via a dedicated SPS datapoint, which can be linked to a manual command or output by an automation.

Channels that are no longer included in the new active arrangement are flushed out. Channels that are kept from the previous arrangement into the new one is kept unchanged and signal continuity is preserved.

Arrangement switching can also be used for testing purposes, by replacing actual sampled values with sampled values received from a simulator device.

Substation topology changes can be managed using a “process bus list”: that list indexes all the sample value frames available under the process bus, whichever the merging unit that transmit them. This index makes it possible to select the voltage used by the synchrocheck function as reference (usually busbar) voltage to permit closing.

An example of this feature implementation is shown in the figure below.

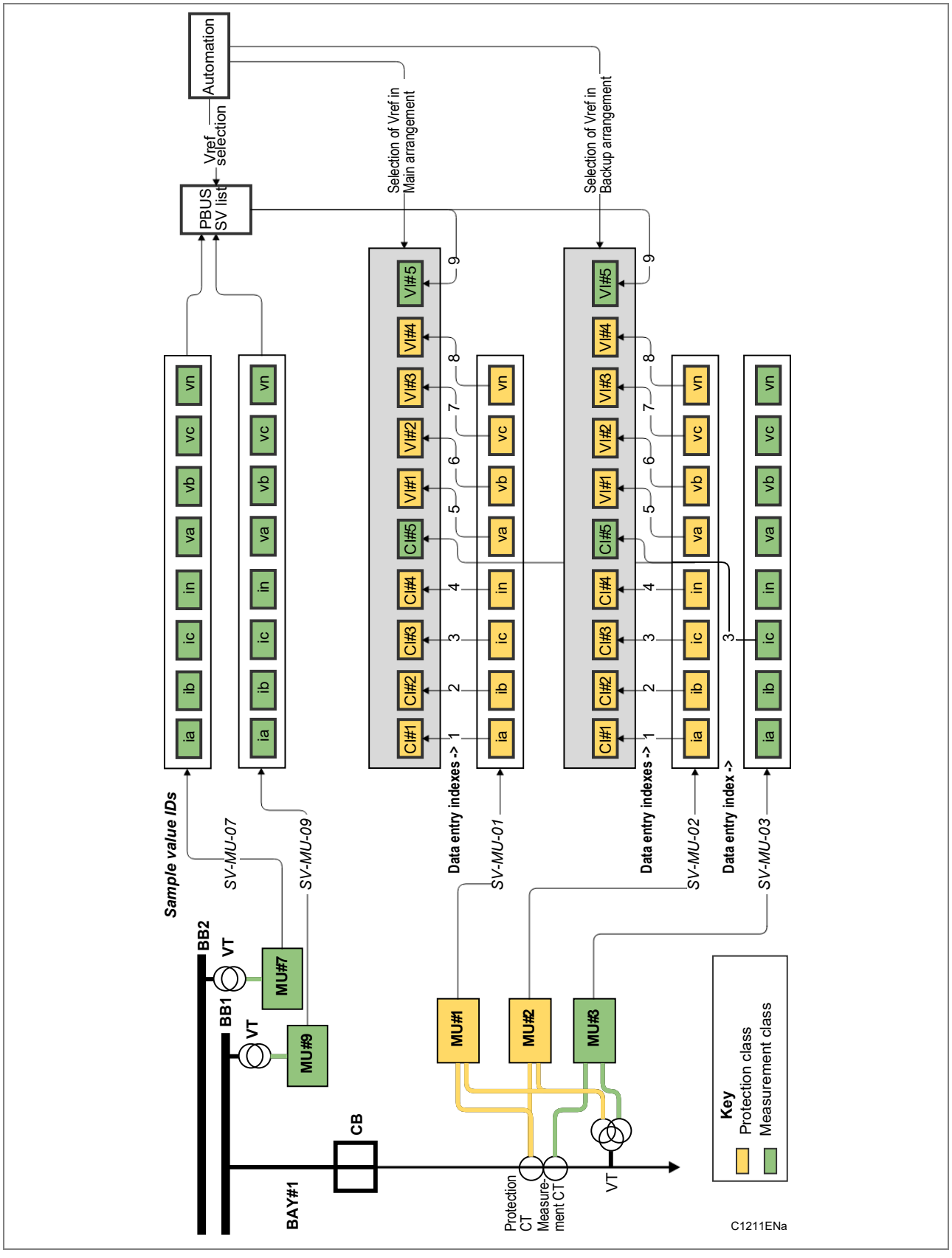


Figure 12: Dynamic arrangement architecture

Dynamic arrangement switchover occurs when the following datapoints' states change:

Event	Description
SV.NODE.SEL.xxxx MPS change	Topology (reference voltage) change
MAIN.BACK.xxxx SPS change	Merging unit redundancy: SV arrangement switchover

When a change event occurs, an **Arrangement Shift Timer** is launched to await a possible new change event. The timer's duration is fixed, to **100ms**.

The following system status indications are available at bay level:

Label	Type	Description	Consequence
GRP.ERR	SPS	Arrangement error status	change request refused
GRP.FAIL	SPS	Arrangement change status	failure mode

5.4.4.4 MERGING UNIT REDUNDANCY

Merging unit redundancy is managed through channel arrangements. Each Sampled Value Group can contain up to two static channel arrangements: one static arrangement can be linked to the main merging unit and the other to the backup merging unit. Both static channel arrangements must have the same usage (protection or measurement) configuration, i.e. each channel in the backup arrangement must have the same usage as its equivalent in the main arrangement.

Example

A Feeder bay fitted with 5 merging units:

- Merging Unit #1 connected on Line #1, with protection class CT/VT
- Merging Unit #2 connected on Line #1, with a protection class CT/VT
- Merging Unit #3 connected on Line #1, with a measurement class CT
- Merging Unit #7 connected on Busbar #2, with a measurement class VT
- Merging Unit #9 connected on Busbar #1, with a measurement class VT

Dynamic arrangement channel	MAIN Static Arrangement (default)		BACKUP Static Arrangement	
	Merging unit	Position in the Ethernet frame	Merging unit	Position in the Ethernet frame
0	#1	1 (I_A)	#2	1 (I_A)
1	#1	2 (I_B)	#2	2 (I_B)
2	#1	3 (I_C)	#2	3 (I_C)
3	#1	4 (I_N)	#2	4 (I_N)
4	#3	1 (I_A) (1)	#3	1 (I_A) (1)
5	#1	5 (V_A)	#2	5 (V_A)
6	#1	6 (V_B)	#2	6 (V_B)
7	#1	7 (V_C)	#2	7 (V_C)
8	#1	8 (V_N)	#2	8 (V_N)
9	#9	5 (V_A) (2)	#7	5 (V_A) (2)

(1) The optional measurement class I_{SA} current can be I_A, I_B, I_C or I_N. In this example, the I_{SA} is I_A.

(2) In a static channel arrangement, the sample value configured for the busbar voltage (VI #5) must NOT be a Sample Value used for one of the line voltages. In the case of a **dynamic arrangement**, this sample value may be replaced with another sample value.

5.4.4.5 PROCESS BUS SAMPLE VALUE LIST (“PBUS SV LIST”)

The reference (usually Busbar) voltage selection is made by extracting the corresponding sampled value reference from a dedicated list, the “PBUS SV list”.

The **PBUS SV list** is a list of Sample Value Frames, provided by merging units connected to the same Process Bus. It is automatically generated on BD generation process, by system configuration tool (SCE), for each Process bus connected to BCU.

The index **0** of the **PBUS-List** is always dedicated to the use case "NOT CONNECTED". All Sample Values equivalent to the voltages (A, B, C, N) are equal to 0.0 in the Sample Value Frame defined by the **index 0**. (the other Sample Values are replaced by static arrangement values into Dynamic Arrangement).

PBUS SV list index	Sampled value id (Merging Unit selected)
0	no merging unit selected (used to the specific use case "not connected")
1	Sample Value Frame #1
2	Sample Value Frame #2
...	Sample Value Frame #...
80 (d)	Sample Value Frame #80

The addition of a Sample Value to the **PBUS List** is detailed in section *5.4.4.7 Reference (Busbar) Voltage Selector* below.

The **PBUS List** outputs are:

- the **Sampled value id** (ENUM) of the Merging unit selected
- the BUSBAR voltage **Data entry index** (ENUM)

The **PBUS list index** is manually created in the SCE application, by assigning a unique index value (from 1 to 80, in steps of 1) to each Merging Unit’s sampled value available on the process bus network (PBUS).

5.4.4.6 SV ARRANGEMENT SELECTOR

An **SV Arrangement selector** is an automation, hosted either in the BCU or in an external compatible device.

The criteria used to select the SV Arrangement are managed by engineering within the automation.

At configuration level (SCE):

2 optional SPS datapoints are used to select the arrangement used by the BCU. They are added under the relevant electrical BAY, for 2 static SV types:

Datapoints	Description
MAIN.BACK.PROT (SPS)	selection by automation of the SampleValueGroup "protection & measurement" as active one
MAIN.BACK.MEAS (SPS)	selection by automation of the SampleValueGroup "measurement" as active one

The SPS datapoint must to have an IEC 61850 address.

At dynamic arrangement function level (BCU):

The SPS datapoint(s) authorize an automation called **Redundancy Controller** to switch between the MAIN or BACKUP static arrangements.

Normal operation

The SV Arrangement selector SPS provided by the automation is VALID.

- if the **SV Arrangement selector SPS** is received in RESET state:

  the "Static arrangement MAIN" is transmitted to Dynamic arrangement.

- if the **SV Arrangement selector SPS** is received in SET state:

  the "Static arrangement BACKUP" is transmitted to Dynamic arrangement.

Fallback mode

The **SV Arrangement selector SPS** provided by the automation is absent (automation not present) or INVALID.

"Static arrangement MAIN" is sent to the Dynamic arrangement.

SV Arrangement selector SPS status	SV Arrangement Selected
RESET	MAIN (default)
SET	BACKUP
INVALID	MAIN

A standard optional Bay SPC can be used to manually control the SampleValueGroup change at system HMI level (aView).

5.4.4.7 REFERENCE (BUSBAR) VOLTAGE SELECTOR

The **Reference Voltage Selector** is an optional automation, hosted on the BCU or on an external device. The criteria used to select the voltage reference are set according to the substation's topology per BAY.

The automation can select the BUSBAR voltage (VI#5) from the "PBUS list" by transmitting its SV "index" via an MPS datapoint.

Optional datapoints are present under the **Dynamic SV Sel.** object, depending on the SampleValueGroup type:

Datapoints	Description
SV.NODE.SEL.PROT (MPS)	selection of the Merging Unit providing the svID for "protection & measurement" SampleValueGroup
SV.NODE.SEL.MEAS (MPS)	selection of the Merging Unit providing the svID for "measurement" SampleValueGroup
REF.CH.SEL.PROT (MPS)	selection of the SV index into the Merging Unit for "Protection" SampleValueGroup
REF.CH.SEL.MEAS (MPS)	selection of the SV index into the Merging Unit for "Measurement" SampleValueGroup

Normal Operation

If the **SV.NODE.SEL.xxxx** provided by the **Reference Voltage Selector** is present and VALID:

- The Sample Value used as voltage BUSBAR (VI#5) into the Dynamic Arrangement is the Sample Value defined by the **SV.NODE.SEL.xxxx**

Regarding the phase selection

If the **REF.CH.SEL.xxxx** provided by the **Reference Voltage Selector** is present and VALID:

- The Sampled Value in the "Sampled Value Control Blocks" (SVCB) used as voltage BUSBAR phase reference into the Dynamic Arrangement is the SV defined by the **REF.CH.SEL.xxxx** MPS datapoint

Fallback Mode

If the **SV.NODE.SEL.xxxx** provided by the **Reference Voltage Selector** is absent or INVALID:

- The Sample Value used as voltage BUSBAR (VI#5) into the Dynamic Arrangement is the Sample Value defined in the static arrangement (MAIN or BACKUP) at configuration level (SCE).

If the **REF.CH.SEL.xxxx** provided by the **Reference Voltage Selector** is absent or INVALID:

- The Sampled Value index used as voltage BUSBAR phase reference into the Dynamic Arrangement is the Sample Value defined by the **reference phase** (A, B, or C) at configuration level (SCE).

5.4.4.8 FALLBACK MODES

5.4.4.8.1 Reference Voltage Selection invalidity

If the **Reference Voltage Selection** index "SV.NODE.SEL.xxxx" is INVALID, or an error of command interpretation at VxWorks level occurs:

- the datapoint GRP.xxx.ERR is SET
- the **index** and the **#SV** affected dynamically to the **Vbusbar** value into the Dynamic arrangement take the **index** and the **#SV** configured at static arrangement level
- the static arrangement taken as reference is the static arrangement selected by the **SV Arrangement** selector:
  - static arrangement "Main" if the SV Arrangement selector is absent, or RESET or INVALID
  - static arrangement "Backup" is SV Arrangement selector is SET, present and VALID

5.4.4.8.2 SV Arrangement invalidity

If the **SV Arrangement selector (SPS)** is absent or INVALID:

- the static arrangement "Main" is taken as reference by default

Note:
*If the **SV Arrangement selector (SPS)** is managed by an automation, it's necessary to configure the **#SV** and the **indexes** in the static arrangement "Main" and the "Backup" of each CI# and VI# used at configuration level (SCE).*

5.4.4.8.3 SV Arrangement after an internal error

If a change occurs outside the **ArrangementShiftTimer** time, or an error is detected after an arrangement' change request (VxWorks to FPGA):

- the datapoint GRP.xxx.FAIL SPS is SET
- the dynamic arrangement behaviour is the same to Reference Voltage Selection invalidity (refer to *5.4.4.8.1 Reference Voltage Selection invalidity*)

5.4.4.9 SIMULATION MODE

5.4.4.9.1 Sampled Value selector

For each sample value frame, on each logical device (BAY) managed by the BCU:

If the Logical Device **LPHD** remains set to **normal** mode (default mode):

- the **SV selector** selects only the Sample Values containing an **SVCB** in **normal** mode (transmitted by the Merging Units present in PBUS)
- the **SV selector** ignores the Sample Values containing an **SVCB** in **simulation** mode

If the Logical Device **LPHD** switches to **simulation** mode (by an operator action on HMI):

- if the Sample Values frames transmitted by the SV generator are NOT received by the **SV selector** block:
  - the **SV selector** selects only the Sample Values containing an **SVCB** in **normal** mode
  - the **SV selector** ignores the Sample Values containing an **SVCB** in **simulation** mode
- When the first Sample Values frame transmitted by the SV generator is received by the **SV selector** block:
  - the **SV selector** selects only the Sample Values containing an **SVCB** in **simulation** mode
  - the **SV selector** ignores the Sample Values containing an **SVCB** in **normal** mode

If the Logical Device **LPHD** switches to **normal** mode (by an operator action on HMI):

- the behaviour of the **SV selector** becomes **normal** mode (Sample Values frames transmitted by the Merging Units present in PBUS)

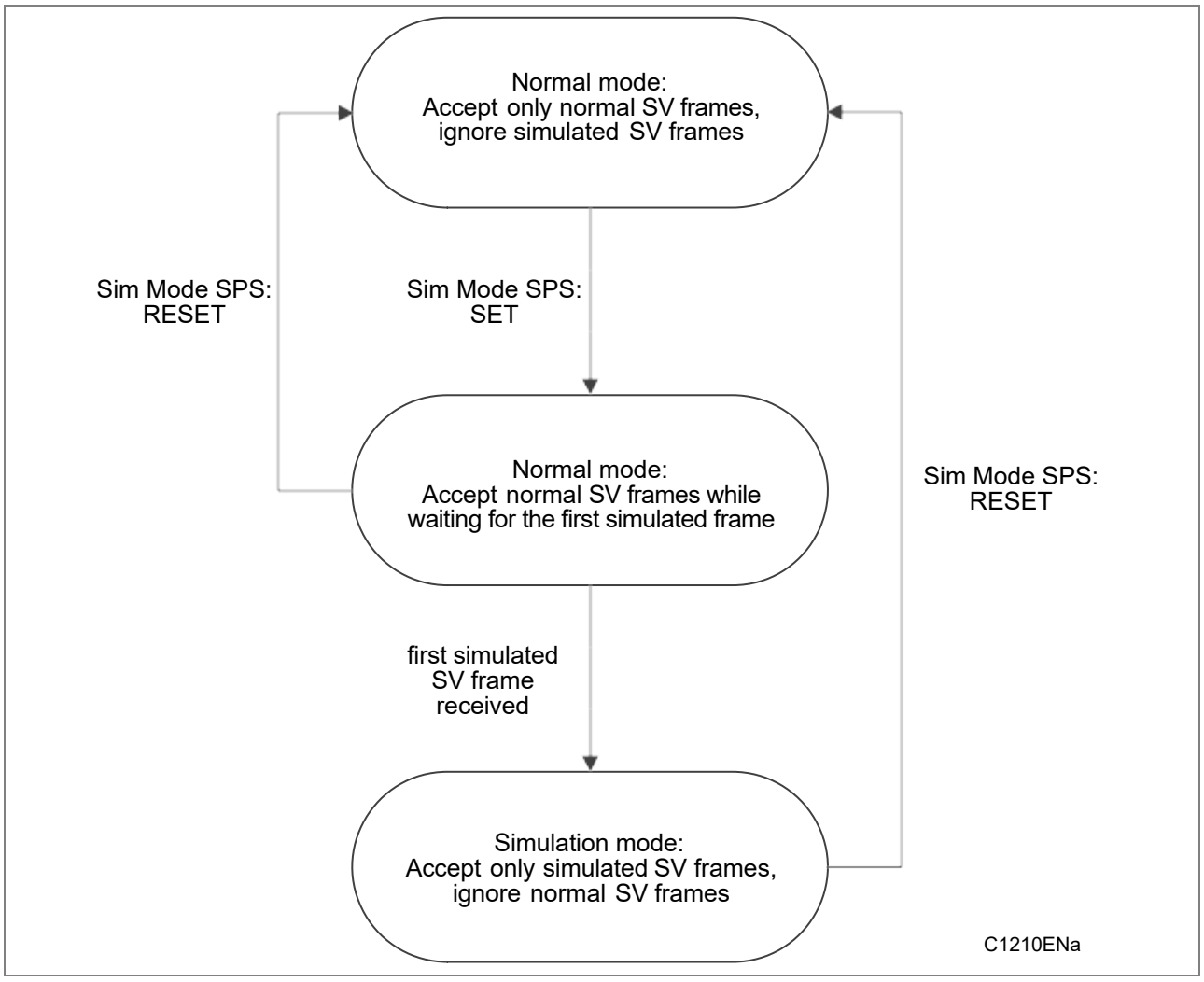


Figure 13: Simulation mode switch

5.4.4.10 SAMPLED VALUES SUPERVISION

DS Agile system makes it possible to monitor Sampled Value (SV) reception.

Supervising SV allows a subscriber IED to get the real-time status of SV reception. Each SV subscribed by one IED can be monitored through specific datapoints.

The SV supervision process is as follows.

5.4.4.10.1 Out of sequence detection

If a subscriber IED has already received a valid/accepted SV message (SmpCnt = a), any SV message with a lower state number or with the following characteristics will trigger an alarm:

- SmpCnt <> a + 1 (considering rollover at SmpCmt: 4000 for network frequency at 50Hz or 4800 for network frequency at 60Hz)
- SmpCnt < a

5.4.4.10.2 Duplicated SV detection

The duplicated SV management principles are the same as duplicated GOOSE. Refer to section **Duplicated GOOSE detection process** for details.

Duplicated Sampled Values are managed based on the source MAC address contained in the SV frame. The MAC address is stored and reset after 300 seconds. If a subscriber IED receives SV with two different MAC addresses, an alarm is raised.

5.4.4.10.2.1 During active subscription

When a subscription to a SvCB is active, the MAC Address of this SvCB is saved. Only SvCB with this same MAC Address is accepted.

When the connection with the publisher is lost, the recorded MAC address is reset. In the case of simulated SV, the source MAC address is not checked.

5.4.4.10.2.2 During start of subscription

When a new SV subscription occurs (for instance when the IED is started or when subscription is disabled/enabled or after the loss of the publisher), a validation period (fixed to 4 SV) is observed to ensure that no duplicated SV is received.

5.4.4.10.2.3 Duplicated SV detection alarm

If a duplicated SV is detected (another MAC address has been stored), the SV is ignored. The SV communication state remains active and an alarm is raised for this SvCB.

5.4.4.10.3 Loss of publisher

Loss of publisher is considered when no SV is received during a 100ms period.

When this period expires, the computed measurements from the SvCB are updated with the quality invalid and failure. In addition, an alarm state is raised, and the subscription state is reset.

5.4.4.10.4 SV supervision states

For each subscribed SvCB, several datapoints can be implemented at configuration level to supervise Sampled values.

- **subscription state** (SPS): supervises the state of each SvCB connection. When SvCB connection is lost, all supervision statuses (subscription and simulation) are reset to 0 with invalid states
- **simulation state** (SPS): monitors if simulated SvCB is accepted and processed. When simulated SvCB is accepted, connection state with the SvCB is considered as active
- **alarm state** (SPS): informs if error(s) occurred during Sample Value subscription. When an issue is detected, an alarm is raised for SvCB. Depending on criticality, SV is ignored or accepted and the SvCB connection state is changed or not.
- **synchronisation state** (MPS): indicates the synchronisation status of the SvCB. When the SV synchronisation state changes, the SvCB connection state remains unchanged but synchronisation state is updated.
- **supervision error** (MPS): indicates the detected error during SV supervision:
  - 0: None (No alarm);
  - 1: Unknown (SV Subscription not active, but error type could not be identified);
  - 2: Not received (SvCB is not received);
  - 3: SmpCnt Alm (The SmpCnt number is out of order);
  - 4: Duplicated SvCB (Duplicated SvCB has been detected).

Only subscription state is mandatory if SV supervision function is required.

For configuration details, refer to section **Sampled values supervision** available in the **Application** chapter of the **DS Agile C26x** user manual.

6 DIRECT PROCESS ACCESS

Several kinds of boards can be used in C26x and extension racks. Digital Input & Outputs, Measurement acquisitions are checked to validate information/action and time tagged on any change of state or value.

The C26x acquires digital and analogue input, counters, digital measurements. Configuration parameters, filtering and triggering are applied to these inputs and depend on their type.

6.1 INPUT CHECK

Input data coming from the physical DS Agile C26x boards or from the different communication networks are periodically checked.

Invalidity status of these data is internally fixed for:

- Self-test (DI, AI, board self-test failure)
- Unknown (DI, AI, communication failure to remote acquisition like IED)
- Toggling (DI, X change of state in given time)
- Over-range (AI, saturation of its transducer, or Counter value reaching limits)
- Open circuit (AI type 4-20 mA with current value under 4mA)
- Undefined (Digital Measurement or Counter with invalid DI coding)

6.2 OUTPUT CHECK

Digital Output boards are periodically checked at their logical level. In the event of a logical circuit test fail the board is set faulty, controls on this board or upon disconnected IEDs are refused.

6.3 TIME TAGGING

All physical input data are time tagged at 1 ms accuracy. All internal logic data are time stamped at 1 ms accuracy.

Analogues acquisition time tagging is done but driven by periodic polling of this kind of board. Periods are based on multiple of 100ms.

Information coming from IED are time tagged by IED itself if it has this facility otherwise it is performed at C26x level when receiving the data.

6.4 DIGITAL INPUT ACQUISITION (DI)

6.4.1 ACQUISITION

The DIU200/DIU210/DIU211 (16 DIs) or CCU200, CCU211 (8 DIs + 4 DOs) boards acquire the binary data.

Digital Input (DI) can have the value 1 or 0. The value 1 shows the presence of an external voltage. The value 0 shows the absence of the external voltage.

When the external voltage is above or below a threshold, the hardware writes the value 1 or 0. The hardware specification document shows the value of the threshold.

A transition from the value 0 to 1 or from 1 to 0 is usually followed by a succession of transitions (bounces) before the value stabilises. The software must filter these bounces.

Each change-of-state of a digital input is time-stamped with a resolution better than 1 ms.

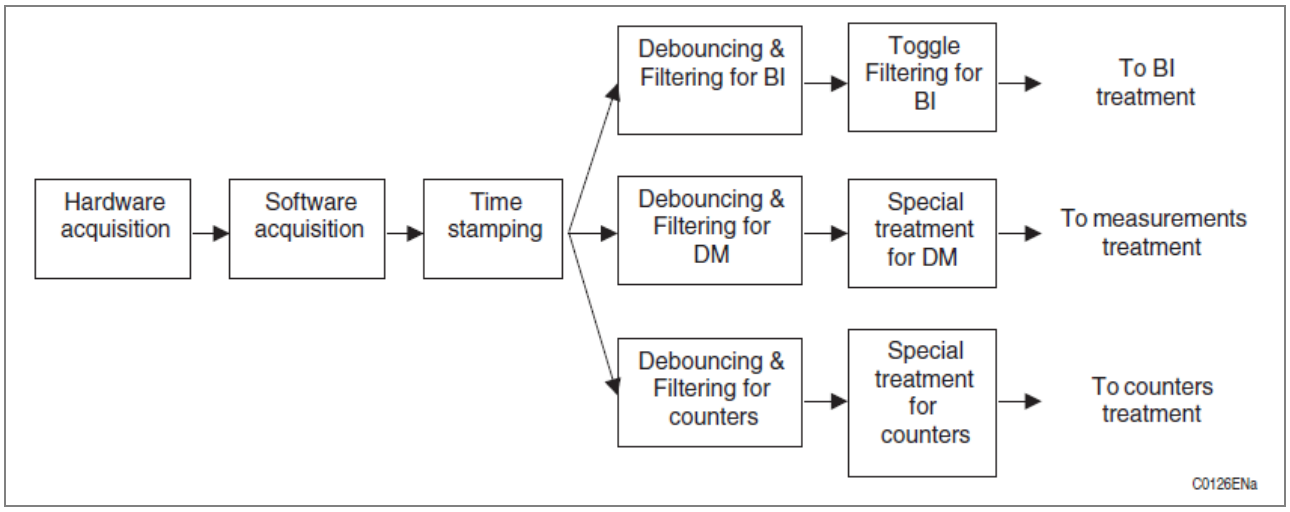


Figure 14: Digital input processing

6.4.2 DEBOUNCING AND FILTERING

A filter is applied on the digital inputs as follows:

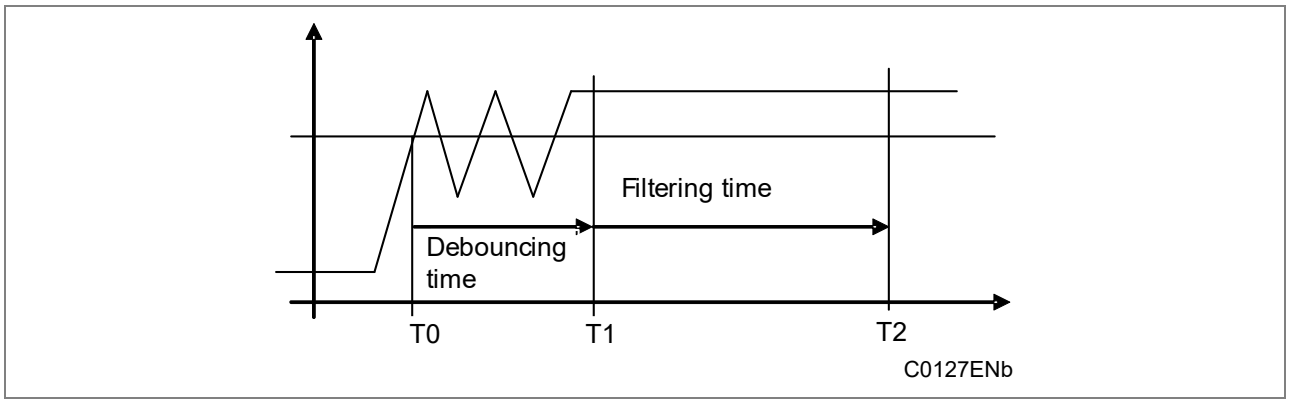


Figure 15: Digital input filtering and debouncing

T0 is the instant of detection of the first transition.

T1 is the instant of validation of the change of state.

T2 is the end of the filtering: the signal remained stable from T1 to T2). The change of state is time stamped at T0.

A value of 0 means that no filter is applied: a change of state is validated as soon as it is detected.

Three pairs (debouncing / filtering) of delays are defined:

- one for all DI that will be used as BI
- one for all DI that will be used as DM
- one for all DI that will be used as counters

6.4.3 TOGGLING

A digital input is said to be toggling if its state has changed more than N times in a given time-period T_1.

A toggling DI returns in the normal state if its state has not changed within another time-period T_2.

N, T_1 and T_2 are parameters determined at configuration time on a per system basis (same parameters for all the DS Agile controllers of a system).

The toggle filtering applies only on DI that will be used as BI (there is no toggle filtering on DI that will be used for counters or DM).

6.5 COUNTERS ACQUISITION (CT)

The counters are acquired on the same boards as the DIs. There are two types of counters SCT (Single counter) and DCT (Double counters).

6.5.1 SINGLE COUNTER (SCT)

An SCT is acquired on a single contact. The value of the accumulator is incremented after a low to high transition, confirmed after a filtering time (T_{count}). T_{count} is defined for the whole system, with a step of 5 ms: the chosen value must be coherent with the pulse frequency (that is, all counters of a system use the same T_{count}).

A subsequent pulse can be taken into account only after a high to low transition.

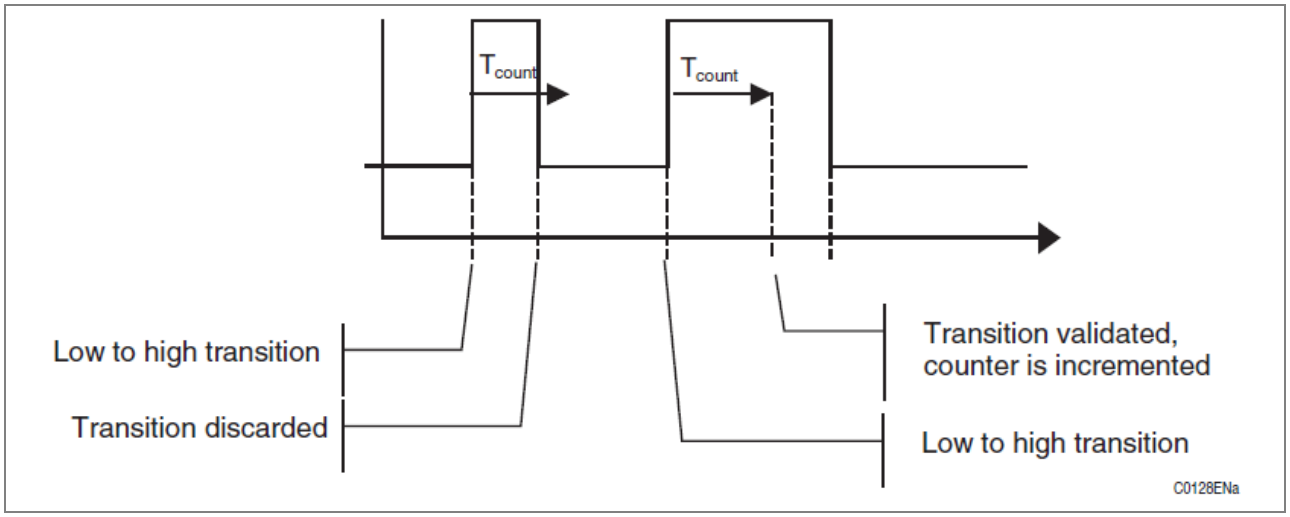


Figure 16: Single counter timing diagram

6.5.2 DOUBLE COUNTER (DCT)

A double counter is acquired on two contacts. One is called the true contact (TC), the other is the complemented contact (CC). Normally these contacts have complementary states.

Pulses are detected in the same manner as for SCT, on the TC variations, using the T_{c0unt} delay (the same T_{c0unt} value is used for SCT and DCT).

A subsequent pulse can be considered only after a high to low transition on TC (and so a low to high transition on CC).

The difference is that both contacts must be in opposite states for transitions to be detected and validated. The counter is invalid if there exists a non-complementarity between the 2 contacts during a delay T_{def}. This delay is defined for the whole system (that is, all DCT use the same delay).

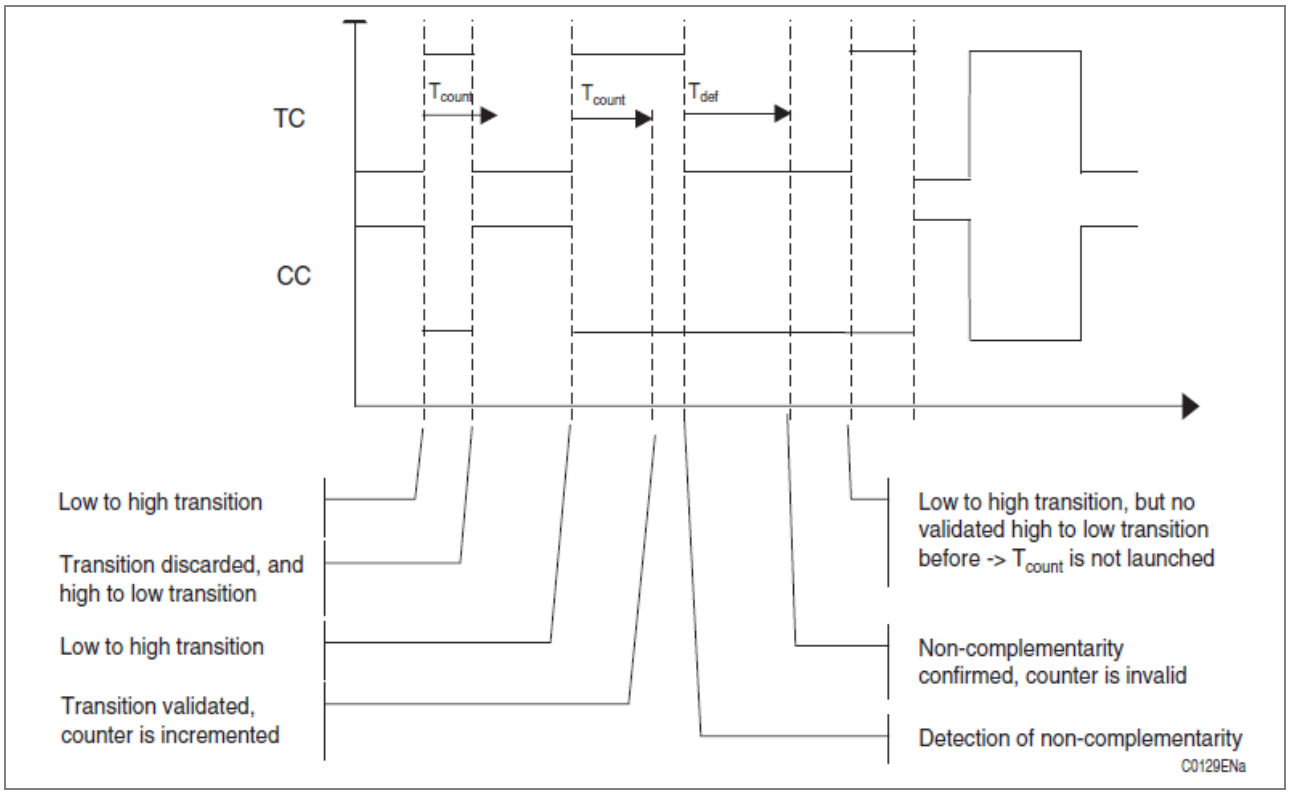


Figure 17: Double counter timing diagram

6.6 DIGITAL MEASUREMENT (DM)

The digital measurements (DM) are derived from the Digital Inputs. They are acquired on the same boards as the DIs. This interface, allowing acquisitions of a digital measurement, is a digital value coded on N wired inputs. Each wired input represents a bit of the value and can take only one of two values: low or high.

Digital Measurements are used to process the **measurements and tap position indications**. A Digital Measurement can be associated to a Read Inhibit (RI) signal. The acquisition process is different depending of the presence of this signal.

6.6.1 ACQUISITION WITHOUT READ INHIBIT SIGNAL

The DM is calculated at each change of state of one of its bits.

A stability processing is applied at each calculation to confirm the value:

- if the difference between the current value and the previous confirmed value is less or equal than V_{stab} (value defined in configuration), then the current value is confirmed

- if the difference is greater than V_{stab}, then the T_{stab} delay is launched (value defined in configuration, from 0 to 60s, with a 10 ms step). If a T_{stab} delay is already launched, this one is cancelled. At the end of the delay, the DM value is confirmed.

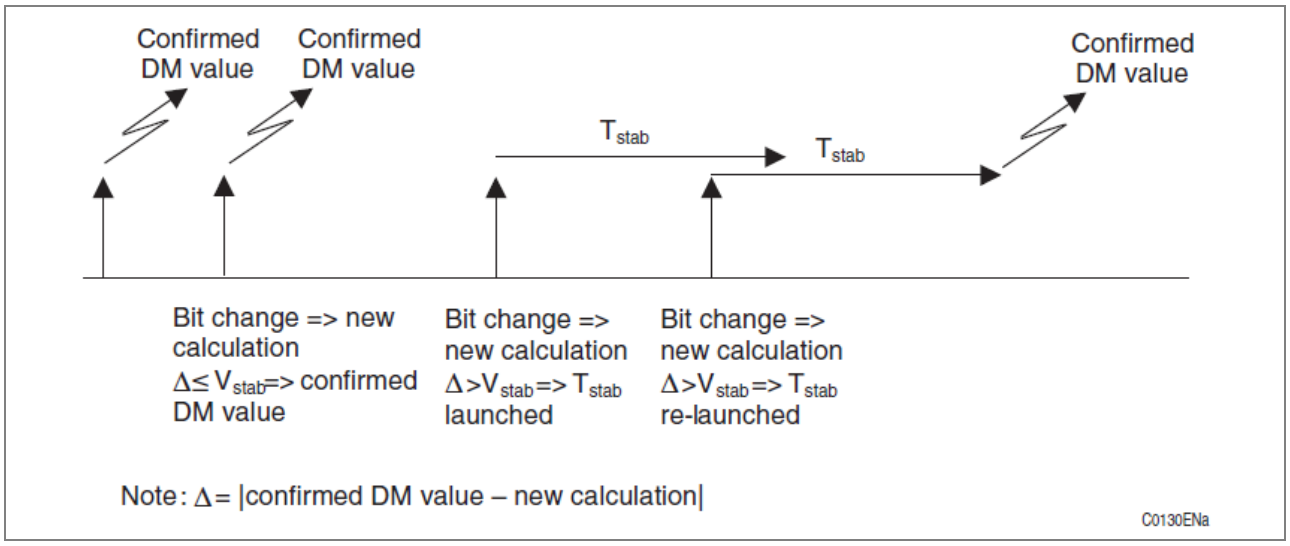


Figure 18: DM value confirmed

Furthermore, an invalidity processing is applied: at the first change of state of one bit following a confirmed DM value, the TI_{nv} delay is launched (value defined in configuration, from 0 to 300s, with a 10 ms step). If the value is not confirmed at the end of this delay, the DM is declared UNDEFINED.

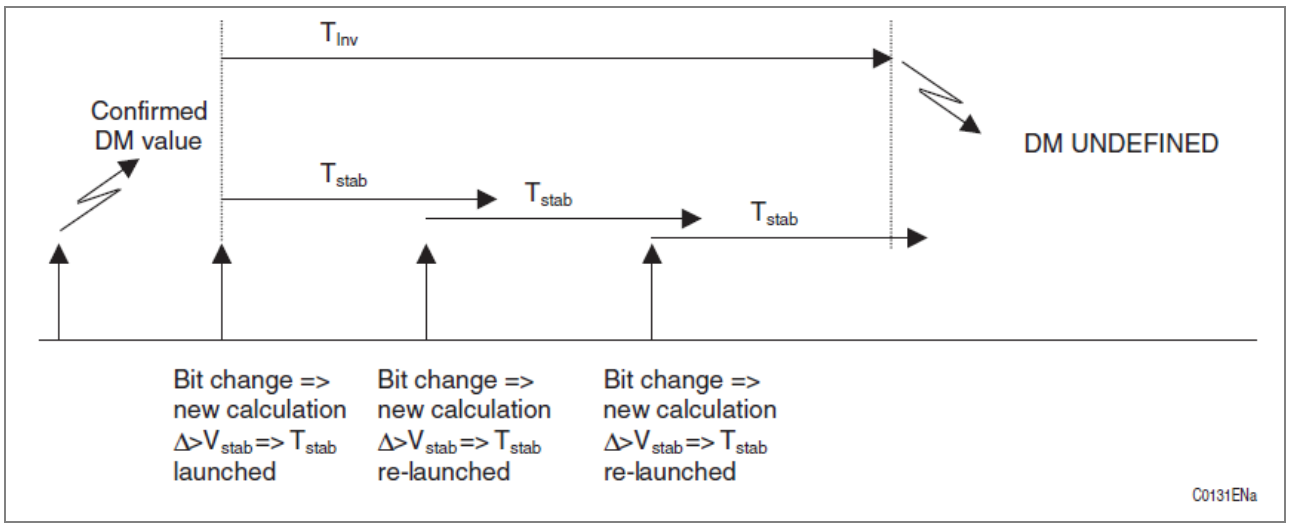


Figure 19: DM undefined

If V_{stab} is equal to 0, there is no stability processing: all DM values are sent at each calculation.

6.6.2 ACQUISITION WITH READ INHIBIT SIGNAL

When the RI signal changes to set state, the T_{inh} delay is launched. If the signal is always set at the end of the delay, the DM is declared UNDEFINED. Otherwise, if the RI signal changes to reset state before the end of the delay, the current DM value is transmitted.

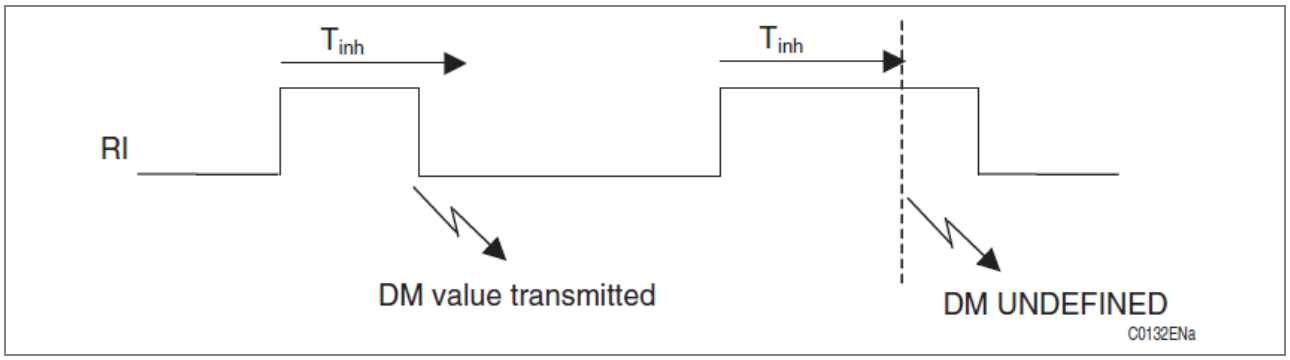


Figure 20: Acquisition with RI

If the RI signal is invalid, the DM will be invalid.

6.6.3 ENCODING

The following codes are allowed for DM:

Code	Number of bits (max. 64)	Range of value
BCD	4 (1 BCD decade)	0 to 9
	8 (2 BCD decades)	0 to 99
	12 (3 BCD decades)	0 to 999
	16 (4 BCD decades)	0 to 9 999
	32 (8 BCD decades)	0 to 99 999 999
	64 (16 BCD decades)	0 to 9 999 999 999 999 999
Binary	n	0 to 2n-1
Gray	n	0 to 2n-1
Decimal	16 (1 bit among 6 for the tens, 1 bit among 10 for the units)	0 to 69
	32 (1 bit among 4 for the thousands, 1 bit among 9 for the hundreds, 1 bit among 9 for the tens, 1 bit among 10 for the units)	0 to 4 999
	64 (1 bit among 9 for the millions, 1 bit among 9 for the hundreds of thousands, 1 bit among 9 for the tens of thousands, 1 bit among 9 for the thousands, 1 bit among 9 for the hundreds, 1 bit among 9 for the tens, 1 bit among 10 for the units)	0 to 9 999 999
1 among N	n	0 to n

You can use one extra bit for the sign (0 = positive value, 1 = negative value).

Capability extension for the Tap Position Indication only:

CODE	Number of bits	Range of value
1 among N	2 to 64	0 to 2 to 0 to 64

6.7 ANALOGUE INPUT ACQUISITION (AI)

The TMU2xx board acquires AC voltages and currents coming from the electrical network.

The AIU201 (4 AIs) or AIU211 (8 AIs) boards acquire DC voltages or currents signals. For them an input range and an acquisition cycle are configured (refer to C26x/EN AP).

6.7.1 INPUT RANGES

For voltage inputs (AIU201 only):

- [–1.25 V ... +1.25 V]
- [–2.5 V ... +2.5 V]
- [–5 V ... +5 V]
- [–10 V ... +10 V]

For current inputs:

- [–1 mA ... +1 mA]
- [–5 mA ... +5 mA]
- [–10 mA ... +10 mA]
- [–20 mA ... +20 mA]

(see C26x/EN AP for settable sensor ranges)

The saturation value depends on the selected range (see C26x/EN TD).

6.7.2 ACQUISITION CYCLE

The analogue inputs are acquired on a periodical basis. Each channel on a board can be assigned one of these cycles independently of the other channels.

There exist two acquisition cycles:

- a short cycle (N_{sc} x 100 ms, N_{sc} settable from 1 to 10, default value: 1)
- a long cycle (N_{lc} x 500 ms, N_{lc} settable from 1 to 20, default value: 2)

6.7.3 SELF-CHECKS

Two kinds of self-checks are performed:

- the board address coherency
- the complementarity control of the measured value

These self-checks are performed at each scan (defined during the configuration phase).

6.7.4 TIME TAGGING

An AI is time stamped with the date/time of the scanned value.

6.8 DIGITAL OUTPUTS (DO)

Digital outputs are used to apply a switching voltage to an external device in order to execute single or dual, transient or permanent commands. The applied voltage is fed from an external power supply. The external voltage is connected to the controlled device by a relay, thus isolating the logic part of the board from the external power supply.

Two types of Digital Outputs are available for the C26x:

- CCU200 boards for controls (8 DIs+4 normal open DOs), this board allows double pole switching controls.
- DOU200 boards for alarms (8 normal open DOs + 2 normal open/normal close DOs).

6.9 DIGITAL SETPOINTS

Digital setpoints are digital values sent on multiple parallel wired outputs. Each wired output represents a bit of the value. Digital setpoints are used to send instruction values to the process or to auxiliary devices.

The Digital Setpoints are processed on the same boards as the Digital Outputs. The Digital Outputs characteristics described above apply on Digital Setpoints. Use only standard DO boards with single pole N/O relays.

6.9.1 ENCODING

The codes that follow are allowed:

CODE	Number of bits (max. 48)	Range of values
BCD	4 (1 BCD decade)	0 to 9
	8 (2 BCD decades)	0 to 99
	12 (3 BCD decades)	0 to 999
	16 (4 BCD decades)	0 to 9 999
	32 (8 BCD decades)	0 to 99 999 999
	48 (12 BCD decades)	0 to 999 999 999 999
Binary	n	0 to 2n-1
Gray	n	0 to 2n-1
Decimal	16 (1 bit among 6 for the tens, 1 bit among 10 for the units)	0 to 69
	32 (1 bit among 4 for the thousands, 1 bit among 9 for the hundreds, 1 bit among 9 for the tens, 1 bit among 10 for the units)	0 to 4 999
	48 (1 bit among 2 for the hundreds of thousands, 1 bit among 9 for the tens of thousands, 1 bit among 9 for the thousands, 1 bit among 9 for the hundreds, 1 bit among 9 for the tens, 1 bit among 10 for the units)	0 to 299 999
1 among N	n	0 to n

A supplementary bit is for the sign (0 indicates a positive value, 1 indicates a negative value).

6.9.2 READ INHIBIT

A dedicated binary output allows/forbids reading the value by the external device.

There is one (or none) read inhibit (RI) output per value.

If the RI output is a logical one (external polarity applied), the reading is permitted.

The procedure used to output a value with a RI output is:

- Reset the RI output to a logical 0: read forbidden.
- Wait for N ms.
- Output the value.
- Wait for N ms.
- Set the RI output to a logical 1: read permitted.

The 0 to 1 transition on the RI output can be used by the external device as a trigger, indicating that a new value is available.

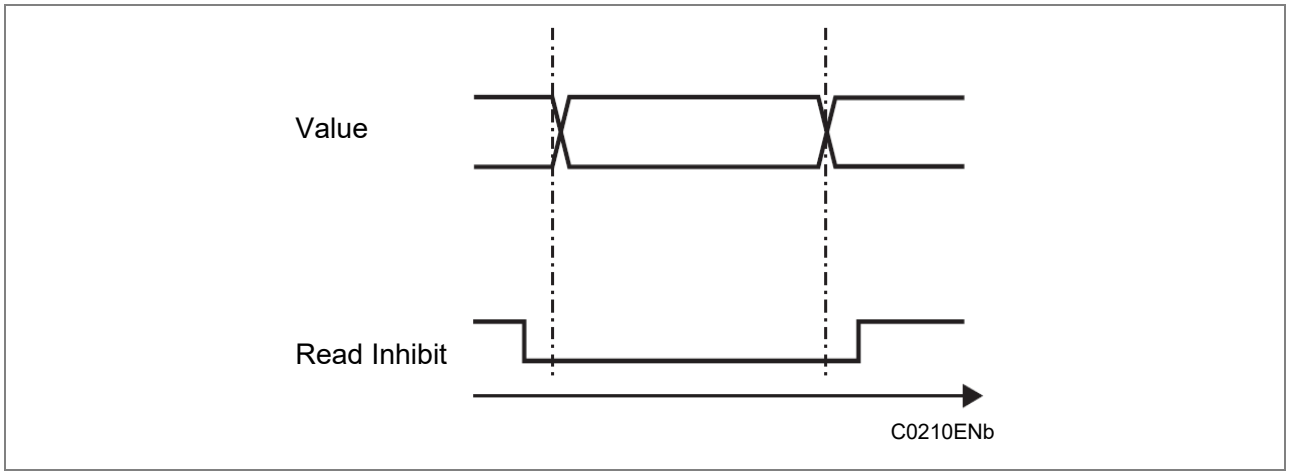


Figure 21: Read inhibit signal for a digital setpoint

6.9.3 OPEN / CLOSE SELECT ORDER

An option includes the order-running-SPS: one for the open order control, and one for the close order control.

The order-running-SPS are available only for Double Point Control (DPC).

When the C26x receives the Select (for SBO control) or the Execute (for DE control) order, and before the checks, it sets the order-running-SPS to the SET position.

When the C26x receives the control acknowledgement, the C26x sets the order-running-SPS to the RESET position

In the event of a direct negative acknowledgement, the C26x may set the order-running-SPS to the SET position and to the RESET position with the same time-stamp.

6.10 ANALOG SETPOINTS

Analog setpoints are measurement values sent on the Analog Output board.

These setpoint commands (with analog indication) are received from the Station Control Point (SCP), Remote Control Point (RCP), or from the local HMI (with LCD).

Analog Setpoints are used to interface auxiliary devices requiring analog inputs (ex: measurement viewers, Generator)

The Analog Output values are secured with an external power supply that allows you to keep the analog output value in the event of a C26x shutdown or power off.

A quality indication is available with the additional Read Inhibit output relays (NO) associated to each analog output.

6.10.1 OUTPUT RANGES

± 5 mA, 0 - 5 mA

± 10 mA, 0 - 10 mA

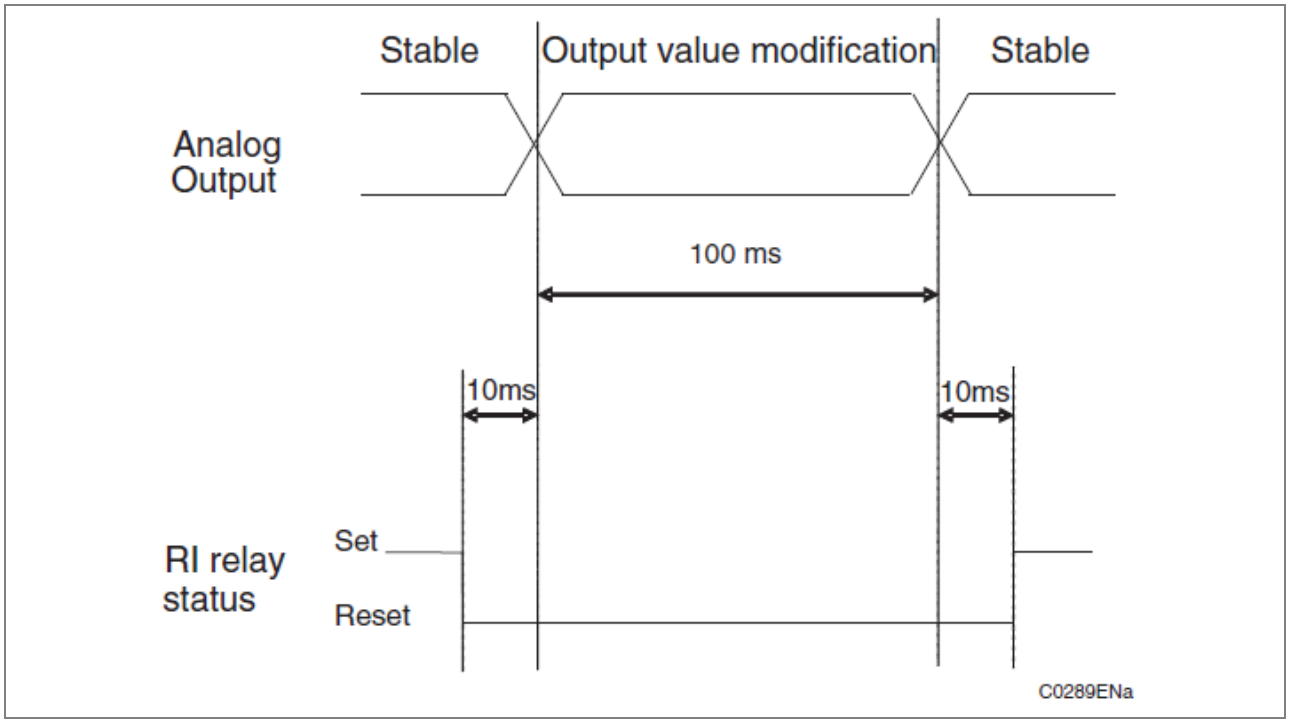
4 - 20 mA, 0 - 20 mA, ± 20 mA

6.10.2 OUTPUT MANAGEMENT

Each current output is individually managed in 2 modes:

- Maintained mode: in the event of a control unit shut down or power off, the output level is maintained (and the Read inhibit relay is set). Only the reception of a new setpoint leads to an output value modification.
- Un-maintained Mode: in the event of a C26x shutdown or power off, the output is set to 0

The AO is stable 100ms after the order. During Analog output value modification, the “Read Inhibit” relay is reset (Open) and indicates that the analog output value is not to be used.



6.10.3 AOU WATCHDOG MANAGEMENT

The AOU board is monitored and the AOU Watchdog (NO relay) resets when:

- The external power supply is off
- The C26x is not operational or powered off (no communication with the CPU board)
- An AOU internal fault is present

Otherwise, the analog output function is valid, the AOU watchdog relay is set.

7 DATA PROCESSING

C26x treatment entries can be Binary Inputs or Analogue Inputs. They are issued from

- IO boards
- C26x internal data: System Input, automation
- Communication acquisition: IED or another controller from LBUS or SBUS

7.1 BINARY INPUT PROCESSING

7.1.1 BINARY INPUT DEFINITION

The five types of Binary Inputs (BI) include:

- Single Point (SP): derived from one BI
- Double Point (DP): derived from two BIs
- Multiple Point (MP): derived from multiple BIs
- System Input (SI): information related to the system, to configurable and built-in automations or to electrical process but without acquisition possibilities
- Group: logical combination of BIs

SP, DP and MP are acquired with digital input boards or with IEDs connected with a serial link.

After the acquisition on the digital input boards, the controller performs toggle filtering. When an input has a hazardous behaviour, such as more than N state changes during a given duration, toggle filtering prevents the input to load into the controller or into other devices.

7.1.1.1 TOGGLING INPUT

A binary input is said to be toggling if its state has changed more than N times within a given time-period T.

After the acquisition on digital inputs boards, the controller performs toggle filtering, this avoids loading the controller itself or other equipment when an input has a hazardous behaviour

An SP associated with a toggling Binary Input is in the TOGGLING state.

A DP or an MP whose one of the associated DI is toggling ist in the TOGGLING state.

7.1.1.2 SUPPRESSION

A binary input can be suppressed by an order issued from an operator. No subsequent change of state on a suppressed BI can trigger any action: for example, display, alarm, transmission. The BI takes the “SUPPRESSED” state. When the operator un-suppresses the BI, this one takes its actual state.

7.1.1.3 SUBSTITUTION

A BI can be substituted to a manual set state by an operator (state “SUBSTITUTED xxx”). The BI stays in the state determined by the operator until s/he un-substitutes it. When a BI is substituted, no changes of state are transmitted, and computations, for instance groupings, are made with the substituted state. When the BI is un-substituted, the actual state is transmitted to higher control levels and subsequent changes of state are transmitted again.

7.1.1.4 FORCING

When data is invalid: that is, SELFCHECK FAULTY, TOGGLING, UNDEFINED or UNKNOWN; it can be manually forced by an operator (state “FORCED xxx”). This feature is similar to the substitution but the data is automatically updated when valid data is available again. A SUPPRESSED or SUBSTITUTED datapoint

cannot be forced. The forcing could also be automatic: in this event, the invalid data is automatically replaced by the state defined in configuration.

7.1.1.5 TRANSMISSION

By configuration, a BI could be transmitted on a client-server basis on the station bus using the two modes:

- Report based mode: in this mode, a confirmed change of status is spontaneously transmitted to the subscribers with the time stamping and the reason for change. The Report mode is used to transmit filtered data for displaying, printing and archiving.
- GOOSE based mode: in this mode, the change of status is transmitted in multicast to the configured receivers. On an IEC 61850-8-1 network, all types of BI can be transmitted using GOOSE. Only the BI unfiltered states are transmitted with their time stamping, the reason for change is not. The GOOSE mode is used to transmit data as soon as possible after their acquisition and as quickly as possible, for automation purpose.

7.1.2 PROCESSING OF SINGLE POINT STATUS

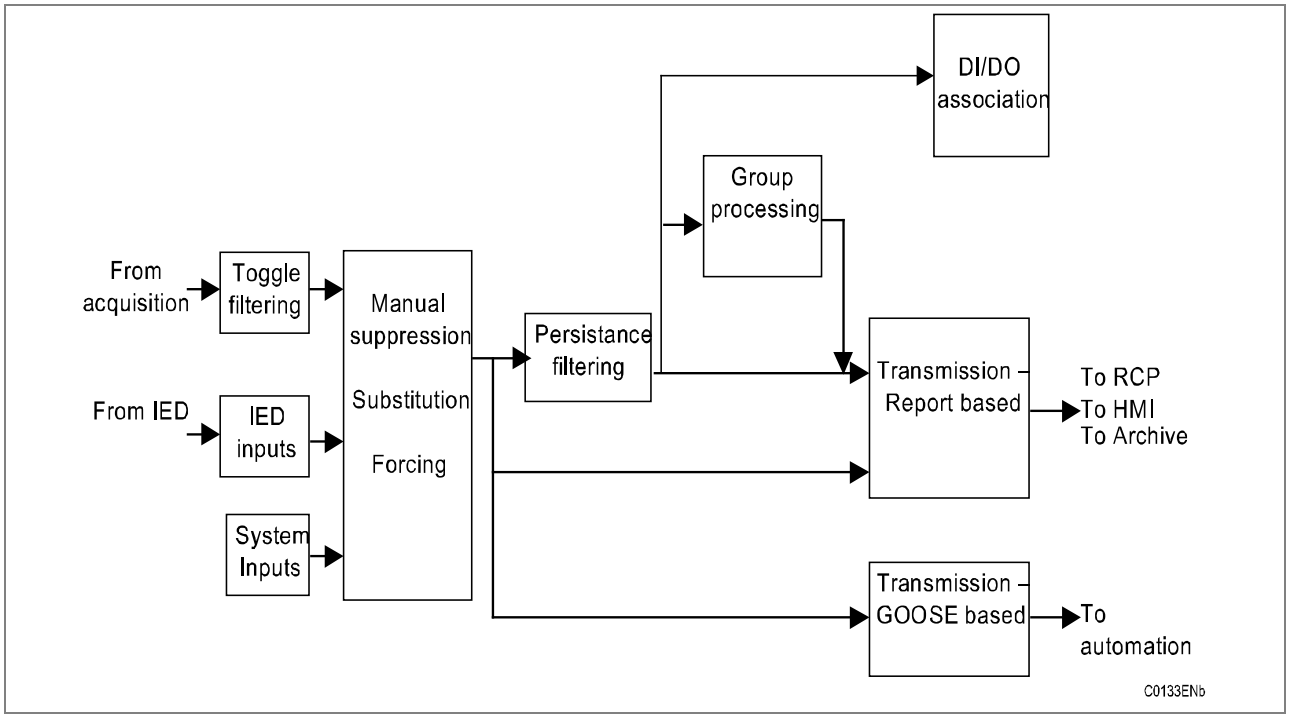


Figure 22: single point status processing

A preliminary treatment (filtering) is applied to specific Single Points (SP) to confirm the state.

The choice of these SPs and the filtering time are fixed by the C26x configuration. If the opposite transition occurs before this delay, both transitions are discarded.

This treatment is called persistent filtering.

- The status is stamped with the time of the transition.

For automation (interlock, PSL, PLC, and built in functions), GOOSE is used. Each valid state (01, 10 and 00) can be set to be seen by the automation as a False, True or Invalid state.

7.1.2.1 PERSISTENCE FILTERING

For some SP, a transition must be confirmed on a given time-period. If the opposite transition occurs before this time, both transitions are discarded.

Two time-out values can be associated with each SP:

- T_S: delay for the SET state confirmation
- T_R: delay for the RESET state confirmation

Both delays are in the range 0 to 300 s in steps of 100 ms. A value of 0 means that no filter is applied.

The time tag is user-selectable:

- Mode 1: the status is stamped with the time of the transition.
- Mode 2: the status is stamped at the end of the persistent filtering.

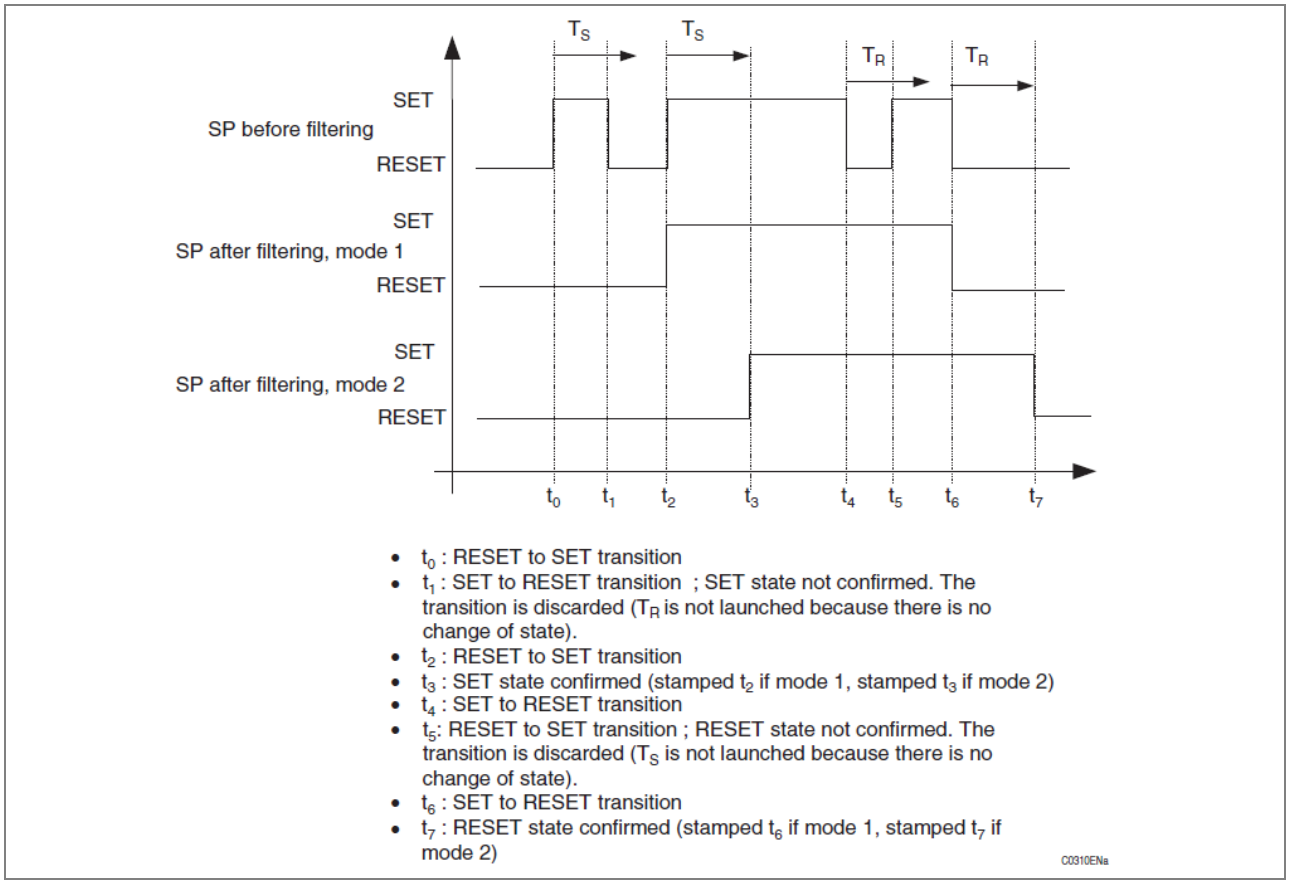


Figure 23: persistence filtering

7.1.2.2 DI/DO ASSOCIATION FOR SP

The aim of this automation is to create a direct association between a Single Point and a Digital Output: a state change on the input produces the opening of the closure of the output.

The relation between the state and the order is defined during the configuration phase.

7.1.3 PROCESSING OF DOUBLE POINT STATUS

A DP is derived from two Digital Inputs. One is called the Closed contact, the other one is the Open contact.

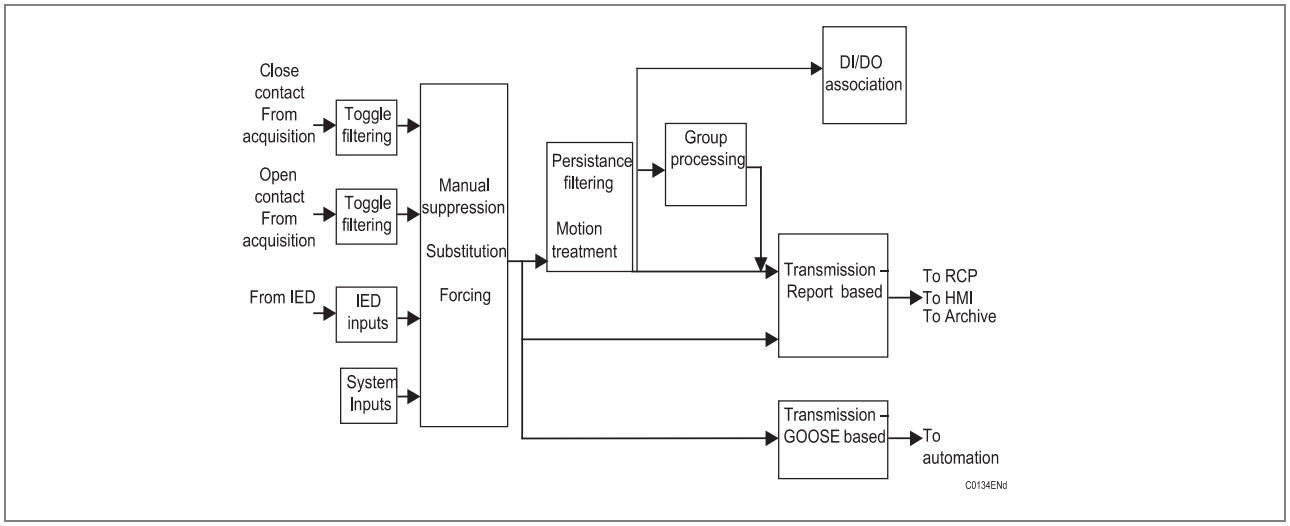


Figure 24: Double point status processing

DPS are commonly used for all switchgears position. From board valid acquisition the two contacts are Close and Open (set by configuration when voltage is present). The position of the switch is:

Closed Contact	Open Contact	DPS State
0	0	Below motion delay, the state is valid MOTION00. After motion treatment, state is valid JAMMED
0	1	OPEN
1	0	CLOSE
1	1	UNDEFINED transmitted with an invalid quality bits in IEC61850

Preliminary treatment for some DPs is applied to limit the MOTION state on a given time-period.

This treatment is called motion treatment.

The time tag is user-selectable:

- Mode 1: the valid state (OPEN or CLOSE) is stamped with the time of the beginning of the MOTION state
- Mode 2: the valid state (OPEN or CLOSE) is stamped with the time of this valid transition

This time stamping can be superseded if a persistence filtering applies.

If the MOTION state is confirmed, it is always stamped with the time of the beginning of the MOTION state. Furthermore, the BI takes the state JAMMED (in the event of a confirmed MOTION00 state) or UNDEFINED (in the event of a confirmed MOTION11 state). In this event, the following valid state (OPEN or CLOSE) is always time-stamped with the time of this valid transition (depending on the persistence filtering feature).

7.1.3.1 MOTION TREATMENT

Two time-out values can be associated with each DP:

- T_{00}: delay for the MOTION00 state
- T_{11}: delay for the MOTION11 state

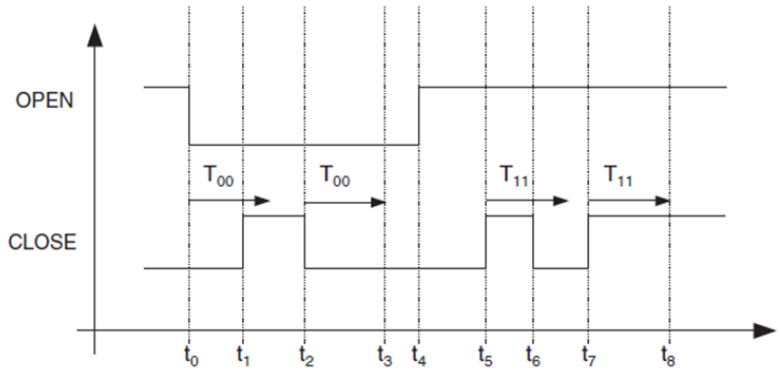
Both delays are in the range 0 to 300 s in steps of 100 ms. A value of 0 means that no filter is applied. In that case, only the state JAMMED is transmitted.

The time tag is user-selectable:

- Mode 1: the valid state (OPEN or CLOSE) is stamped with the time of the beginning of the MOTION state
- Mode 2: the valid state (OPEN or CLOSE) is stamped with the time of this valid transition

This time stamping can be superseded if a persistence filtering applies.

If the MOTION state is confirmed, it is always stamped with the time of the beginning of the MOTION state. Furthermore, the BI takes the state JAMMED (in the event of a confirmed MOTION00 state) or UNDEFINED (in the event of a confirmed MOTION11 state). In this event, the following valid state (OPEN or CLOSE) is always time-stamped with the time of this valid transition (depending on the persistence filtering feature).



- t_0 : MOTION00 transition
- t_1 : MOTION00 state not confirmed, CLOSE state time-stamped t_0 if mode 1, t_1 if mode 2 (if no persistence filtering applies)
- t_2 : MOTION00 transition
- t_3 : MOTION00 state confirmed, state JAMMED time-stamped t_2
- t_4 : OPEN transition, time-stamped t_4 whatever was the mode (if no persistence filtering applies)
- t_5 : MOTION11 transition
- t_6 : MOTION11 state confirmed, state UNDEFINED time-stamped t_5

C0311ENb

Figure 25: Motion treatment

7.1.3.2 DP PERSISTENCE FILTERING

For some DP, a valid state (OPEN or CLOSE) must be confirmed on a given time-period. If a transition occurs before this delay, the state is discarded.

Two time-out values can be associated with each DP:

- T_C: delay for the CLOSE state confirmation
- T_0: delay for the OPEN state confirmation

Both delays are in the range 0 to 300 s in steps of 100 ms. A value of 0 means that no filter is applied.

The time tag is user-selectable:

- Mode 1: the status is stamped with the time of the transition
- Mode 2: the status is stamped at the end of the delay.

Note:
If persistence filtering is applied, the OPEN or CLOSE state cannot be time-stamped from the beginning of non-complementarity: that is, mode 1 of motion treatment cannot apply.

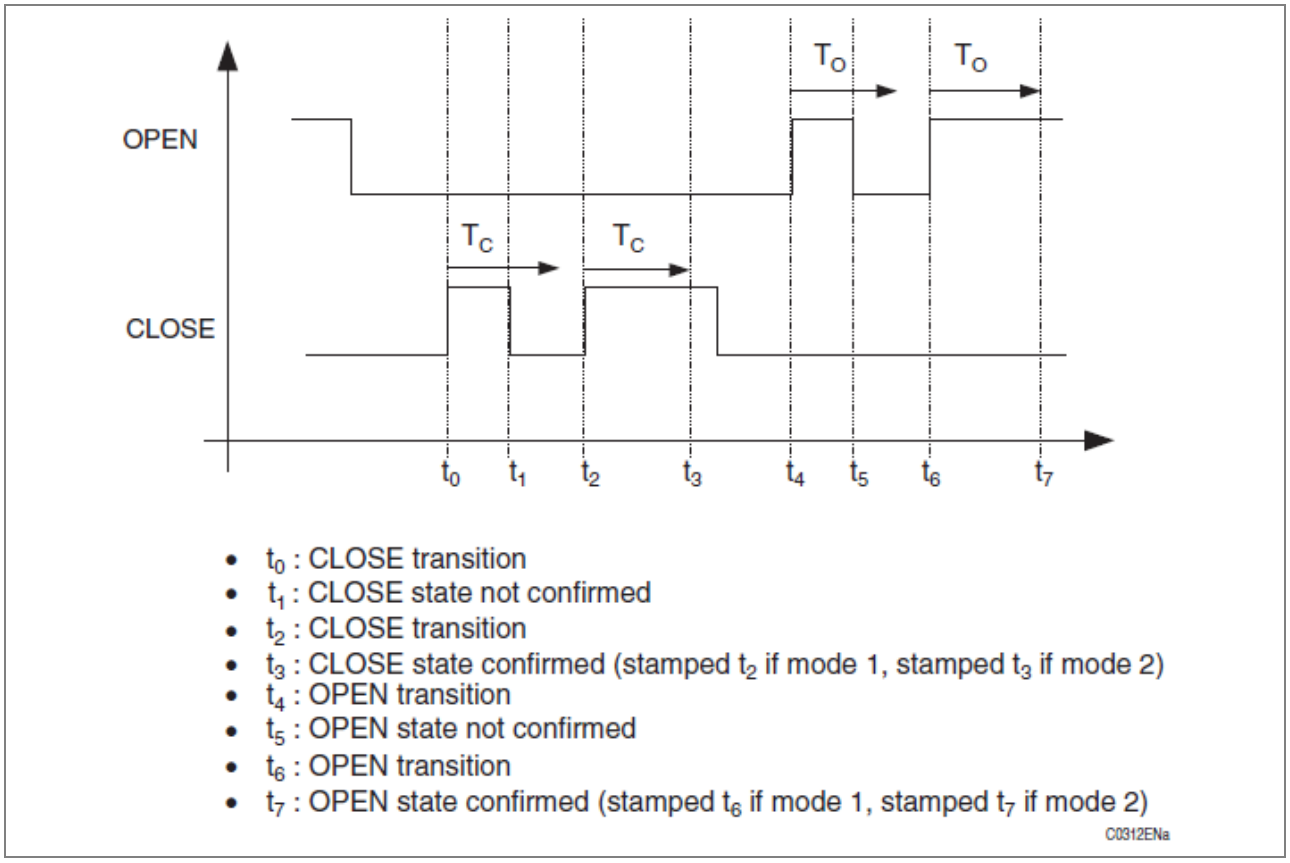


Figure 26: DP persistence filtering

7.1.3.3 DI/DO ASSOCIATION FOR DP

The aim of this automation is to create a direct association between a Double Point and a Digital Output: a state change on the input produces the opening or the closure of the output.

The relation between the state and the order is defined during the configuration phase.

7.1.3.4 MOTION STATES MANAGEMENT

MOTION state are the valid intermediate state of the Double Point Status (DPS), when the DPS state changes from OPEN to CLOSE or from CLOSE to OPEN. The codes for the DPS data on the C26x server, on IEC 61850-8-1, and on DS Agile clients show in the table that follows:

Server	Server	Data on IEC 61850-8-1		DS Agile Client
DI acquired C26x	Resulting state C26x	stVal	quality	Resulting state C26x/aView/Gateway PC
0-0 (time< complementarity delay jammed)	MOTION00	Intermediate-state 0x00	valid q= 0x00	MOTION00
0-0 (time> complementarity delay jammed)	JAMMED	bad-state 0xC0	valid q= 0x00	JAMMED
0-1	OPEN	off 0x40	valid q= 0x00	OPEN
1-0	CLOSE	on 0x80	valid q= 0x00	CLOSE
1-1 (time< complementarity delay undefined)	MOTION11	bad-state 0xC0	invalid q= 0x40	UNDEFINED
1-1 (time< complementarity delay undefined)	UNDEFINED			

7.1.4 PROCESSING OF MULTIPLE POINT STATUS

A Multiple Point (MP) is derived from N Digital Inputs. It could be also called “1 among N” BIs. Transient filtering is also added on acquisition for the events where no Digital Inputs is SET or more than one Digital Inputs are SET. After this delay, the MP becomes UNDEFINED.

N is fixed by C26x configuration from 2 to 32. There is no GOOSE transmission mechanism.

You can use an MP in two ways

- As a status (MPS): in this event, N is as many as 16
- As a value, only for TPI: in this event, N is as many as 64

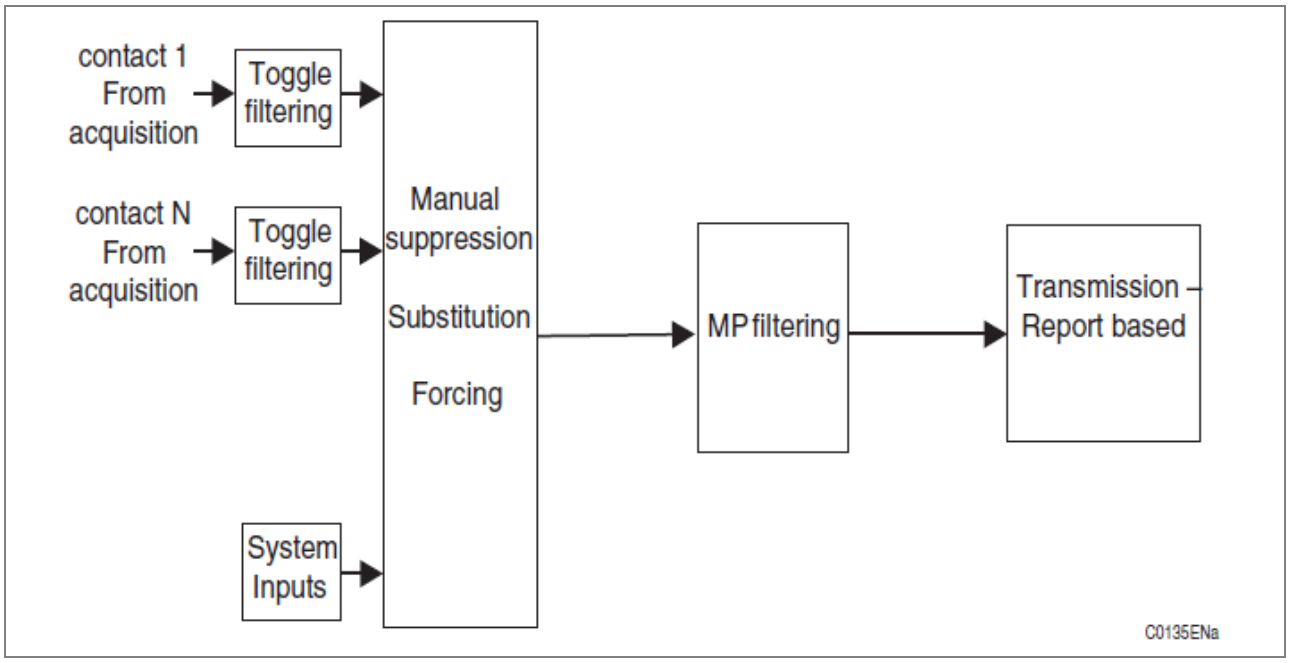


Figure 27: Multi point status processing

7.1.4.1 MULTIPLE POINT RESULTING STATES

The MP resulting states, following the various filters that can be applied, are:

- STATE1 to STATE32
- UNDEFINED
- TOGGLING
- SELFCHECK FAULTY
- UNKNOWN
- SUPPRESSED
- FORCED STATE1 to FORCED STATE32
- SUBSTITUTED STATE1 to SUBSTITUTED STATE32

Note 1:
State names that will be displayed at the user interface are defined at configuration time.

Note 2:
For TPI states, refer to TPI section.

7.1.4.2 MULTIPLE POINT FILTERING

MP is not being considered in the UNDEFINED state if the position has changed by more than one step.

MP is UNDEFINED after a user selectable time filtering (from 0 to 60 seconds, step 100 ms) when no DI is in the SET state (all RESET) or if more than one is in the SET state:

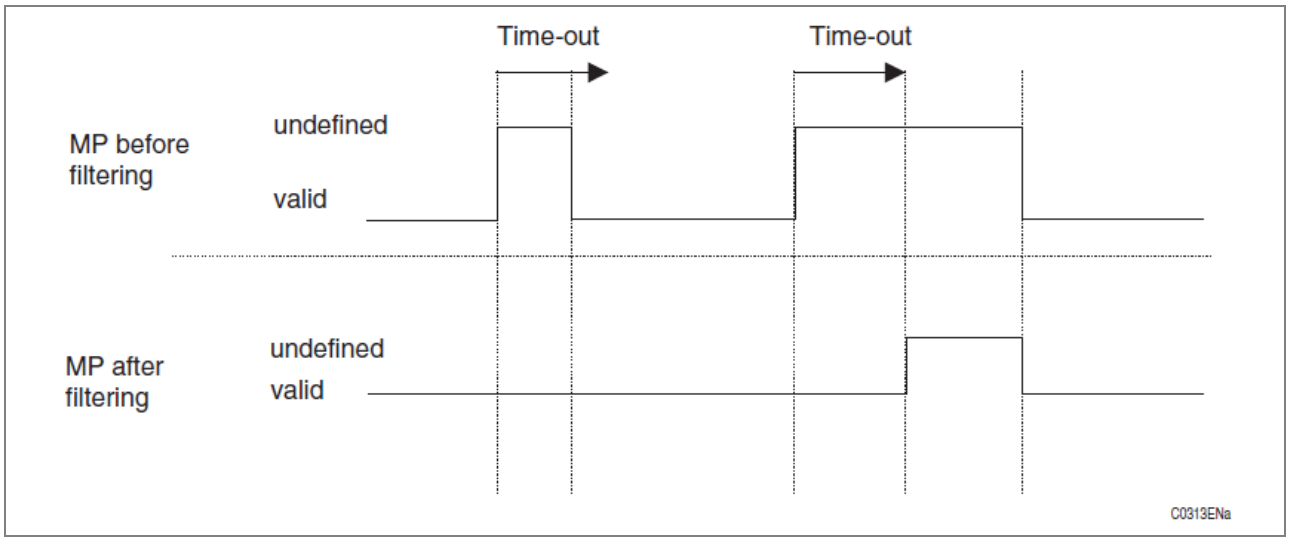


Figure 28: multiple point filtering

The MP is time-tagged with the date of the last BI change.

7.1.5 COUNTING

Counter pulses can be acquired through digital inputs or received from IEDs.

The counter accumulators are stored in non-volatile memory.

There are two types of counter processes:

1 With reset after an accumulation cycle.

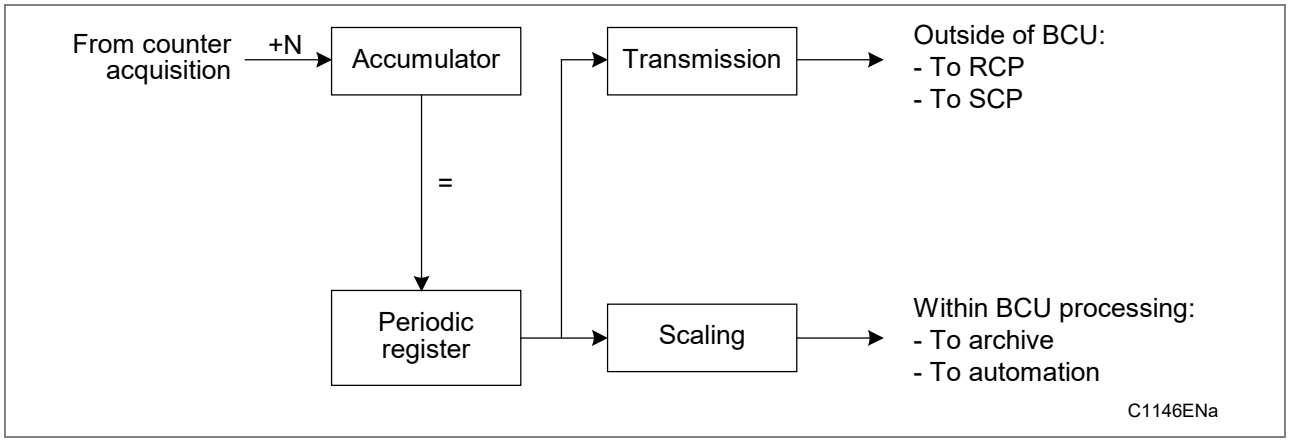


Figure 29: Counter processing with reset after an accumulation cycle.

2 Without reset after an accumulation cycle.

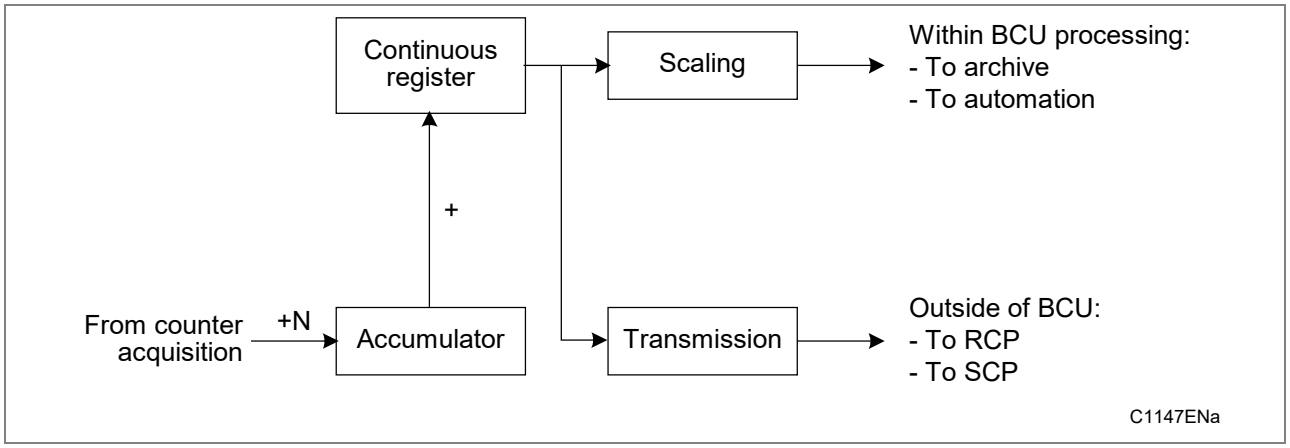


Figure 30: Counter processing without reset after an accumulation cycle.

The accumulator is incremented for each valid counter pulse.

Note:
For an already totalized counter, the accumulator's value is equal to value reported by the IED.

Registers

- The periodic register is used to store the accumulator's value of each periodic cycle.
- The continuous register is used to store all the accumulator's values since the beginning of the acquisition.

Periodic processing

A periodic cycle is defined by the internal clock:

- The period duration is settable: 10', 15', 30', 1h up to 24h
- Each period is set to begin at a precise time, on a regular basis (12:00 , 12:30 , 13:00 ...).

This choice is defined during the configuration phase.

For each periodic cycle:

- The content of the accumulator is added to the continuous register.
- The content of the accumulator is transferred to the periodic register.
- The accumulator is reset to 0 immediately after it has been transferred to the periodic register and added to the continuous register (a pending pulse is not lost).
- Either the continuous register or the periodic register is transmitted. The choice is made by configuration and is applicable to each accumulator.

If the chosen transmitted register exceeds its maximum value (2^{31}), the counter status is set to OVERRANGE. Only a counter modification can re-validate the counter.

Counter initialisation

Counter acquired through a digital input: The accumulator value stored in non-volatile memory is used.

Counter received from an IED: The accumulator data received during the IED's General Interrogation (GI) is transmitted.

Invalidity management in case of DI acquisition failure

In case of acquisition failure (SELFCHECK FAULTY or UNDEFINED states), the counters coming from the accumulator as well as from the continuous register and the periodic register are immediately transmitted as INVALID states with their current values.

At the end of the period, they will be re-transmitted as INVALID. In the following periods, they will be sent as INVALID with their value set to 0 (if configured to '**reset after cumul period**').

When the acquisition state becomes VALID, the accumulator + the continuous and the periodic registers are immediately sent as VALID with the current value (if configured to '**reset after cumul period**').

Invalidity management in case of IED disconnection

In case of an IED's disconnection, the accumulator + the continuous and the periodic register are immediately transmitted as UNKNOWN with their current values.

At a period's expiration, they will be re-transmitted as UNKNOWN.

In the following periods, they will be sent as UNKNOWN with the value set to 0 (if configured to **'reset after cumul period**').

When the acquisition becomes valid, the accumulator and the continuous and the periodic registers are immediately transmitted as VALID with the current value set to 0.

Time Change management

In case of time change, the accumulator, as well as both the continuous and periodic registers, are immediately transmitted as INVALID with their current values and the period re-calculated.

At a period's expiration, the accumulator, as well as both the continuous and periodic registers, are transmitted as VALID with their cumulative value (before & after time modification).

Synchronisation changes have no impact on the counter process.

Scaling

Scaling is used to print or display a counter.

EPI is a parameter giving the amount of energy in KW-h or KVAR-h equivalent to a pulse.

The value displayed is: **N x EPI KW-h** (where N is the value of a counter).

Counter resulting states

The state of a counter can be:

State	Description
VALID	Not in one of the states below listed below
SELFCHECK FAULTY	Due to the SELFCHECK FAULTY of the DI
UNKNOWN	If the counter is received via a transmission link, the information is unknown when the link is disconnected
UNDEFINED	Due to a counting failure of double-counter (non-complementarity of the 2 contacts)
OVERRANGE	When the value exceeds the set maximum value

Transmission

The counters are transmitted on a Client-Server basis on the Station Bus using same mechanisms as for the measurements.

During a loss of communication between a client and a server, the states of all the server counters are set to UNKNOWN on the Client.

The counter's information transmitted in a report comprises:

- the '**Continuous register**' or '**Periodic register**' value (depending on the configuration)
- the time stamp (using UTC time) and time quality
- the resulting state (mapped on the quality field on Station Bus)
- the reason for change, which could be one of the below values:
  - cyclical change (*SET* if the value has changed)
  - change of quality (*SET* if the quality has changed)
  - change due to control (*SET* if the value or quality change is due to a control)

The counter data transmitted through a GOOSE is the same as in a report, except for the "**Reason for change**" and the timestamp.

Counter combinations and modifications

The following table indicates the various combinations a counter can be found in, with the resulting status on the devices.

SERVER	DATA OVER IEC61850		CLIENT		
Current Status C264	actVal	Quality	C26x/Gateway	aView	
			Resulting status	Validity	Quality
VALID	X	All bits at 0(0x0000)	VALID	0-Valid	
SELFCHECK FAULT	X	b1=1, b6=1, other bits at 0(0x4200)	SELFCHECK FAULT	1-Invalid	SELFCHECK FAULT
N/A	X	b1=1, other bits at 0(0x4000)		N/A	
UNKNOWN	X	b1=1, b7=1, other bits at 0(0x4100)	UNKNOWN	1-Invalid	UNKNOWN
OVERRANGE	X	b1=1, b2=1, other bits at 0(0x6000)	OVERRANGE	1-Invalid	OVERRANGE
UNDEFINED	X	b1=1, b8=1, other bits at 0(0x4080)	UNDEFINED	1-Invalid	UNDEFINED

All other stVal/q combinations are managed as UNKNOWN by IEC61850 clients.

X: any value.

N/A: Not Applicable: The data transmitted over IEC 61850 does not match the current status of a C26x. These stVal/q values can be transmitted by another type of IEC61850 Server).

Counter Modification

When an accumulator's value is modified, the request is immediately taken into account.

The continuous register is set with the accumulator's value found at the end of the cycle.

The modification can result from a counter reset.

Note:
As the counters are transmitted as 32-bit floating points for IEC 61850 compliance, if a counter value is greater than 21474836.0 (or lower than -21474836.0 for negative values), the accuracy is no longer guaranteed for the floating point values.

7.1.6 SYSTEM INPUTS (SI)

System inputs (SI) are binary information related to:

- An equipment or system internal state, such as hardware faults or system faults
- A configurable or built-in automation (status of the automation, binary input created by the automation, …)
- Electrical process data that have no acquisition possibilities: no acquisition through DI or through serial communication. However, they must be managed by the C26x. The states of this data are saved in non-volatile memory.

An SI is of SP, DP or MP type and can belong to any type of group.

The processing of a SI is given in the SP / DP / MP data flow.

7.1.7 IED INPUTS

These inputs are acquired from IEDs or protective relays via serial links.

If they are not time tagged by the IED, they are by the control unit at the time of reception. This must be configured for each IED.

An IED input is of SP, DP or MP type.

Double inputs can be processed in IEDs. If they are not, the control unit must receive each individual input and perform the DP processing. This must be configured for each IED.

The processing of an IED input is given in the SP / DP / MP data flow.

7.1.8 GROUP PROCESSING

A group is a logical OR, AND, NOR or NAND combination of Binary Inputs (BIs) or groups.

A group component can be an SPS, a DPS (direct or via IED), an SI or another Group. A component can belong to several groups.

A group is processed as an SPS. It is time-stamped with the date / time of the last data-point that changed the group status.

A group is calculated with filtered BIs (persistent filtering or motion treatment if configured). BIs from other BCUs are received in reports.

The binary inputs states are taken into account as follows:

Single Point Status	treated in a group as
SET, FORCED SET, SUBSTITUTED SET	Set
RESET, FORCED RESET, SUBSTITUTED RESET	Reset
SELFCHECK FAULTY, TOGGLING, UNKNOWN	Invalid
SUPPRESSED	Suppressed

Double Point Status	treated in a group as
CLOSE, FORCED CLOSE, SUBSTITUTED CLOSE	Set
OPEN, FORCED OPEN, SUBSTITUTED OPEN	Reset
JAMMED, FORCED JAMMED, SUBSTITUTED JAMMED, UNDEFINED, SELFCHECK FAULTY, TOGGLING, UNKNOWN	Invalid
SUPPRESSED	Suppressed

OR	SET	RESET	INVALID	SUPPRESSED
SET	Set	Set	Set	Set
RESET	Set	Reset	Invalid	Reset
INVALID	Set	Invalid	Invalid	Invalid

OR	SET	RESET	INVALID	SUPPRESSED
SUPPRESSED	Set	Reset	Invalid	Suppressed

AND	SET	RESET	INVALID	SUPPRESSED
SET	Set	Reset	Invalid	Set
RESET	Reset	Reset	Reset	Reset
INVALID	Invalid	Reset	Invalid	Invalid
SUPPRESSED	Set	Reset	Invalid	Suppressed

NOT	
SET	Reset
RESET	Set
INVALID	Invalid
SUPPRESSED	Suppressed

SP and SI from different hierarchical levels can be mixed, for instance a group at substation control unit level can be composed of SP acquired at bay control unit level or at substation control unit level.

A group is time stamped with the date / time of the last datapoint that has modified the group status.

7.1.9 SBMC MODE PROCESSING

When a Bay is in Site Based Maintenance Control (SBMC) mode, the Binary Inputs (related to this Bay and defined as “SBMC-dependent”) take the forced state defined in the configuration.

This forced information is delivered to the Remote Control Point (RCP) as long as the SBMC mode is active on the Bay.

For a group a special feature is implemented: a BI belonging to a group, that is dependent of SBMC bay state, is not taken into account in group computation if the bay is set in SBMC mode. If all the BI of a group belong to one or more bays, that are all in SBMC mode, the group is then in the suppressed state. At the end of a bay SBMC mode, all groups owning BI of this bay are re-computed.

7.1.10 BI SENT TO AUTOMATISM FEATURES

In event that an automatism operates on a client control unit, with BI information coming from a server control unit, BI are generally transmitted in the GOOSE based mode. In some events where the GOOSE based mode is not used, BI information received by IEC 61850-8-1 report must be used in automatism features.

In any events where GOOSE based mode and report based mode are used at the same time, the BI information used is the one received by GOOSE (faster transmission than reports).

7.2 MEASUREMENT INPUT PROCESSING

Measurement Values can be Analogue or Digital.

Analogue Measurements are acquired from communications (station bus IEDs or process bus sampled values) or from the BCU’s or SCU’s boards:

- For DC: AIU201 or AIU211 on BCU or SCU
- For AC: TMU2xx on BCU or sampled values from process bus merging units.

Digital Measurement comes from Digital input boards on the BCU or SCU.

7.2.1 MEASUREMENT INPUT PROCESSING - FOCUS

We examine four areas of focus, as follows:

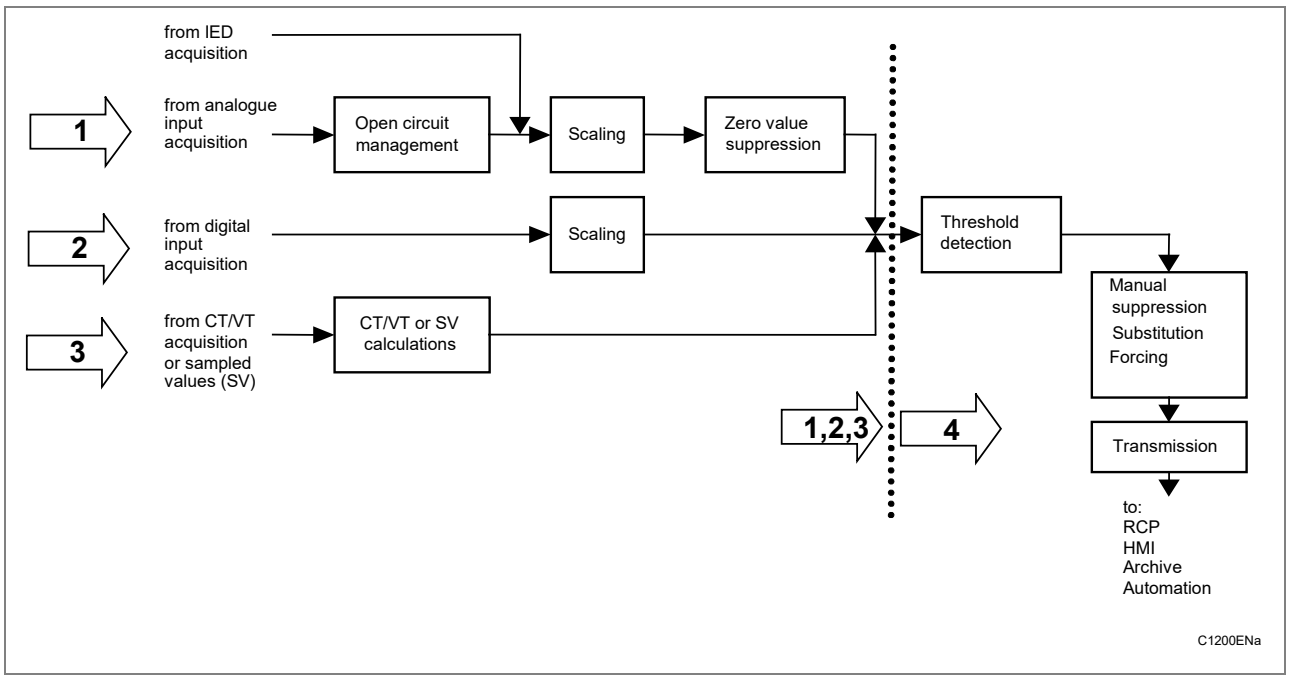


Figure 31: Measurement value processing

- Focus 1: Analogue measurement processing as far as threshold detection
- Focus 2: Digital measurement processing up to threshold detection
- Focus 3: CT / VT or SV measurement processing up to threshold detection
- Focus 4: All measurement values, from threshold detection to transmission

7.2.2 FOCUS 1: ANALOGUE MEASUREMENT PROCESSING UP TO THRESHOLD DETECTION

A measurement value is processed as shown below:

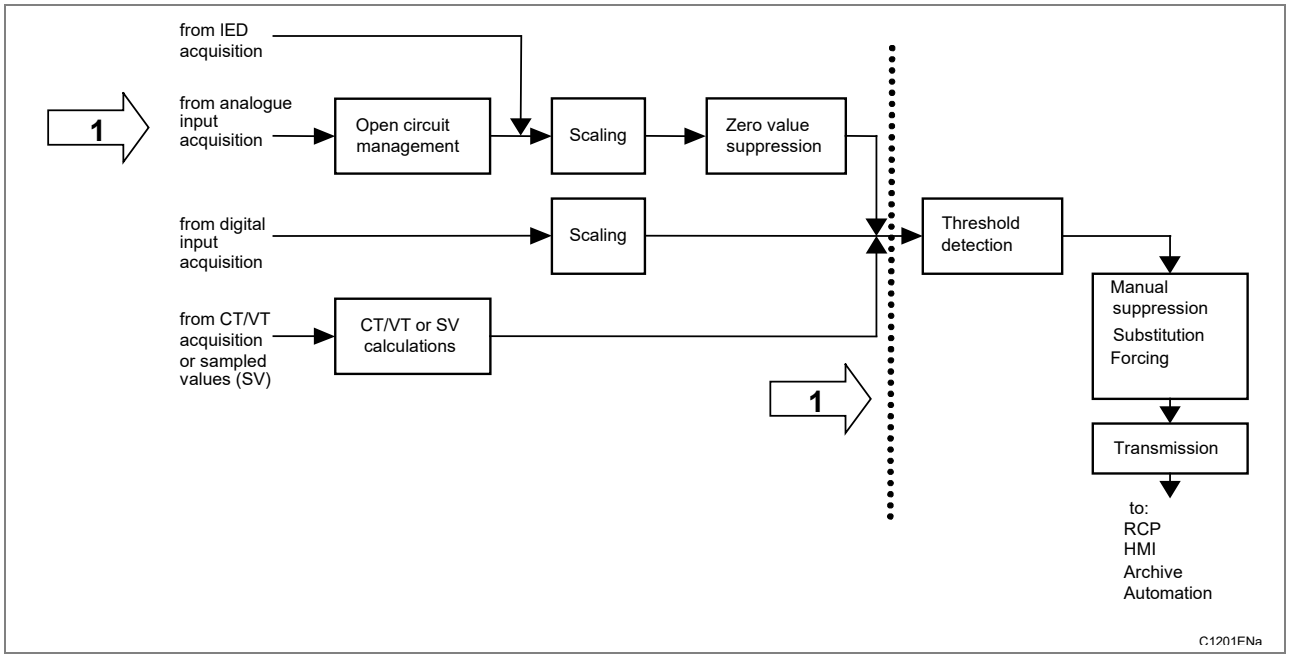


Figure 32: Process of a measurement value

7.2.2.1 NEAR ZERO FILTERING

A specific threshold is used to filter measurement near to zero value.

This **threshold** is a percentage of the maximum range value (i.e : -10mA for a range of 0..10mA). Its value depends on the range configured.

The "near to zero" threshold is equal to [0 .. *MAX*] mA,

- **threshold = - MAX * 1%**

  with :

  - MAX : negative value of AI full range (in V or mA)

The "near to zero" value of 1% is a constant fixed by software.

The "near to zero" **threshold** is used to filter the measurements, in the filtering process of C26X.

- "Measured Value" : last MV acquired
- "minimum range" : 0.0 (in V or mA)
- "maximum range" : full range value (in V or mA)
- threshold : see table below

The measured values can be replaced by a value equal to 0.0, and the relative MV status, according on the following conditions:

Condition	Transmitted Value	MV Status
Measured Value < threshold	0.0	INVALID
threshold ≤ Measured Value < minimum range	0.0	VALID
minimum range ≤ Measured Value < maximum range	Measured Value	VALID

7.2.2.2 OPEN CIRCUIT MANAGEMENT

For 4-20 mA transducers, **the control unit meets the NAMUR NE43** recommendation (refer to figure below).

On 4-20mA measurements, the 4.0 mA acquired value corresponds to 0.0 mA measured value.

Condition	Transmitted Value	MV status
Measured Value < 0 mA	0.0	INVALID
0 mA ≤ Measured Value < 3 mA	0.0	OPEN CIRCUIT
3 mA ≤ Measured Value < 4 mA	0.0	VALID
4 mA ≤ Measured Value < 20 mA	Measured Value	VALID

The "Open circuit" thresholds are fixed by software.

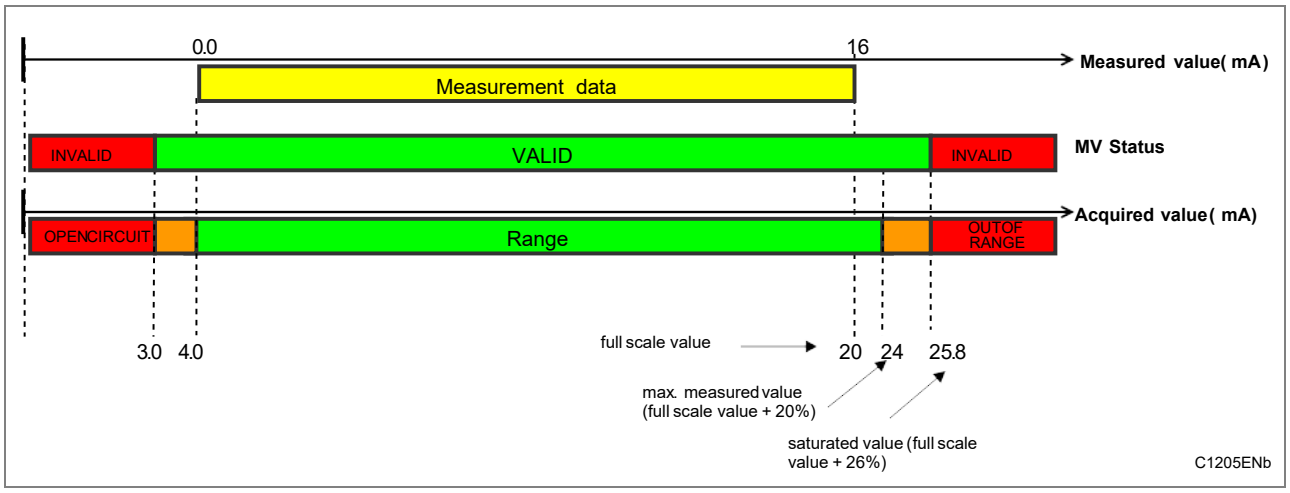


Figure 33: NAMUR NE43 validity range

7.2.2.3 SCALING

The real value represented by the measurement can be computed by a linear or a quadratic transformation:

- Linear, single slope

  Value = A*X + B

- Linear, multi-segment

  Value = A_i*X + B_i with $X_i \leq X < X_{i+1}$.

  As many as 20 configurable segments [X_i .. X_i+1]

- Quadratic

  Value = $A\sqrt{X} + B$

  or with offset:

  Value = $\sqrt{AX + B}$

Transformation law and A / B coefficients are defined in configuration.

7.2.2.4 ZERO VALUE SUPPRESSION

A threshold named **zero value suppression (% of full-scale value)** allows not to transmit the measurement value included in those thresholds.

It is defined for all analogue measurements (not digital measurements) in the SCE (from 0 to 10%, step 0,1%, default value = 0).

'**Threshold = 0**' means there is no zero value suppression.

This threshold is applicable for positive and negative values.

The acquired value is set to **0.0** and the quality is set to **VALID,** if its measured value (MV) is between the 2 thresholds (i.e. in the zero suppression area).

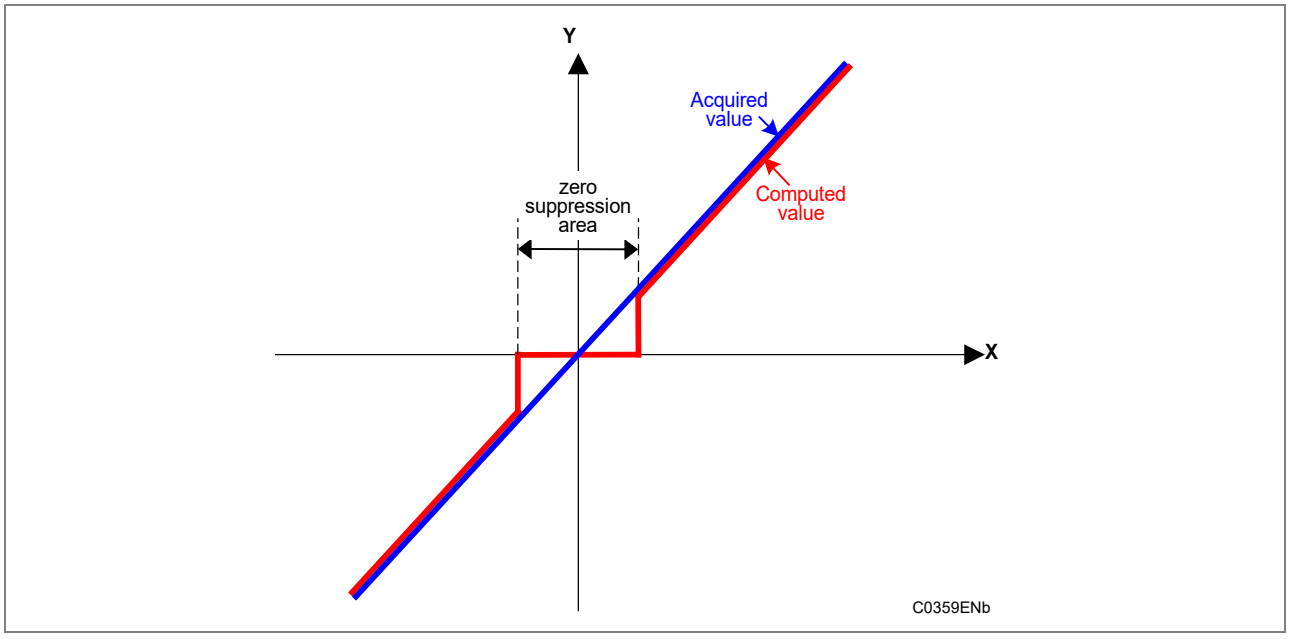


Figure 34: Zero value suppression

The computed value is used in all functions:

- Transmission
- Automation
- Display

7.2.3 FOCUS 2: DIGITAL MEASUREMENT PROCESSING UP TO THRESHOLD DETECTION

A Digital Measurement is derived from a Digital input. Digital Measurements are used for process measures or Tap indications.

A measurement value is processed as shown below:

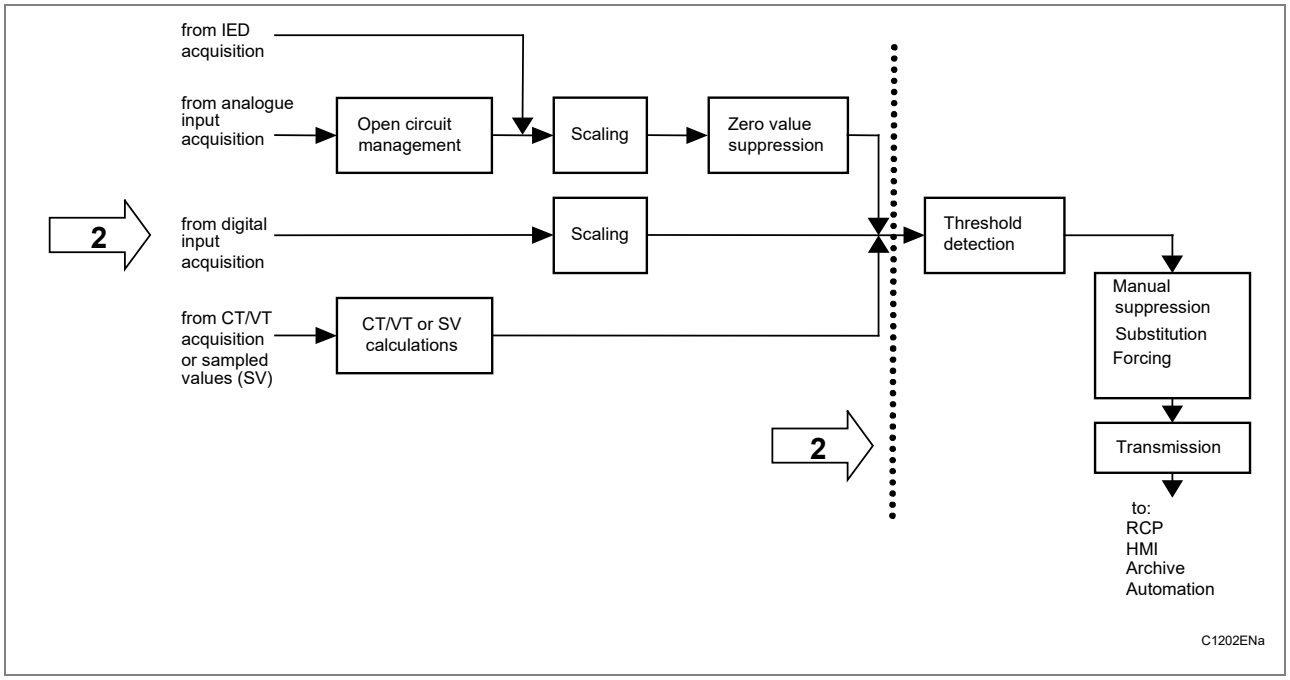


Figure 35: Process of a measurement value

For the conditions that follow, the DM is UNDEFINED:

- The value is not stable.
- BCD: a quartet is more than 9
- Decimal: no bit is set or more than one for tens or unit.

Two other bits can be used:

- For read inhibit: in this event, the DM is acquired when the Read Inhibit bit is set.
- For the sign.

7.2.4 FOCUS 3: TMU2XX - CT/VT MEASUREMENT PROCESSING UP TO THRESHOLD DETECTION

A measurement value is processed as shown below:

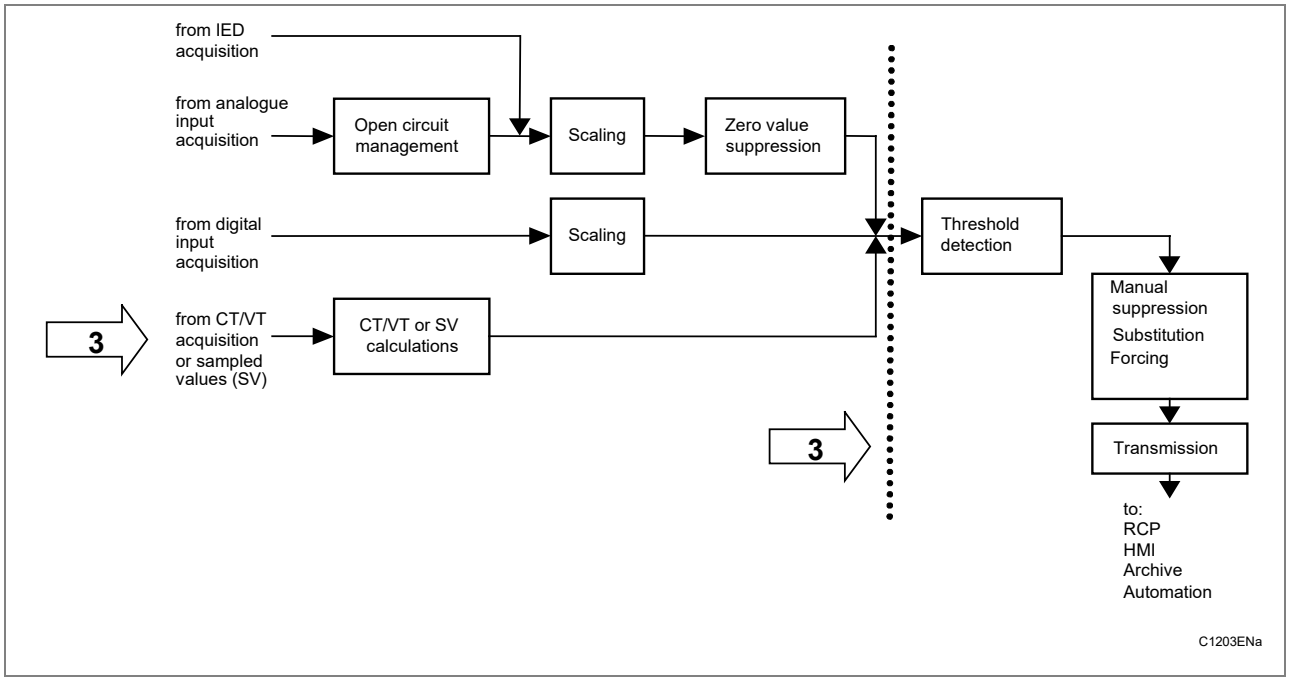


Figure 36: Process of a measurement value

It is impossible to connect the control units directly to the high voltage electrical network. The control units receive the data from the Current Transformers (CT) and from Voltage Transformers (VT) installed on the TMU2XX boards.

The purposes of the CT and VT include:

- To deliver current and voltage data that gives a reliable picture of what happens in the high voltage part of an electrical substation
- To make the galvanic insulation between the high voltage part and the measurement circuits,
- To protect the measurement circuits against damage when a fault comes onto the high voltage network.

A given electrical network sends voltage (V) and current (I) data to a CT / VT inputs acquisition function installed on a TMU2XX board.

From the output of the CT / VT inputs acquisitions function, these samples become inputs of the CT / VT calculation function

The CT / VT calculation function performs basic mathematical processing on the stored samples and gives this set of computed measurements, such as power, frequency, and so on, to the C26x main CPU.

These measurements are used by the synchrocheck function.

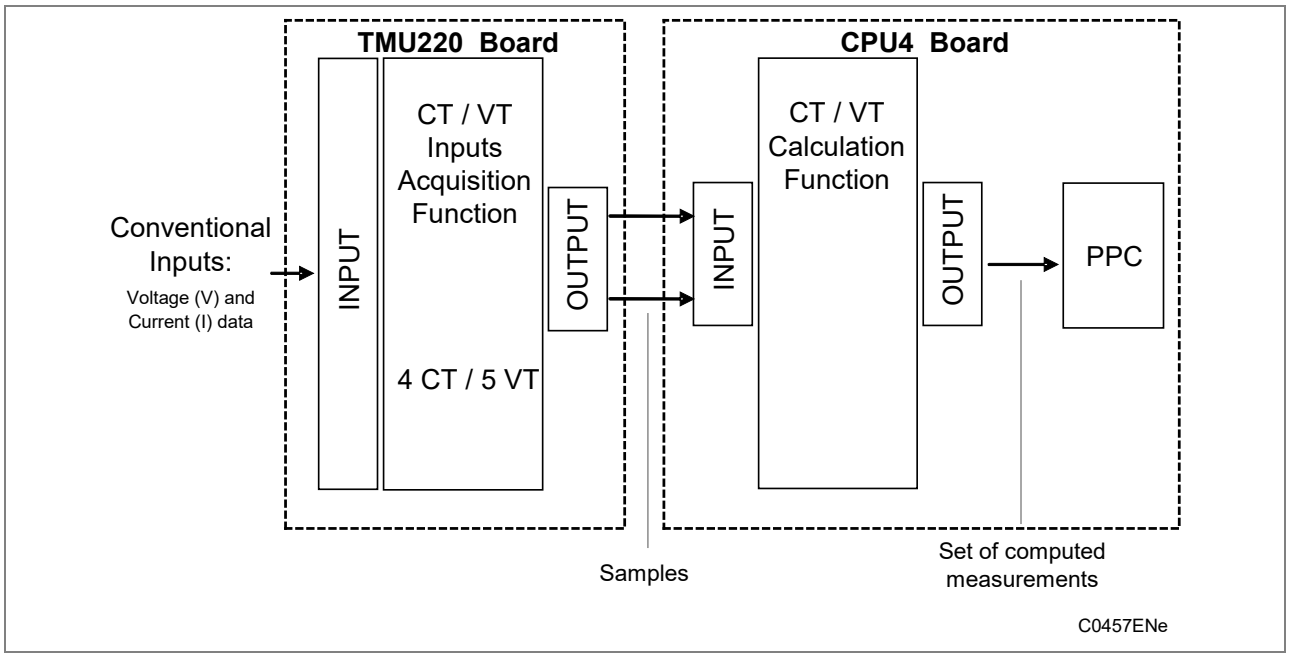


Figure 37: Overview: TMU220 board - CT / VT calculations

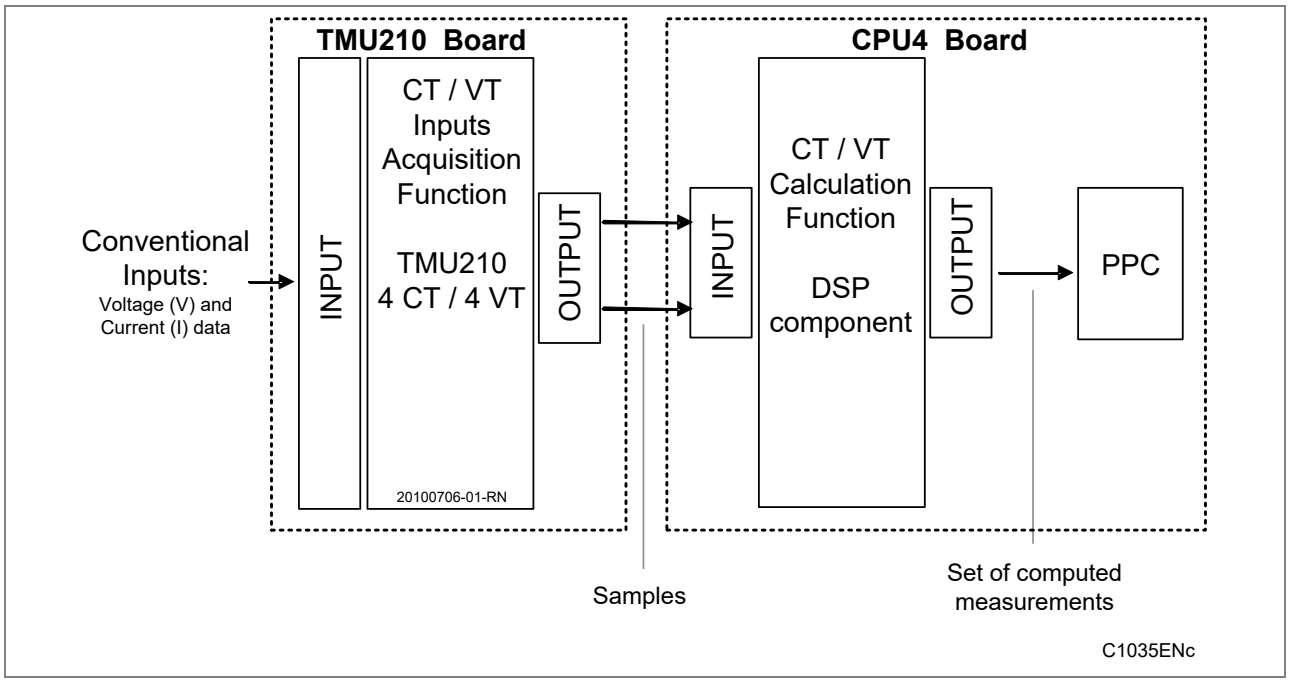


Figure 35: Overview: TMU210 board – CT / VT calculations

7.2.5 FOCUS 4: ALL MEASUREMENT VALUES: THRESHOLD DETECTION THROUGH TRANSMISSION

The process of a measurement value shows as follows:

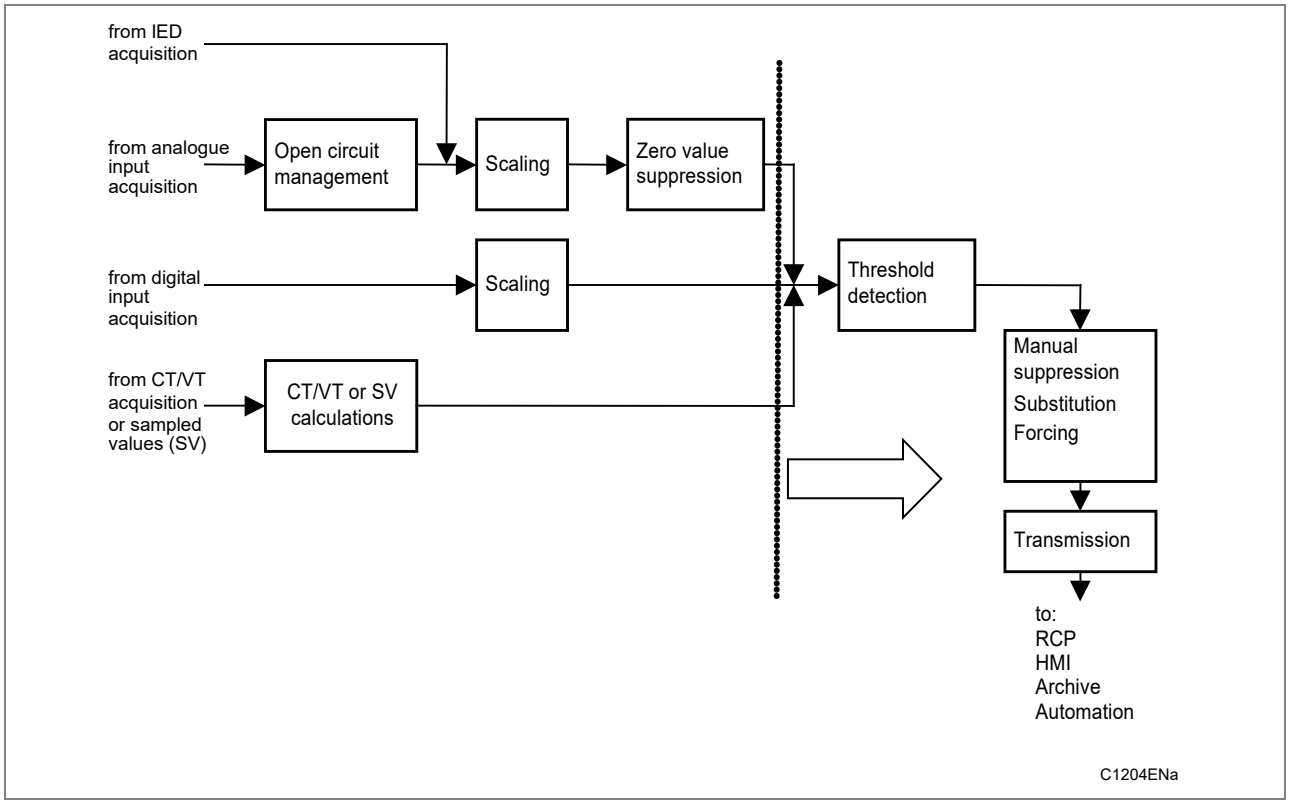


Figure 38: Process of a measurement value

Six thresholds can be defined for each measurement: 3 high thresholds and 3 low thresholds.

A hysteresis value configured on a per measurement basis is associated to the threshold management.

This value is a percentage of the full-scale value of the measurement: The value defined in "Hysteresis (% of full-scale value)" setting is used for **upper** hysteresis range, and for **lower** hysteresis range.

The hysteresis can be an integer value, between **1%** to **50%** max of full range.

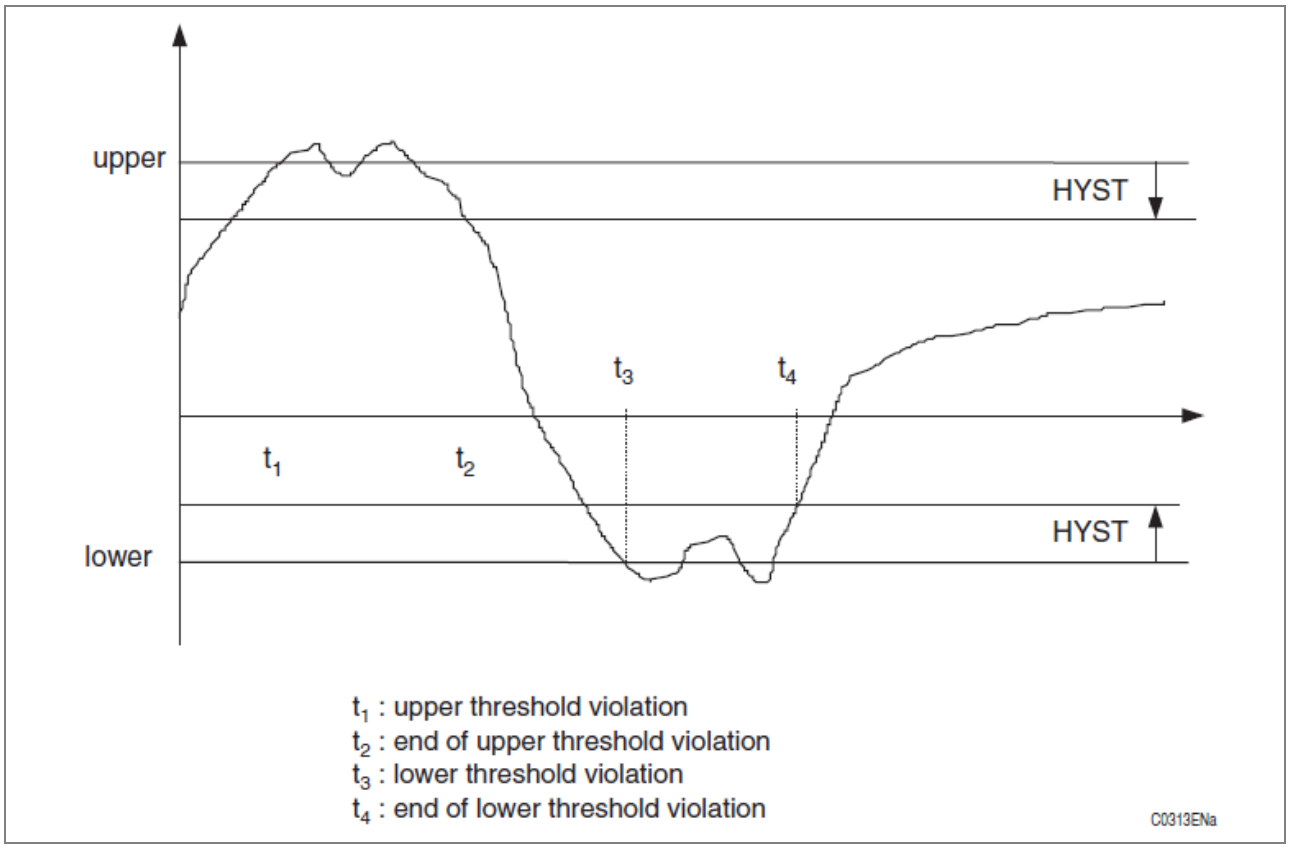


Figure 39: Threshold detection

7.2.6 TMU2XX - CT / VT CALCULATIONS - GENERAL

The voltage measurements come from the VT installed on the TMU2xx boards.

- TMU210 (4 CT and 4 VT)
- TMU220 (4 CT and 5 VT)

For the TMU220

The CPU4 board computes the samples from the TMU220 and processes the set of computed measurements.

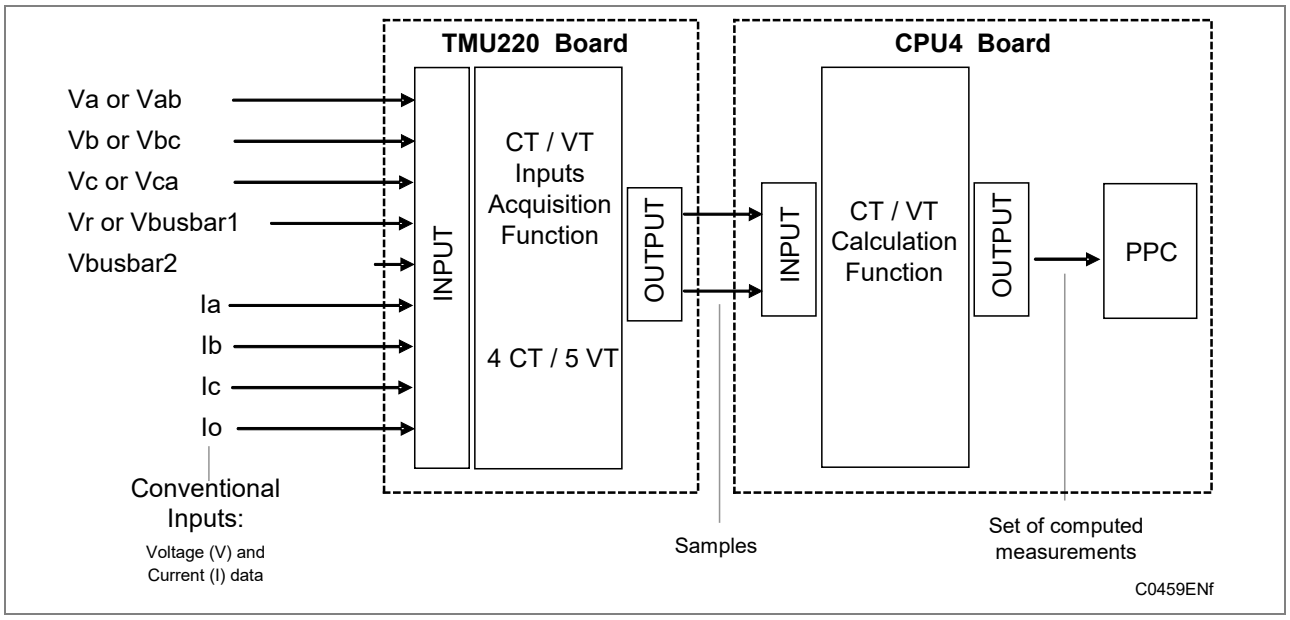


Figure 40: Detail: TMU 220 board - CT / VT calculations

TMU220 board – Signals, Ratings, and Range

Signals	Ratings	Range
V_{AN}, V_{BN}, V_{CN}, $V_0/V_{busbar1}$, $V_{busbar2}$		57 V to 273 V
I_A, I_B, I_C, I_0	1 A or 5 A	

For the TMU210

The hardware attributes of the TMU210 are different and oriented towards protection.

The DSP component computes the samples from the TMU210 analogue inputs, and from the digital inputs and digital outputs. The DSP component sends the set of computed measurements to the CPU4.

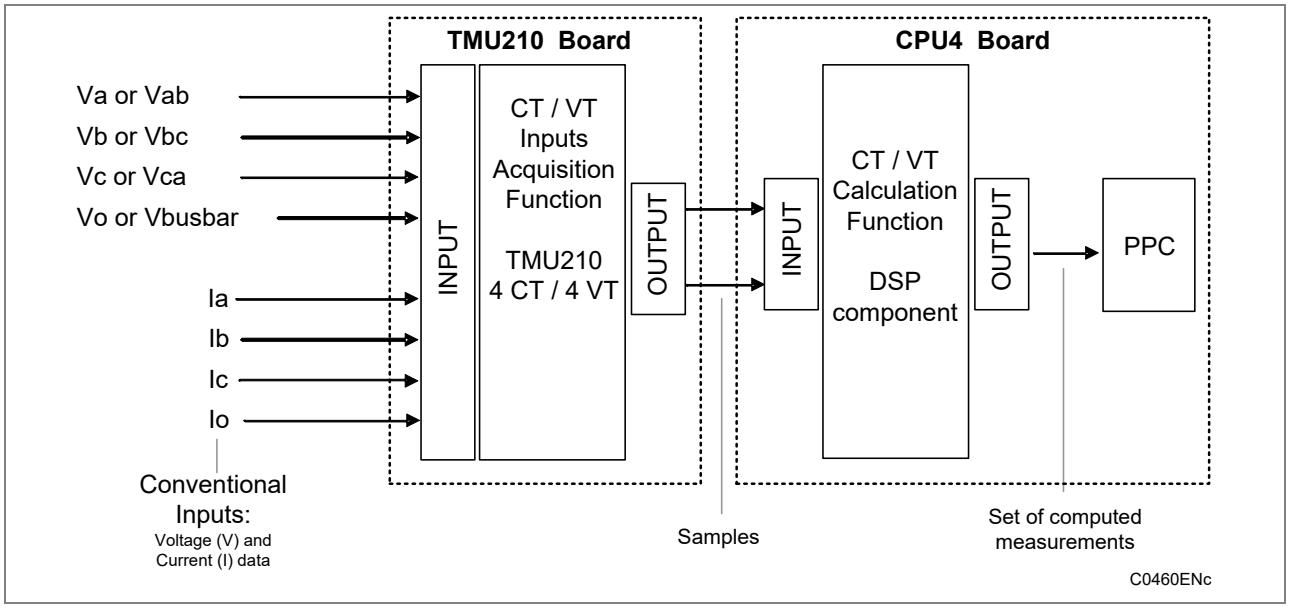


Figure 41: Detail: TMU210 board - CT / VT calculations

TMU210 board – Signals, Ratings, and Range

Signals	Ratings	Range
V_{AN}, V_{BN}, V_{CN}, $V_0/V_{busbar1}$,	NA	57 V to 130 V
I_A, I_B, I_C,	1 A or 5 A	0.1 to 40 In
I_0 nomimal:	1 A or 5 A	
I_0 nomimal: Normal		0.1 to 40 I0n
I_0 nomimal: Sensitive		0.01 to 8 I0n
I_0 nomimal: Very sensitive		0.002 to 1 I0n

CT / VT Functions

These functions use the measurements from the TMU2xx boards:

- Internal synchrocheck: Types 1 and 4
- Waveform

The CT/VT measurements can be included in the waveform function.

2 types of waveform are defined: Fast waveform and Slow waveform.

Board	Internal S/C Type 1			Internal S/C Type 4	Protection	Fast waveform (Dist. rec.)	Slow waveform
TMU210	X				X	X	X
TMU220	X			X		X	X

The measurements available as slow waveforms depend on the TMU2xx board used.

7.2.7 TMU2XX - FREQUENCY NETWORK CHANNEL SELECTION

7.2.7.1 SELECTION SEQUENCE

The frequency measured is called "**frequency network**" and depends on the TMU2xx configuration regarding to the **reference phase side**.

When:

- "**phase wired line side**" is selected, then "frequency network" is the **LINE** frequency
- "**phase wired busbar side**" is selected, then "frequency network" is the **BUSBAR** frequency

The **reference phase** configured at SCE level (TMU2xx) is used to select automatically the channel on which the **frequency network** measurement value is calculated.

For the TMU220

Frequency network is performed in the following order:

Priority	Channel	Channel phase
1 (High)	Voltage	Phase defined on **reference phase**
2	Voltage	V_{busbar}
3	Voltage	V_{busbar_bis} (if TMU220 is used and 5th VT configured
4	Voltage	V_B and then V_C if the reference voltage if V_A
5	Voltage	V_C and then V_A if the reference voltage if V_B
6	Voltage	V_A and then V_B if the reference voltage if V_C
7	Current	I1
8	Current	I2
9	Current	I3
10 (Low)	Current	I4

For the TMU210

Frequency network is performed in the following order:

Priority	Channel	Channel phase
1 (High)	Voltage	V4 (if phase reference configured at "wired busbar side")
2	Voltage	V1 (if phase reference configured at "wired line side")
3	Voltage	V2
4	Voltage	V3
5	Current	I1
6	Current	I2
7 (Low)	Current	I3

Note: current I4 is not considered as a "network" current and is always used as neutral current.

Minimum threshold for frequency network:

- If the signal with the highest priority disappears (signal lower than a minimum threshold for frequency network), the frequency is based on the signal with next priority.
- If a signal with a higher priority appears (signal higher than the minimum frequency network threshold), the frequency network is based on this signal, even if the current reference signal is still present.
- If all the signals go below the minimum thresholds, the "**meas quality when missing**" option, present at C26x\Hardware\TMU2xx configuration level (SCE) makes it possible to select 2 different behaviors when all the Input signals disappear:
  - **Behavior 1**: measurements associated with the acquired signals are set at value 0.0 and state VALID
  - **Behavior 2**: measurements associated with the acquired signals are set at value 0.0 and state FAULTY

Downgraded mode:

If the frequency signal configured as "frequency network" value is INVALID:

- Then, the DSP automatically changes the reference phase side (LINE to BUSBAR, or BUSBAR to LINE)
- The frequency value of the other reference side displays on the C26x front panel (LHMI):
  - if the reference phase side is "**phase wired line side**", and the frequency value is INVALID, then the frequency value of the BUSBAR displays on the C26x front panel (LHMI).
  - If the reference phase side is "**phase wired busbar side**", and the frequency value is INVALID, then the frequency value of the LINE displays on the C26x front panel (LHMI).

7.2.7.2 VALIDITY OF MEASUREMENTS AFTER FILTERING AND STABILIZATION

After that frequency network channel selection is established, all measurements are computed and filtered.

The validity of measurements is considered as VALID, after a stabilisation time of **5** periods of the signal, i.e. about **100ms** after the frequency network channel selection sequence.

7.2.8 TMU220: CT / VT CALCULATIONS – INPUTS

7.2.8.1 CONFIGURATION

In agreement with the electrical system configuration, these parameters are defined:

- Nominal Network frequency: 50 or 60 Hz
- Nominal voltage of the VT: 57-130 V
- Nominal current of the CT: 1 A or 5 A
- Connection type: wye (star) or delta
- Reading cycle measurement: from the UC
- Measurement quality when missing: FAULTY or VALID value 0
- Reference voltage
- Phase reference side, for synchrocheck.

7.2.8.2 SAMPLES

The inputs of the CT / VT Calculation function (issued from the Conventional CT/VT inputs) include:

In the event of a star (wye) coupling:

- Samples of I_A
- Samples of V_{AN}
- Samples of I_B
- Samples of V_{BN}
- Samples of I_C
- Samples of V_{CN}
- Samples of I_N
- Samples of $V_{busbar1}$ (or of V_0) if the synchrocheck function is enabled
- Samples of $V_{busbar2}$ if the synchrocheck function is enabled
- Validity of each sample.

In the event of a delta coupling:

- Samples of I_A
- Samples of I_B
- Samples of I_C
- Samples of I_N
- Samples of V_{AB}
- Samples of V_{BC}
- Samples of V_{CA}
- Samples of $V_{busbar1}$
- Samples of $V_{busbar2}$
- Validity of each sample.

80 samples per period are available.

7.2.9 TMU220: CT / VT CALCULATIONS – OUTPUTS

7.2.9.1 MEASUREMENTS - GENERAL

Whatever the signal frequency, 80 samples are available for all the input signals.

All these samples are gathered in a revolving list stored in active memory.

A timer is adapted permanently to the frequency of the signal and provides the frequency measurement

The primary measurements that follow are derived from sample values:

- RMS Current and Voltage
- P: Active Power (Watts)
- Q: Vars (using Active Power calculation method with the voltage samples delayed by 90°)

The measurements that follow are obtained from the Fourier of sample values or the Fourier values of the above-derived measurements (DFT).

- Sequence Components (I1, I2, I0, V1, V2, V0)
- Fundamental and harmonics
- Phase angles
- Power Factor
- SVA
- THD and TDD
- Specials (for products with synchrocheck)

7.2.9.2 SET OF MEASUREMENTS

The CT / VT calculation function provides the following values:

- RMS currents and voltages
- Frequency
- Active power P (Watts – total and on a per phase basis)
- Reactive power Q (Vars – total and on a per phase basis)
- Apparent power S (VA – total and on a per phase basis)
- Power factor pf (total and on a per phase basis) – pf = P / S
- Sequence components: I1, I2, I0, V1, V2
- Phase angles
- Total Harmonic Distortion (THD, sum of all voltage harmonics) & Total Demand Distortion (TDD, sum of all current harmonics referenced to a rated current In) – Harmonics are evaluated through to the 15^{th} order.
- Fundamental (H1 harmonic) of phase A current
- Fundamental (H1 harmonic) of phase B current
- Fundamental (H1 harmonic) of phase C current
- Fundamental (H1 harmonic) of phase A voltage
- Fundamental (H1 harmonic) of phase B voltage
- Fundamental (H1 harmonic) of phase C voltage
- Fundamental measurements
- Synchrocheck data: ΔF ΔV ΔΦ
- With the synchrocheck option, the values that follow are computed:
  - Slip frequency
  - Amplitude
  - Phase difference
  - Synchrocheck voltage

These measurements are available to the CPU at every measurement reading cycle defined by the configuration.

A configuration option [meas quality when missing] allows to choose 2 different behaviours when all the Input signals disappear: all below the minimum thresholds, 10 V for voltage and 100 mA for current:

- Behaviour 1: the measurements associated with the acquired signals are set to value 0 and state VALID
- Behaviour 2: the measurements associated with the acquired signals are set to value 0 and state FAULTY

7.2.9.3 ACCURACY OF MEASUREMENTS

The measurements obtained from the Fourier of sample values, or from the Fourier values of the derived measurements (DFT) have the same accuracy as the corresponding measured values.

Measurements	Accuracy (F < 70 Hz)	Accuracy (F > 70 Hz)
RMS phase currents	I < In: 0.2% In I > In: 0.2% In Min. threshold: 1 mA	I < In: 4% In I > In: 4% In Min. threshold: 1 mA
RMS Phase-to-Neutral voltages	V < 45 V: 0.3% 45 V 45 V < V < 200V: 0.2% Vn V > 200 V: 0.3% Vn Min. threshold: 1 mV	V < 45 V: 4% Vn V > 45 V: 4% Vn Min. threshold: 1 mV
RMS Phase-to-Phase voltages	V < 45 V: 0.3% 45 V 45V < V < 200 V: 0.2% Vn V > 200V : 0.3% Vn Min. threshold: 1 mV	V < 45 V: 4% Vn V > 45 V: 4% Vn Min. threshold: 1 mV
Frequency accuracy (45 to 66 Hz)	0.01 Hz +/- 2 mHz Min. threshold: 2 mHz	
Power	0.5%	
Absolute phase accuracy	1°	
Phase difference	+/- 2°	
Min time to establish all measurements values (“dead line to line”)	100 ms	
Min time to switch between voltage reference	50 ms	

7.2.9.4 LIST OF MEASUREMENTS

Measurement Type	Label
Standards analog measurements	
RMS value of the voltage phase A	Va
RMS value of the voltage phase B	Vb
RMS value of the voltage phase C	Vc
RMS value of neutral voltage	Vn
RMS value of the voltage phase AB	Vab
RMS value of the voltage phase BC	Vbc
RMS value of the voltage phase CA	Vca
RMS value of the current phase A	Ia
RMS value of the current phase B	Ib
RMS value of the current phase C	Ic
RMS value of neutral current	In
Active power phase A	Pa
Reactive power phase A	Qa
Apparent power phase A	Sa
Power factor phase A	cosφa
Phase angle phase A	φa
Active power phase B	Pb
Reactive power phase B	Qb
Apparent power phase B	Sb
Power factor phase B	cosφb
Phase angle phase B	φb
Active power phase C	Pc
Reactive power phase C	Qc
Apparent power phase C	Sc
Power factor phase C	cosφc
Phase angle phase C	φc
Total active power	Pt
Total reactive power	Qt
Total apparent power	St
Total power factor	cosφt
Total phase angle	φt
Residual active power	Pr
Residual reactive power	Qr
Residual apparent power	Sr
Residual power factor	cosφr
Residual phase angle	φr
Network frequency	Fn
Line frequency	Fline
Busbar frequency	Fbus
RMS value of the busbar voltage (Phase-to-Neutral)	Vbusbar 1
RMS value of the busbar current phase (In)	Ibusbar
RMS value of the busbar voltage(Phase-to-Neutral)	Vbusbar 2

Standard Synchrocheck measurements	
Frequency difference	ΔF = |Freq of Line Voltage - Freq of Busbar Voltage|
Voltage difference	ΔV = |Line Voltage - Busbar Voltage|
Phase difference	Δφ = |Phase of Line Voltage - Phase Busbar Voltage|
Signed dV	dV = Line Voltage - Busbar Voltage
Signed dF	dF = Freq of Line Voltage - Freq of Busbar Voltage
Signed dPhi	dPhi = Phase of Line Voltage - Phase Busbar Voltage
Synchrocheck type 3 (1 CB 1/2)	
Signed dV for CB2	dV2
Signed dF for CB2	dF2
Signed dPhi for CB2	dPhi2
Signed dV for CB3	dV3
Signed dF for CB3	dF3
Signed dPhi for CB3	dPhi3
Harmonics levels	
Ratio harmonic 2 to 15 / fundamental voltage phase A	H2Va to H15Va
Distortion rate voltage phase A	THD Va
Ratio harmonic 2 to 15 / fundamental voltage phase B	H2Vb to H15Vb
Distortion rate voltage phase B	THD Vb
Ratio harmonic 2 to 15 / fundamental voltage phase C	H2Vc to H15Vc
Distortion rate voltage phase C	THD Vc
Ratio harmonic 2 to 15 / fundamental voltage phase AB	H2Vab to H15Vab
Distortion rate voltage phase AB	THD Vab
Ratio harmonic 2 to 15 / fundamental voltage phase BC	H2Vbc to H15Vbc
Distortion rate voltage phase BC	THD Vbc
Ratio harmonic 2 / fundamental voltage phase CA	H2Vca to H15Vca
Distortion rate voltage phase CA	THD Vca
Ratio harmonic 2 to 15 / fundamental current phase A	H2Ia to H15Ia
Distortion rate current phase A	THD Ia
Ratio harmonic 2 to 15 / fundamental current phase B	H2Ib to H15Ib
Distortion rate current phase B	THD Ib
Ratio harmonic 2 to 15 / fundamental current phase C	H2Ic to H15Ic
Distortion rate current phase C	THD Ic
Fundamental sequence components	

Direct component of voltage	Vnps
Inverse component of voltage	Vpps
Homopolar component of voltage	Vzps
Vnps / (Vnps+Vpps) ratio	Vnpr
Direct component of current	Inps
Inverse component of current	Ipps
Homopolar component of current	Izps
Inps / (Inps+Ipps) ratio	Inpr
Fundamental voltage phase A	H1Va
Fundamental voltage phase B	H1Vb
Fundamental voltage phase C	H1Vc
Fundamental current phase A	H1Ia
Fundamental current phase B	H1Ib
Fundamental current phase C	H1Ic
Automatic Voltage Regulation (AVR)	
Phase difference Ia / Va	Ia/Va
Phase difference Ib / Vb	Ib/Vb
Phase difference Ic / Vc	Ic/Vc
Phase difference Iab / Uab	Iab/Uab
Phase difference Ibc / Ubc	Ibc/Ubc
Phase difference Ica / Uca	Ica/Uca
RMS value of the current phase AB	Iab
RMS value of the current phase BC	Ibc
RMS value of the current phase CA	Ica
Fresnel diagram vectors	
Complex module of voltage Va (eff. value * √2)	ρVa
Complex argument of voltage Va - phaseRef	ΘVa
Complex module of voltage Vb (eff. value * √2)	ρVb
Complex argument of voltage Vb - phaseRef	ΘVb
Complex module of voltage Vc (eff. value * √2)	ρVc
Complex argument of voltage Vc - phaseRef	ΘVc
Complex module of voltage Vn (eff. value * √2)	ρVn
Complex argument of voltage Vn - phaseRef	ΘVn
Complex module of current Ia (eff. value * √2)	ρIa
Complex argument of current Ia - phaseRef	ΘIa
Complex module of current Ib (eff. value * √2)	ρIb
Complex argument of current Ib - phaseRef	ΘIb
Complex module of current Ic (eff. value * √2)	ρIc
Complex argument of current Ic - phaseRef	ΘIc
Complex module of current In (eff. value * √2)	ρIn
Complex argument of current In - phaseRef	ΘIn

7.2.9.5 ALGORITHMS

Frequency

The frequency is directly computed through the timer frequency.

The reference phase used to set the timer frequency is chosen in the configuration (“reference phase”).

Fourier Transform

The DFT (Discrete Fourier Transform) is calculated for each electrical period. This gives (among other things) the value of the phase angle and the magnitude of the fundamental.

RMS values

$$Vrms = \sqrt{\frac{1}{80}\sum_{i=0}^{79} V_i^{\,2}}$$

Phase powers in wye coupling

Active power: Pa, Pb, Pc

$$P = \frac{1}{80}\sum_{i=0}^{79} V_i I_i$$

Reactive power: Qa, Qb, Qc

$$Q = \frac{1}{80}\sum_{i=0}^{79} V_i I_{i-16}$$

Note:
The reactive power is computed by taking the values of the current a quarter of period before [sin(x) = cos (x – pi/2)]

Total power

Wye coupling: Total Power

$$P = Pa + Pb + Pc$$

$$Q = Qa + Qb + Qc$$

Delta Coupling: Total Active Power

$$P = \frac{1}{80}\sum_{i=0}^{79} U_{BC}(i).I_B(i) - U_{CA}(i).I_A(i)$$

Delta Coupling: Total Reactive Power

$$P = \frac{1}{80}\sum_{i=0}^{79} U_{BC}(i).I_B(i-\pi/2) - U_{CA}(i).I_A(i-\pi/2)$$

Note:
The reactive power is computed by taking the values of the current a quarter of period before [sin(x) = cos (x – pi/2)]

Apparent power: $S = \sqrt{P^2 + Q^2}$

Power factor: $\cos(\varphi) = \frac{P}{S}$

Angle: $\varphi = \tan^{-1}(\frac{Q}{P})$

Harmonics

Harmonic values are directly issued from the DFT.

Sequence components

The sequence component computation is based on the fundamental values of phase and magnitude (from the DFT): that is its imaginary part and real part.

- Positive-sequence component

$$\mathrm{Re}(pos) = \frac{1}{3} \times \left(\mathrm{Re}(A) + \mathrm{Re}(B) \times \cos(120) - \mathrm{Im}(B) \times \sin(120) + \mathrm{Re}(C) \times \cos(120) + \mathrm{Im}(C) \times \sin(120)\right)$$

$$\mathrm{Im}(pos) = \frac{1}{3} \times \left(\mathrm{Im}(A) + \mathrm{Im}(B) \times \cos(120) + \mathrm{Re}(B) \times \sin(120) + \mathrm{Im}(C) \times \cos(120) - \mathrm{Re}(C) \times \sin(120)\right)$$

- Negative-sequence component

$$\mathrm{Re}(neg) = \frac{1}{3} \times \left(\mathrm{Re}(A) + \mathrm{Re}(B) \times \cos(120) + \mathrm{Im}(B) \times \sin(120) + \mathrm{Re}(C) \times \cos(120) - \mathrm{Im}(C) \times \sin(120)\right)$$

$$\mathrm{Im}(neg) = \frac{1}{3} \times \left(\mathrm{Im}(A) + \mathrm{Im}(B) \times \cos(120) - \mathrm{Re}(B) \times \sin(120) + \mathrm{Im}(C) \times \cos(120) + \mathrm{Re}(C) \times \sin(120)\right)$$

- Zero-sequence component

$$\mathrm{Re}(0) = \frac{1}{3} \times \left(\mathrm{Re}(A) + \mathrm{Re}(B) + \mathrm{Re}(C)\right)$$

$$\mathrm{Im}(0) = \frac{1}{3} \times \left(\mathrm{Im}(A) + \mathrm{Im}(B) + \mathrm{Im}(C)\right)$$

Synchrocheck measurements

$\Delta F = | F_{line} - F_{busbar} |$

$\Delta V = | V_{line} - V_{busbar} |$

$\Delta \varphi = | \varphi_{line} - \varphi V_{busbar} |$

7.2.10 TMU210: CT / VT CALCULATIONS – INPUTS

7.2.10.1 CONFIGURATION

In agreement with the electrical system configuration, the following parameters are defined:

- Nominal Network frequency (50 or 60 Hz)
- Nominal phase voltage of the VT (57-130V)
- Nominal earth voltage of the VT (57-130V)
- Nominal phase current of the CT (1A or 5A)
- Nominal earth current of the CT (1A or 5A)
- Earth current origin (computed or wired)
- Sensitivity of the earth CT (normal, sensitive, very sensitive)
- Transformer ratio of the EPATR core balance CT
- Connection type (3VPN, 3VPN+V0, 2VPN+V0, 2VPP+V0, 3VPP+V0, 3VPN+Vbusbar, 3VPP+V0)
- Reading cycle measurement (from the PPC)

7.2.10.2 ACQUISITION

The TMU210 processes **40** samples per cycle.

This sampling rate is fixed on time (no frequency tracking).

A specific algorithm in **DSP** converts the number of TMU210 samples to **80** samples per cycle.

The measurements are updated by the DSP each cycle (20ms @50Hz).

Samples per cycle	Network frequency	Sampling rate	Application
40 (80)	50 Hz	4000 Hz / 4000 SA/s	built-in functions slow/fast waveform non-tariff metering protections (ELECTRE, ANSI)
40 (80)	60 Hz	4800 Hz / 4800 SA/s	

The provided samples are:

- 4 currents transformers inputs (1A or 5A), selectable by jumper:
  - **CI#1** (used for I_A)
  - **CI#2** (used for I_B)
  - **CI#3** (used for I_C)
  - **CI#4** (used for I_N)
- 4 voltages transformers inputs, with 2 ranges according to TMU210 board reference:
  - **VI#1** (used for V_A)
  - **VI#2** (used for V_B)
  - **VI#3** (used for V_C)
  - **VI#4** (used for Vneutral or Vref)

7.2.10.3 SAMPLES

With the TMU210 board with respect to the type of connection, some restrictions exist because of the fourth VT.

The inputs of the CT / VT Calculation function (issued from the Conventional CT/VT inputs) include:

In case of star coupling:

- CI#1: samples of IA
- CI#2: samples of IB
- CI#3: samples of IC
- CI#4: samples of IN (conf in V0) or I_{busbar} (conf in Vb)
- VI#1: samples of VAN
- VI#2: samples of VBN
- VI#3: samples of VCN
- VI#4: samples of VN (conf in V0) or V_{busbar} (conf in Vb)
- Validity of each sample.

In case of delta coupling:

- CI#1: samples of IAB
- CI#2: samples of IBB
- CI#3: samples of ICA
- CI#4: samples of IN (conf in V0) or I_{busbar} (conf in Vb)
- VI#1: samples of VAB
- VI#2: samples of VBC
- VI#3: samples of VCA
- VI#4: samples of VN (conf in V0) or V_{busbar} (conf in Vb)
- Validity of each sample.

7.2.11 TMU210: CT / VT CALCULATIONS – OUTPUTS

7.2.11.1 MEASUREMENTS – GENERAL

Whatever the signal frequency, 32 samples are available for all the input signals.

All these samples are gathered in a revolving list stored in active memory.

A timer is adapted permanently to the frequency of the signal and provides the frequency measurement

The primary measurements that follow are read directly from sample values:

- RMS: Currents and Voltages
- Thermal status

The following measurements are obtained from the Fourier of sample values or from the Fourier values of the derived measurements (DFT):

- DFT: Currents and Voltages
- DFT Sequence Components: Current and Voltage (positive and negative)
- Current - voltage angle
- Active phase Power
- Active earth Power
- Reactive phase power
- Power Factor
- Synchrocheck measurements

7.2.11.2 SET OF MEASUREMENTS

The CT / VT calculation function produces:

- RMS currents and voltages (phase in star wiring, phase-to-phase in delta wiring)
- Instantaneous voltages (phase in star wiring)
- Frequencies (line or busbar if V4 is connected to a busbar)
- Fundamental measurements and Derived values
- Current – voltage angles
- Total Active power P
- Total Reactive power Q
- Total Apparent power S
- Cos φ power factor
- Thermal status
- With the synchrocheck option, the values that follow are computed:
  - Synchrocheck data: ΔF ΔV $\Delta \Phi$
  - Slip frequency
  - Amplitude

- Phase difference
- Synchrocheck voltage

These measurements are made available to the controller and refreshed upon each measurement reading cycle defined in the configuration.

7.2.11.3 LIST OF MEASUREMENTS

Measurements	Accuracy	Unit
RMS phase currents Rms_I_A Rms_I_B Rms_I_C Rms_I_N	 2%	 In
RMS phase voltages Rms_V_{AN}_V_{AB} Rms_V_{BN}_V_{BC} Rms_V_{CN}_V_{CA} Rms_V_0 Rms_V_{busbar}	 2%	 Volts
Frequency F: frequency tracking F81: frequency used by 81 Index of F Index of F81 Rate of frequency_81	0.01Hz 0.03Hz/sec	 Hertz Hertz Hertz/sec
DFT phase currents I_A I_B I_C I_0 I_0_computed EPATR I_0	 2%	 In In In I0n I0n Amps
DFT phase voltages V_{AN} V_{BN} V_{CN} V_{AB} V_{BC} V_{CA} V_0 V_{busbar}	 2%	 Volts
DFT Sequence voltages V1 V2		 Volts
DFT Sequence currents I1 I2		 In
Total power Active phase power (P) Active earth power(P0) Reactive power (Q) Cos phi (power factor)	 <3% <3%	 Watts Watts Vars
Thermal status		%

Measurements	Accuracy	Unit
Synchrocheck		
Delta F		Hertz
Delta V		Volts
Delta phi		Degree
Line frequency		Hertz
Busbar frequency		Hertz
Phase angle between line and busbar		Degree
Anticipation angle		Degree
Frequency shift		%
Frequency shift acceleration		%

7.2.11.4 EFFECTIVE FUNDAMENTAL MEASUREMENTS

The measurement updated by the C26x equipped with a TMU210 board are acquired.

The list below describes the relation "coupling mode " vs measurements.

The current value is defined according to the rated current, due to the dependence on the selected current caliber (1 or 5A).

Measure	Unity of measure	Direct / Indirect						
I_A	I_n	Direct						
I_B	I_n	Direct						
I_C	I_n	Direct						
I_n	I_n	Direct						
Coupling Mode	**Unity of measure**	**$3V_{pn}$**	**$3V_{pn}+V_0$**	**$2V_{pn}+V_0$**	**$2V_{pp}+V_0$**	**$3V_{pp}+V_0$**	**$3V_{pn}+V_{busbar}$**	**$3V_{pp}+ V_{busbar}$**
V_A	V	direct	direct	direct	indirect	indirect	direct	
V_B	V	direct	direct	direct	indirect	indirect	direct	
V_C	V	direct	direct	indirect	indirect	indirect	direct	
V_{AB}	V	indirect	Indirect	indirect	direct	direct	Indirect	direct
V_{BC}	V	indirect	Indirect	indirect	direct	direct	Indirect	direct
V_{CA}	V	indirect	Indirect	indirect	indirect	direct	Indirect	direct
V_n	V	indirect	direct	direct	direct	direct	Indirect	
V_{Busbar}	V						direct	direct
I_0	I_n	indirect						
I_1	I_n	indirect						
I_2	I_n	indirect						
V_0	V	indirect						
V_1	V	indirect						
V_2	V	indirect						

7.2.11.5 SECONDARY TO PRIMARY RATIOS FOR MEASUREMENTS CONVERSION

The values transmitted by the TMU210 board are given at secondary side of CT/VT (57.7V for voltages, and 5A for currents). The C264 processes (in SV block/DSP components) are performed using the secondary side of CT/VT values only.

These ratios are configured at SCE level in **C266/hardware/TMU210**.

7.3 MANUAL OPERATIONS ON DATAPOINTS

7.3.1 SUPPRESSION

A measurement can be assigned to the SUPPRESSED state by an order issued from an operator. No subsequent change of value or state on a "SUPPRESSED" measurement can trigger any action: for example, display, alarm, transmission. The measurement takes the SUPPRESSED state. When the operator "un-suppresses" the measurement, this one takes its actual state.

7.3.2 SUBSTITUTION

The value of a measurement can be substituted by an operator (state “SUBSTITUTED”, value defined by the operator). The measurement stays in this state until he un-substitutes it.

When a measurement is substituted, no change of value nor state is transmitted, and computations are made with the substituted state. When the measurement is un-substituted, the actual state and value are transmitted to higher control levels and subsequent changes of state and value are transmitted again.

7.3.3 FORCING AN INVALID MEASUREMENT

When a measurement is invalid: that is, SELFCHECK FAULTY, UNDEFINED, OPEN CIRCUIT, SATURATED or UNKNOWN); it can be manually forced by a user (state “FORCED”, value defined by the operator). This feature is similar to the substitution, but the information is automatically updated when valid information is available again.

The forcing could also be automatic: in this event, the invalid information takes automatically the FORCED state and the value defined in configuration.

The forced/substituted data are saved in SRAM (kept for minimum 48h without C26x power supply).

The modified states are not reset by a C26x reboot.

A database switch (or evolution) reset the forced/substituted data.

7.4 MEASUREMENT RESULTING STATES

The Measurement resulting states, following the various filters, that you can apply include:

State	Meaning
VALID	Not in one of the following states
SELFCHECK FAULTY	AI, DI board fault
SUBSTITUTED	Operator action set MV value as valid state
FORCED	Automatic valid state and configured value when AI is invalid
SUPPRESSED	Operator set MV in this invalid state
UNKNOWN	MV is acquired via a transmission link, and the link is disconnected
SATURATED	MV is beyond its nominal input range
UNDEFINED	MV is Digital Measurement with invalid coding or computation on analogue leads to error
OPEN CIRCUIT	MV is DC 4-20 mA with input value under 4mA
OVERSHOOT[1..3]	One of the 3 overshoot thresholds has been crossed
UNDERSHOOT[1..3]	One of the 3 undershoot thresholds has been crossed

Note:
For AI acquisition, the AUI2xx can distinguish a SATURATION status from an input channel, and transmit a specific status bit on the C26x I/O bus. The C26x transmits an "OUT OF RANGE" status, compliant with the CT/VT or SV state.

7.4.1 TRANSMISSION

The measurement value and state are transmitted on the Ethernet IEC 61850 network, using two modes:

- **Report based mode** (client-server): the measurement is transmitted to the subscribers with its value, its status, its time stamping and the reason for change.
- **GOOSE based mode (only on IEC 61850-8-1 network)** (subscriber-publisher): the measurement is transmitted in multicast to the configured receivers.

Notes

- A C26x client can have 150 numbers of IEC 61850-8-1 servers and a C26x server can have 20 numbers of IEC 61850-8-1 clients
- GOOSE size is restricted to 128 binary inputs and 64 measurements

7.4.1.1 DOWNGRADED MODE (COMMUNICATIONS LOSS)

During a loss of communication between a client and a server, all server measurements are set to UNKNOWN on the client.

Quality change of measurement

In case of a quality of measurement changes, for trigger or deadband or cyclic transmission modes :

- quality changes (VALID to INVALID) on a measurement value (MV) among the group cause the immediate transmission of the MV, outside the GROUP
- quality change (INVALID to VALID) on the same measurement value (MV) cause the immediate transmission of the MV, outside the GROUP

Note:
INVALID: refers to "measurements resulting state" description
GROUP: group(s) of measurement values (MV), transmitted by trigger/deadband/cyclic transmission modes

7.4.1.2 MEASUREMENTS TRANSMITTED IN REPORTS

The measurement information transmitted in a report includes:

- The real value: that is, after scaling
- The resulting state: mapped on the quality field on IEC 61850-8-1
- The time stamping: in GMT time; and time quality
- The reason for the change:
  - Change of quality: set if the measurement resulting state has changed
  - Cyclic change: set if the measured value has changed, without modification of the resulting state
- The Operating mode (‘test’ tag)

7.4.1.3 MEASUREMENTS TRANSMITTED IN GOOSE

The measurement information transmitted in a **GOOSE** is the same than in a report, except for the "reason for change" and the time-stamping.

7.4.1.4 TRANSMISSION OF RESULTING STATES

All **resulting state** changes are always transmitted. A measurement value can be transmitted **periodically, on trigger** or **upon variation**. All other **stVal/q** combinations are managed as UNKNOWN by IEC 61850 Clients.

Server	Data over IEC 61850		Client
Current State (C26x)	**Range**	**Quality**	**Resulting state (C26x - aView - Gateway)**
VALID	0	All bits to 0 (0x0000)	VALID
SELFCHECK FAULT	0	b1=1, b6=1, other bits to 0 (0x4200)	SELFCHECK FAULT
N/A(1)	0	b1=1, other bits to 0 (0x4000)	
UNKNOWN	0	b0=1, b1=1, b7=1, other bits to 0 (0xC100)	UNKNOWN
SUPPRESSED	0	b14=1, other bits to 0 (0x0002)	SUPPRESSED
FORCED	0	b13=1, other bits to 0 (0x0004)	FORCED
SUBSTITUED	0	b10=1, other bits to 0 (0x0020)	SUBSTITUED
OUT OF RANGE	0	b1=1, b2=1, other bits to 0 (0x6000)	OUT OF RANGE
FIRST LOW THRESHOLD VIOLATION (L)	2	b1=1, b3=1, other bits to 0 (0x5000)	FIRST LOW THRESHOLD VIOLATION
SECOND LOW THRESHOLD VIOLATION (LL)	4	b1=1, b3=1, other bits to 0 (0x5000)	SECOND LOW THRESHOLD VIOLATION
THIRD LOW THRESHOLD VIOLATION (LLL)	-2	b1=1, b4=1, other bits to 0 (0x2400)	THIRD LOW THRESHOLD VIOLATION
FIRST HIGH THRESHOLD VIOLATION (H)	1	b1=1, b3=1, other bits to 0 (0x5000)	FIRST HIGH THRESHOLD VIOLATION
SECOND HIGH THRESHOLD VIOLATION (HH)	3	b1=1, b3=1, other bits to 0 (0x5000)	SECOND HIGH THRESHOLD VIOLATION
THIRD HIGH THRESHOLD VIOLATION (HHH)	-1	b1=1, b4=1, other bits to 0 (0x2400)	THIRD HIGH THRESHOLD VIOLATION
UNDEFINED	0	b1=1, b8=1, other bits to 0 (0x4080)	UNDEFINED
OPEN CIRCUIT	0	b1=1, b9=1, other bits to 0 (0x4040)	OPEN CIRCUIT

(1) N/A: Not Applicable (the data transmitted over IEC 61850 do not match with a current status of a C26x. Those **stVal/q** values could be transmitted by another type of IEC 61850 Server).

7.4.1.5 PERIODIC TRANSMISSION

A Measurement Value can be transmitted periodically or upon variation (% of nominal), and anyway on state change.

Two periods are defined in database, independently for each C26x:

- a short period, settable from *0* to *60* seconds (step 0.1 second),
- a long period, defined as an integer multiple of the short period, from *0* to *600* x the short period's duration.

Setting a period to *0* means periodic transmission is disabled:

- for both short and long periods if it is the short period
- for the long period only if it is the only one set to *0*

Each measurement is associated with either one of the two periods. All the measurements associated with a period are transmitted at the beginning of each cycle.

All the measurements values transmitted within one transmission cycle are the most recently acquired values.

7.4.1.6 TRANSMISSION UPON VARIATION

Measurements can be transmitted upon variation: a value is sent if the acquired value (Vacq) is different from more than a specified amount **ΔV** from the previously transmitted value (**Vt**) (i.e. |Vacq-Vt| > ΔV).

ΔV is computed either as a

- ‰ of the current value (last transmitted value):

  $\Delta V = (p/1000) * |V_t|$
  where
  - **p** is the deadband, with a value in the range 0 .. 255
  - $\mathbf{V_t}$ is the last transmitted measurement value.

or as a

- ‰ of the full-scale value:

  $\Delta V = (p/1000) * |V_{max} - V_{min}|$
  where
  - **p** the deadband, with a value in the range 0 .. 255
  - $\mathbf{V_{max}}$ is the maximum value defined in Values Features of measurement (MV)
  - $\mathbf{V_{min}}$ is the minimum value defined in Values Features of measurement (MV)

7.4.1.7 TRANSMISSION UPON TRIGGER

In addition to the periodic or variation-initiated transmission modes, one or several measurement values (MV) can be associated with a "trigger".

Only rising edge triggers are managed by DS Agile. The trigger automatically drops off is automatic after the transmission.

The following triggers are available:

Datapoint	Condition(s) of trigger pick-up
SPS	SET state, FORCED SET state, SUBSTITUED SET state
DPS	CLOSED state, FORCED CLOSED state, SUBSTITUTED CLOSED state

Trigger Control

The trigger(s) can be:

- wired to a digital input channel (DI)
- generated by an automation (FBD, PLC)
- activated by an operator action (aView)

On trigger rising edge, the measurement value(s) (MV) associated with this trigger is/are transmitted immediately.

At C26x boot

If the trigger is RAISED at the initialisation of the C26x, the associated measurement value(s) (MV) is/are transmitted immediately after the end of C26x initialization time.

Steady state

As long as the trigger is RAISED, the associated measurement value(s) (MV) is/are transmitted:

- in case of a **state change** (refer to the "Resulting states" list description)
- according to their **transmission on event** mode configuration(s) (periodic according its cycle or upon variation) C26x

7.4.1.8 MEASUREMENTS MANAGED BY THE C26X UNIT

Ref.	Label	Measurement type	Star wiring	Delta wiring	Unit	TMU 220	SV
Standard analog measurements							
0	VAN	RMS value of the voltage phase B	measured	not available	Volts	Yes	Yes
1	VBN	RMS value of the voltage phase B	measured	not available	Volts	Yes	Yes
2	VCN	RMS value of the voltage phase C	measured	not available	Volts	Yes	Yes
3	Vr	RMS value of neutral voltage	derived	not available	Volts	Yes	Yes
4	VAB	RMS value of the voltage phase AB	derived	measured	Volts	Yes	Yes
5	VBC	RMS value of the voltage phase BC	derived	measured	Volts	Yes	Yes
6	VCA	RMS value of the voltage phase CA	derived	measured	Volts	Yes	Yes
7	IA	RMS value of the current phase A	measured	measured	Amps	Yes	Yes
8	IB	RMS value of the current phase B	measured	measured	Amps	Yes	Yes
9	IC	RMS value of the current phase C	measured	measured	Amps	Yes	Yes
10	Ir	RMS value of the neutral current	derived	derived	Amps	Yes	Yes
11	PA	Active power phase A	measured	Not available	W	Yes	No
12	QA	Reactive power phase A	measured	Not available	VAR	Yes	No
13	SA	Apparent power phase A	derived	Not available	VA	Yes	No
14	cosφA	Power factor phase A	derived	Not available	#	Yes	No
15	φA	Phase angle phase A	derived	Not available	Degree	Yes	No
16	PB	Active power phase B	measured	Not available	W	Yes	No
17	QB	Reactive power phase B	measured	Not available	VAR	Yes	No
18	SB	Apparent power phase B	derived	Not available	VA	Yes	No
19	cosφB	Power factor phase B	derived	Not available	#	Yes	No
20	φB	Phase angle phase B	derived	Not available	Degree	Yes	No
21	PC	Active power phase C	measured	Not available	W	Yes	No
22	QC	Reactive power phase C	measured	Not available	VAR	Yes	No
23	SC	Apparent power phase C	derived	Not available	VA	Yes	No
24	cosφC	Power factor phase C	derived	Not available	#	Yes	No
25	φC	Phase angle phase C	derived	Not available	Degree	Yes	No
26	Pt	Total active power	derived	derived	W	Yes	Yes
27	Qt	Total reactive power	derived	derived	VAR	Yes	Yes
28	St	Total apparent power	derived	derived	VA	Yes	No
29	cosφt	Total power factor	derived	derived	#	Yes	Yes
30	φt	Total phase angle	derived	derived	Degree	Yes	No
31	Pr	Active power	measured	Not available	W	Yes	No
32	Qr	Reactive power	measured	Not available	VAR	Yes	No
33	Sr	Apparent power	derived	Not available	VA	Yes	No
34	cosφr	Power factor	derived	Not available	#	Yes	No
35	φr	Phase angle	derived	Not available	Degree	Yes	No
36	Fn	Network frequency (related to reference phase side)	derived	derived	Hertz	Yes	Yes
Measurements for standard Synchrocheck							
37	ΔF	Frequency difference	derived	derived	Hertz	Yes	No
38	ΔV	Voltage difference	derived	derived	Volts	Yes	No
39	Δφ	Phase difference	derived	derived	Degree	Yes	No

Ref.	Label	Measurement type	Star wiring	Delta wiring	Unit	TMU 220	SV
Harmonics levels							
40 to 53	h2vA to h15vA	Ratio harmonic 2 to 15 / fundamental voltage phase A	DFT	DFT	Volts	Yes	No
54	THD Va	Distortion rate voltage phase A	DFT	DFT	%	Yes	No
55 to 68	h2vB to h15vB	Ratio harmonic 2 to 15 / fundamental voltage phase B	DFT	DFT	Volts	Yes	No
69	THD Vb	Distortion rate voltage phase B	DFT	DFT	%	Yes	No
70 to 83	h2vC to h15vC	Ratio harmonic 2 to 15 / fundamental voltage phase C	DFT	DFT	Volts	Yes	No
84	THD Vc	Distortion rate voltage phase C	DFT	DFT	%	Yes	No
85 to 98	h2UAB to h15UAB	Ratio harmonic 2 to 15 / fundamental voltage phase AB	DFT	DFT	Volts	Yes	No
99	THD Vab	Distortion rate voltage phase AB	DFT	DFT	%	Yes	No
100 to 113	h2UBC to hU15BC	Ratio harmonic 2 to 15 / fundamental voltage phase BC	DFT	DFT	Volts	Yes	No
114	THD Vbc	Distortion rate voltage phase BC	DFT	DFT	%	Yes	No
115 to 128	h2UCA to h15UCA	ratio harmonic 2 / fundamental voltage phase CA	DFT	DFT	Volts	Yes	No
129	THD Vca	Distortion rate voltage phase CA	DFT	DFT	%	Yes	No
130 to 143	h2IA to h15IA	ratio harmonic 2 to 15 / fundamental current phase A	DFT	DFT	Amps	Yes	No
144	THD Ia	Distortion rate current phase A	DFT	DFT	%	Yes	No
145 to 158	h2IB to h15IB	ratio harmonic 2 to 15 / fundamental current phase B	DFT	DFT	Amps	Yes	No
159	THD Ib	Distortion rate current phase B	DFT	DFT	%	Yes	No
160 to 173	h2IC to h15IC	ratio harmonic 2 to 15 / fundamental current phase C	DFT	DFT	Amps	Yes	No
174	THD Ic	Distortion rate current phase C	DFT	DFT	%	Yes	No
Phase sequence							
175	Vnps	Direct component of the voltage	DFT derived	not available	V	Yes	No
176	Vpps	Inverse component of the voltage	DFT derived	not available	V	Yes	No
177	Vzps	Homopolar component of the voltage	DFT derived	not available	V	Yes	No
178	Vnpr	Vnps / (Vnps+Vpps) ratio	DFT derived	not available	%	Yes	No
179	Inps	Direct component of the current	DFT derived	DFT derived	A	Yes	No
181	Izps	Homopolar component of the current	DFT derived	not available	V	Yes	No
182	Inpr	Inps / (Inps+Ipps) ratio	DFT derived	DFT derived	%	Yes	No
Specific measurement (synchrocheck, protection functions, ...)							
183	Vbusbar 1	RMS value of the busbar voltage (Phase-to-Neutral)	measured	Not available	V	Yes	Yes
184	Ibusbar	RMS value of the busbar current phase (In)	measured	measured	A	Yes	No
185	Vbusbar 2	RMS value of the busbar voltage (Phase-to-Neutral)	measured	Not available	V	Yes	No
186		Fundamental voltage phase A			V	Yes	No
187		Fundamental voltage phase B			V	Yes	No
188		Fundamental voltage phase C			V	Yes	No
189		Fundamental current phase A			A	Yes	No
190		Fundamental current phase B			A	Yes	No
191		Fundamental current phase C			A	Yes	No

Ref.	Label	Measurement type	Star wiring	Delta wiring	Unit	TMU 220	SV
Synchrocheck type 1, 4							
192	dV	Signed dV			V	Yes	Yes
193	dF	Signed dF			Hertz	Yes	Yes
194	dPhi	Signed dPhi			Degree	Yes	Yes
Other measurements							
300	mod_Ia	Complex module of current Ia			A	No	No
301	mod_Ib	Complex module of current Ib			A	No	No
302	mod_Ic	Complex module of current Ic			A	No	No
303	mod_Io	Complex module of current Io			A	No	No
304	mod_Vab	Complex module of voltage Vab			V	No	No
305	mod_Vbc	Complex module of voltage Vbc			V	No	No
306	mod_Vca	Complex module of voltage Vca			V	No	No
307	mod_Vo	Complex module of voltage Vo			V	No	No
312		Thermal status			%	No	No
313	Irc	Computed residual current			A	No	Yes
320		Phase difference Ia / Ubc			Degree	No	Yes
321		Phase difference Ib / Uca			Degree	No	Yes
322		Phase difference Ic / Uab			Degree	No	Yes
Automatic Voltage Regulation (AVR)							
340		Phase difference Ia / Va for AVR			Degree	Yes	Yes
341		Phase difference Ib / Vb for AVR			Degree	Yes	Yes
342		Phase difference Ic / Vc for AVR			Degree	Yes	Yes
343		Phase difference Iab / Uab for AVR			Degree	Yes	Yes
344		Phase difference Ibc / Ubc for AVR			Degree	Yes	Yes
345		Phase difference Ica / Uca for AVR			Degree	Yes	Yes
346	IAB	RMS value of the current phase AB			A	Yes	Yes
347	IBC	RMS value of the current phase BC			A	Yes	Yes
348	ICA	RMS value of the current phase CA			A	Yes	Yes
Synchrocheck ARS							
350	ARS	ARS phase deviation	derived	derived	Degree	No	Yes
Fresnel diagram vectors							
360	ρVA	Complex module of voltage VA (eff. value * √2)	measured	not available	V	Yes	Yes
361	ΘVA	Complex argument of voltage VA-phaseRef	derived	not available	Degree	Yes	Yes
362	ρVB	Complex module of voltage VB (eff. value * √2)	measured	not available	V	Yes	Yes
363	ΘVB	Complex argument of voltage VB-phaseRef	derived	not available	Degree	Yes	Yes
364	ρVC	Complex module of voltage VC (eff. value * √2)	measured	not available	V	Yes	Yes
365	ΘVC	Complex argument of voltage VC-phaseRef	derived	not available	Degree	Yes	Yes

Ref.	Label	Measurement type	Star wiring	Delta wiring	Unit	TMU 220	SV
366	ρVN	Complex module of voltage VN (eff. value * √2)	measured	not available	V	Yes	Yes
367	ΘVN	Complex argument of voltage VN-phaseRef	derived	not available	Degree	Yes	Yes
368	ρIA	Complex module of current IA (eff. value * √2)	measured	not available	A	Yes	Yes
369	ΘIA	Complex argument of current IA-phaseRef	derived	not available	Degree	Yes	Yes
370	ρIB	Complex module of current IB (eff. value * √2)	measured	not available	A	Yes	Yes
371	ΘIB	Complex argument of current IB-phaseRef	derived	not available	Degree	Yes	Yes
372	ρIC	Complex module of current IC (eff. value * √2)	measured	not available	A	Yes	Yes
373	ΘIC	Complex argument of current IC-phaseRef	derived	not available	Degree	Yes	Yes
374	ρIN	Complex module of current IN (eff. value * √2)	measured	not available	A	Yes	Yes
375	ΘIN	Complex argument of current IN -phaseRef	derived	not available	Degree	Yes	Yes

7.5 TAP POSITION INDICATION (TPI) MEASUREMENT PROCESSING

7.5.1 ACQUISITION FROM DIGITAL INPUTS

The tap position is acquired on digital input boards. It could be:

- A Multiple Point, if so, the resulting states are considered as values
- A digital measurement using one of the following encoding:
  - Decimal
  - Gray
  - BCD

7.5.2 ACQUISITION FROM ANALOGUE INPUTS

The tap position is acquired by measuring a current input.

A minimum value, Imin (mA), corresponds to the lowest position, 1, of the tap, and a maximum value, Imax, corresponds to the highest value, N.

The input current should take only discrete values: Ik =Imin + (K -1)(Imax-Imin)/(N-1) , where K is the position of the tap.

However, the tap is assumed in position K if the current is in the range [Ik-ΔI/2 .. Ik+ΔI/2], with ΔI = N% of (Imax – Imin). The N percentage is defined in configuration.

The tap position is considered UNDEFINED outside of this range.

7.5.3 MANUAL SUPPRESSION

A TPI can be suppressed by an order issued from an operator. No subsequent change of value or state on a suppressed TPI can trigger any action: for example, display, alarm, transmission. The TPI takes the “SUPPRESSED” state. When the operator unsuppresses the TPI, the latter takes its actual state.

7.5.4 SUBSTITUTION

The value of a TPI can be substitute by an operator (state “SUBSTITUTED”, value defined by the operator). The TPI stays in this state until he unsubstitutes it.

When a TPI is substituted, no changes of value nor state is transmitted, and computations, for instance groupings, are made with the substituted state. When the TPI is unsubstituted, the actual state and value are transmitted to higher control levels and subsequent changes of state and value are transmitted again.

7.5.5 FORCING AN INVALID TPI

When a TPI is invalid: that is, SELFCHECK FAULTY, UNDEFINED or UNKNOWN; it can be manually forced by a user (the “FORCED” state value is defined by the operator). This feature is similar to substitution but the indication is automatically updated when valid information is available again.

The automatic forcing function is not provided for TPI.

7.5.6 TPI RESULTING STATES

The state of a tap position can be:

State	Comment
VALID	NOT in one of the following states:
SELFCHECK FAULTY	Results from a fault on an AI board or on a DI board
SUBSTITUTED	See section Substitution above
FORCED	See section Forcing an invalid TPI above
SUPPRESSED	See section Manual suppression above
UNKNOWN	If the tap position is acquired via a transmission link, the information is “unknown” when the link is disconnected.
UNDEFINED	Results from the erroneous encoding of a digital acquisition, a saturation, an open circuit or an out-of-range value for an analogue acquisition.
OVERSHOOT[1..3]	There are 3 “Overshoot” states, one for each high threshold crossing. Only one may be set at any one time
UNDERSHOOT[1..3]	There are 3 “Undershoot” states, one for each low threshold crossing. Only one may be set at any one time

7.5.7 SCALING

The TPI value is transmitted as a scaled value rather than as a direct measurement.

The true value of the measurement is computed using a linear, single-slope transform:

TPI value = **ax + b**

where:

- x = measured tap position
- a and b = integer numbers, settable using DS Agile SCE (see chapter C26x/EN AP).

The scaled value is transmitted to the substation’s control point (DS Agile aView) and to the SCADA.

7.5.8 TRANSMISSION

The TPIs are transmitted on a client-server basis over the IEC 61850 network using the report mechanism.

During a loss of communication between a client and a server, all server TPIs are set to UNKNOWN on the client.

A TPI is transmitted as soon as a value change or a status change is detected. The TPIs transmitted in a report are:

- TPI value
- Resulting state: mapped on the quality field for IEC 61850
- Time-stamping: in GMT time; and time quality
- Reason for the change:
  - Change of data: set if the value changed
  - Change of quality: set if the quality changed
  - Change due to control: set if the state or quality change is due to a control

The TPI information transmitted in a GOOSE is the same as in a report, except for the "reason for change" and time-stamping.

7.6 ACCUMULATOR INPUT PROCESSING

The accumulator stores its current value in a static memory volatile memory (secured with a capacitor, >48h autonomy). At configured sample an accumulated value is extracted for inner computation and transmission (Common Data Class BCR on IEC 61850-8-1).

Digital Inputs are used to count pulses. There is Single counter (SCT) based on one DI and Double Counter (DCT) based on two DIs that count complementary states.

At processing level special persistent and complementary filters eliminate non-stable pulses. The integer counter (also transmitted) can be scaled (among of energy of valid pulse).

7.7 ENERGY COUNTING

Leading and lagging current are phenomena that occur as a result of alternating current.

In an AC circuit, the current and voltage do not peak at the same time but vary sinusoidally.

In electric power flow, it is important to know how much current is leading or lagging because it creates the reactive power in the system, as opposed to the active (real) power.

The energy counting function aims to calculate exported & imported active energy (in Wh) and exported & imported reactive energy (in Varh) from active and reactive power issued from CT/VT calculation, digital, analogue boards measurements or measurement IEDs.

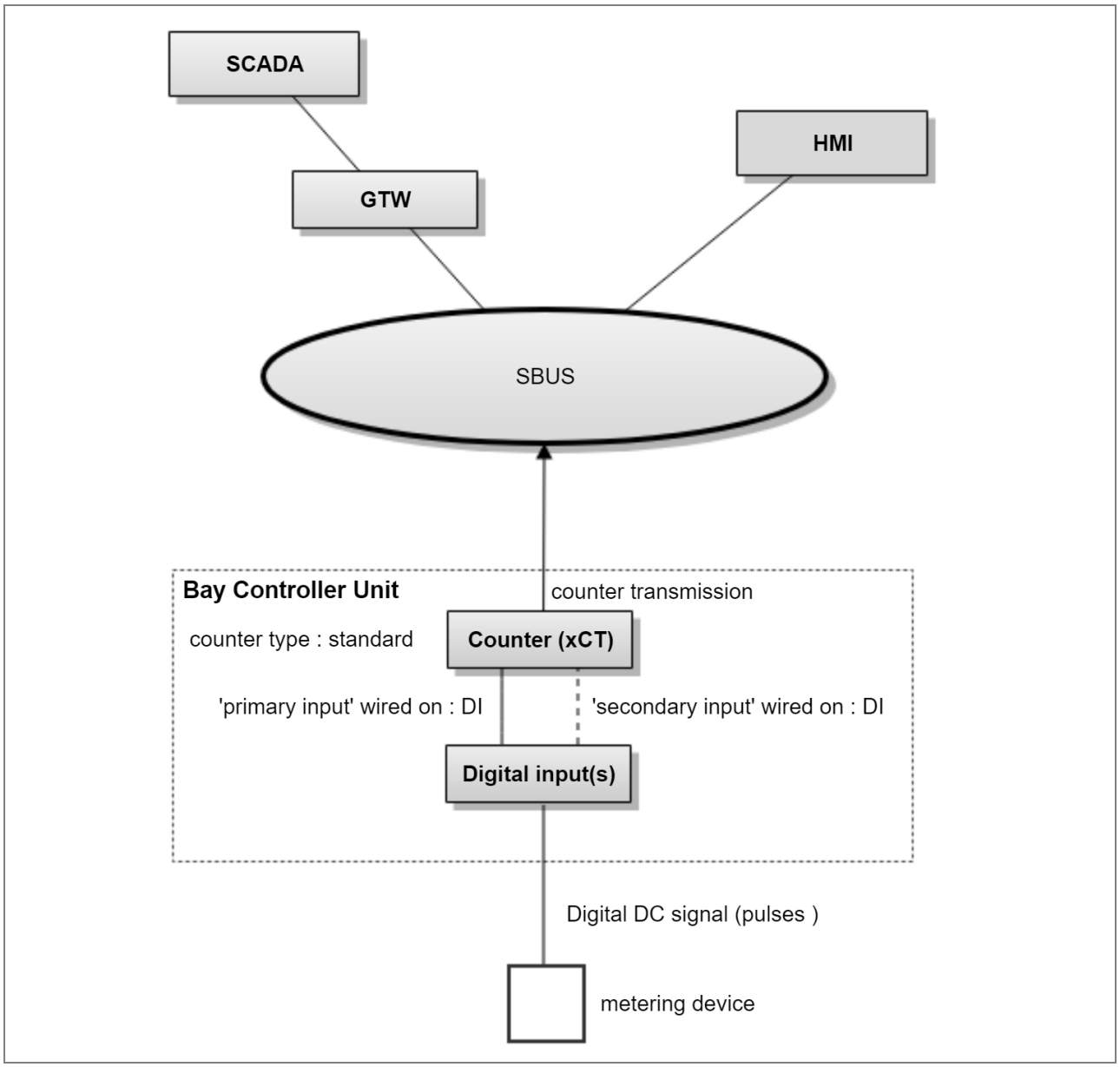
The energy flow may be defined at:

- acquisition module level (TMU2xx board) by configuring the **Power Flow mode**.
- counter level by configuring the counter and the energy type.

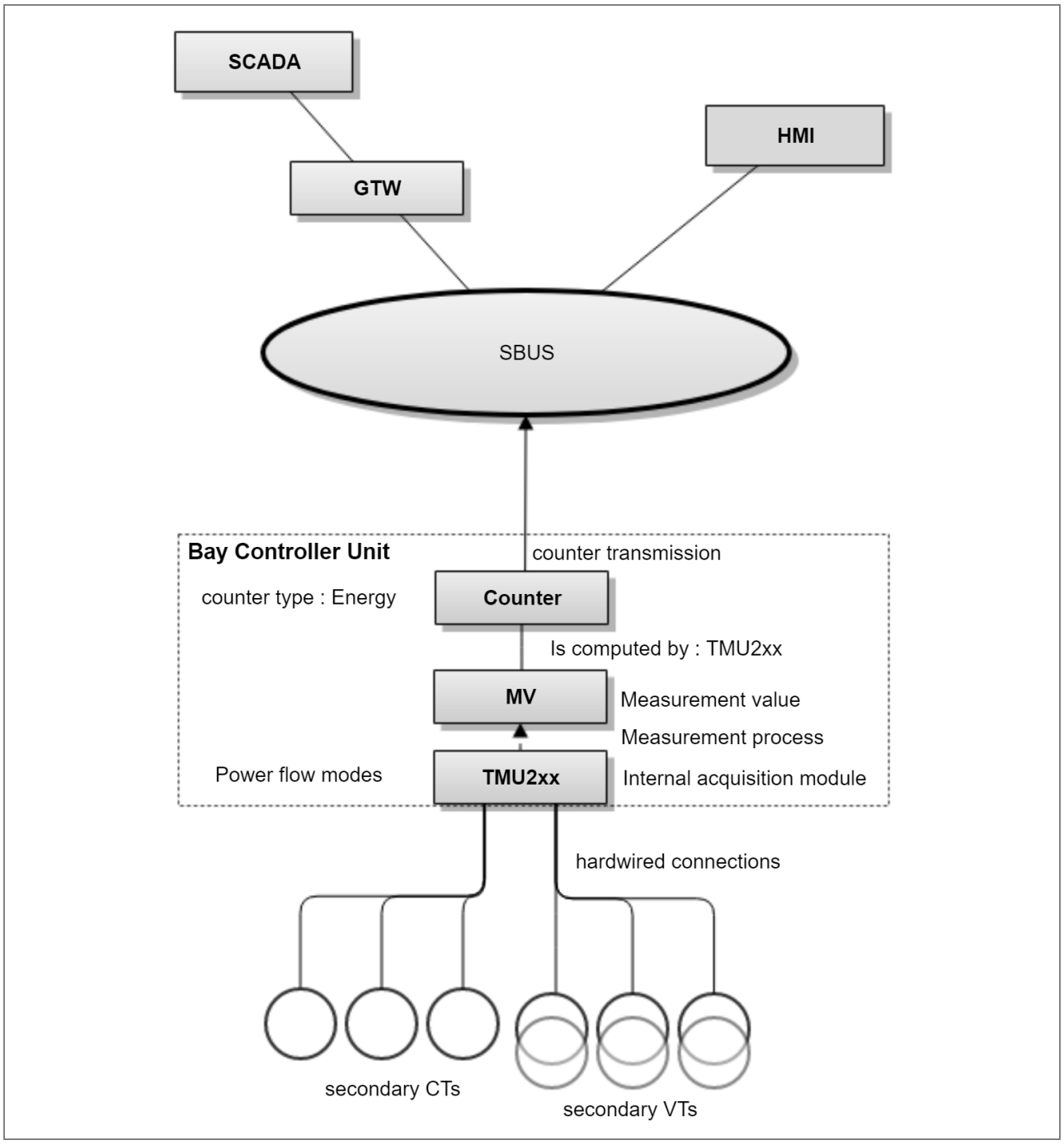
Different types of counters are used in DS Agile:

- **Standard Counters**
- **Energy Counters**

Standard counters are used when **energy** quantity is issued from an external metering device providing calibrated pulses via DC signals:



Energy counters are used when **power** quantity is issued from an internal acquisition module (TMU210 or TMU220) through measurement value (MV).



Energy counters manage different power flow directions: **import** or **export**. This information is set at configuration level, in the general counter's attributes.

When power is measured by an analogue acquisition module (TMU2xx) or an external Merging Unit (MU), the "**power flow mode**" defined at module configuration level determinates the sign of active and reactive powers. The energy sign is adapted by software to represent a positive energy counter, whatever the direction of power flow.

Energy counters manage different energy types:

- **active energy** (P), expressed in Wh, KWh, MWh depending on the energy measured. This is the power actually consuming.
- **reactive power** (Q), expressed in Varh, Kvarh, Mvarh depending on the energy measured. This power is stored in components, then released again back to the source through the AC cycle.

The energy measured is set at configuration level, in the general counter's attributes.

The choice of this attribute depends on the relation with power measurement:

- "**Active energy**" for a relation with Measurement "power Px" (x = A, B, C or Total)
- "**Reactive energy**" for a relation with Measurement "power Qx" (x = A, B, C or Total)

7.7.1 ACQUISITION PROCESS

The energies are transmitted on a client-server basis on the Station Bus using the same mechanisms as the counters.

Values of energy counters are transmitted on a client-server basis on the IEC 61850-8-1 network using mechanism through the LN **MMTR**.

Energy counters can be updated by different inputs:

Measurement Device	Transmission Mode	Relation with Counter	Power Flow Mode
External metering IED	Energy digital pulses	Single Counter (SCT) or Double Counter (DCT)	Up to 4 energy counters, without energy quadrant selection
Internal analogue acquisition module (TMU220, TMU210)	Power values	Measurement Value (MV)	Energy quadrant configured on TMU attributes

During a loss of communication between a client and a server, all server energy counters are set to UNKNOWN state on the client.

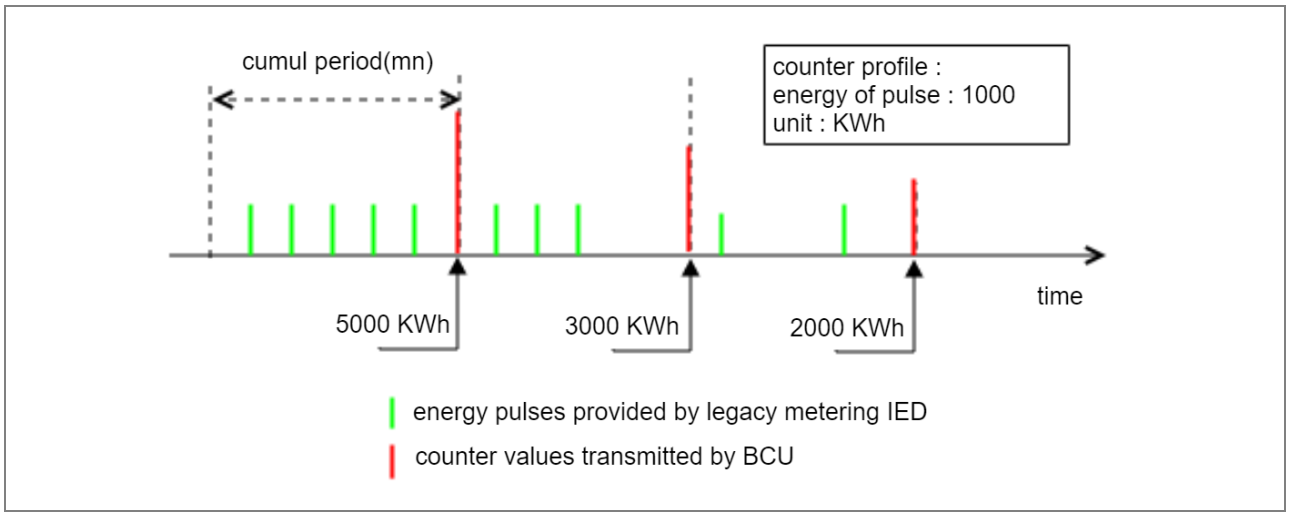
7.7.1.1 STANDARD COUNTERS

At configuration level, "standard" counters use a "**primary input**" relation wired to one DI input (SCT counter), and optionally a "**secondary input**" wired to another DI input (DCT counter).

The quantity of **energy** defined by each pulse is configured in the counter‘s "used profile".

At bay controller level (C264), the transmitted energy value is the sum of the "**pulses * energy of pulse**" during the cumulative period.

- When the attribute "**IED value already totalized**" is set to "**No**":
  - at each cumulative period, the C264 transmits the sum of energy pulse(s) transmitted by the IED during the period. The "energy of pulse" represents the value of each pulse.
- When the attribute "**IED value already totalized**" is set to "**Yes**":
  - at each cumulative period, the C264 transmits the energy value totalized by the IED. The "energy of pulse" shall be in accordance with the cumulative value of energy.

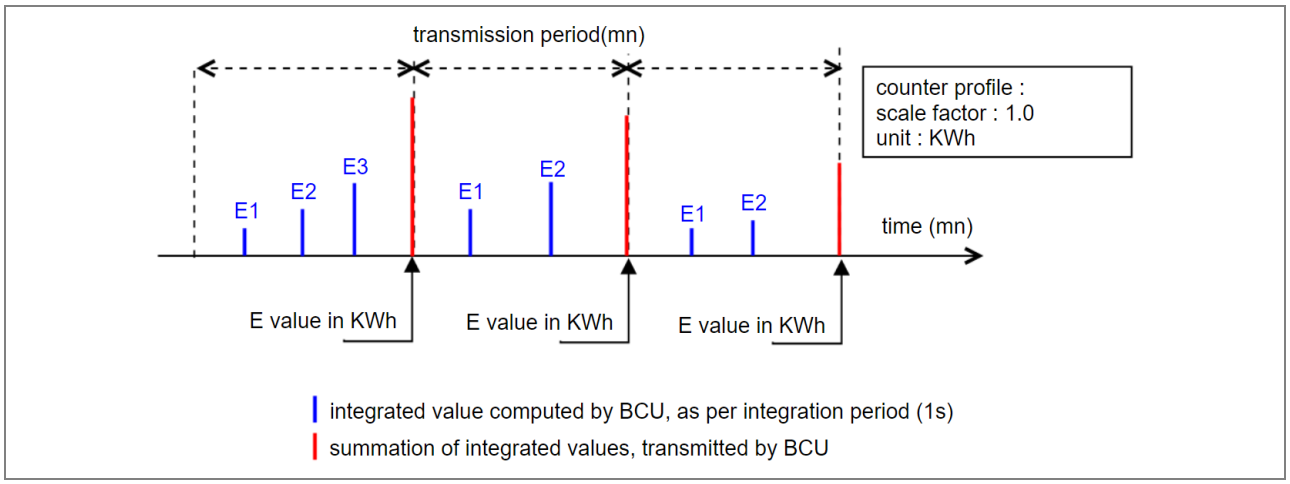


7.7.1.2 ENERGY COUNTERS

When power is measured by an analog acquisition module (TMU2xx) or an external Merging Unit (MU), **Energy** counters use the "**integrates : MV electrical datapoint**" relation.

The value is multiplied by the "**scale factor**" value set at configuration level, depending on CT and VT secondary/primary ratio.

The energy measurement "unit" is defined at counter profile level.



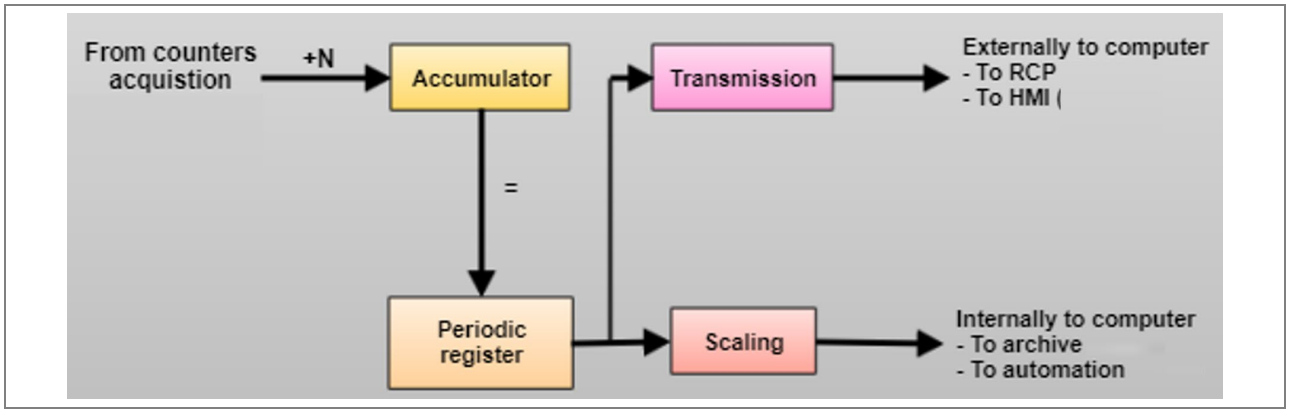
7.7.2 ENERGY COUNTER PROCESSING

Calculation of the energy is done periodically. The period is defined by the internal clock of the controller. The choice of the origin of the periodic signal is defined during the configuration phase on a per controller basis. Whatever is the origin of an integrated measurement, the integration is done after scaling with a step of one second.

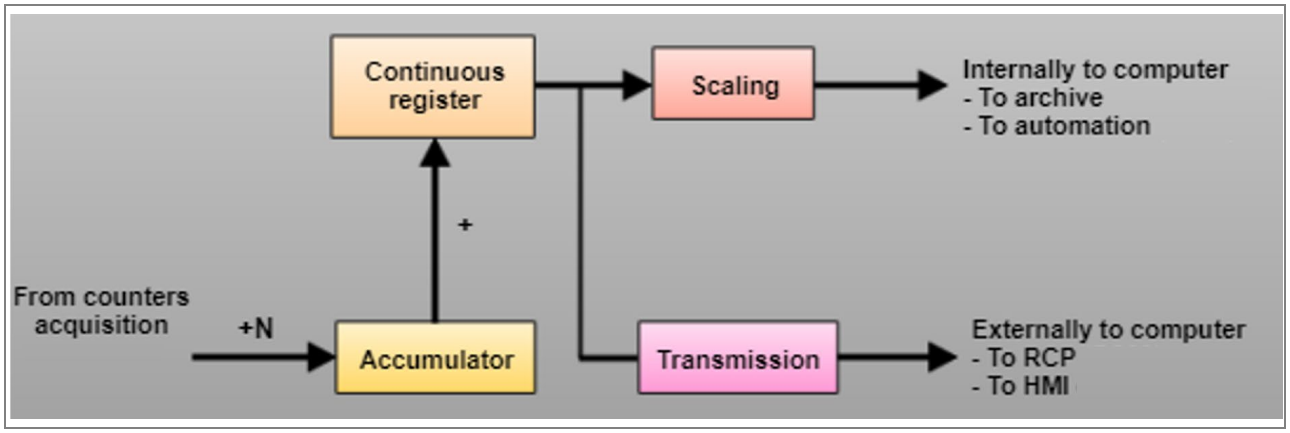
An interpolated point is calculated between 2 measured values. A time extrapolation is made to define the value in energy in hours each second (Wh or VARh).

When power is measured by an analogue acquisition module (TMU2xx) or an external Merging Unit (MU), if the "**reset after transmission period**" attributes is set to "**Yes**", the transmitted counter value is the sum of the integrated values computed during each "**transmission period (mn)**" defined at configuration level.

- With **reset after transmission**:
  - The "accumulator" is incremented at each VALID counter pulse.
  - For **already totalized** counter, the accumulator's value is equal to value reported by IED.
  - The "**periodic register**" is used to store the accumulator's value of each periodic cycle.



- Without **reset after transmission**:
  - The "accumulator" is incremented at each VALID counter pulse.
  - For already totalized counter, the accumulator's value is equal to value reported by IED.
  - The "continuous register" is used to store all the accumulator's values since the origin.



7.7.3 SCALING FACTOR

The energies integrated by the Bay Controller Unit (BCU) are computed in secondary CT/VT values.

To transmit the amount of energy in primary value, it is necessary to add a linearization method of power measurands.

To determinate the ratio primary/secondary of voltage, the primary voltage value, the secondary voltage value expressed at TMU2xx or SV module in V and the type of connection (star or delta) set at configuration level are used.

7.7.4 ENERGY COUNTER TRANSMISSION

The energy counters values are integrated with measurement values (MV), updated by the C26X post-processing.

In case of internal power measurement made by an analogue acquisition module (TMU2xx) or by external Merging Unit (MU), the integration can be done only after receiving two consecutive valid values with the same sign of the measurement. The integration result is added to the associated export or import counter according to the sign of the measurement.

The integration is stopped as soon as the power measurement becomes invalid or changes of sign. The integration is restarted as soon as two consecutive valid measurement values with the same sign are received.

Integrated values are transmitted with INVALID value set to 0.0 at C264 startup or reboot. After rebooting, a new integration period is started and new counter values are transmitted at the end of the transmission period. Values containing MV with a different time stamp are transmitted with INVALID value set to 0.0.

7.7.5 LIMITATIONS

The IEC61850-9.2LE Sample Values cannot be used for Energy counters.

Note:
Do not use the energy counter values for the billing application.

7.8 BASIC DATA HANDLING

7.8.1 TEST MODE

The C26x Test Mode allows you to deactivate the DOU/CCU/HBU relays output in the event of a control sequence.

This feature makes it possible to:

- manage the Test or Test/Blocked mode upon the operator's request
- manage the control feedback datapoints

In the event of a controller redundancy, the Test or Test/Blocked mode activation is performed independently for each C26x (Main 1 rack and Main 2 rack) from SMT. If the Active C26x is set to Test, On-Blocked or Test Blocked mode, it remains Active. A Standby C26x cannot be switched to On-Blocked, Test & Test-Blocked mode. The A Standby C26x keeps its current mode.

If the control is related to a datapoint: that is, feedback datapoint defined in configuration; this one takes the control value in Test Mode:

- Open / Reset order => Open state for DPS, Reset state for SPS
- Close / Set order => Close state for DPS, Set state for SPS

Test mode management

The C26x Test/Blocked mode can be changed from the C26x front panel (LHMI) or via the SMT.

The operator can also use the 'Operating Mode' Setpoint or IEC 61850 address LD0\LLN0\Mod to change the Test/Blocked mode of C26X at HMI level (AVIEW).

To leave the Test/Blocked mode, the user, through the SMT, changes the C26x mode to Operational. The C26x automatically goes in Maintenance mode (transient) before going in Operational mode.

The user of the Test or Test/Blocked mode owns all responsibility of controls performed during the Test/Blocked mode, and before leaving the Test/Blocked mode, he owns all responsibility to restore the system. In Test/Blocked Mode, all controls performed may impact IsaGRAF programs or PSL automatisms.

Note 1:
Digital and Analogue Setpoint with measurement feedback are not managed in Test Mode: that is, they are managed as in Operational mode.

Note 2:
IEC 61850-8-1 exchanges (reports, gooses) are not impacted by the C26x Test Mode. That means that a control done in Test Mode, that is sent to another controller - that is not in test mode - or to an IED (legacy or not) may be fully and physically executed on the device.

7.8.2 DEVICE ORDER RUNNING

An "order running" SPS is managed on a per module basis. The “bay order running” is still managed.

In the event of a Direct Execute control, this SPS is:

- SET as soon as the C26x accepts the control: that is, after the control checks
- RESET when the final control acknowledgement is sent

In the event of an SBO control, this SPS is:

- SET as soon as the C26x accepts the control selection: that is, after the selection checks
- RESET when the final control acknowledgement is sent

7.8.3 CURRENT EXECUTION STATUS SPS FOR OPEN/CLOSE CONTROL COMMANDS

Optional SPS datapoints are available to indicate the current execution status of switchgear open and close **DPC** control commands: **Open ctrl SPS** for open commands and **Close ctrl SPS** for close commands.

In the event of a Direct Execute control, this SPS is:

- SET as soon as the execute control is received by the C26x: that is, before the checks
- RESET when the final control acknowledgement is sent

In the event of an SBO control, this SPS is:

- SET as soon as the control selection is received by the C26x: that is, before the checks
- RESET when the final control acknowledgement is sent

In the event of a direct negative acknowledgement, these SPS may be SET, then RESET with the same time stamp.

7.8.4 OPEN/CLOSE COMMAND STATE SPS DATAPOINTS FOR C26X OUTPUT CONTACTS

Output contacts used to transmit SPC commands

One SPS is available to indicate the open and closed states of a contact. It can be assigned to SPC controls.

on/off order SPS:

- SET when the contact to which the operate command is wired is in closed position
- RESET when the contact to which the operate command is wired is in open position

Output contacts used to transmit DPC commands

Two SPS are available to indicate the open and closed states of contacts. They can be assigned to DPC controls.

Close order SPS:

- SET when the contact to which the close command is wired is in closed position
- RESET when the contact to which the close command is wired is in open position

Open order SPS:

- SET when the contact to which the open command is wired is in closed position
- RESET when the contact o which the open command is wired is in open position

Note:
These SPS datapoints reflect their associated SPC/DPC states only if the latter are "wired" to output contacts on a C26x.

7.8.5 CONTROLS MANAGEMENT FROM PSL

A control issued from a PSL (or a DI/DO association) will be accepted even if another control is already running on the same output. In this event, the previous control is stopped and the new control is launched (except if the new one is the same command as the previous one: in that case, the new control is refused).

There are three ways to manage this. PSL refers to FBD or DI/DO association, and Operator refers to IEC 61850-8-1 / ISAGRAF / local front panel HMI:

- Control 1 from PSL and Control 2 from Operator
- Control 1 from Operator and Control 2 from PSL
- Control 1 from PSL and Control 2 from PSL

The event "Control 1 from Operator and Control 2 from Operator" is already managed: in this event, the control 2 is rejected.

Events – Control 2 different from Control 1

Control 1	Control 2	Action	Acknowledgement
PSL	Operator	Control 1 cancelled	n/a (no ack managed in PSL)
Operator	PSL	Control 1 cancelled	Ack “Operator cancel”
PSL	PSL	Control 1 cancelled	n/a (no ack managed in PSL)
Operator	Operator	Control 2 ignored	Ack “Control in progress”

Events – Control 2 identical to Control 1

Control 1	Control 2	Action	Acknowledgement
PSL	Operator	Control 2 ignored	Ack “Control in progress”
Operator	PSL	Control 2 ignored	n/a (no ack managed in PSL)
PSL	PSL	Control 2 ignored	n/a (no ack managed in PSL)
Operator	Operator	Control 2 ignored	Ack “Control in progress”

7.8.6 CAVEAT: PSL (FBD) AND REDUNDANT OPERATION

C26x A is in active mode and C26x B is in standby mode. On aView, the operator uses C26x DI operation mimics and applies input to the PSL. After the Timer time (T-ON is equal to 20 seconds), these events occur:

The FBD output, an SPS on C26x A/B, goes to the SET position

- FBD output 1, an SPC wired on DO of A/B and looped to DI for feedback, goes to the SET position
- FBD output 2, an SPC wired on DO of A/B and looped to DI for feedback, goes to the SET position

When C26x B goes into active mode and C26x A goes into standby mode, these events occur:

- The FBD output 1 (SPC) and the FBD output 2 (SPC) stay in the SET position
- The FBD Output (SPS) goes to the RESET position for the Timer time (T-ON is equal to 20 seconds).

After this time, the FBD Output (SPS) goes to the SET position.

When you use DS Agile S1 to modify the time of the timer, the FBD Output (SPS) goes to the RESET position. It stays in the RESET position for the modified time and then goes to the SET position.

When C26x A goes into the Faulty mode and C26x B goes into the active mode, the FBD Output (SPS) goes to the RESET position for the duration equal to the Timer time. Then the FBD Output (SPS) goes to the SET position. The FBD Output 1 (SPC) and FBD Output 2 (SPC) stay in the SET position.

8 CONDITION MONITORING FUNCTIONS

The C26x includes comprehensive monitoring and control functionality.

Condition monitoring includes the following monitoring features:

- Circuit breaker monitoring
- Switchgear monitoring
- Tap Changer monitoring & Diverter Switch monitoring
- Low voltage motor monitoring & residual lifetime monitoring

8.1 GENERALITIES

8.1.1 BEHAVIOUR IN CASE OF EXTERNAL REQUESTS

Condition monitoring functions have specific behaviour in case of monitoring counter modification.

External requests, such as **OperCount Reset**, **SumSwar Reset**, **Abra Reset** or **OperTime Reset**, are rejected by the C264 if the real time status of the electrical device is:

- Circuit Breaker (Circuit breaker monitoring function): OPENING or CLOSING
- Switchgear (Switchgear monitoring function): OPENING or CLOSING
- Tap Changer / Diverter switch (Diverter Switch monitoring function): MOVING
- Tap Changer / tap (Tap Changer monitoring function): ACTIVE_POWERED
- Low voltage Motor (Low voltage monitoring function): OPERATING

8.1.2 FUNCTION BLOCKING

Each monitoring function can be blocked, for primary device maintenance purposes, for instance, or unblocked using the **Blocking SPC** control datapoint.

The function can be blocked only if it is active (**On/off SPC** at SET state).

8.1.3 DEFAULT MODES

By default, each condition monitoring function is Off. The On/Off state information SPS is reset.

When an On/Off control SPC activation request is received, the condition monitoring function is activated. The On/Off state information SPS is set.

The current state On or Off is saved and restored upon the C264 reboot.

When an On/Off control SPC de-activation request is received, the condition monitoring function is disabled. The On/Off state information SPS is reset.

By default, each condition monitoring function is not Blocked. The Blocked state information SPS is reset.

When a Blocking control SPC activation request is received, the condition monitoring function is blocked and the Blocked state information SPS is set.

The current Blocked or not Blocked state is not saved nor restored upon the C264 reboot.

When a Blocking control SPC de-activation request is received, the condition monitoring function is unblocked and the Blocked state information SPS is reset.

8.1.4 MEASUREMENT AND COUNTER

8.1.4.1 STORAGE

Monitoring measurements and counters are first stored in the database with the value “0”. A PRESET value can be manually set within the counter range, at HMI level (aView) through SETPOINTS.

Monitoring measurements and counters stored by a monitoring built-in function are kept in the C264 memory. These measurements and counters are not affected by Flash Format, Update bootloader, Update bitstream, bootInstall, Clean database or Switch Database actions.

This information is reset only upon the operator’s request through the related SETPOINT.

8.1.4.2 SAVING ID

For each measurement (MV) and counter (CT) of built-in monitoring functions, a **saving ID** value must be configured manually.

Each **saving ID** must be unique in the C264 database and identical between two versions in case of database switch.

8.1.5 WARNING & ALARM MANAGEMENT

When the operation counter is incremented, the operation counting alarm and warning thresholds are compared:

- If an alarm threshold is overshoot, the operation count alarm information (SPS) is set.
- If the warning threshold is overshoot, the operation count warning information (SPS) is set.

8.2 CIRCUIT BEAKER MONITORING

8.2.1 GENERAL DESCRIPTION

System operator must know the status of all the circuit-breakers under control. The CB-position-switch outputs are connected to the C264's digital inputs and therefore provide the indication of state through the communication bus to a remote control center.

Circuit breakers require periodic maintenance of their operating mechanisms and contacts to ensure they operate when required and that the fault capacity is not affected adversely. The requirement for maintenance is a function of the number of trip operations, the cumulative current broken and the type of breaker. The C264 bay controller records all of these parameters and hence be configured to send an alarm when maintenance is due.

The CBM functions makes it possible to change from time-based maintenance to condition based maintenance.

8.2.2 INCLUDED FEATURES

Circuit Breaker Monitoring features are dedicated for single-pole and three-pole CB, oil or SF6 insulation, with spring or hydraulic mechanisms.

The following values are monitored:

- Mechanical:
  - Digital operation counter for single-pole and three-pole mechanism (to replace existing local mechanical counter)
  - Last operation opening and closing times counters
- Electrical:
  - Last operation current broken
  - Current broken summation counter
  - Last operation primary contact wear
  - Primary contact wear summation counter

The monitored data is used to manage real times alarms and advanced alarms.

8.2.3 FUNCTION SCOPE

The CBM function is available for a C26x installed in a digital substation, equipped with Merging Units (for CT/VT acquisition), and SCU for CB operations counting and time duration.

In a DCS digital architecture, the SCU controls alone the Circuit Breakers operations:

- on GRID topology modification (manual operation)
- on protections trips (automatic operation)

In this case, the CBM function records all the operations of circuit breaker.

The Merging units must be connected to "protection" secondary winding of CT, to be able to acquire the full scale of current (up to 20.Ir).

8.2.4 LIMITATIONS

"CB Monitoring" function can monitor up to 2 CB per C26X, for three-poles or single-pole CB (one per bay).

The "Current broken and Contact abrasion" function operates only during OPEN operation, on:

- manual operation (modification of GRID topology)
- and protection trip

Note

The "pre-arcing time" described in IEC standard (during closing operation) is almost 1ms for HVAC CB. This time is too short for C26X acquisition, to acquire with precision a "contact abrasion" value by operation.

8.2.5 CURRENT BROKEN AND CONTACT ABRASION

8.2.5.1 CURRENT BROKEN DEFINITION AND CALCULATION

The "current broken" (or breaking current in IEC) value defines the RMS current value interrupted by the high voltage interrupter, during the last opening CB order, at the time of HV contact separation.

This time is materialized by the CB contact 52a (taking account of the mechanical time / electrical time adjustment delay).

Note.

A Start delay during opening (ms) can be fixed at SCE level and adjusted by settings MiCOM S1, during CB commissioning or CB maintenance period, to define the beginning of "arcing time".
The goal is to limit the time error due to the HV arcing contact degradation.
The start of this delay is the "CB contact 52a opening" time. The delay can be positive or negative.

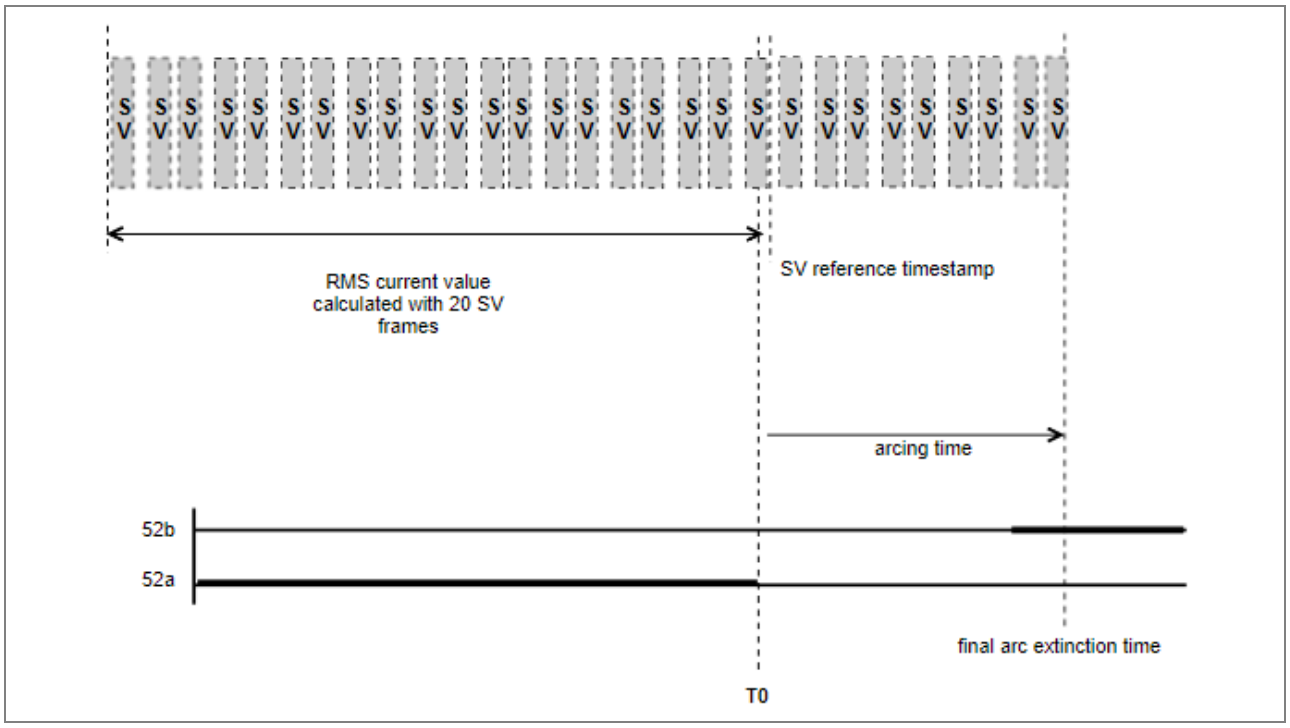
The timestamp of CB contact 52a change event (T0) is compared to the Sample Values Frames' timestamps available at C26X acquisition level.

The SV frame with the nearest timestamp to T0 is taken as an "SV reference".

The RMS current value, calculated with a complete frequency cycle (20 SV frames @50Hz) previously at the "SV reference" timestamp, is taken as the "Current Broken" value.

Note:

The previous complete cycle before the HV contact separation is taken into account, to calculate the "Current Broken" value with the maximum of inductive and resistive current.



8.2.5.2 CONTACT ABRASION DEFINITION AND CALCULATION

The "contact abrasion" value defines the electrical energy generated during the arcing time on high voltage interrupter chamber.

The computation of the integrals is based on the following approximation:

$$\int_{t0}^{t0+\Delta t} i(t)dt = \frac{T}{80} \sum_{j=0}^{nb-1} | i[tj] |$$

where:

- i is the HV current analog value
- nb is the number of acquired samples
- Δt is the time during which the samples are taken
- T is the period of the signal.
- t0 is the start counting time
- tj = t0 + j x T/80 (next sample)

This formula leads to the following equations for contacts abrasion:

$$(I2T_PhaseA)N = (I2T_PhaseA)N - 1 + \frac{T}{80}\sum_{j=0}^{nb-1} | ia^2[tj] |$$

$$(I2T_PhaseB)N = (I2T_PhaseB)N - 1 + \frac{T}{80}\sum_{j=0}^{nb-1} | ib^{2[tj]} |$$

$$(I2T_PhaseC)N = (I2T_PhaseC)N - 1 + \frac{T}{80}\sum_{j=0}^{nb-1} | ic^2[tj] |$$

8.2.5.3 ARCING TIME

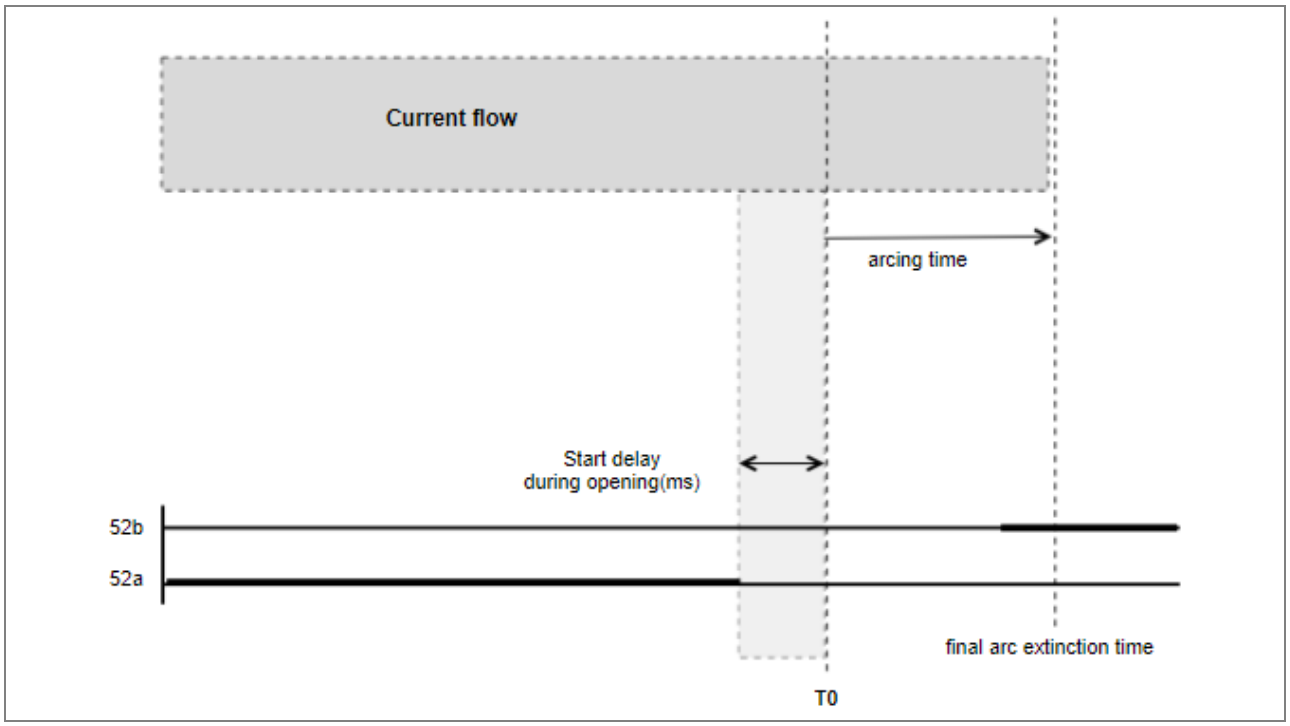
The Arcing time is the interval of time between the instant of the first initiation of an arc and the instant of **final arc extinction** in all poles.

For Circuit Breaker opening operation, the value of current circulating per pole is calculated between a time T0 and the time defined by the "final arc extinction".

For the CBM function, the **final arc extinction** is materialized by the HV current value measured less than a configured threshold **current (%In).**

The value of the current is monitored per pole basis, for single-pole and three-pole CBs.

In case of a current with FAULTY quality detected at acquisition level, the "Current broken" and "Contact abrasion" computations are stopped.



8.2.5.4 CURRENT BROKEN AND CONTACT ABRASION VALUES

The resulting calculation values are stored in the following set of measurements applied for each phase (A, B and C):

- **AccAbr PhX**: Cumul. abrasion phX (kA²/s)
- **ActAbr PhX**: Abrasion last open phX (kA²/s)
- **OpTmCls PhX**: Closing time meas. phX (ms)
- **OpTmOpn PhX**: Opening time meas. phX (ms)
- **AccSwA PhX**: Sum. of switched current ph X
- **SwA PhX**: Last switched current ph X (A/s)

8.2.5.5 OPERATIONS

The CB Monitoring function can be blocked thanks to its CB Monitoring function blocking SPC. the feedback Blocking SPS (declared in SCE) occurs to give the "blocking mode" information.

The CB Monitoring function is activated or blocked per circuit breaker (single-poles or three poles).

If the CB Monitoring function blocking SPS is in the SET state, then the CBM function is blocked (will not operate).

If the CB Monitoring function blocking SPS is in the RESET state, then the CBM function is unblocked (operates normally).

8.2.5.6 OPENING AND CLOSING TIME

The CB Monitoring function manages 4 time measurements for opening operations and 3 time measurements for closing operations.

The time measurement regarding opening operations of each pole is sent as soon as the Circuit Breaker is opened.

The time measurement regarding closing operations of each pole is sent as soon as the Circuit Breaker is closed.

On a 3-poles CB, the time values are duplicated on the time datapoint for poles A, B and C.

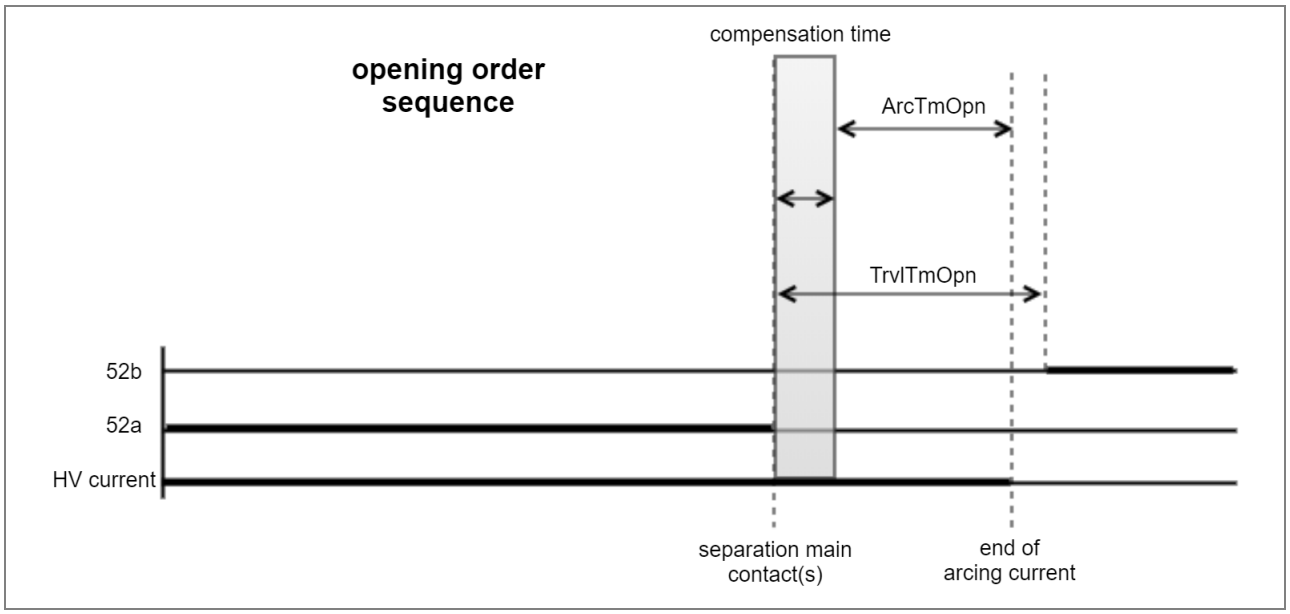
On a single-pole CB, the time values are measured as per pole basis.

Depending on the CBM options, time measurements for opening and closing operations vary.

A) If the CBM function **is not equipped with CB coil sensors**, the definition of timings are as follows:

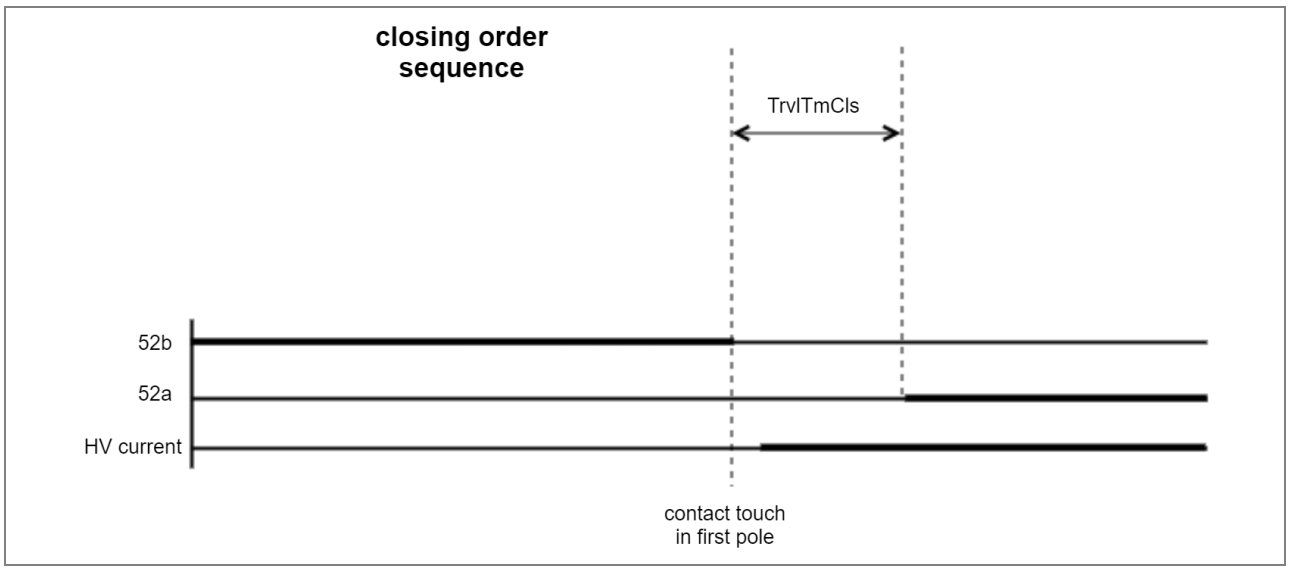
For opening operations:

- The Travel time “**TrvlTmOpn**" is the number of milliseconds, elapsed between the end of the Circuit Breaker close state (52a), and the beginning of the Circuit Breaker open state (52b),
- The Arcing time "**ArcTmOpn**" is the number of milliseconds, elapsed between the end of the compensation time (setting), and the end of arcing current (setting)



For closing operations:

- The Travel time "**TrvlTmCls**" is the number of milliseconds, elapsed between the beginning of the Circuit Breaker close state (52b), and the end of the Circuit Breaker close state (52a).

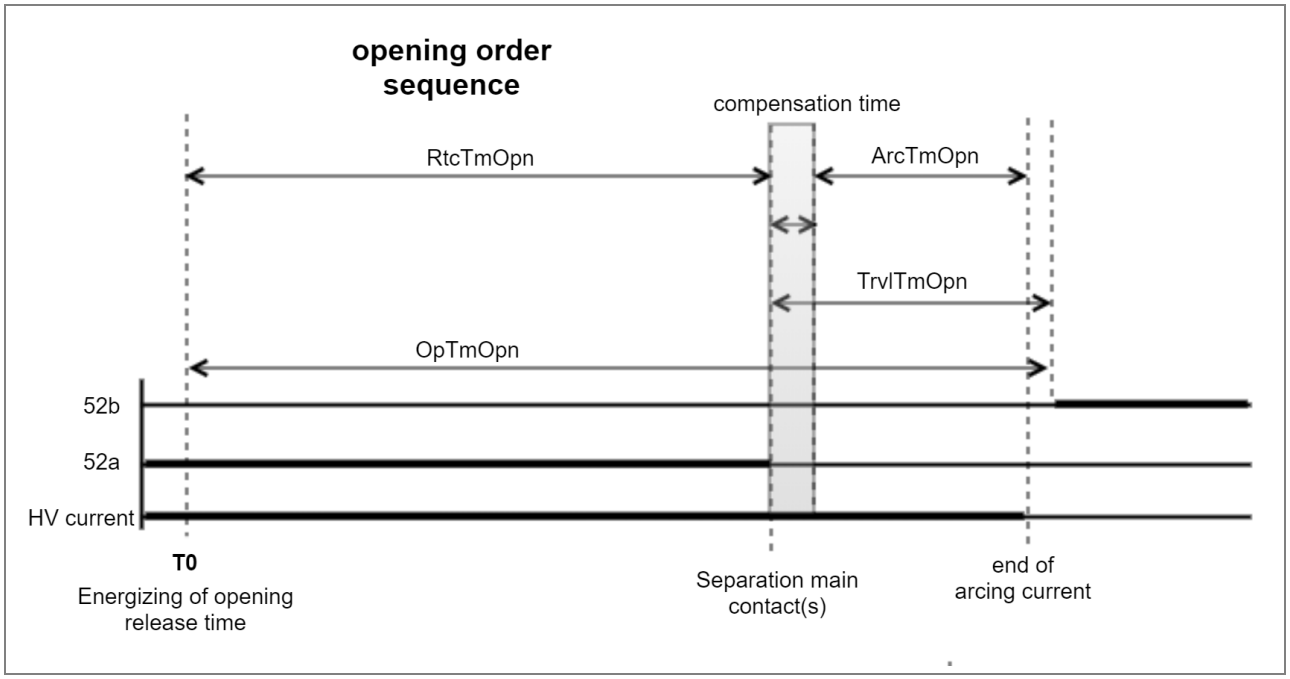


Note: pre-arcing time is not calculated on closing operation.

B) If the CBM function **is equipped with CB coil sensors**, timings are defined as follows:

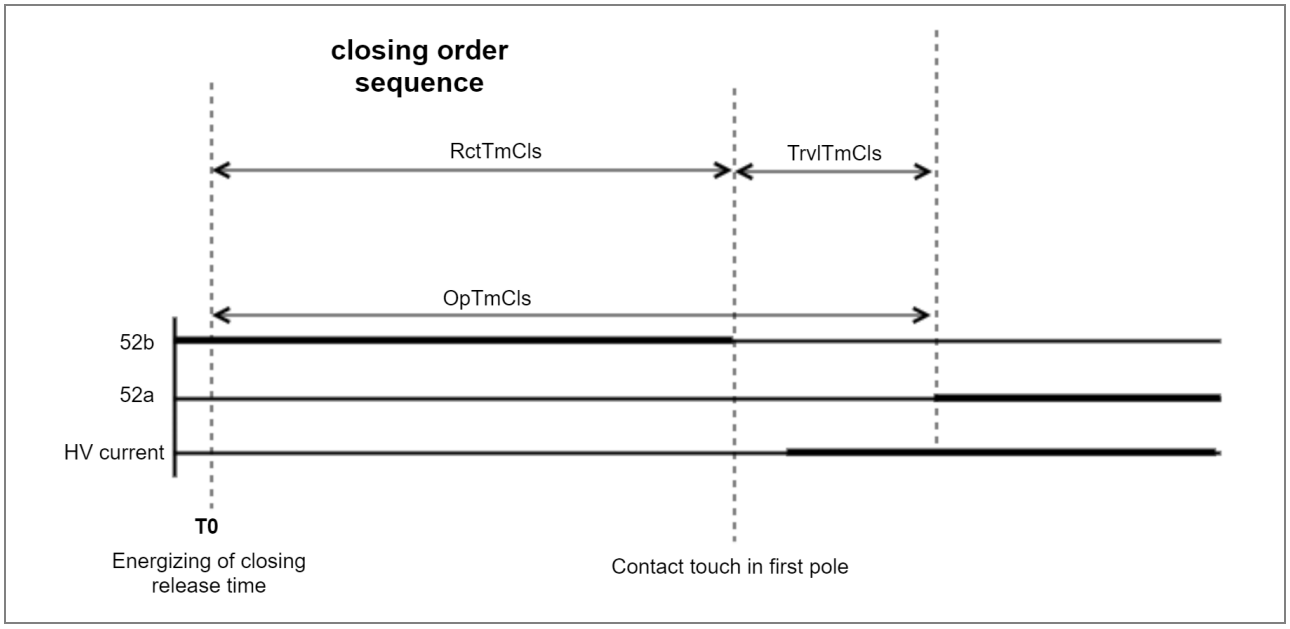
For opening operations:

- The Operation time "**OpTmOpn**" is the number of milliseconds, elapsed between the CB opening order (energizing of opening release) and the end of the Circuit Breaker open state (52b)
- The Reaction time "**RctTmOpn**" is the number of milliseconds, elapsed between the CB opening order (energizing of opening release) and the beginning of the Circuit Breaker open state (52a)
- The Travel time "**TrvlTmOpn**" is the number of milliseconds, elapsed between the end of the Circuit Breaker close state (52a), and the beginning of the Circuit Breaker open state (52b)
- The Arcing time "**ArcTmOpn**" is the number of milliseconds, elapsed between the end of the compensation time (setting), and the end of arcing current (setting)



For closing operations:

- The Operation time "**OpTmCls**" is the number of milliseconds, elapsed between the CB closing order (energizing of closing release) and the end of the Circuit Breaker close state (52a)
- The Reaction time "**RctTmCls**" is the number of milliseconds, elapsed between the CB closing order (energizing of closing circuit) and the beginning of the Circuit Breaker close state (52b).
- The Travel time "**TrvlTmCls**" is the number of milliseconds, elapsed between the beginning of the Circuit Breaker close state (52b), and the end of the Circuit Breaker close state (52a).



Note: pre-arcing time is not calculated on closing operation.

Refer to section "Opening coil or closing coil energization times definition" description below for further details.

8.2.5.7 DEFINITION OF THE OPENING OR CLOSING COIL ENERGIZATION TIMES

A physical option of the CBM function consists in adding CB coil energization detectors, materialised by hall effect sensors and current threshold detector, installed on Circuit Breaker coil circuits.

The CB coil energization detector is wired on a digital input (DI) board of the C264 unit hosting the CBM function.

CB coil energization detectors (CoilWatch) is materialized by **6** hall effect sensors and current threshold detector (1Aeff) installed on coils circuitry.

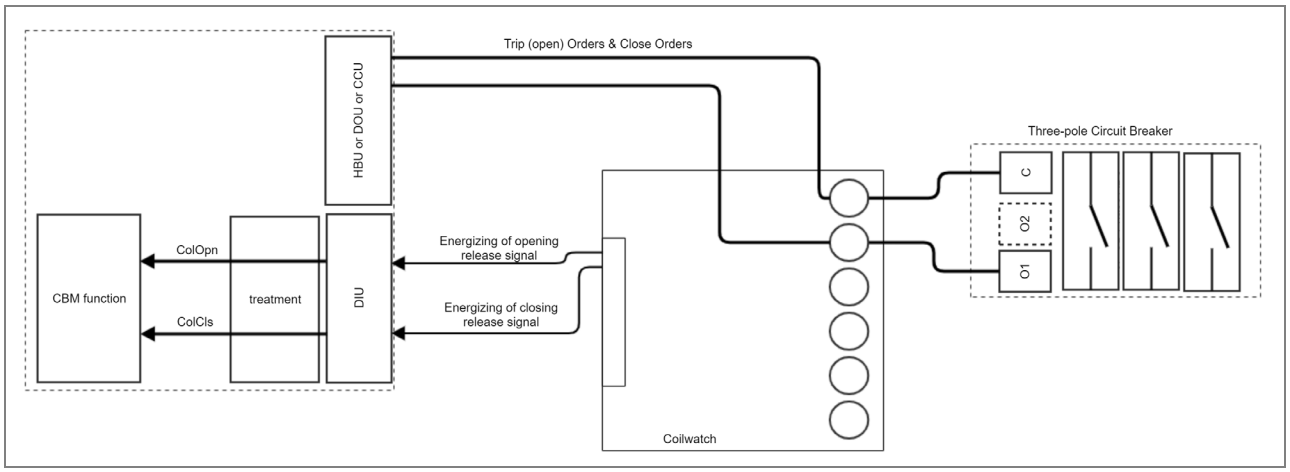
When a current above the predefined threshold is detected on a coil circuitry, the detector sends a SET value via the digital input to the CBM function.

At configuration level, two optional datapoints can be added to the CBM function to define the timestamp of the energizing of opening release event (**CoilOpn** SPS) and the timestamp of the energizing of closing release event (**CoilCls** SPS).

When these datapoints are instantiated on the CBM function, the "opening time" is calculated with the T0 time defined by the timestamp of SET state of the **CoilOpn** datapoint and the "closing time" is calculated with the T0 time defined by the timestamp of SET state of the **CoilCls** datapoint.

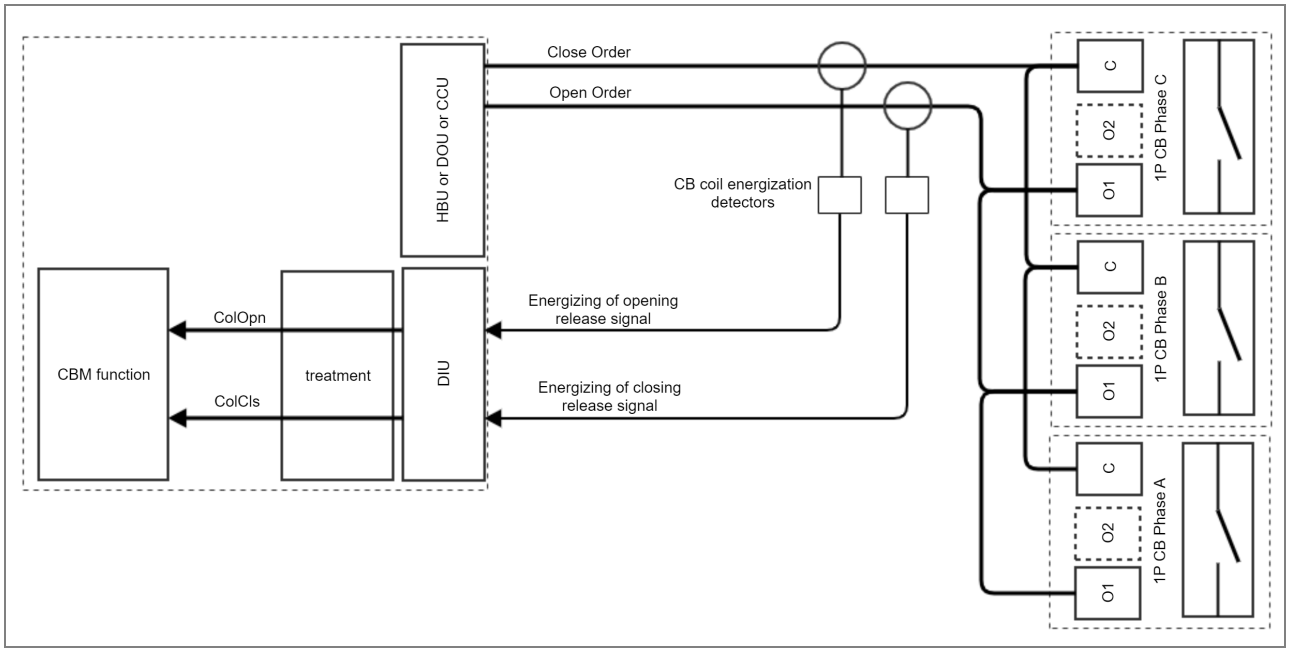
Depending on the CB type, the CBM function manages 2 different use cases:

- **three-pole CB** with trip coil (O1) and close coil (C) controls for opening and closing orders:



Note: on three-pole CB, the timings measured are duplicated on the datapoint per pole A, B, and C.

- **single-pole CB** with independent trip coil (O1) close coil (C), and backup trip coil (O2), with parallel controls for opening and closing orders:



Note: single-pole CBs with independent trip coil (O1) close coil (C) providing one independent open signal, and one close signal as per pole basis, is not managed by the CBM function.

In all cases, the backup trip coil (O2) is linked to the trip coil (O1) on the same coil energization detectors.

8.2.5.8 ALARMS AND WARNINGS

The following warning and alarm SPS are set when thresholds of Contact abrasion measurements are reached. There is one alarm and one warning datapoint per pole.

- "Abrasion warning" SPS for pole X. It is set when the cumulative I².t for pole X measurement reaches the "Contact abrasion function warning" threshold.
- "Abrasion alarm" SPS for pole X is set when the cumulative I².t for pole X measurement reaches the "Contact abrasion function alarm" threshold.

Note:

Only one alarm and one warning threshold are defined in configuration for the 3 poles.

The function operates on each pole separately.

The SPS remains in the SET state, until a RESET is performed on the corresponding measurement value.

8.2.6 OPERATION COUNTER

8.2.6.1 OPERATION COUNTR CALCULATION

In case of single-pole CB:

When the Circuit Breaker pole X managed by the "Operation counter" function goes in the OPEN state, the counter of pole X is incremented.

When the Circuit Breaker pole X managed by the "Operation counter" function goes in the CLOSE state, the counter of pole X is incremented.

In case of three-pole CB:

When the Circuit Breaker managed by the "Operation counter" function goes in the OPEN state, the counters of all the poles are incremented.

When the Circuit Breaker managed by the "Operation counter" function goes in the CLOSE state, the counters of all the poles are incremented.

The counters are incremented only if the Circuit Breaker auxiliary contacts spend from a valid state(close/open) to a valid state(open/close). In other words, when the Circuit Breaker managed by the "Operation counter" function goes in a non-open or non-close state, no counter is incremented.

8.2.6.2 OPERATION COUNTER VALUES

The resulting calculation values are stored in the following counter applied for each phase (A, B and C):

- **OpCnt PhX**: Cumulated number of CB operation on phase X

The result of the "Operation counter" function is stored in a non-volatile memory (SRAM), which is not lost even on database change (if the measurements still exist in new database).

The first time the measurements appear in the database, they are initialized with a 0 value and it can be setting value (in range of counter).

8.2.6.3 OPERATION

The "Operation counter" function operates on opening and closing states.

In any case, the "Operation counter" function operates:

- on manual operation (modification on GRID topology)
- on protection trip

8.2.6.4 ALARMS AND WARNINGS

The following warning and alarm SPS are set when thresholds of CB operation counters are reached.

The thresholds are defined for the three poles.

These SPS are managed per pole.

Circuit breaker Operation counter warning

- The “Operation counter warning” SPS for pole X is set when the operation counter for pole X reaches the “CB operation warning” threshold.
- The “Operation counter alarm” SPS for pole X is set when the operation counter for pole X reaches the “CB operation alarm” threshold.

Note:

Only one threshold is defined in configuration per poles. The function operates on each pole separately.

The SPS remains in the set state until a reset is performed on the corresponding counter value.

8.3 SWITCHGEAR MONITORING

The switchgear monitoring feature is an operation counter that is incremented each time the switching device opens or closes (open/close sequence counting and opening/closing time measurement). The counter value can be modified on the C26x front panel LHMI.

8.3.1 INPUT DATA POINTS

For each switchgear monitoring function occurrence, the information available at the computer level is the switchgear position (wired DPS).

The switchgear monitoring function accepts inputs as below:

- An open start operation event,

  The open start operation event is given by the end of close position. The switchgear position close contact has moved from close to open.

- An open-end operation event,

  The open-end operation event is given by the end of switchgear movement to open position. The switchgear position open contact has moved from open to close.

- A close start operation event,

  The close start operation event is given by the end of open position. The switchgear position open contact has moved from close to open.

- A close end operation event,

  The close end operation event is given by the end of switchgear movement to close position. The switchgear position close contact has moved from open to close.

8.3.2 OUTPUT DATA POINTS

The switchgear monitoring function manages the following “output” datapoints:

- Operation count alarm information (SPS)
- Operation count warning information (SPS)
- Operation count counter (CT)
- Opening time measurement (MEAS)
- Closing time measurement (MEAS)

with the following configuration attributes:

- Operation count alarm threshold
- Operation count warning threshold

8.3.3 OPERATIONS AND TIME MANAGEMENT

The switchgear monitoring function operates only if the switchgear position goes from a valid position (open or close) to another valid position (close or open).

If the switchgear position is close, when the open start operation event is received by a switchgear monitoring function, the timestamp of the starting event is memorized.

When the open-end operation event operation is received by a switchgear monitoring function, if the new switchgear position is open, its operation counter is incremented. The timestamp of the ending event is taken, and the difference with the last memorized timestamp is performed. The switchgear opening time measurement (MEAS) is updated with the value and transmitted.

If the switchgear position is open, when the close start operation event is received by a switchgear monitoring function, the timestamp of the starting event is memorized.

When the close end operation event operation is received by a switchgear monitoring function, if the new switchgear position is close, its operation counter is incremented. The timestamp of the ending event is taken, and the difference with the last memorized timestamp is performed. The switchgear closing time measurement (MEAS) is updated with the value and transmitted.

Downgraded modes

After an open or close start operation event has been received, if the switchgear position does not reach the required state (open or close), but goes in the jammed, undefined, faulty or toggling state, the operation counter is not incremented, and the last memorized timestamp is reset (to not be reused for the next open/close operation).

When an open or close start operation event is received, if the switchgear position is not a valid state (open or close), but the jammed, undefined, faulty or toggling state, the operation counter is not incremented even if the switchgear position reached is valid (open or close). The switchgear opening, or close time value is not computed.

Values restored upon C264 reboot

On computer starting sequence, the current values of the operation counter are restored.

If the operation count alarm threshold is overshoot, the operation count alarm information (SPS) is set.

If the operation count warning threshold is overshoot, the operation count warning information (SPS) is set.

8.3.4 LIMITATIONS

- The computer can manage only up to **64** switchgear monitoring functions at a time.
- A switchgear monitoring function cannot be set OFF if the switchgear position change is in progress. In this case, the OFF control is refused (Automation running negative acknowledge).
- A switchgear monitoring function cannot be BLOCKED if the switchgear position change is in progress. In this case, the "Blocking" control is refused (Automation running negative acknowledge).
- The current values of the operation counter are stored being unique user defined identifier. The SCE checks the identifiers are all unique. But an identifier must not be used for different datapoints in successive databases (the range for identifier values is 1 to 65535).

8.4 DIVERTER SWITCH MONITORING

The diverter switch is a part of tap changer. The diverter switch monitoring function counts the number of diverter switch operating sequences and records the abrasion while the diverter switch is operating and powered by an input voltage.

8.4.1 INPUT DATA POINTS

The computer is aware of diverter switch operations, being to the Tap in Progress datapoint (TCIP).

In addition, a datapoint (SPS) giving the **voltage presence** at the transformer level is required (the abrasion of contacts recording is performed only if the voltage is present at transformer level).

An optional datapoint can indicate a **tap changer fault** (in order to cancel the counting and current recording operations).

The diverter switch monitoring function accepts inputs as below:

- The **Tap in Progress** (TCIP) state change event
- the **Voltage present** (SPS) state change event
- the **tapChanger.Fault** (SPS) state change event (optional, with AVR function instanced)

The Tap in Progress state change to SET, is the diverter switch starting event.

The Tap in Progress state change to RESET, is the diverter switch ending event.

The **voltage present** state and the optional tap changer fault state can change anytime, without any relation with the Tap in Progress state change.

8.4.2 OUTPUT DATA POINTS

The diverter switch monitoring function manages the 3 phases of the diverter switch.

The following “output” datapoints are defined and managed per phase:

- Contact abrasion alarm information (SPS)
- Contact abrasion warning information (SPS)
- Operation counting alarm information (SPS)
- Operation counting warning information (SPS)
- Last switch current value measurement (MEAS)
- Cumulated abrasion value measurement (MEAS)
- Operation counter (CT)

with the following configuration on attributes:

- An abrasion alarm threshold
- An abrasion warning threshold
- An Operation counting alarm threshold
- An Operation counting warning threshold
- A switched onload time coef. (0 to 100% / step 1%)

8.4.3 DIVERTER SWITCH ABRASION CALCULATION

The below 5 requirements are applicable, only if the voltage presence state SPS is set (voltage present at transformer level). Otherwise, the abrasion recording is not performed. The operation count is performed either the voltage present state SPS is set or reset.

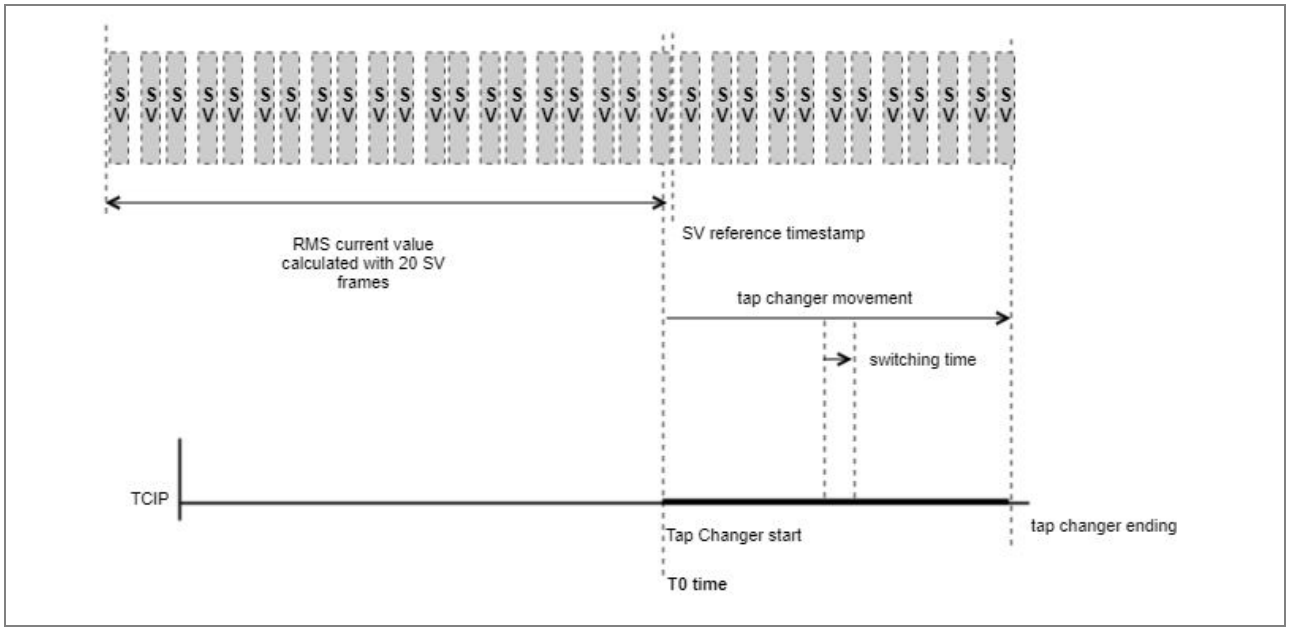
The "Current switched" (or breaking current in IEC) value defines the RMS current value interrupted by the last diverter switch operation, as per pole-basis, for the three-pole diverter.

This time is materialized by the Tap Changer In Progress information (TCIP), representing the time between the start of tap changer gear movement, and the end of this movement.

The timestamp of TCIP at SET state change event (T0) is compared to the Sample Values Frames timestamps, present in same time at C26X acquisition level.

The SV frame with the nearest timestamp to T0 is taken as an "SV reference".

The RMS current value, calculated with a complete frequency cycle (20 SV frames @50Hz) previously at the "SV reference" timestamp, is taken as the **Last switched phase X current** value, and represents the current switched by the diverter on each pole.



Note:
This function is based on the principle that the previous complete cycle before the tap changer gear start is considered, to calculate a current value close to the current effectively switched at switching time by the diverter switch.

"Abrasion" value for the diverter switch datasheet is equivalent to "current broken" value for a Circuit Breaker.

When the abrasion recording is in progress, if the diverter switch **ending** event is received, the abrasion recording is stopped. The last switch current measurement (MEAS) is updated with the abrasion recorded, and this value is added to the cumulated switch current measurement (MEAS). The both measurements are transmitted immediately.

When the abrasion recording is in progress, if the diverter switch **cancel** event is received, the abrasion recording is stopped. The last switch current measurement (MEAS) and the cumulated switch current measurement (MEAS) are not updated (and of course not transmitted).

Warning and alarm management

When the cumulated abrasion measurement (MEAS) is updated, a comparison with the abrasion alarm and warning thresholds is performed. If the alarm threshold is overshoot, the abrasion alarm information (SPS) is set. If the warning threshold is overshoot, the abrasion warning information (SPS) is set.

When the cumulated abrasion measurement (MEAS) is updated, a comparison with the abrasion alarm and warning thresholds is performed. If the alarm threshold is overshoot, the abrasion alarm information (SPS) is set. If the warning threshold is overshoot, the abrasion warning information (SPS) is set.

If the abrasion alarm threshold is overshoot, the abrasion alarm information (SPS) is set. If the abrasion warning threshold is overshoot, the abrasion warning information (SPS) is set.

If the operation counting alarm threshold is overshoot, the operation counting alarm information (SPS) is set. If the operation counting warning threshold is overshoot the operation counting warning information (SPS) is set.

Values restored upon C264 reboot

On computer starting sequence, the current values of the cumulated abrasion measurement and the operation count counter are restored.

8.4.4 LIMITATIONS

- The described monitoring function is dedicated only for an on-load tap changer(OLTC), equipped with a motorized mechanism to change automatically the tap position.
- The computer can manage only one diverter switch monitoring function at a time.
- The diverter switch monitoring function cannot be set "Off" if a diverter switch operation is in progress. In this case, the "Off" control is refused (Automation running negative acknowledge).
- If the diverter switch monitoring function is set "On" while a diverter switch operation is in progress, the "On" control is accepted, but the abrasion is not immediately recorded, and the operation count is not immediately performed. Only the next diverter switch operation will be treated.
- The diverter switch monitoring function cannot be blocked if a diverter switch operation is in progress. In this case, the "Blocking" control is refused (Automation running negative acknowledge).
- If a diverter switch operation occurs during the computer start-up sequence, the abrasion is not recorded, and the operation count is not performed. Only the next diverter switch operation will be treated.
- The current values of the cumulated abrasion measurement and the operation count counter are stored thanks to unique user defined identifier. This identifier must not be used for different datapoints in successive databases (the range for identifier values is 1 to 65534).
- The diverter switch monitoring function can operate only if the Tap in Progress, voltage presence and tap changer fault (if configured) datapoints are valid. For all the requirements described above, the 3 datapoints are supposed valid.

8.5 TAP CHANGER MONITORING

Voltage regulation of transformers with on-load tap-changers is an important issue for energy supply companies as the voltage in the public low-voltage grid must be kept constant.

The C264 makes this control task simple and straightforward. The C264 is informed of tap activation operations thanks to the TCIP and TPI datapoints. To compute the time spent on each tap, the **voltage present** datapoint is also required. With these signals, the on-load tap-changer moves to the next position and the transformer's voltage value is adapted to the preset desired voltage level.

Given that tap oxidation is mainly due to current flowing between mobile and fixed parts of the taps, the time spent on each tap is incremented only when a high voltage signal is present on the windings where the OLTC is installed.

Tap changer oxidation is not a time critical process. Consequently, the "time passed on each tap" value is sampled each minute.

Because the OLTC monitoring function only knows the "**Tap Changer In Progress**" time stamp (TCIP event), the winding RMS current value switched by the diverter is measured at the beginning of the switch movement. There is an assumption that, in a balanced network mode, the current on contact separation (few milliseconds later) is the same as the RMS current value.

The "cumulated abrasion" summation is computed by RMS values for OLTC diverter switch.

8.5.1 INPUT DATAPOINTS

The tap changer monitoring function uses the following input data:

- The "**Tap in Progress**" state change event:
  - SET: tap change start event.
  - RESET: tap change end event
- The "**Tap Position Indication**" value change event,
- The "**voltage present**" state change event.

Each tap change event starts the operating time recording of the new active tap and the end of operating time recording of the former active tap.

The "**voltage present**" state can change anytime, without any relation with the "Tap in Progress" state change.

The current tap is memorized by the tap changer monitoring function. The new tap is given by the new "**Tap Position Indication**" value.

The nominal sequence is as follows:

1 The "**Tap in Progress**" SPS is set.
2 The "**Tap Position Indication**" value changes,
3 The "**Tap in Progress**" SPS is reset.

Before step 1, tap N is active

After step 3, tap n-1 or tap n+1 is active.

Between step 1 and 3 no tap is active.

8.5.2 OUTPUT DATAPOINTS

The tap changer monitoring function manages the following datapoints:

- Operating time alarm information (SPS),
- Operating time warning information (SPS),
- Operation count alarm information (SPS),
- Operation count warning information (SPS),
- Operating time measurement (MEAS),
- Operation count counter (CT).

With the following attributes:

- Operating time alarm threshold,
- Operating time warning threshold,
- Operation count alarm threshold,
- Operation count warning threshold,
- Operating time measurement broadcast period (from 1 to 1440 minutes).

8.5.3 OPERATIONS AND TIME MANAGEMENT

The tap activation count and operating time recording are possible only if the "**voltage present**" state (SPS) at transformer level is set.

When the tap changer monitoring function receives a tap change starting event for the current tap, the timestamp of this event is compared with the last memorized timestamp. The tap operating time measurement (MEAS) is updated with that value and transmitted.

The new tap is issued by the "Tap Position Indication" value. When the tap changer monitoring function receives a tap change ending event, the timestamp of this event is memorized. The new tap operation counter is incremented, and the new value is transmitted.

When the operation counter is incremented, the operation count alarm and warning thresholds are compared:

- If the alarm threshold is overshoot, the operation count alarm information (SPS) is set.
- If the warning threshold is overshoot, the operation count warning information (SPS) is set.

Every minute, the current timestamp is taken into account, and the difference with the last memorized timestamp is computed. The current tap operating time measurement (MEAS) is updated with that value and the current timestamp is memorized as the last new timestamp.

When the "operating time measurement broadcast period delay" is over, the current "tap operating time measurement" (MEAS) is transmitted. The "operating time measurement broadcast period delay" is then restarted.

*Note: In case of manual operation of tap changer position (TPI) with "**voltage present**", the SPI changes without TCIP change event received. In this case, the operation counter is also incremented.*

Values restored upon C264 reboot

After a computer reboot, if the **voltage present** state SPS is set, the tap changer monitoring function operates immediately. The current values of the operating time measurement and the operation counter are restored.

If an alarm threshold is overshoot (operation count or operating time), the corresponding alarm information (SPS) is set. If a warning threshold is overshoot (operation count or operating time), the corresponding warning information (SPS) is set.

8.5.4 LIMITATIONS

- The C264 can manage only **1** tap changer monitoring function at a time.
- The maximum number of Tap Changer positions is **49** per tap changer.
- If the voltage is present at transformer level, the tap changer monitoring function cannot be:
  - set at "Off". The "Off" control will be refused (negative acknowledge).
  - "blocked". The "Blocking" control is refused (negative acknowledge).
- The current values of operating time measurement and operation counter are stored thanks to unique user defined identifiers. This identifier must not be used for different datapoints in successive databases (the range for identifier values is 1 to 65534).
- The voltage is still present at transformer level while the C264 is rebooting, the operating time lost is 1 mn max plus the C264 booting delay.
- The tap changer monitoring function can operate only if the "Tap in Progress" and "Tap Position Indication" datapoints are valid.
- The average accuracy for operating time value is **1 mn**.

8.6 MOTOR MONITORING

The Low Voltage Motor Monitoring feature is intended to survey and quantify the activity on secondary devices low voltage motors (cooling groups air fans, cooling groups hydraulic pumps, tap changer drive…).

This monitoring function is limited to basic monitoring:

- starting sequences counter: the number of starts during a period, between reset counter to actual time
- operation-time counter: the time (in minutes) during which the motor is running

These two functions are used to:

- define the cooling system fans selection
- display the values on HMI (cyclic update)
- transmit the values to external application (ex: asset management)
- calculate the residual lifetime according to motor datasheet settings (by another C26X function)

It can be deployed on AC motors (single-poles or three-poles) or DC motors. It can be associated with thermal, magnetic, undervoltage and overcurrent protections.

8.6.1 WIRING SCENARIOS

Default solution: the computer is controlling both the motor start and stop operations, thanks to its own output relays.

- BCU controls the LV motor feeder contactor by a permanent control (startup SPC)

  In this case, the BCU don't need any other information to monitor the LV motor operation
- BCU controls the LV motor feeder contactor by a transient control (startup SPC). This requires an electrical latching on LV feeder contactor.

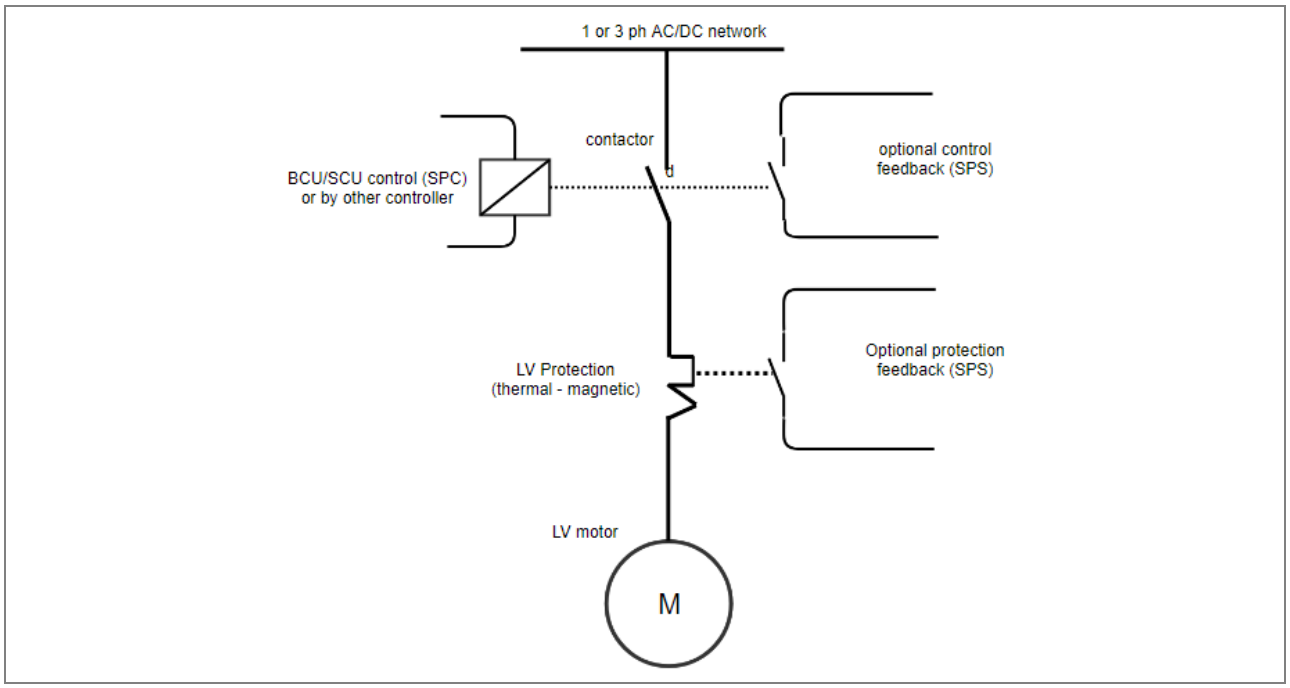
  In this case, the BCU needs a feedback (startup SPS) to monitor the LV motor operation
- BCU doesn't control the LV motor feeder contactor (controlled by another controller)

  In this case, the BCU needs a feedback (startup SPS) to monitor the LV motor operation

Alternative scenario

Another possibility is the presence of a protection feedback (SPS). To take this information into account (the LV motor doesn't run if the protection has tripped), the engineering department can create an FBD automation to compute the logical status of contactor feedback SPS and protection feedback SPS. This computed SPS is used as input "feedback SPS" in the monitoring function.

Same strategy is used to compute the "feedback SPS" with other SPS issued on other protections.



8.6.2 INPUT DATAPOINTS

The motor monitoring function accepts as inputs:

- a start operating event and
- an end operating event

The **start operating event** can be either:

- the relay activation event or
- the motor starting event given by an external information (SPS).

The **end operating event** can be either:

- the relay end of activation event or
- the motor end operating event given by an external information (the same SPS as for starting operating event).

Any instance of motor monitoring is:

- Triggered for begin/end of motor activation by either:
  - A Motor Activation control (SPC) or
  - A Motor Activation position (SPS)
- Set On or Off, and can be blocked thanks to a control datapoints:
  - An On/Off control (SPC) and its feedback: On/Off state information (SPS)
  - A Blocking control (SPC) and its feedback: Blocked state information (SPS)

8.6.3 OUTPUT DATAPOINTS

An instance of motor monitoring defines:

- 6 output datapoints:
  - An operating time alarm information (SPS)
  - An operating time warning information (SPS)
  - An operation count alarm information (SPS)
  - An operation count warning information (SPS)
  - An operating time measurement (MEAS)
  - An operation count counter (CT)
- 5 configuration attributes
  - An operating time alarm threshold
  - An operating time warning threshold
  - An operation count alarm threshold
  - An operation count warning threshold
  - An operating time measurement broadcast period (range: 1 to 1440 minutes)

8.6.4 DEFAULT OPERATION VALUES

If an OFF control is received during the motor operation, then the control is automatically refused by the computer (negative acknowledge). The motor monitoring function cannot be set to OFF if the motor is operating.

If a BLOCK control is received during the motor operation, then the control is automatically refused by the computer (negative acknowledge). The motor monitoring function cannot be set to blocked if the motor is operating.

8.6.5 OPERATIONS

The following actions are performed upon reception of a start operating event:

- The operation counter is incremented
- The process of measuring the operating time is started
- The operating time measurement broadcast period timer is started

The following actions are performed upon reception of an end operating event

- The process of measuring the operating time is stopped
- The operating time measurement is updated
- The updated operating time measurement is distributed to the monitoring entity
- The operating time measurement broadcast period timer stopped

The operating time measurement is updated is updated every minute during the motor operation period.

When the operating time measurement broadcast period timer is over:

- The operating time measurement is distributed to the monitoring entity
- The operating time measurement broadcast period timer is reset and started

8.6.6 ALARMS AND WARNINGS

The overshoot of the operation count alarm and warning thresholds is performed when incrementing the operation counter. The operation count alarm information (SPS) and the operation count warning information (SPS) are set if needed.

The alarms and warning thresholds overshooting is verified upon:

- Increment of operation counter
- Operating time measurement update
- Reboot of the computer

If one of the thresholds is overshoot, its corresponding warning or alarm datapoint are raised.

8.6.7 BEHAVIOUR UPON COMPTER REBOOT

The following actions are performed upon reboot of the computer

- The value of operating time measurement is restored
- The operation counter is restored
- If the motor is operating, the process of measuring the operating time is started

8.6.8 LIMITATIONS

The Motor object can be added only to a cooling group object (up to 9 motors) or to a tap changer (up to 1 motor). Both objects can be added only to Transformer objects.

8.7 RESIDUAL LIFETIME MONITORING

This function is automatically added to any Motor Monitoring function.

The goal of this feature is to estimate the “time-to-live” of a motor by comparing its operating time against the values provided by the manufacturer.

These values provided by the manufacturer are integrated as attributes of the motor feature and are provided during the feature configuration.

The calculation of the residual lifetime measurement takes into account the initial motor’s lifetime provided by the manufacturer, the motor operating time, the number of start operations and the factor applied to start operations.

8.7.1 INPUT DATAPOINTS

The Residual Lifetime Monitoring function uses the following datapoints from the Motor Monitoring function:

- Operating time measurement (MEAS)
- Operation count counter (CT)

8.7.2 OUTPUT DATAPOINTS

The Residual Lifetime Monitoring function defines the following output datapoints:

- Lifetime alarm (SPS)
- Lifetime measurement (MEAS)

8.7.3 OPERATIONS AND TIME MANAGEMENT

Note that the lifetime function cannot be directly stopped nor blocked. However, it only computes the residual lifetime when its container Low Voltage Motor Monitoring function is started and unblocked.

Under this condition, the calculation of the lifetime measurement is performed in two cases:

- At a fixed frequency configured by a function’s attribute
- Upon computer starting sequence

This calculation takes into account the initial motor’s lifetime provided by the manufacturer, the motor operating time, the number of start operations and the consumption factor applied to start operations.

8.7.4 ALARMS AND WARNINGS

The overshoot of the minimum lifetime threshold is performed when the Lifetime measurement is updated.

If the threshold is overshoot, the lifetime alarm is raised (datapoint is Set).

8.7.5 LIMITATIONS

The motor residual life function cannot be set Off nor blocked.

9 PROTECTION FUNCTIONS

The C26x provides current protection functions. This chapter describes the operation of these functions including the principles and applications.

9.1 DIRECTIONAL ELEMENT

If fault current can flow in both directions through a protected location, a directional overcurrent element is needed to determine the direction of the fault. Once the direction has been determined the device can decide to allow or not to operate. To determine the direction of a phase overcurrent fault, the device must compare the phase angle of the fault current with that of a known reference quantity. The phase angle of this known reference quantity must be independent of the faulted phase. Typically, this will be the line voltage between the other two phases.

The phase fault elements are internally polarized by the quadrature phase-phase voltages, as shown in the table below:

Phase of protection	Operate current	Polarizing voltage
A Phase	IA	VBC
B Phase	IB	VCA
C Phase	IC	VAB

Under system fault conditions, the fault current vector lags its nominal phase voltage by an angle depending on the system X/R ratio. The IED must therefore operate with maximum sensitivity for currents lying in this region. This is achieved using the characteristic angle setting. This setting represents the angle by which the current must be displaced from the voltage to obtain maximum sensitivity.

The opening angle of the forward or reverse operate zone can also be set independently by using **Operate Angle** setting in the SCE. This allows to set an operate angle less than 180°.

For close up three-phase faults, all three voltages will collapse to zero and no healthy phase voltages will be present. For this reason, a synchronous polarisation feature that stores the pre-fault voltage information and continues to apply this to the directional overcurrent elements for a time period of a few seconds is implemented. This ensures that either instantaneous or time-delayed directional overcurrent elements will be allowed to operate, even with a three-phase voltage collapse.

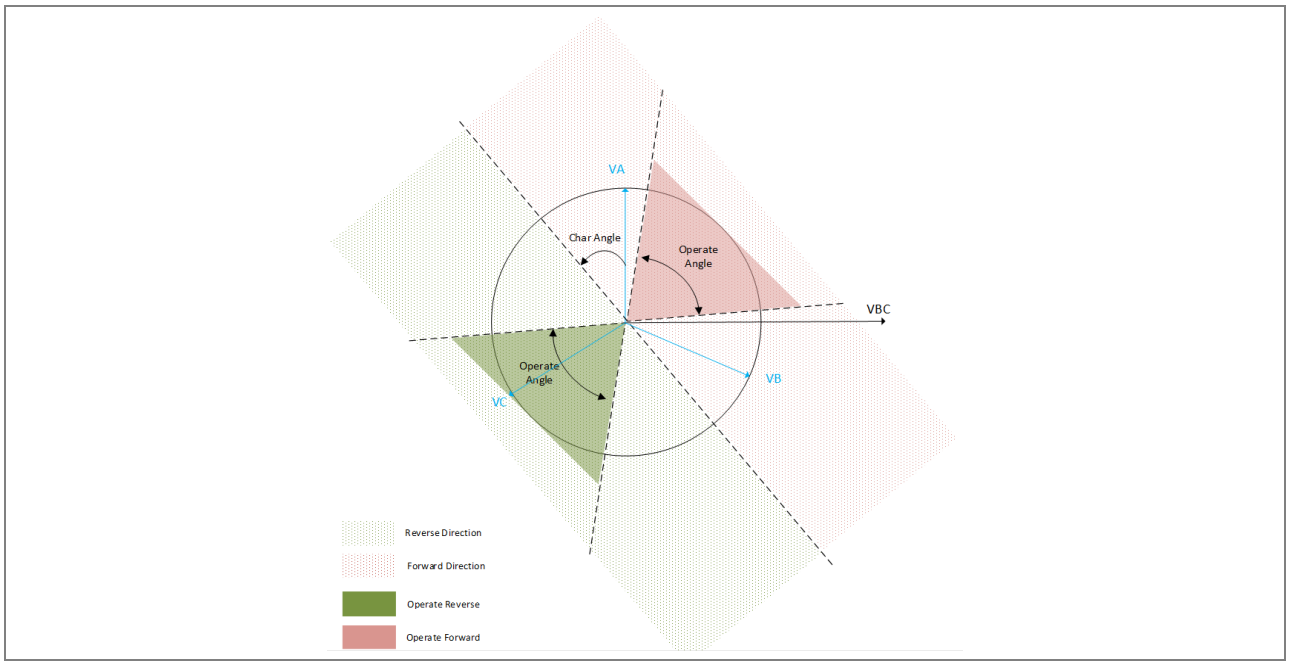


Figure : Operate current IA so polarizing voltage VBC

9.2 CURVE ELEMENT

IDMT characteristics are described by operating curves. Traditionally, these were defined by the performance of electromechanical relays. In numerical protection, equations are used to replicate these characteristics so that they can be used to grade with older equipment.

The Inverse Time Overcurrent Curves are the **IEEE, ANSI, IEC, US standard** curve shapes. This allows for simplified coordination with downstream devices.

The **Definite Time** curve is also an option that may be appropriate if only simple protection is required.

All these characteristics are represented by the following equations:

The IEC 60255 IDMT Operate equation is:

$$t_{op} = T\left(\frac{\beta}{\left(\frac{I}{I_s}\right)^{\alpha} - 1} + L\right) + C$$

and the IEC 60255 IDMT Reset equation is:

$$t_r = T\left(\frac{\beta}{1 - \left(\frac{I}{I_s}\right)^{\alpha}}\right)$$

where:

- t_{op} is the operating time
- t_r is the reset time
- T is the time multiplier setting called TMS for IEC/UK curves and TD for IEEE/US curves
- (I/Is) is the ratio of the measured current divided by the threshold current
- β is a constant, which can be chosen to satisfy the required curve characteristic
- α is a constant, which can be chosen to satisfy the required curve characteristic
- C is a constant for adding definite time, defined by DT Adder (Definite Time Adder) setting
- L is a constant (usually only used for ANSI/IEEE curves)

The constant values for the curves are defined as follows:

Curve Description	β constant	α constant	L constant
IEC Standard Inverse Operate	0.14	0.02	0
IEC Standard Inverse Reset	8.2	6.45	0
IEC Very Inverse Operate	13.5	1	0
IEC Very Inverse Reset	50.92	2.4	0
IEC Extremely Inverse Operate	80	2	0
IEC Extremely Inverse Reset	44.1	3.03	0
UK Long Time Inverse Operate* (refer to the Note below)	120	1	0
UK Rectifier Operate* (refer to the Note below)	45900	5.6	0

Curve Description	β constant	α constant	L constant
IEEE Moderately Inverse Operate	0.0515	0.02	0.114
IEEE Moderately Inverse Reset	4.85	2	0
IEEE Very Inverse Operate	19.61	2	0.491
IEEE Very Inverse Reset	21.6	2	0
IEEE Extremely Inverse Operate	28.2	2	0.1217
IEEE Extremely Inverse Reset	29.1	2	0
CO8 US Inverse Operate	5.95	2	0.18
CO8 US Inverse Reset	5.95	2	0
CO2 US Short Time Inverse Operate	0.16758	0.02	0.11858
CO2 US Short Time Inverse Reset	2.261	2	0
ANSI Normally Inverse Operate	8.9341	2.0938	0.17966
ANSI Normally Inverse Reset	9	2	0
ANSI Short Time Inverse Operate	0.03393	1.2969	0.2663
ANSI Short Time Inverse Reset	0.5	2	0
ANSI Long Time Inverse Operate	2.18592	1	5.6143
ANSI Long Time Inverse Reset	15.75	2	0
ANSI Very Inverse Operate	3.922	2	0.09820
ANSI Very Inverse Reset	9	2	0
ANSI Extremely Inverse Operate	5.64	2	0.02434
ANSI Extremely Inverse Reset	9	2	0

Note (*): When using UK Long Time Inverse, UK Rectifier or RI for the Operate characteristic, DT (Definite Time) is always used for the Reset characteristic.

Rapid Inverse (RI)

The RI characteristics are defined by the following equation:

$$t_{op} = T\left(\frac{1}{0.339 - \left(\frac{0.236}{\frac{I}{I_s}}\right)}\right)$$

where:

- t_{op} is the operating time
- T is the time multiplier setting called k(RI)
- (I/Is) is the ratio of the measured current divided by the threshold current

IDG

IDG curve is commonly used for time delayed earth fault protection in the Swedish market. This curve is available in any stage of the Earth Fault protection.

IDG curve is represented by the following equation :

$$t_{op} = 5.8 - 1.35 log_e\left(\frac{I}{I_s}\right)$$

where:

- t_{op} is the operating time
- I is the measured current
- Is is an adjustable setting, which defines the start point of the characteristic

Important note:

When using UK Long Time Inverse, UK Rectifier or RI, DT (Definite Time) is always used for the Reset characteristic.

When using IDG curve for the Operate characteristic, DT (Definite Time) with a value of 0 is always used for the Reset characteristic.

EPATR B

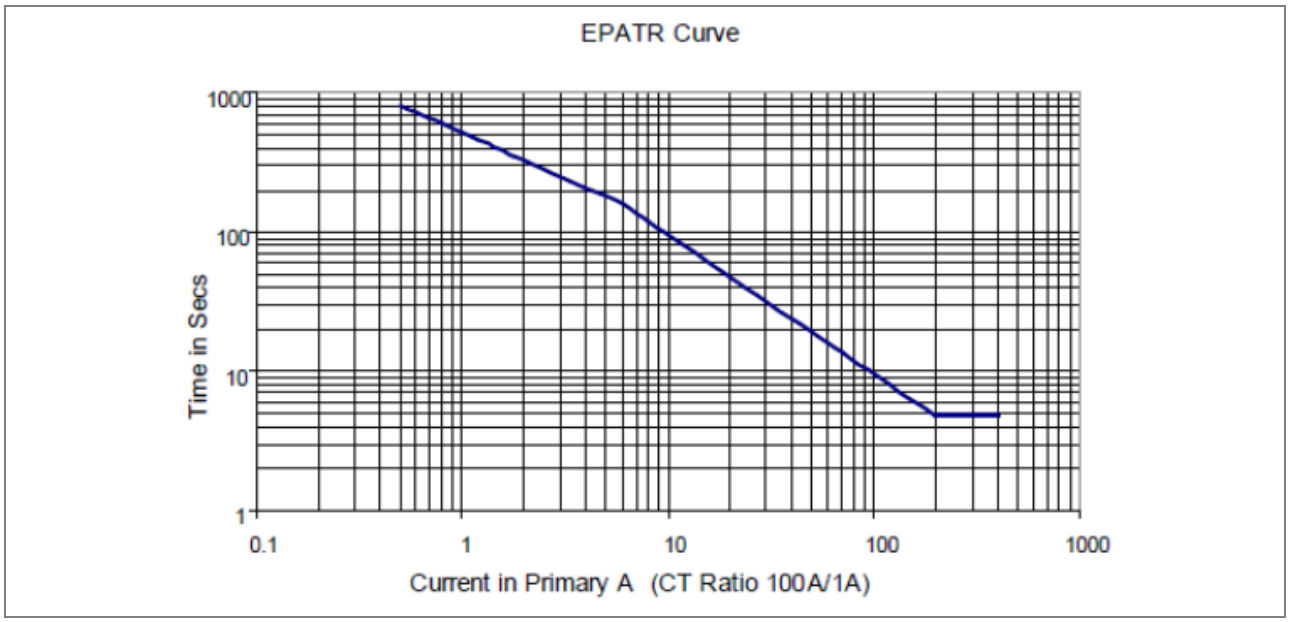
EPATR B curve is commonly used for time delayed Sensitive Earth Fault or Earth Fault. This curve is based on primary current, using a fix CT ratio of 100:1 A.

The EPATR B curve has 3 separate segments defined in terms of the primary current. It is defined as follows:

Segment	Primary Current Range Based on 100A:1A CT Ratio	Current/Time Characteristic
1	I = 0.5A to 6.0A	t = 360 TMS / I^0.667
2	I = 6.0A to 200A	t = 656 TMS / I
3	I above 200A	t = 3.28 x TMS

Where TMS is Time Multiplier Setting.

EPATR B characteristic with TMS = 1



9.3 OVERCURRENT PROTECTION (50/51)

Most electrical power system faults result in an overcurrent of one kind or another. It is the job of the protection function embedded in the C264 to protect the power system from faults. The general principle is to isolate the faults as quickly as possible to limit the danger and prevent fault currents flowing through systems, which can cause severe damage to equipment and systems.

At the same time, only strictly necessary parts of the power grid should be cut off, in order to prevent unnecessary blackouts.

The protection devices that control the tripping of the power grid's circuit breakers are highly sophisticated electronic units, providing an array of functionality to cover the different fault scenarios for a multitude of applications.

To ensure that only the necessary circuit breakers are tripped and that these are tripped with the smallest possible delay, the IEDs in the protection scheme need to co-ordinate with each other. The most commonly applied characteristic in coordinating overcurrent devices is the IDMT (Inverse Definite Minimum Time) type.

9.3.1 PHASE OVERCURRENT PROTECTION IMPLEMENTATION

The C26x offers a Phase Overcurrent protection function (ANSI 50/51).

Overcurrent protection function	IEEE/ANSI C37.2 Function	IEC 61850-7-4 Logical Nodes
Instantaneous phase overcurrent protection	50	PTOC
Time delayed phase overcurrent protection	51	

Although not as common as earth faults (single phase to earth), phase faults are typically more severe.

The phase Overcurrent protection function:

- Detects short circuits in electrical devices
- Can be used as backup overcurrent protection in addition to the main protection

The Overcurrent element can be configured with standard inverse curves or can be set to definite time.

The C26x provides six stages of segregated three-phase overcurrent protection, each with independent time delay characteristics. The settings are independent for each stage, but for each stage, settings apply to all phases.

There is no intentional “hysteresis” when the current is above the set start threshold. However, the accuracy is guaranteed within the current input accuracy of 2%. Phase Overcurrent stages are level detectors that detect when the current magnitude exceeds a set threshold. When this happens, a Start signal is generated unless it is inhibited by a blocking signal. This Start signal initiates the operate timer, which can be configured as an IDMT timer or DT timer. The element drops from start without operation, if the measured current drops below 95% of the set start threshold, before the time for operation is reached.

9.3.1.1 SETTINGS

Phase Overcurrent function provides 6 independent stages, each with its specific settings.

These settings can be modified via MiCOM S1.

Refer to the **Settings** chapter of the C264 user manual for the description of each MiCOM S1 settings

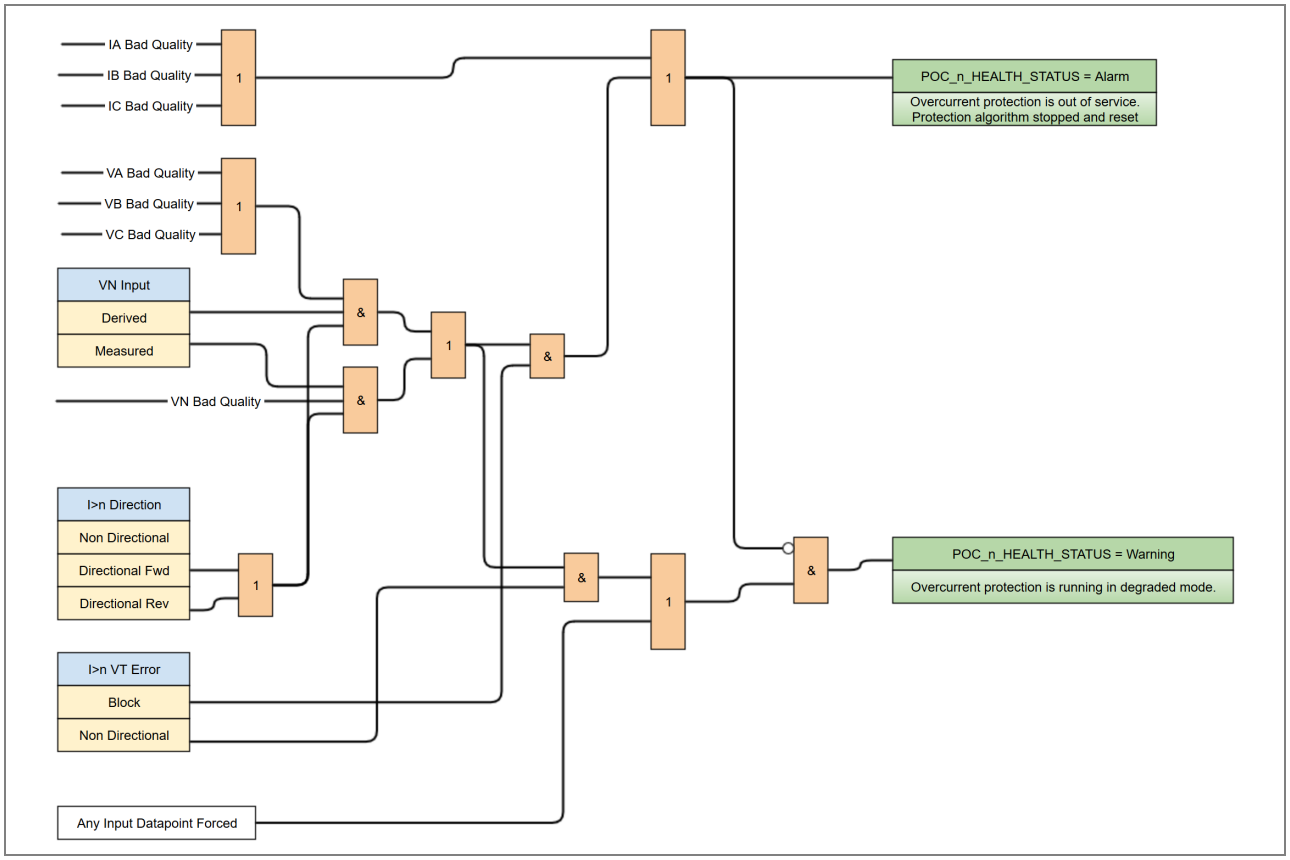
For input and output datapoint configuration, please refer to the **Application** chapter of the C264 user manual (section **Defining Protection Functions**).

9.3.1.2 INPUT DATAPOINTS

- **POC_n_TIMER_BLOCK**: Input signal used to block Operate timer only per stage. Timer block will have no effect when the element has operated. When the element has not operated, timer block will start the reset timer and when elapsed, it resets the operate timer.
- **POC_INHIBIT**: this signal disables the protection function and reset all associated datapoints and timers.
- **AR_BLOCK**: Setting "I>n Blocking" is used to determine if AR is blocking a given stage. It has same behaviour as if POC_n_TIMER_BLOCK was set for all DT stages. This signal blocks DT stage(s) only.
- **VTS_BLOCK**: VT supervision indicates a VT failure so directional cannot be achieved. According to “I>n VT Error” and “I>n Direction” settings, the stage will be blocked or change in non-directional as described above in setting part. Only start signal is impacted.
- **POC_CMD_CONTROL**: Command used to enable/disable overcurrent protection.
- **POC_n_CMD_CONTROL**: Command used to enable/disable overcurrent protection per stage.

9.3.1.3 OUTPUT DATAPOINTS

- **POC_n_BLOCK_STATUS**: Indicates if a specific stage is blocked.
- **POC_n_HEALTH_STATUS**: Indicates health of a specific stage. 3 possible states:
  - OK
  - Warning: overcurrent is running in degraded mode.
  - Alarm: overcurrent is out of service. Protection is not running



- **POC_n_PH_A_START**, **POC_n_PH_B_START**, **POC_n_PH_C_START**: Indicates a start on phase A, B or C of a specific stage.
- **POC_n_3PH_START**: Indicates a start on at least one phase of a specific stage.
- **POC_n_PH_A_OPERATE**, **POC_n_PH_B_OPERATE**, **POC_n_PH_C_OPERATE**: Indicates an operate on phase A, B or C of a specific stage.
- **POC_n_3PH_ OPERATE**: Indicates an operate on at least one phase of a specific stage.
- **POC_CMD_STATUS**: Feedback of POC_CMD_CONTROL.
- **POC_n_CMD_STATUS**: Feedback of POC_n_CMD_CONTROL.
- **POC_BLOCK_STATUS**: Indicates if at least one stage is blocked.
- **POC_n_HEALTH_STATUS**: Indicates health status per stage.
- **POC_n_DIR_STATUS**: Indicates fault direction per stage.

9.3.1.4 PERFORMANCE OF OVERCURRENT PROTECTION FUNCTION

IDMT Start	1.05 x Setting +/-5%
DT Start	Setting +/- 2%
Drop-off (IDMT and DT)	0.95 x setting +/- 5%
IDMT operation (for IEC and UK curves)	+/- 5% or 60 ms, whichever is greater (1.05 – <2) Is +/- 5% or 40 ms, whichever is greater (2 – 20) Is
IDMT operation (IEEE and US curves) For TD setting < 100s	+/- 5% or 60 ms, whichever is greater (1.05 – <2) Is +/- 5% or 40 ms, whichever is greater (2 – 20) Is
IDMT operation (IEEE and US curves) For TD setting > 100s	+/- 15% (1.05 - 20) Is
Disengagement	< 40 ms
DT operate	+/- 2% or 70 ms, whichever is greater (1.05 – <2) Is +/- 2% or 50 ms, whichever is greater (2 – 20) Is
DT reset	Setting +/- 5%
Repeatability	+/- 2.5%
Overshoot of overcurrent elements	<30 ms
Directional angle accuracy	+/- 2° with hysteresis <3°

9.4 EARTH FAULT PROTECTION (50N/50G/51N/51G/67N)

Earth faults are overcurrent faults where the fault current flows to earth. Earth faults are the most common type of fault.

Earth faults can be measured directly from the system by means of :

- A separate current Transformer (CT) located in a power system earth connection (Ground Earth Fault).
- A residual connection of the three-line CTs, where the Earth faults can be derived mathematically by summing the three measured phase currents (Neutral Earth Fault).

Depending on configuration, it will provide one or more of the above means for Earth fault protection.

The C26 provides four independent stages of Earth Fault protection fully configurable. For each stage it is possible to define :

- time delay characteristics : DT or IDMT curves
- current used : derived or measured
- directional or not

Being able to individually configure each step, measured/derived and directional, has a number of application advantages. For example, some applications may require directional earth fault protection for upstream equipment and backup earth fault protection for downstream equipment. This can be achieved with a single IED, rather than two.

9.4.1 EARTH FAULT PROTECTION IMPLEMENTATION

The C26x offers an Earth Fault protection function (ANSI 50N/50G/51N/51G/67N):

Overcurrent protection function	IEEE/ANSI C37.2 Function	IEC 61850-7-4 Logical Nodes
Neutral Overcurrent Protection (derived)	50/51N	Earth Fault (derived) (EFD)
Sensitive Ground Overcurrent Protection	50/51G	Sensitive earth fault (SEF)
Neutral Directional Overcurrent Protection	67N	Earth Fault 2 (EFD)

The "Earth Fault" protection function provides four levels of protection against earth faults that can be switched independently. The settings are independent for each stage, but for each stage, settings apply to all phases.

Earth Fault Overcurrent stages are level detectors that detect when the current magnitude exceeds a set threshold. When this happens, a Start signal is generated unless it is inhibited by a blocking input signal. This Start signal initiates the operate timer, which can be configured as an IDMT timer or DT timer. The element drops from start without operation, if the measured current drops below 95% of the set start threshold, before the time for operation is reached.

9.4.1.1 CONFIGURATION AND SETTINGS

Earth Fault function provides 4 independent stages, each with its specific settings.

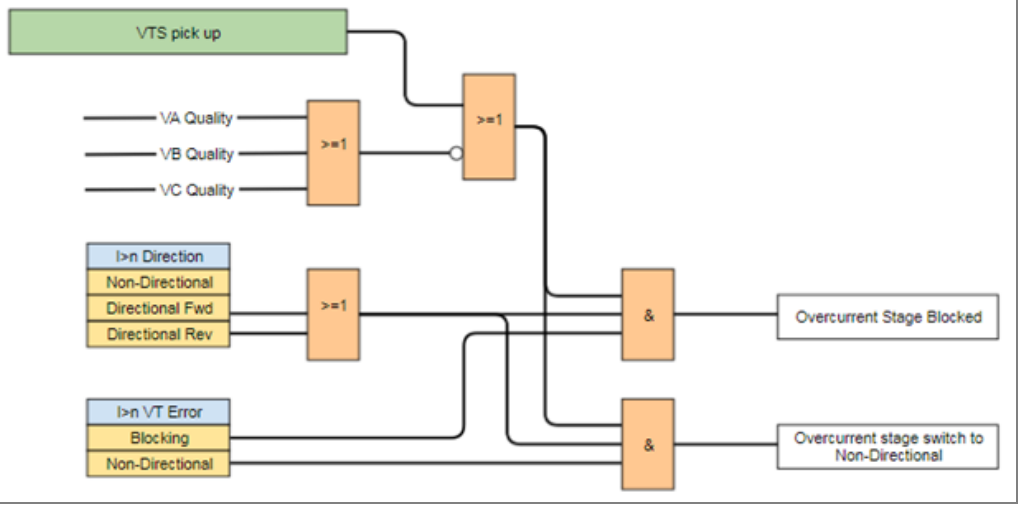
Description of MiCOM S1 settings

Note: n represents one stage (from n1 to n4) according to configuration.

Setting	Description	Range
Earth Fault	Enables/disables the whole Earth Fault protection	• Enable (default value), • Disable
EF> Polarization	Allows to choose the polarization vector for all stages	• VN • Neg Phase Sequence
EF> VNpol Set	Defines the polarization voltage threshold for all stages to avoid taking into account acquisition noise; Visible if "EF> Polarization" = "Zero Sequence″.	• From 0.005 to 0.800 x Vn in steps of 0.005 x Vn
EF> V2pol Set	Defines the polarization voltage threshold for all stages to avoid taking into account acquisition noise; Visible if "EF> Polarization" = "Neg Phase Sequence″.	• From 0.005 to 0.250 x Vn in steps of 0.005 x Vn
EF> I2pol Set	Defines the polarization current threshold for all stages to avoid taking into account acquisition noise. Visible if "EF> Polarization" = "Neg Phase Sequence″.	• From 0.08 to 1.00 x In in steps of 0.01 x In
EF>n Status	Enables/disables the Earth Fault stage. Visible if "Earth Fault=Enable″.	• Enable (default value), • Disable
EF>n Direction	Defines the direction of fault to be considered. If the calculated direction is different from configured direction, then start and operate signals will not pick-up. Visible if " EF>n Status=Enable".	• Non-Directional (default value) • Directional Fwd • Directional Rev
EF>n Char Angle	Defines the characteristic angle for the directional element. This setting is only shown in **Advanced** display mode. Visible if : "EF>n Direction" <> Non-Directional	From -180 to 180°, in steps of 1° Default: 45°
EF>n Operate Angle	Defines the opening angle of the forward or reverse operate zone. This setting is only shown in **Advanced** display mode. Visible if : "EF>n Direction" <> Non-Directional	From 0 to 180° in steps of 1° Default: 180°

Setting	Description	Range
EF>n Characteristic	Sets the characteristic (DT or IDMT) of the stage. Visible if ("EF>n Status=Enable")	• **DT** (default value) • **IEC S Inverse** • **IEC V Inverse** • **IEC E Inverse** • **UK LT Inverse** • **RI** • **IEEE M Inverse** • **IEEE V Inverse** • **IEEE E Inverse** • **US Inverse,** • **US ST Inverse** • **IDG** • **ANSI N Inverse** • **ANSI ST Inverse** • **ANSI LT Inverse** • **ANSI V Inverse** • **ANSI E Inverse** • **EPATR B**
EF>n Reset Char	This setting is a selection of a Definite Time (DT) or Inverse reset time for curves. • If DT reset is selected, Earth Fault stage will reset after a time delay provided by “EF>n tReset” setting. • If Inverse reset is selected, the time to reset is calculated based on the reset equation for the selected inverse curve.	• Inverse (default value), • DT
EF>n Time Delay / DT Adder / IDG Time	This setting is a factorization of 3 settings: • **Time Delay**, to define a time delay for DT characteristic • **DT Adder**, to add an additional fixed time delay to an IDMT Operate characteristic. • **IDG Time**, to set the minimum operating time at high levels of fault current	From 0.00 to 100.00s in steps of 0.01s (default 0.00s)

Setting	Description	Range
EFI>n TMS / TD / k(RI) / IDG Is	This setting is a factorization of 4 settings: • **TMS**, Time Multiplier Setting to adjust operate time of IEC, EPATR-B and UK IDMT characteristic • **TD**, Time Multiplier Setting to adjust operate time of IEEE, ANSI and US IDMT characteristic • **k(RI)**, Time Multiplier Setting to adjust operate time of RI characteristic. • **IDG Is**, Time Multiplier Setting to adjust operate time of IDG characteristic Visible if ("EF>n Characteristic<>DT")	From 0.010 to 100.000s in steps of 0.010s • Default: 1.000s
EF>n Current Set	Sets the pick-up threshold of Earth Fault stage. This setting, associated with time setting, must be defined in accordance with the hardware capacity of the device. Visible if ("EF>n Status=Enable")	From 0.05 to 40.00 x In in steps of 0.01 x In • Default: 0.20 x In
EF>n Reset Mode	This setting is based on IEC 60255-151 reset characteristics. • If Definite Time is selected, the relay shall return to its reset state after a user-defined reset time delay, i.e., Reset Time. During the reset time, the element shall retain its state value. • If Dependent Time is selected, the relay shall return to its reset state after a user-defined reset time delay, i.e., Reset Time. During the reset time, the timer will be decremented.	• Definite Time, • Dependent Time (default value)
EF>n tReset	This setting defines the Reset time for the Definite Time Reset characteristic. Visible if not("EF>n Reset Char=DT")	From 0.00 to 100.00s in steps of 0.01s • Default: 0s
EF>n Input	Defines which current input is used.	• Measured (default value) • Derived
EF>n Blocking	Block will reset the start signal, if element is not operated. If element is operated, it does not have any effect	• None (default value), • AR

I>n VT Error	This setting defines the behavior of OC stage when Directional is selected and a problem occur on a VT. Two possible causes to detect VT issues are: VTS pick up and bad voltage quality	Block (default value), Non-Directional
		

For input and output datapoint configuration, please refer to the **Application** chapter of the C264 user manual (section **Defining Protection Functions**).

9.4.1.2 PERFORMANCE OF OVERCURRENT PROTECTION FUNCTION

IDMT Start	1.05 x Setting +/-5%
DT Start	Setting +/- 2%
Drop-off (IDMT and DT)	0.95 x setting +/- 5%
IDMT operation	+/- 5% or 60 ms, whichever is greater (1.05 – <2) Is +/- 5% or 40 ms, whichever is greater (2 – 20) Is
Disengagement	< 40 ms
DT operate	+/- 2% or 70 ms, whichever is greater (1.05 – <2) Is +/- 2% or 50 ms, whichever is greater (2 – 20) Is
DT reset	Setting +/- 5%
Repeatability	+/- 2.5%
Directional angle accuracy	+/- 2° with hysteresis <3°
Zero sequence polarising accuracy	Directional Start: +/- 2° Hysteresis: < 3° VN> Start: Setting +/- 10% VN> drop off: 0.9 x Setting +/- 10%
Negative sequence polarising accuracy	Directional Start: +/- 2° Hysteresis: < 3° VN> Start: Setting +/- 10% VN> drop off: 0.9 x Setting +/- 10% IN> Start: Setting +/- 10% IN> drop off: 0.9 x Setting +/- 10%

9.5 CIRCUIT BREAKER FAILURE (50BF)

When a fault occurs, one or more protection devices will operate and issue a trip command to the relevant circuit breakers. Operation of the circuit breaker is essential to isolate the fault and prevent, or at least limit, damage to the power system.

For transmission and sub-transmission systems, slow fault clearance can also threaten system stability. It is therefore common practice to install circuit breaker failure protection, which monitors that the circuit breaker has opened within a reasonable time.

If the fault current has not been interrupted following a set time delay from circuit breaker trip initiation, breaker failure protection will operate.

The circuit breaker failure protection provides two parallel elements to monitor CB that can be initiated by :

- Internal initiation. Any internal operate signal should trigger CB Fail protection.
- External initiation. Any trip from another device can be connected through logic to this external initiation to trigger CB Fail protection.

Each element consists of two-stage with two dedicated timers.

First timer is used to raise a retrip signal, second timer is used to raise a back-trip signal.

These two signals can be mapped to a physical digital output.

9.5.1 CIRCUIT BREAKER PROTECTION IMPLEMENTATION

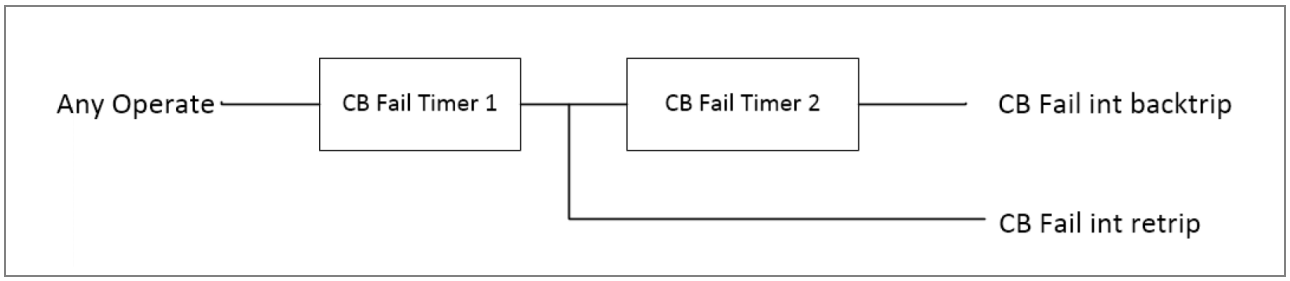
9.5.1.1 CONFIGURATION AND SETTINGS

Setting	Description	Range
CB Fail	Enables/disables the Circuit Breaker Failure protection	• Enable (default value), • Disable

9.5.1.2 INTERNAL INITIATION

CB monitoring can be initiated by internal initiation. Two timers, **CB Fail Timer 1** and **CB Fail Timer 2** are used:

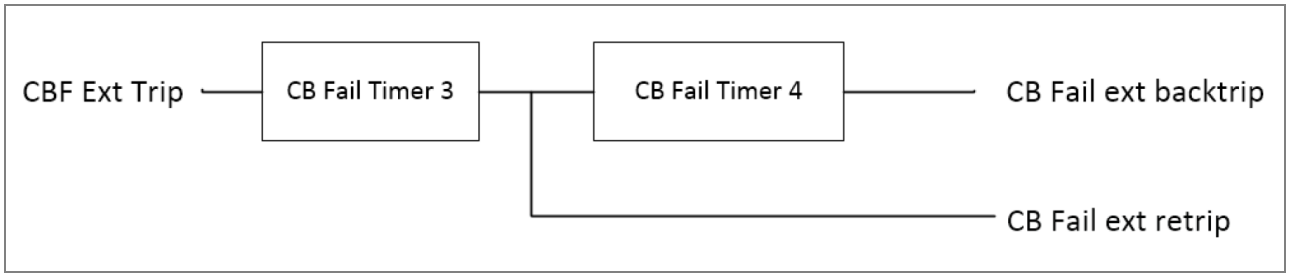
Warning : in the diagram below, the Any Operate datapoint is not used to automatically trigger the CB fail timer. If the user wants the "Any operate" datapoint to trigger the CB fail timer, he/she must use an FBD or Automation to link "Any operate" to "CB Trip" which, on SET, will trigger CB Fail timers. These relations must be defined manually.



Setting	Description	Range
Int CB Fail Mode	Enables/disables the Internal Circuit Breaker Failure protection	• Enable (default value), • Disable
CB Fail Timer 1	Defines the time before to raise an internal retrip signal Visible if "CB Fail" = Enable	From 0.00 to 50.00s in steps of 0.01s Default: 0.20s
CB Fail Timer 2	Defines the time before to raise an internal backtrip signal Visible if "CB Fail" = Enable	From 0.00 to 50.00s in steps of 0.01s Default: 0.20s
Int CBF Reset	Defines the condition to reset the circuit breaker fail protection initiated by internal condition. • If this setting is set to "I<" or "I< & CB Open" and "Int IN< Status" is enabled, both undercurrent (phase and ground) have to be detected to reset CB Fail. • If this setting is set to "I<" or "I< & CB Open" and "Int IN< Status" is disabled, only phase undercurrent has to be detected to reset CB Fail. Visible if "CB Fail" = Enable	• I< (default value) • CB Open • I< & CB Open
Int I< Current Set	Defines the threshold for phase undercurrent used to reset circuit breaker fail protection initiated by internal condition Visible if "Int CBF Reset" <> CB Open	From 0.05 to 4.00 x In in steps of 0.01 x In Default: 0.10 x In
Int IN< Status	Enables/disables monitoring of ground current. This monitoring should be used only with measured current. Visible if "CB Fail" = Enable	• Enable • Disable (default value)
Int IN< Current Set	Defines the threshold for ground undercurrent used to reset circuit breaker fail protection initiated by internal condition Visible if ("Int CBF Reset" <> CB Open) and (Int IN< Status = enable)	From 0.05 to 4.00 x In in steps of 0.01 x In Default: 0.10 x In

9.5.1.3 EXTERNAL INITIATION

CB monitoring can be initiated by external initiation. Two timers, **CB Fail Timer 3** and **CB Fail Timer 3** are used:



Setting	Description	Range
Ext CB Fail Mode	Enables/disables the External Circuit Breaker Failure protection	• Enable (default value), • Disable
CB Fail Timer 3	Defines the time before to raise an external retrip signal Visible if "CB Fail" = Enable	From 0.00 to 50.00s in steps of 0.01s Default: 0.20s
CB Fail Timer 4	Defines the time before to raise an external backtrip signal Visible if "CB Fail" = Enable	From 0.00 to 50.00s in steps of 0.01s Default: 0.20s
Ext CBF Reset	Defines the condition to reset the circuit breaker fail protection initiated by external condition. • If this setting is set to "I<" or "I< & CB Open" and "Ext IN< Status" is enabled, both undercurrent (phase and ground) have to be detected to reset CB Fail. • If this setting is set to "I<" or "I< & CB Open" and "Ext IN< Status" is disabled, only phase undercurrent has to be detected to reset CB Fail. Visible if "CB Fail" = Enable	• I< (default value) • CB Open • I< & CB Open
Ext I< Current Set	Defines the threshold for undercurrent used to reset circuit breaker fail protection initiated by external condition. Visible if "Ext CBF Reset" <> CB Open	From 0.05 to 4.00 x In in steps of 0.01 x In Default: 0.10 x In
Ext IN< Status	Enable/disable monitoring of ground current. This monitoring should be used only with measured current. Visible if "CB Fail" = Enable	• Enable • Disable (default value)
Ext IN< Current Set	Defines the threshold for ground undercurrent used to reset circuit breaker fail protection initiated by external condition Visible if ("Ext CBF Reset" <> CB Open) and (Ext IN< Status = enable)	From 0.05 to 4.00 x In in steps of 0.01 x In Default: 0.10 x In

9.5.1.4 INPUT DATAPOINTS

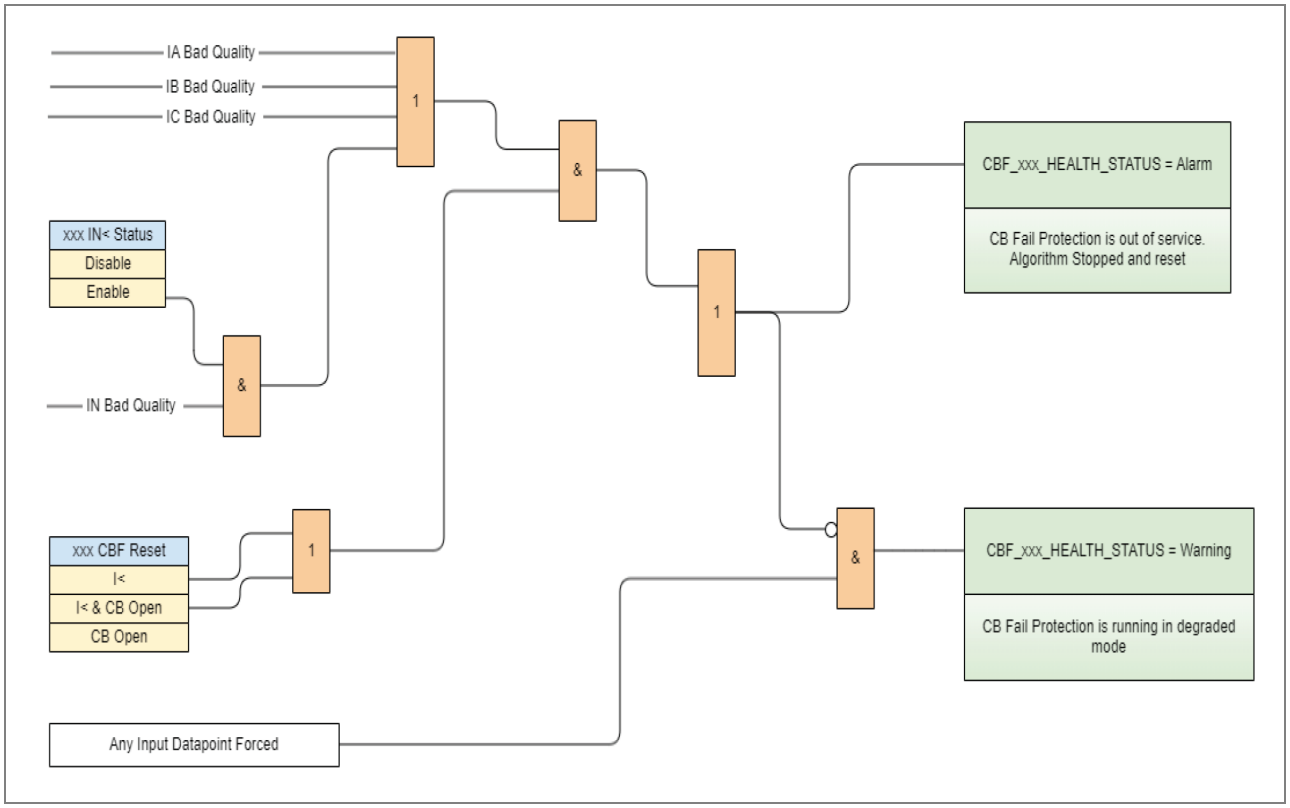
- **CBF Int Trip**: Input signal used to trigger internal CB Fail.
- **CB Open**: Common signal used to know CB position as described BCU - Protection Common Behavior.
- **CBF Ext Trip**: Input signal used to trigger external CB Fail.
- **CBF_CMD_CONTROL**: Command used to enable/disable circuit breaker failure protection
- **CBF_INHIBIT**: This signal will disable the protection function and reset all associated datapoints and timers.

9.5.1.5 OUTPUT DATAPOINTS

Following table describes output signals and status.

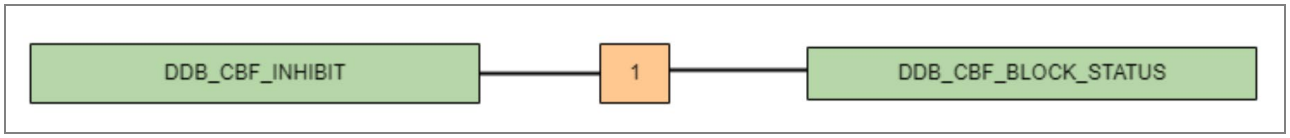
Setting	Description
CB Fail Int retrip	Indicates that CB Fail Timer 1 elapsed
CB Fail Int backtrip	Indicates that CB Fail Timer 2 elapsed
CB Fail Int health status	Indicates health status
CB Fail Ext retrip	Indicates that CB Fail Timer 3 elapsed
CB Fail Ext backtrip	Indicates that CB Fail Timer 4 elapsed
CB Fail Ext health status	Indicates health status
CBF_CMD_STATUS	Feedback of CBF_CMD_CONTROL
Internal Start	Indicates if internal CB Fail was initiated
External Start	Indicates if external CB Fail was initiated

9.5.1.5.1 Heath Status



xxx = int for module with internal meaning / ext for module with external meaning.

9.5.1.5.2 Block Status



9.5.1.6 ZERO CROSSING DETECTION

- PHASE_A_UNDERCURRENT_AND_ZERO_CROSSING: monitors internal undercurrent and zero crossing function.
- PHASE_B_UNDERCURRENT_AND_ZERO_CROSSING: monitors internal undercurrent and zero crossing function.
- PHASE_C_UNDERCURRENT_AND_ZERO_CROSSING: monitors internal undercurrent and zero crossing function.
- EF_UNDERCURRENT_AND_ZERO_CROSSING: monitors internal undercurrent and zero crossing function.

PHASE_X_UNDERCURRENT_AND_ZERO_CROSSING is an MPS which contains an enum with 4 possible values:

State Value	Condition
0	UNDERCURRENT = FALSE / ZERO CROSSING = FALSE
1	UNDERCURRENT = FALSE / ZERO CROSSING = TRUE
2	UNDERCURRENT = TRUE / ZERO CROSSING = FALSE
3	UNDERCURRENT = TRUE / ZERO CROSSING = TRUE

Same behavior as EF_UNDERCURRENT_AND_ZERO_CROSSING.

9.5.1.7 PERFORMANCE OF CB PROTECTION FUNCTION

I< Pick-up	Setting +/- 5% or 20 mA, whichever is greater
I< Drop-off	1.05 x setting +/- 5% or 20 mA, whichever is greater
Timers	+/- 2% or 50 ms, whichever is greater
Reset time	< 35 ms
Decay current	Decay current shall not be considered as load current so CBF should be reset in case of decay current and current criterion selected by setting to reset. When there is a fault and the circuit breaker interrupts the CT primary current, the flux in the CT core decays to a residual level. This decaying flux introduces a decaying DC current in the CT secondary circuit known as subsidence current. The closer the CT is to its saturation point, the higher the subsidence current. The time constant of this subsidence current depends on the CT secondary circuit time constant and it is generally long. If the protection clears the fault, the CB Fail function should reset fast to avoid maloperation due to the subsidence current.

10 CONTROL SEQUENCES

10.1 DESCRIPTION

A Control Sequence is a basic built-in function on a module (switch, relay, and function). It receives control order, sending back response and acknowledgement. After the checks, control sequence sends control (protocol or DO), and check correct execution with feedback from protocol or from DI.

10.1.1 GENERAL

The C26x allows the following functions:

- Control of switching devices (circuit-breaker, disconnector, …)
- Control of transformers
- Control of secondary devices
- Locking of switching devices
- Control of IEDs
- Control of automatisms

These types of controls are allowed:

- Select control request
- Execute control request
- Cancel control request

Upon reception of one of these requests, the control unit's behaviour varies according to:

- The configuration of the device control,
- The type of the device,
- The control unit operating mode.

10.1.1.1 DEVICE CONTROL CONFIGURATION

By configuration, at SCE level, a control may be executed in one of the following modes:

- "**Direct Execute**" mode: usually for ancillary devices a control may be performed directly without the selection phase.
- "**Select Before Operate once**" mode" (**SBO once**): usually for circuits breakers and disconnectors. The device must be selected before allowing the execution. In that event the device is managed in two phases: selection and execution. Device unselection is done by sending a cancel request.
- "**Select Before Operate many**" (**SBO many**): usually for transformers. The device must be selected before executing one or more controls before reaching the expected position (low/raise). In that event the device is managed in two phases: selection and execution. The execution phase is repeated for every new control without sending a new select request. To end the controls sequence, the initiator of the request must send a cancel request.
- By configuration, each DPC order (close order or open order) and each SPC can activate simultaneously two DO contacts.

10.1.1.2 TYPES OF DEVICES

Every control sequence may be different according to the type of the device to control. The complexity of the control sequence may be more or less important depending on the device:

- Synchronised or non-synchronised circuit-breakers, disconnectors and earthing switches: They are managed in **"Direct execute"** mode or **"SBO once"** mode with optional hardware selection of the device in SBO mode.
- Transformers: They are managed in the three modes: **"Direct Execute"**, **"SBO once"** and **"SBO many"** mode with optional hardware selection of the device in SBO mode.
- Ancillary devices: they are usually managed in **"Direct Execute"** mode but can be managed also in **"SBO once"** mode.
- System Controls: System outputs are used to activate or inactivate automatic functions on the control unit: for example, Auto-recloser ON/OFF; change operating modes; and so on.
- Controls via Setpoints: are managed in **"Direct Execute"** mode and in **"Direct Execute with SBO popup"** mode.

10.1.2 CONTROL SEQUENCE PHASE MANAGEMENT

According to the configuration of the device control, a control sequence is performed in one, two, or three phases. Each phase of a control sequence (selection, execution and cancellation) may have a normal or abnormal termination and positive or negative acknowledgement is sent to the IEC 61850-8-1 clients subscribed during the configuration process.

- **One phase – "Direct Execute" mode:**
  - **Execution phase**: If the execution phase ends normally the control unit generates a positive acknowledgement and the control sequence ends. In the event of an abnormal termination, the control sequence is aborted and the control unit generates a negative acknowledgement. The hardware selection of the device in "Direct Execute" mode is not permitted.
- **Two phases – "SBO once" mode:**
  - **Selection phase**: In the selection phase for a normal termination the control unit generates a positive acknowledgement and proceeds to the next phase of the sequence (execution phase).
  - **Execution phase**: If the execution phase ends normally the control unit generates a positive acknowledgement and the control sequence ends. In the event of an abnormal termination, the control sequence is aborted and the control unit generates a negative acknowledgement.
- **Three phases – "SBO many" mode:**
  - **Selection phase**: In the selection phase for a normal termination the control unit generates a positive acknowledgement and proceeds to the next phase of the sequence (execution phase)
  - **Execution phase**: If the execution phase ends normally the control unit generates a positive acknowledgement and waits a new execution request. In the event of an abnormal termination, the control sequence is aborted and the control unit generates a negative acknowledgement.
  - **Cancellation phase**: The control unit deselects the device and exits the control sequence sending positive acknowledgement. In the event of a failure to deselect the device, the control unit sends a negative acknowledgement.

The following figures show the three control modes of the control unit:

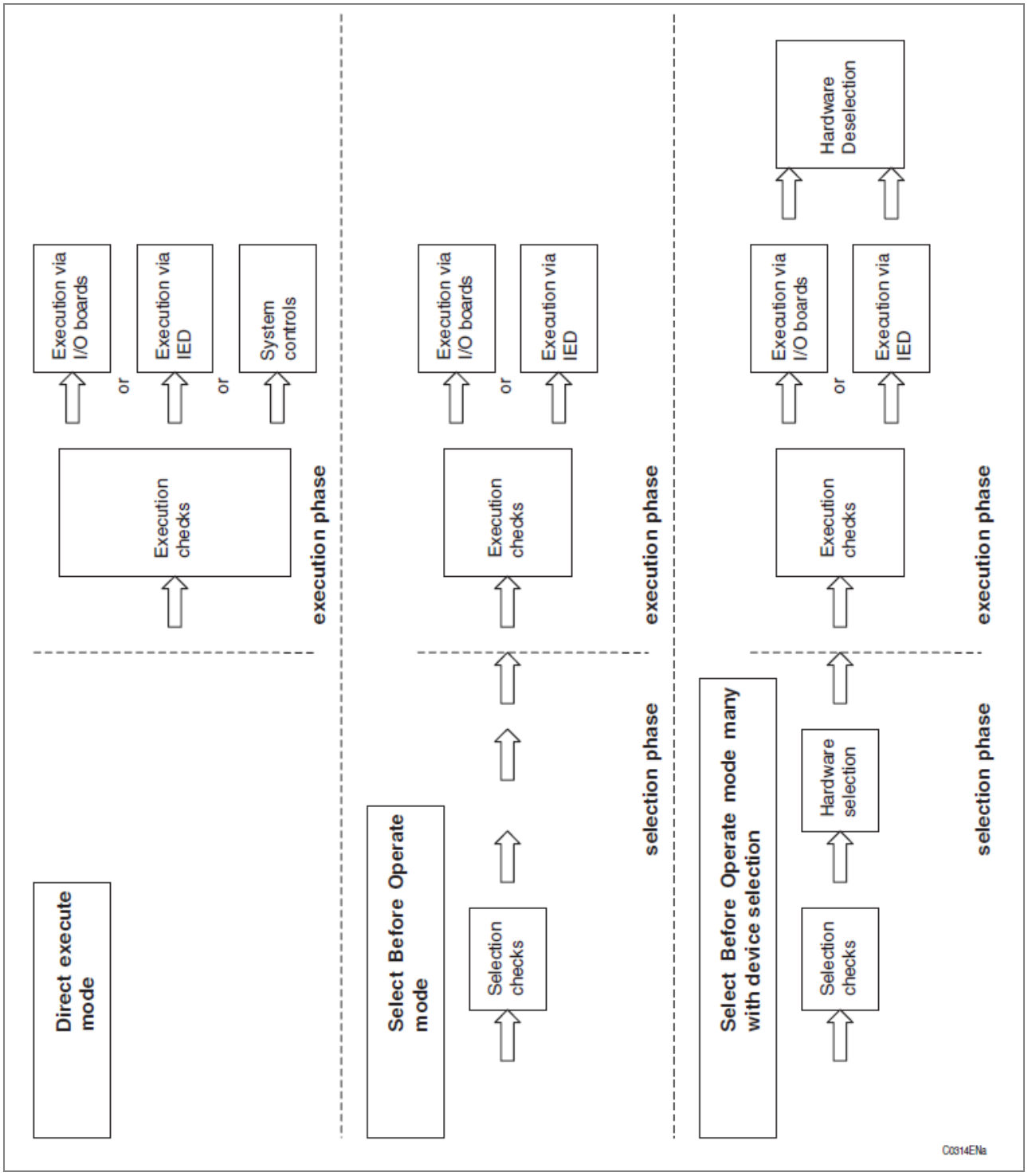


Figure 42: Control modes of the control unit (1)

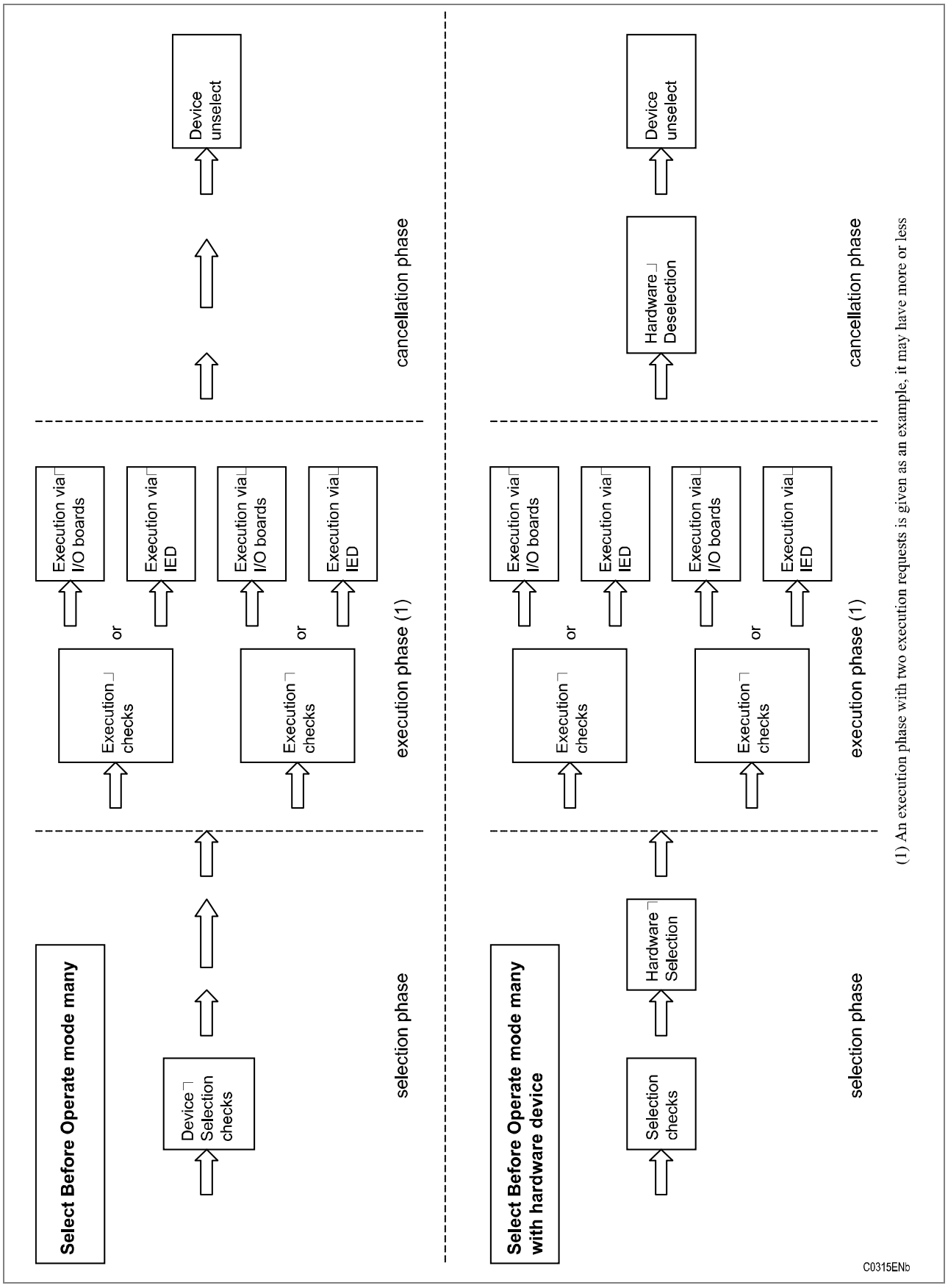


Figure 43: Control modes of the control unit (2)

10.1.3 DIRECT EXECUTE MODE

In this mode a control of device is directly executed without need to be previously selected. Usually concerns ancillary devices managed via I/O boards (SPC, DPC, and Setpoints) or via IED.

The **"Direct Execute"** sequence ends normally after reception of the expected position information of the device or correct value (if setpoint control). Abnormally if the received position or value is unexpected, or not received in the predefined delay by configuration.

Note that a **"cancel"** request in **"Direct Execute"** mode has no guarantee to be performed before the execution of the request.

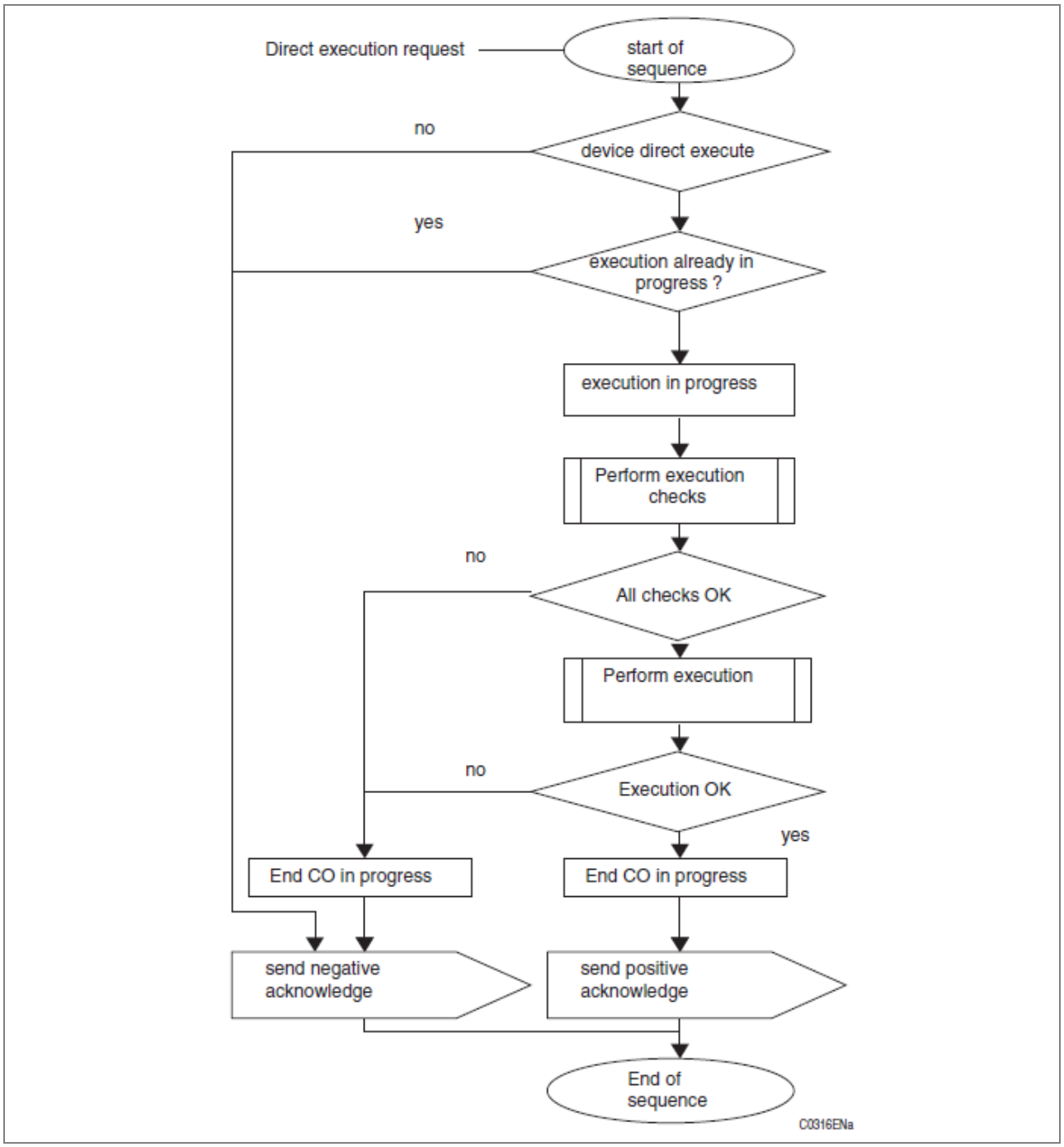


Figure 44: Execution phase for direct execute mode

10.1.4 SBO ONCE MODE

10.1.4.1 SELECTION PHASE IN “SBO ONCE” MODE

During the selection phase initialised by a selection request of the control, the controller performs selection checks in order to check whether the device is selectable or not.

If no fail occurs during these checks, the device is selected, and positive acknowledgement is sent. Otherwise the selection request is rejected and a negative acknowledgement is sent giving fails cause. If the selection of the device is accepted, the controller starts a delay and waits for:

- An execution request: open/close, low/raise
- A cancel of the selection request.

At the end of this delay if the execution or the cancel request is not sent, the device is automatically unselected without a negative acknowledgement. The selection delay is defined during the configuration step.

Note that only one selection is permitted at a time for a device. When a device is already selected any other selection is not taken into account (none acknowledgement is sent) whichever of the initiator.

The diagram that follows shows the selection phase of a device configured in SBO once mode.

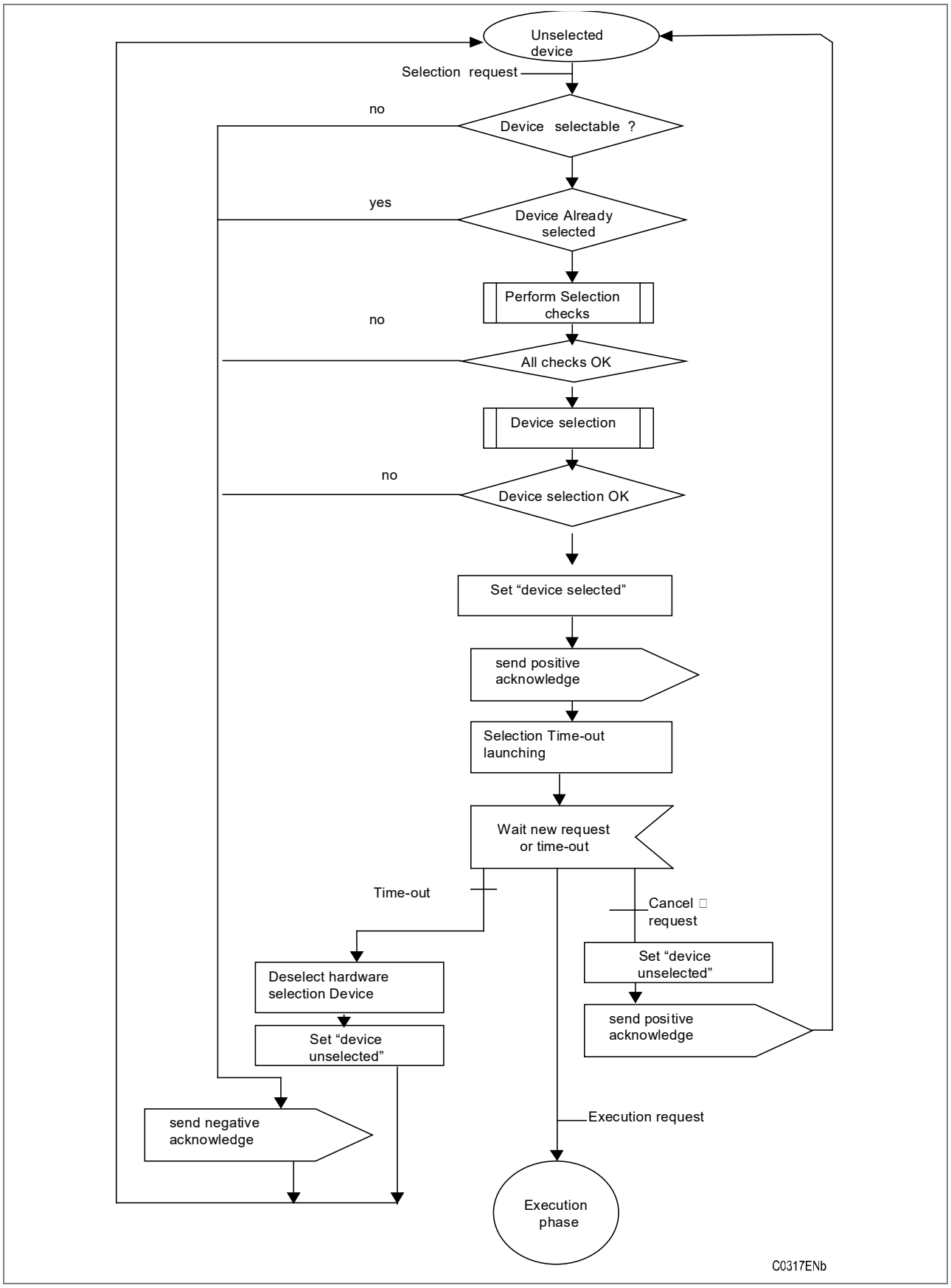


Figure 45: Selection phase in SBO once mode

10.1.4.2 EXECUTION PHASE IN "SBO ONCE" MODE

The execution phase can start only after reception of an execution request and if the device has been selected before.

In this phase, the control unit performs the execution checks, and if no fail, it proceeds to the execution according to the configuration, via the IO boards or IED communication.

If the execution ends normally, a positive acknowledgement is sent, and the control sequence ends. In the event of a failure, the control sequence is aborted and the control unit sends a negative acknowledgement.

During this phase a **"cancel**" request is not guaranteed except for synchronised circuit-breakers devices (refer to specifics treatments for synchronised circuit-breakers below).

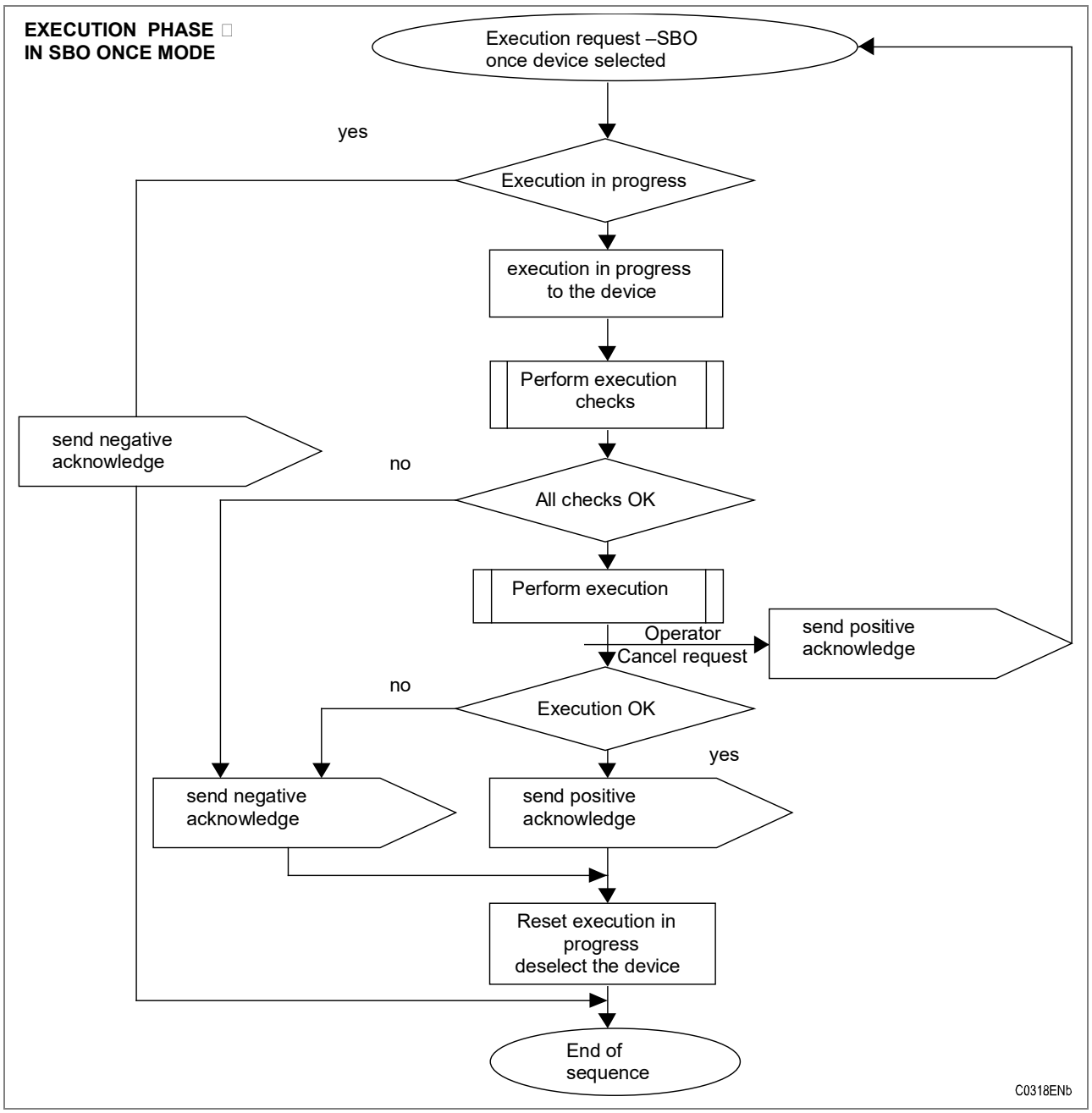


Figure 46: Execution phase on SBO once mode

10.1.5 SBO MANY MODE

This mode allows you to perform one or more control executions after the selection phase. It is usually used for the tap positioning process in where many controls are sent before reaching the desired position.

10.1.5.1 SELECTION PHASE IN SBO MANY MODE

The selection phase is identical to the “SBO once” mode selection phase.

10.1.5.2 EXECUTION PHASE IN SBO MANY MODE

The difference with the SBO once mode is that after having performed an “execution request”, the controller stays in execution phase waiting a new execution order or a **“cancel**” request. The execution phase ends only after a **“cancel**” request by the initiator.

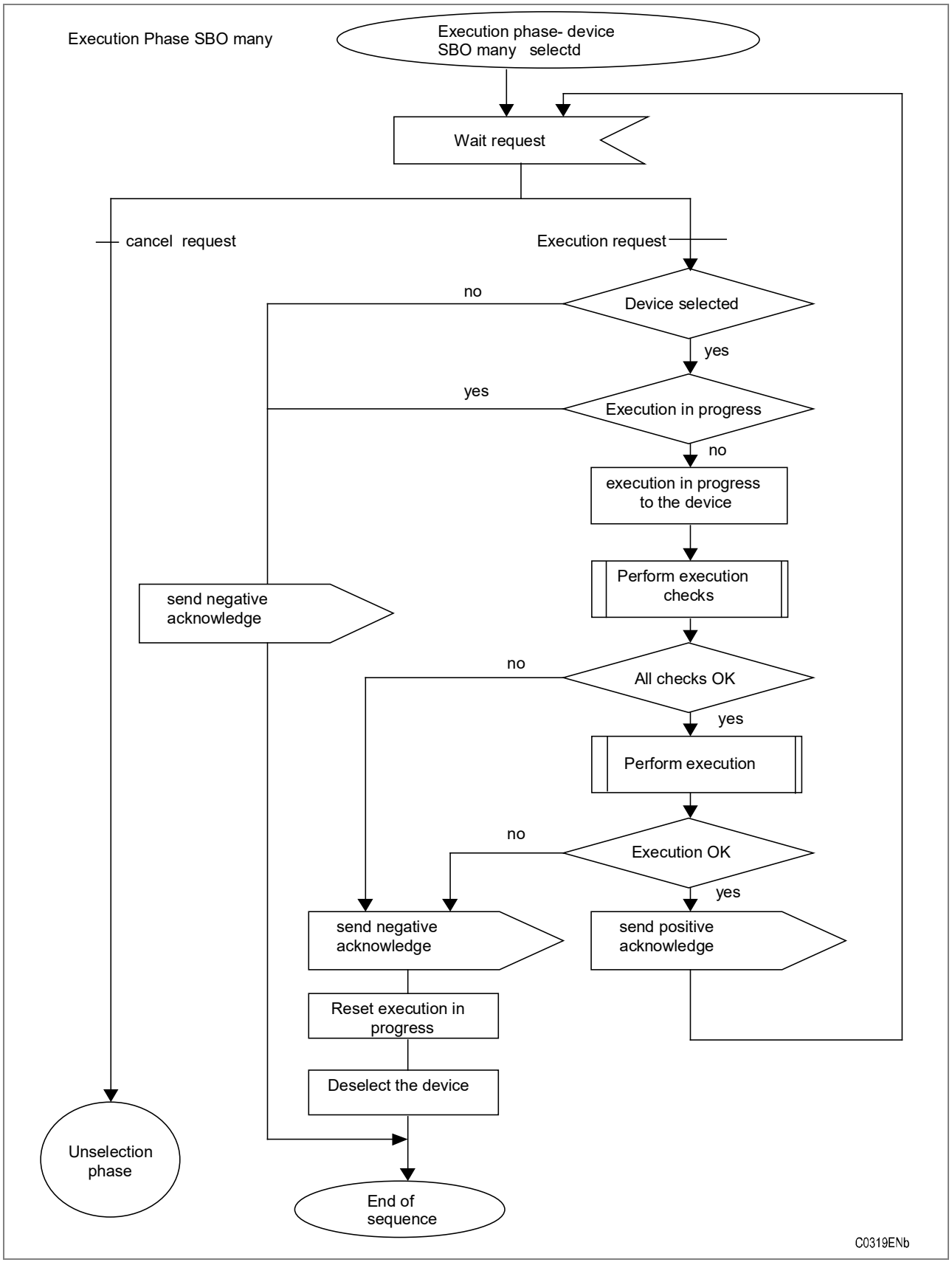


Figure 47: Execution phase in SBO many mode

10.1.5.3 UNSELECTION PHASE IN SBO MANY MODE

If the operator cancels the command while it is selected, the control unit deselects the device and sends a positive acknowledgement.

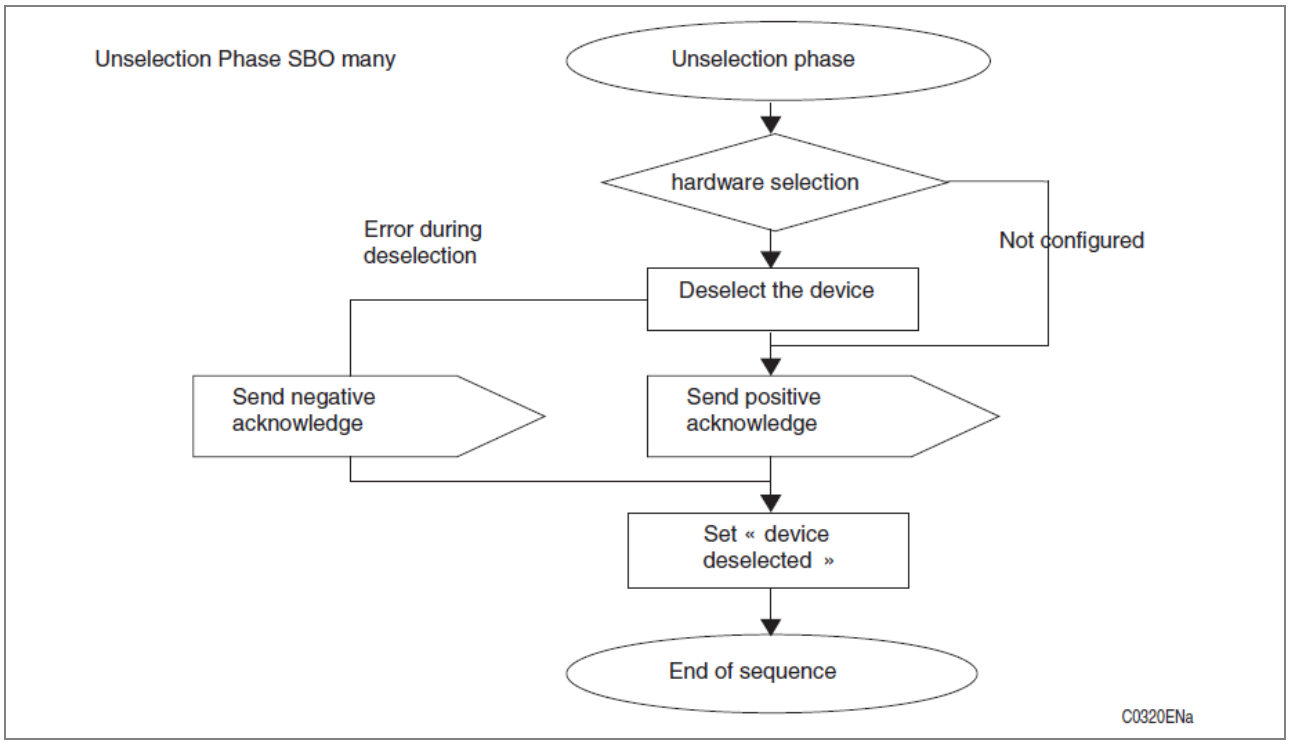


Figure 48: Unselection phase in SBO many mode

10.1.6 GENERIC SELECTION CHECKS

Checks performed during the selection phase Include:

- Inter-control delay
- control unit mode
- Substation and bay mode states
- Interlock and topological interlocking states
- Automation running control
- Device selectable
- Locked device state
- Status of the device
- Uniqueness
- Current value

In the event of a failure, if the rights have been granted to him/her through SCE, the initiator of the request may bypass the checks:

- Interlock and topological interlocking states

The diagram below sketches the checking process.

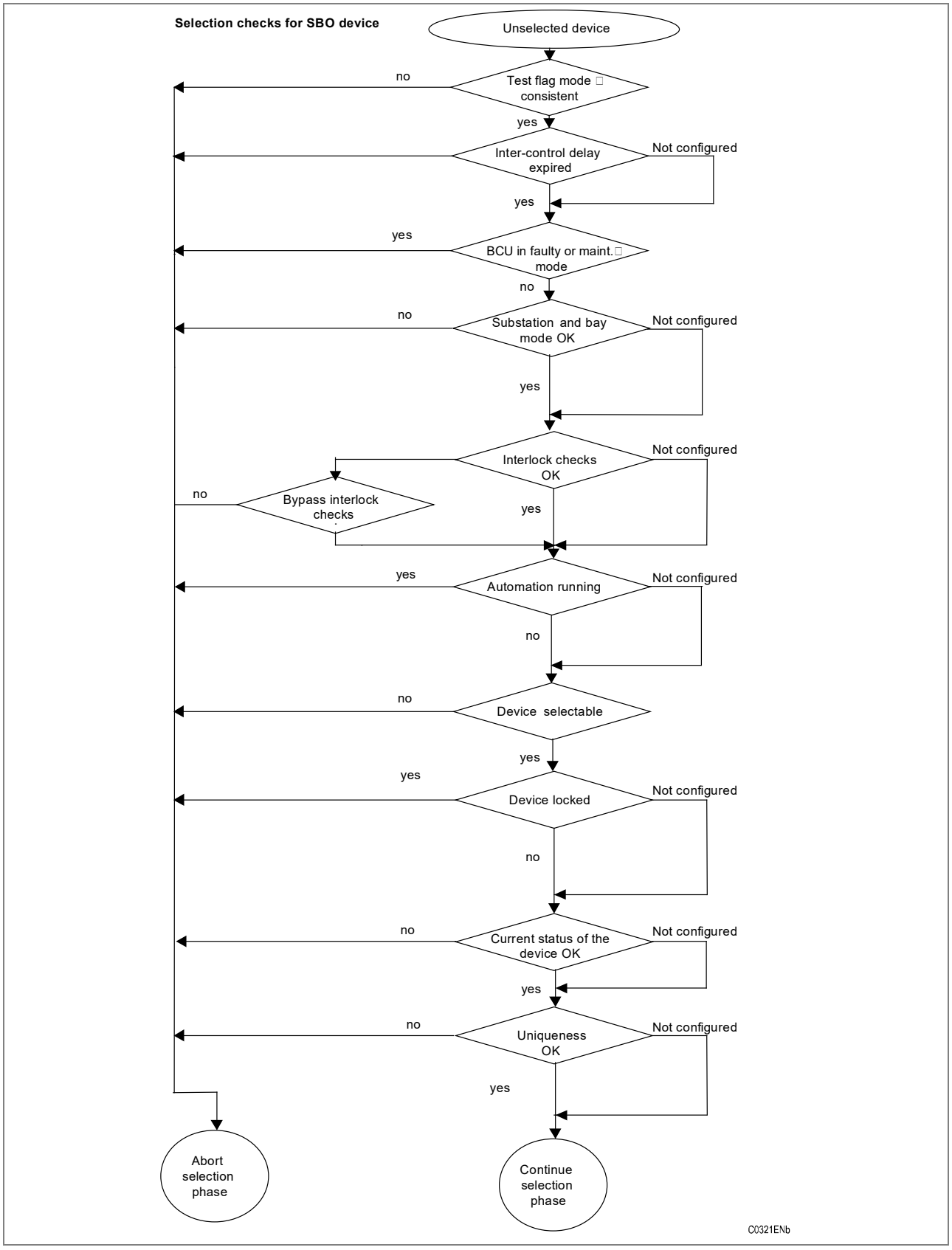


Figure 49: Selection checks for SBO device

10.1.6.1 INTER-CONTROL DELAY

For wired commands only, it is possible to define a user-selectable time-delay during which no new command to the same device is permitted. If this time-delay is set and has not elapsed when the new command is received, that command is not executed and a negative acknowledgement is sent.

10.1.6.2 C26X MODE

Control requests are accepted or not depending on the operating mode of the control unit.

- **Control test flag**: control requests are accepted only if the test flag status of the control matches the test/on state of the C26x.
- **Maintenance mode**: control requests are not accepted if the controller is in **maintenance** mode except system controls concerning control mode or database management.
- **Faulty mode**: no control is accepted when the controller is in this mode.
- **Changing mode**:
  - From **"operational"** mode to **"test"** mode: the specific control **"test"** mode is refused if at least one control is in progress.
  - From **"test"** mode to **"operational"** mode: the specific control **"test"** mode is refused if at least one control is in progress.
  - From **"operational"** mode to **"maintenance"** mode: all device controls in progress are aborted and no acknowledgement is sent.

10.1.6.3 SUBSTATION AND BAY MODE CONTROL

A device control may be dependent or not on the substation mode and bay mode. For every device control the configuration gives the dependency or not to the following modes:

- **Substation mode dependency** (local/remote)
- **SBMC mode dependency** (bay in maintenance or not)
- **Bay mode dependency** (local/remote)

The bay mode is checked by the controller managing the device if bay mode dependency is configured for this device.

The substation and SBMC modes are checked by the controller having slave protocols and only for controls coming from SCADA and if substation mode dependency is configured for this device.

If the request is refused the selection sequence is aborted with a negative acknowledgement.

10.1.6.4 INTERLOCK CONTROL

The configuration process allows to assign or not a logical equation to each order (close and open) of the device. If configured by the user, its state (true/false) may affect the control sequence. If it is false, the selection is refused, except if interlock bypass is set.

In the event of a failure, the sequence is aborted with a negative acknowledgement.

10.1.6.5 AUTOMATION RUNNING CONTROL

Each device may be locked by the presence of an input information (digital input, IED input) assigned during configuration. A "system input information" giving automatism state (active/inactive) can be used to prevent manually control execution in event an automatism is active for device monitoring.

In this event the sequence is aborted with a negative acknowledgement.

10.1.6.6 DEVICE SELECTABLE

A device is selectable if during configuration step its control is described to be managed in **"SBO once"** or **"SBO many"** mode and is not already selected. Otherwise the selection request is refused with negative acknowledgement.

10.1.6.7 LOCKED DEVICE CONTROL

The user may lock a device in order to avoid any wrong move. If the selection concerns a locked device the request is refused.

In event the device is locked the sequence is aborted with a negative acknowledgement.

10.1.6.8 CURRENT STATUS OF THE DEVICE

The status check of the device is optional. It is given by a binary input or computed using more than one binary input (event of circuit-breakers). Its behaviour can be chosen (during the configuration step) among one of the four following events: it is given by a binary input or computed using more than one binary input (event of circuit-breakers).

- The request is accepted whatever the status of the device (no check)
- The request is accepted only if the device is in the opposite state and valid
- The request is accepted only if the device is in the opposite state, jammed or undefined
- The request is refused only if the device is in the same state and valid. In any event, if the request is refused, a negative acknowledgement is sent back

10.1.6.9 UNIQUENESS

It is possible by configuration to prevent to have more than one control at a time.

- For the whole substation
- Inside a bay

The following figure describes the algorithm used between control units.

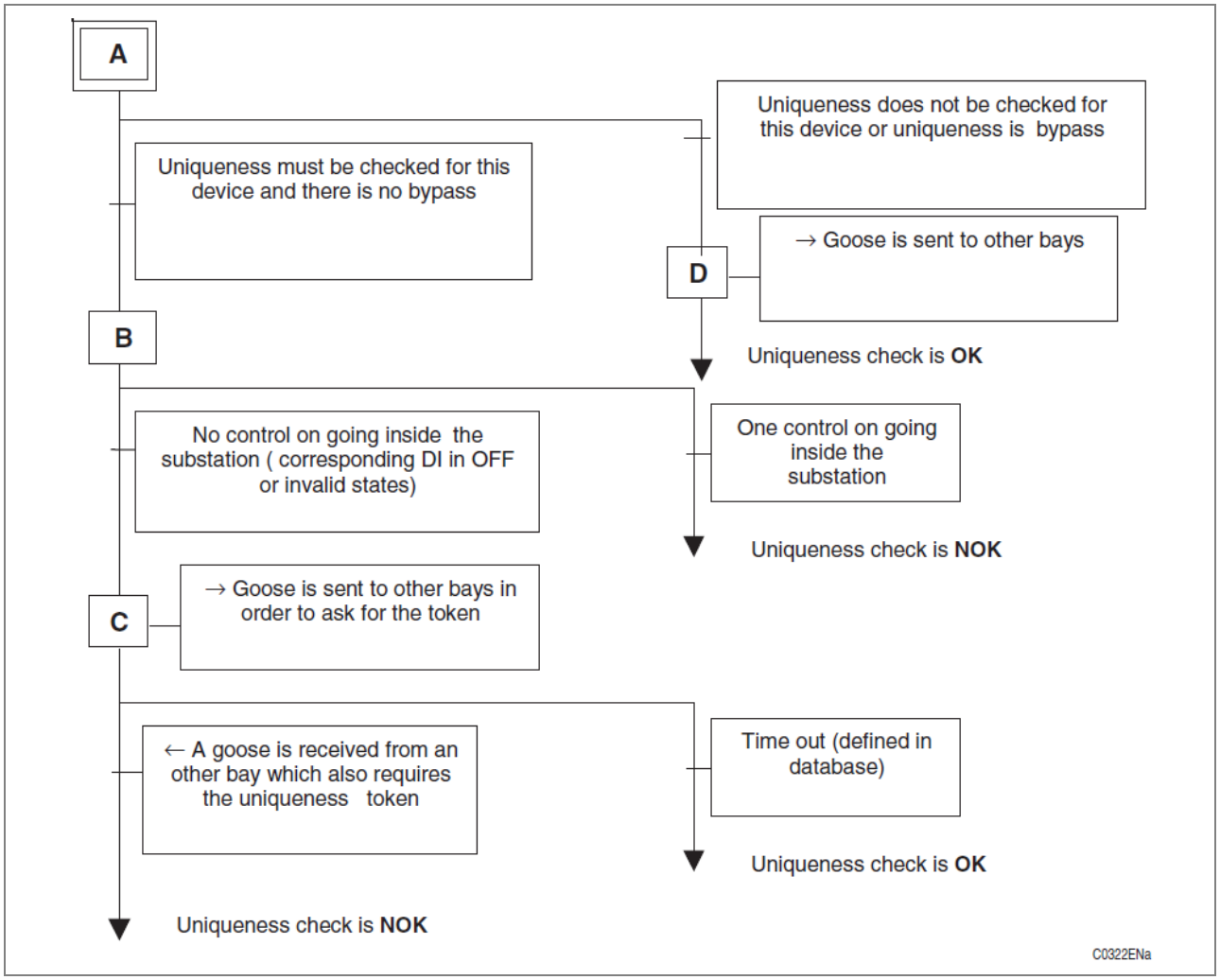


Figure 50: Uniqueness check

If a device is under control and another control is sent on this device, the second one is ignored.

In the event of a uniqueness of the command at least to one of these levels the selection is refused, with negative acknowledgement.

10.1.7 SELECTION BEHAVIOUR

In **SBO once** mode and **SBO many** mode, the configuration process allows to describe optionally, a device selection to control the device.

The following configurations must be considered:

- **Configuration 1**: device with a control for selection and its associated selection position information.
- **Configuration 2**: device with a control for selection (without input selection information).

Whatever the request control (select open/select close, select raise/select low) the selection of the device is performed as follows:

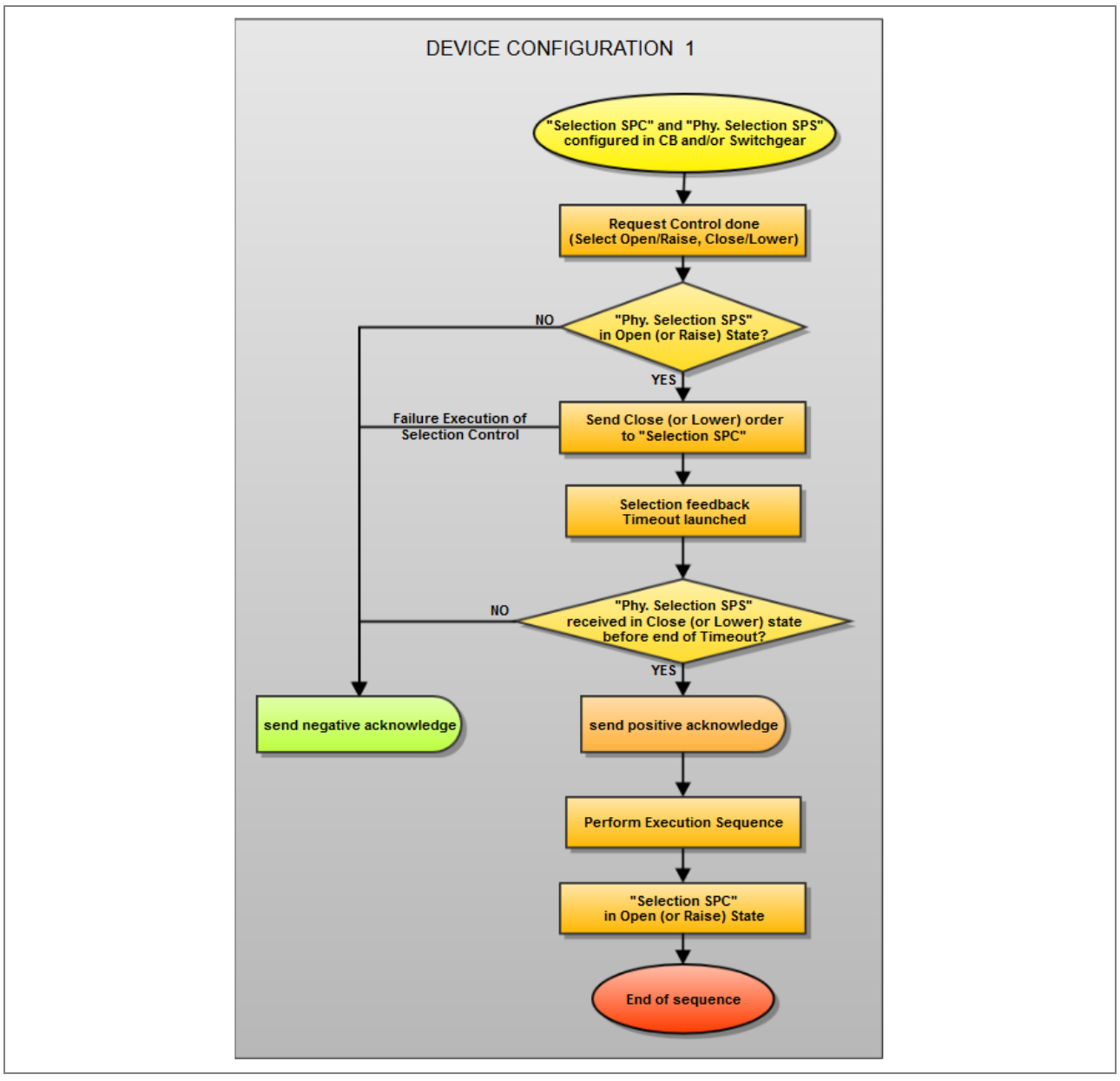
- **Configuration 1:**

The control unit

1 verifies the selection position information, it must be open: if it is close, it is an abnormal situation, the selection sequence is stopped with a negative acknowledgement.

2 sends a “close” order of the selection control (via I/O boards or IED) and waits the selection position information in a given delay (by configuration).

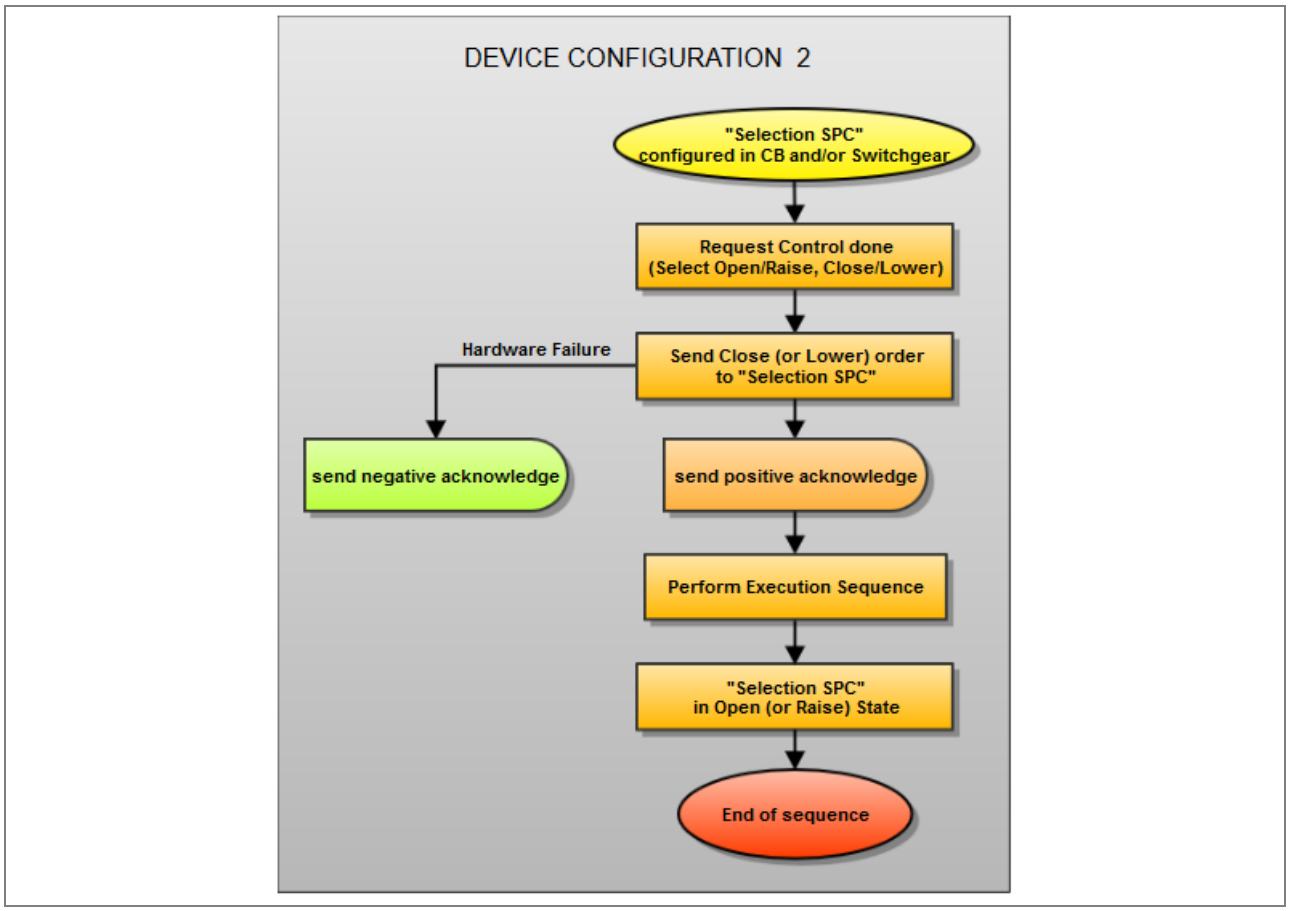
If the selection control has been normally executed, and the selection position information of the device become “set” in the given delay, the selection sequence ends sending a positive acknowledgement. The control unit starts its execution sequence. In the event of a failure of the execution of the selection control or if the selection position information remains open in the given delay the selection sequence ends abnormally sending a negative acknowledgement.



- **Configuration 2:**

For this configuration, in which only the output control of the selection is configured, the control unit: sends a “close” order of the selection control (via I/O boards or IED). If the selection control has been normally executed, the selection sequence ends by sending a positive acknowledgement and the control unit start its execution sequence.

In the event of a failure of the execution of the selection control, the sequence ends abnormally by sending a negative acknowledgement.



10.1.8 GENERIC EXECUTION CHECKS

During the execution phase, whatever the execution mode (SBO once, SBO many or Direct Execute) the control unit, before proceeding to the execution of the request, performs the following checks:

- Inter-control delay
- control unit mode
- Substation and bay mode states
- Interlock and topological interlocking states
- Automation running control
- Device selectable (SBO mode only)
- Locked device state
- Current status of the device
- Uniqueness
- Current value

Execution checks are identical to those of the selection phase. Moreover, In the event of an **"SBO once"** mode or **"SBO many"** mode the control unit verifies that the device was previously selected.

The checks of the execution phase in **"SBO many"** mode are identical as above but they are repeated for every execution request (low/raise).

In **"Direct Execute"** mode the device selection is not verified because it is not permitted.

10.1.9 EXECUTION BEHAVIOUR

On this stage the control request is executed via:

- I/O boards
- IED communication
- System supervisor of the control unit for system outputs

The execution via I/O boards is performed only if the control unit is in "**operational"** mode. If the control unit is in **test/blocked** or **on-blocked** mode, the output relay is not set. In this event the control unit simulates a positive acknowledgement of hardware execution. It allows to perform control sequence safety in order to test Automatisms configuration, control sequence configuration etc. Controls to IEDs are sent if the control unit is in "**operational"** mode or "**test"** mode.

10.1.9.1 EXECUTION VIA I/O BOARDS

According to the devices features the execution of the control via I/O boards may be performed using:

- Single Points Control
- Double Control Points
- Digital Setpoints
- Analogue Setpoints

Single Point Control and Double Point Control

However, the execution control sequence depends on the activation mode of the xPC. By configuration, this activation mode of SPC and DPC may be "transient", "permanent" or "permanent until feedback".

- **Transient**: the contact is closed and then re-opened automatically after a delay (defined during the configuration of the xPC). For a DPC, configuration gives two delays need to be configured, one for open and one for close.
- **Permanent**: For this type of output control, the contact is held in the requested position state until a reverse order is received.
- **Permanent until feedback**: The contact is held in the requested position state until confirmation of the position of the device or after timeout awaiting the new position of the device. In this event, the input information of the device status must be configured.

Digital and Analogue Setpoints

Digital Setpoints are executed via Digital Output boards. This type of control is managed in "Direct Execute mode" only.

Analogue Setpoints are executed via Analogue Output boards. This type of control is managed in "Direct Execute mode" only.

10.1.9.2 EXECUTION VIA IED COMMUNICATION

When an execution request is performed via IED communication, the requested order is converted to a message to be sent to the IEDs, according the communication protocol.

10.1.9.3 SYSTEM CONTROLS EXECUTION

For systems outputs the control unit activate/deactivate the associated function (control unit mode) and if a specific system input (SPS or DPS) is configured for this control, it takes the requested state and it stored in non-volatile memory.

10.1.10 CONTROLS TIME SEQUENCING

Time sequencing of control is dependent of its configuration:

- Control mode: Direct Execute, SBO once, SBO many
- Device features: selection control wired/not wired, selection position wired/not wired, device position wired/not wired and so on
- Output control type: permanent , pulse
- Destination: I/O board, IED
- Time-out delays: selection phase time-out, selection Feedback delays, open/close Feedback delay and so on.

10.1.10.1 DIRECT EXECUTE TIME SEQUENCING

The timing diagram shows an example of normal termination on Direct Execute sequence.

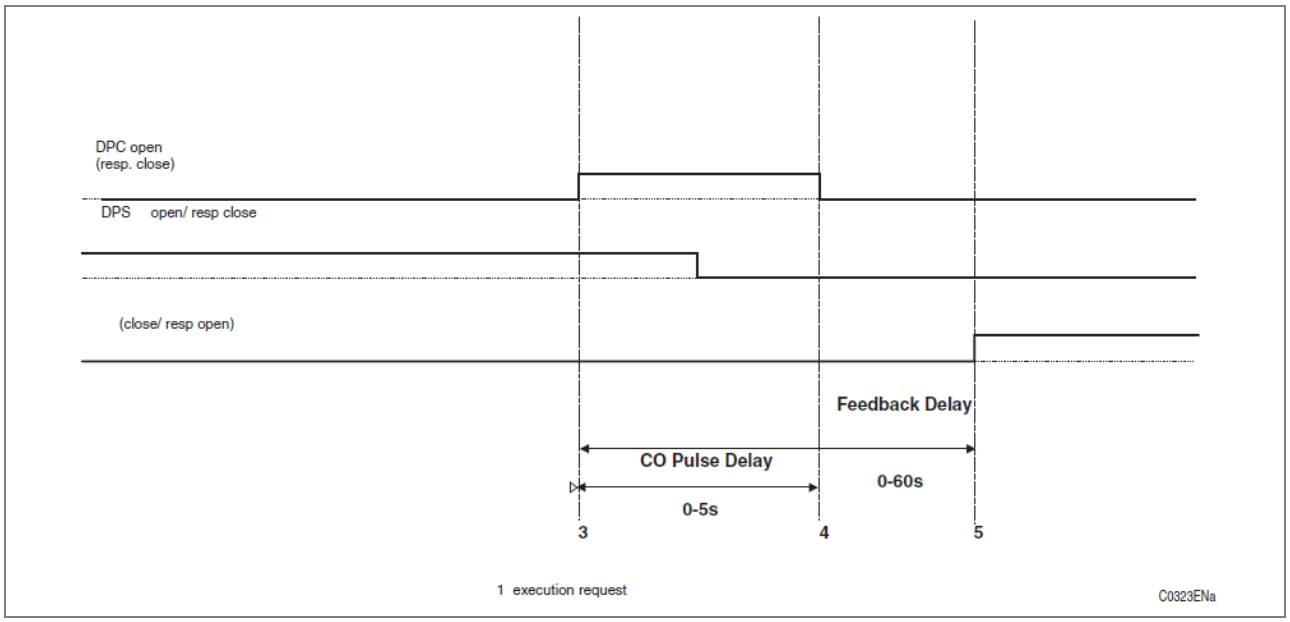


Figure 51: Normal termination of direct execute sequence

The timing diagram below shows an abnormal termination of Direct Execute sequence. The device has not taken the expected position in the given delay.

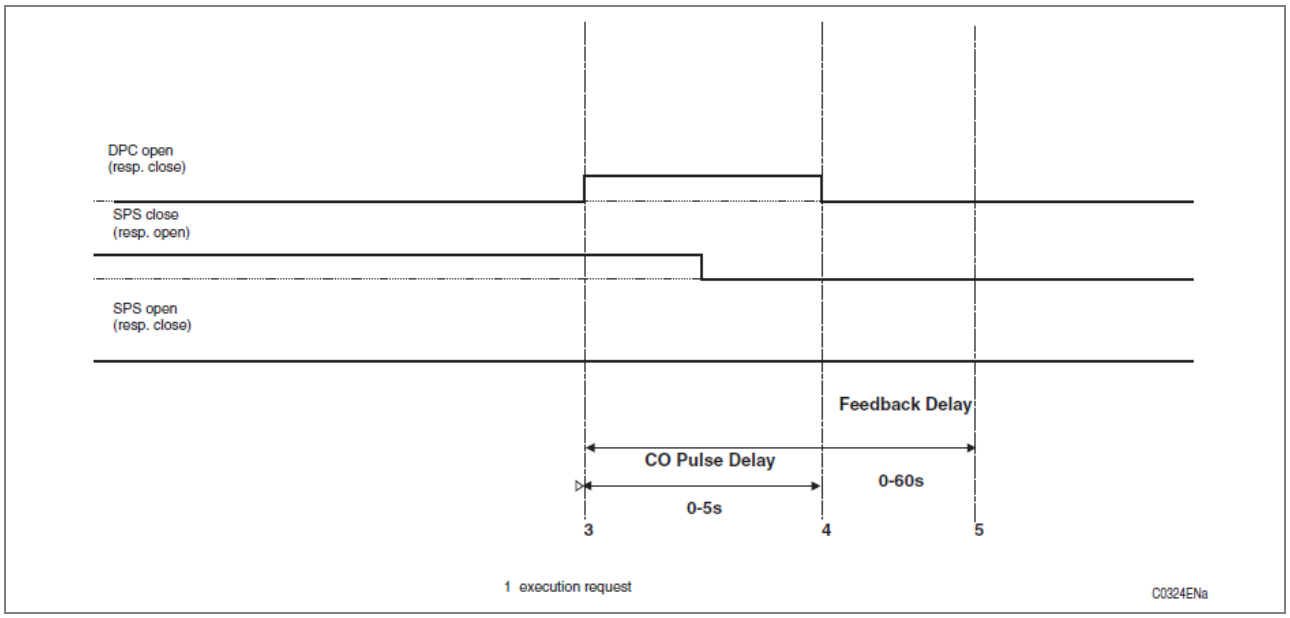


Figure 52: Abnormal termination of direct execute sequence

10.1.10.2 SBO ONCE TIME SEQUENCING

The configurations below are given as examples

Device Configuration A: the optional selection control and Selection position information are configured

The timing diagram below shows a normal termination of the control sequence.

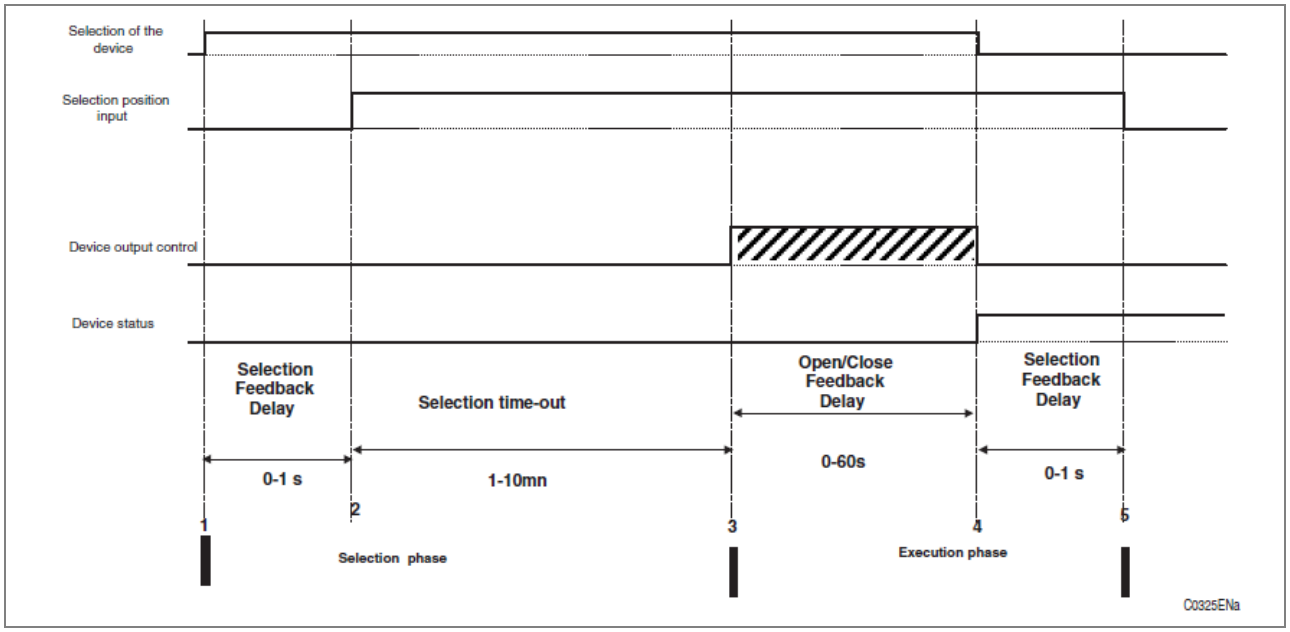


Figure 53: Normal termination of the control sequence

- Stage 1: device selection (closing the associated output control)
- Stage 2: the selection is confirmed by the associated input information in the feedback delay (0 – 1-sec user selectable)
- Stage 3: close the device before the end of the selection timeout delay (0 – 10 MN user selectable)
- Stage 4: the device has taken the expected position (close) in the feedback delay (0–60 sec user selectable). The control unit deselect the device (open selection output control)
- Stage 5: confirmation of the deselecting of the device in the same given delay than stage 2.

The timing diagram below shows controls sequence that is aborted after time-out of the selection delay.

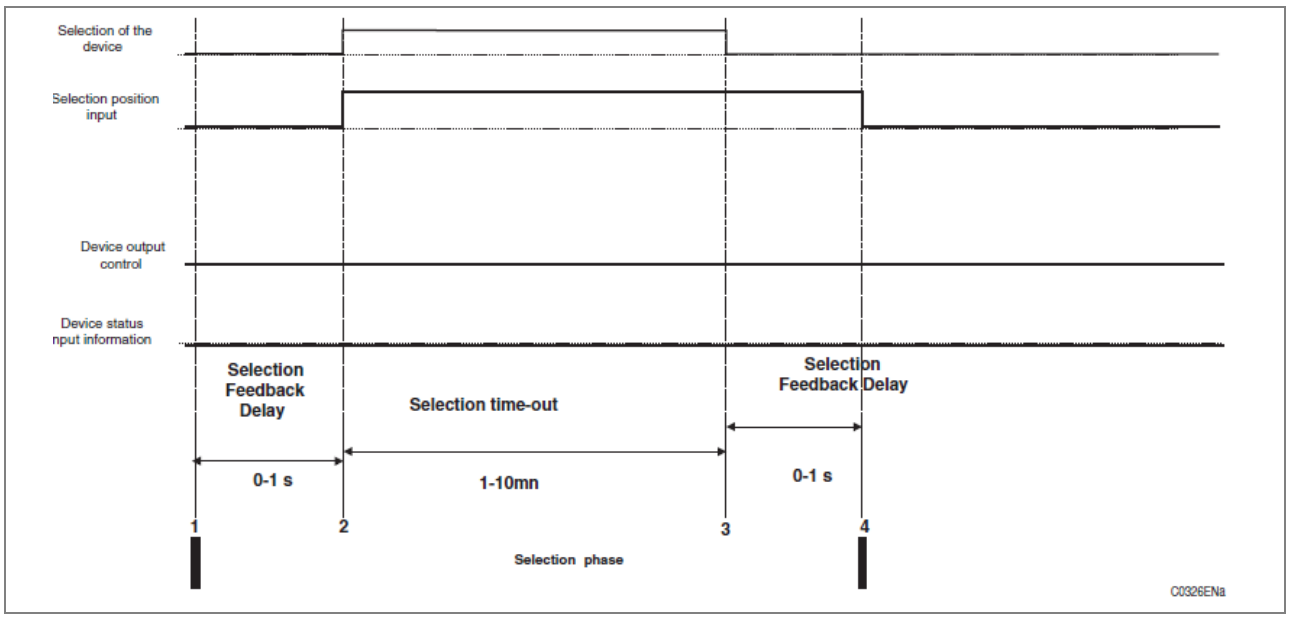


Figure 54: Aborted control sequence

- Stage 1: device selection (closing the associated output control)
- Stage 2: the selection is confirmed by the associated input information in feedback delay
- Stage 3: timeout of the delay - the device is deselected
- Stage 4: confirmation of the deselecting of the device

Device Configuration B: the optional selection control is configured and selection position information is not configured

The timing diagram below shows a normal termination of the control sequence.

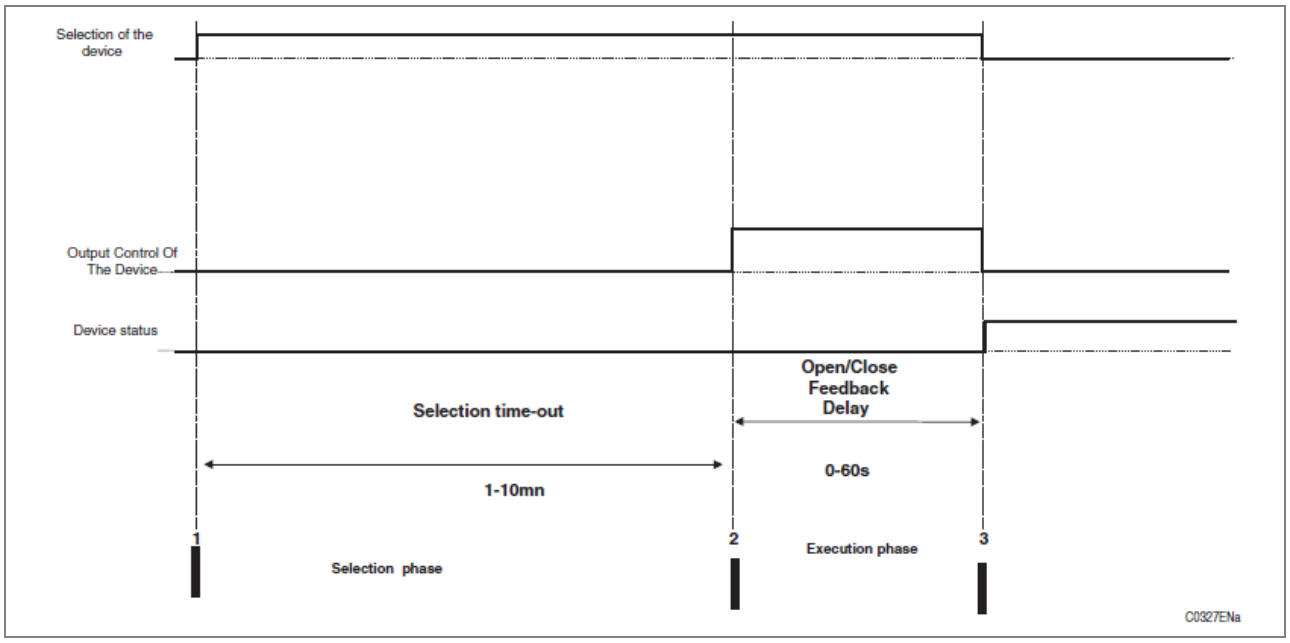


Figure 55: Normal termination of the control sequence

- Stage 1: device selection (closing the associated output control)
- Stage 2: close the device before the end of the selection timeout delay (0 – 10 MN user selectable)
- Stage 3: The device has taken the expected position (close) in the feedback delay (0–1-sec user selectable). The control unit deselect the device (open selection output control)

10.1.10.3 SBO MANY TIME SEQUENCING

SBO many mode is exclusively used for control of transformers. Refer to associated section.

10.1.11 HOW AN XPS STARTS A CONTROL SEQUENCE

The supervision datapoints, referred to as xPS, include:

- Single Point Status (SPS)
- Double Point Status (DPS)
- Multi Point Status (MPS)

The xPS datapoints allow you to start a device control sequence: for example, an operator control from a hardwired mimic. These xPS datapoints start the control in the same way when the IEC 61850-8-1 or the local C26x HMI start the control. The sequence cancel command is not permitted. Only Direct Execute (DE) types of controls are permitted.

10.2 CONTROL OF NON SYNCHRONISED BREAKERS

10.2.1 NON-SYNCHRONISED CIRCUIT-BREAKER FEATURES

For the circuit-breakers, the table that follows gives the inputs and outputs that are controlled by the unit:

Three-pole circuit-breaker		
	Outputs to CB	**Inputs from CB**
Device control	(2) DPC, device open/close control	(3) DPS, physical position of the device (1 pole) (12) SPS (optional), pole discrepancy (ph not together) indication (1) System DPS, feedback of the control (i)
Device selection (hardware)	(10) SPC (optional), device selection control	(13) SPS (optional), device selection position indication

Single pole circuit-breaker			
	Outputs to CB 3-p operations	**Outputs to CB 1-p operations**	**Inputs from CB**
Device control	(2) DPC, device open/close control	(7) DPC, control to open phase A (8) DPC, control to open phase B (9) DPC, control to open phase C (2) DPC, control to close the device	(4) DPS, physical position of pole A (5) DPS, physical position of pole B (6) DPS, physical position of pole C (12) System SPS, "ph not together" indication (ii) (1) System DPS, control feedback (iii)
Device selection (hardware)	(10) SPC (optional), device selection control	(10) SPC (optional), device selection control	(13) SPS (optional), device selection position indication

(i) The computed value matches the state of the CB's auxiliary contacts when there is no pole discrepancy, i.e. if the value of **ph not together** is *false*, otherwise the computed value is *jammed*.

(ii) The computed **ph not together** value is *false* if all the CB poles are in the same open or closed position. It is *true* when a pole discrepancy is detected.

(iii) The computed value matches the state of phase A if the state of **ph not together** is equal to *false* (i.e. no pole discrepancy is detected), otherwise the computed value is *jammed*.

10.2.2 CONTROL SEQUENCE OF NON-SYNCHRONISED CIRCUIT-BREAKERS

Non-synchronised circuit-breakers are managed in **"Direct Execute"** mode and in **"SBO once"** mode. Refer to the generic description above.

10.3 CONTROL OF SYNCHRONISED BREAKERS

Synchronised circuit-breakers are managed in **"SBO once**" mode only. The following paragraph describes the specific features of synchronised circuit-breakers whether they are synchronised by an external or by an internal synchrocheck module.

10.3.1 SYNCHRONISED CIRCUIT-BREAKER FEATURES

For the circuit-breakers, the table that follows gives the inputs and outputs that are controlled by the unit:

Three-pole circuit-breaker with synchrocheck		
	Outputs to CB	**Inputs from CB**
Device control	(2) DPC: device open/close control (11) SPC: close with synchrocheck control	(3) DPS: physical position of the device (1 pole) (12) SPS (optional): pole discrepancy (ph not together) indication (1) system DPS: feedback of the control (i)
Device selection (hardware)	(10) SPC (optional): device selection control	(13) SPS (optional): device selection position indication
Enable/disable close with synchrocheck schemes	(14) SPC or (15) DPC (optional): synchrocheck scheme on/off control	(16) SPS or (17) DPS (optional for external S/C): synchrocheck scheme on/off indication
Enable/disable synchrocheck function (internal S/C only) (vi)	(18) SPC: synchrocheck function on/off control for specific CB	(19) SPS: synchrocheck function on/off control for specific CB

Single pole circuit-breaker with synchrocheck			
	Outputs to CB 3-p operations	**Outputs to CB 1-p operations (conventional wiring only)**	**Inputs from CB**
Device control	(2) DPC: Device open/close control (11) SPC: Close control with synchrocheck	(7) DPC: open phase A control (8) DPC: open phase B control (9) DPC: open phase C control (2) DPC: close of device control (11) SPC: Close control with synchrocheck	(4) DPS: physical position of phase A (5) DPS: physical position of phase B (6) DPS: physical position of phase C (12) System SPS: ph not together indication (ii) (1) System DPS: control feedback (iii)
Device selection (hardware)	(10) SPC: (optional) device selection control	(10) SPC (optional): device selection control	(13) SPS (optional): device selection position indication
Enable/disable close with synchrocheck schemes (iv)	(14) SPC or (15) DPC: (optional) synchrocheck scheme on/off control	(14) SPC/(15) DPC: (optional) synchrocheck scheme on/off control	(16) SPS or (17) DPS: (optional for external S/C) synchrocheck scheme on/off indication
Enable/disable synchrocheck function (internal S/C only) (v)	(18) SPC: synchrocheck function on/off control for specific CB	(18) SPC: synchrocheck function on/off control for specific CB	(19) SPS: synchrocheck function on/off control for specific CB

(i) The computed double signal is equal to the state of the CB auxiliary contacts when there is no pole discrepancy, i.e. if the value of **ph not together** is *false*, otherwise the computed signal is equal to *jammed*.

(ii) The computed **ph not together** signal is equal to *false* if all the poles are in the same open or closed position. It is equal to *true* when a pole discrepancy is detected.

(iii) The computed signal is equal to the state of phase A if the state of **ph not together** is equal to “false” (i.e. no pole discrepancy is detected), otherwise the computed signal is equal to “jammed”.

(iv) Wired SPC and SPS for external synchrocheck and system SPC and SPS for internal synchrocheck. If not configured, the external synchrocheck module or the internal synchrocheck function is considered as permanently disabled. DPC & DPS are used only for manual synchrocheck.

The **“Open” control sequence** of synchronised circuit-breakers remains identical to the non-synchronised circuit-breakers.

The **“Close” control sequence** is different according to the configuration the synchrocheck type:

- **External synchrocheck**: The closure of the device is assumed by an external synchrocheck module
- **Internal synchrocheck**: The closure of the device is assumed by an internal synchrocheck function

A Close control sequence can be configured with:

- **Manual set on** of the external synchrocheck module or internal synchrocheck function
- **Automatic set on** of the external synchrocheck module or internal synchrocheck function

Furthermore, waiting closes the CB by the external module the initiator of the request may:

- Cancel the request
- Close the device by forcing request

10.3.2 CIRCUIT-BREAKERS WITH EXTERNAL SYNCHROCHECK

10.3.2.1 CLOSE CB BY EXTERNAL AUTOMATIC SYNCHROCHECK

The following scheme shows a “close” control for a device in which the external synchrocheck module is enabled automatically by the controller.

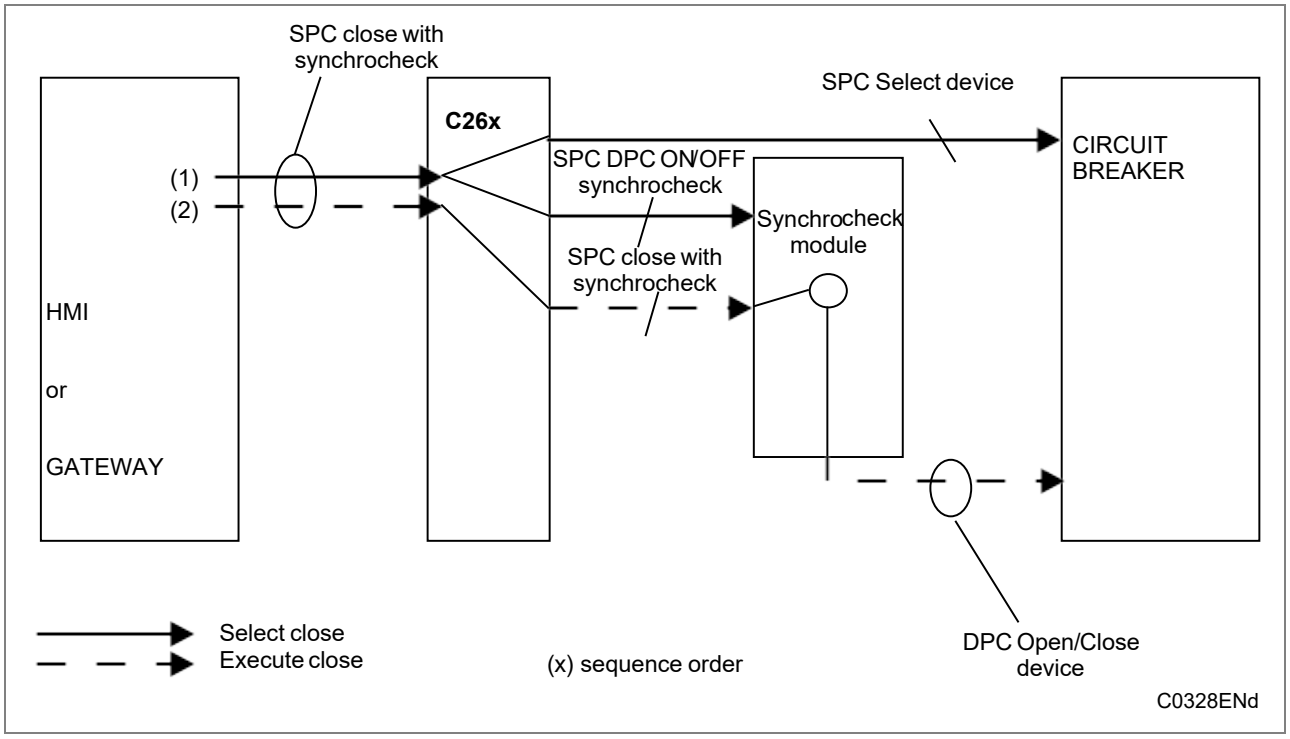


Figure 56: Close CB by external automatic synchrocheck

The “close” control sequence performed on the C26x is done as follows:

Selection phase

1 If the control is configured, enable synchrocheck module

2 If configured, check synchrocheck on/off information related to the output

3 If configured, close the device selection output to select the device

4 If configured, check selection device input information associated to the output

5 Wait for the execution request or timeout selection

In the event of a failure of one of these operations, the controls sequence is stopped with a negative acknowledgement

Execution phase

1 Close the device using synchrocheck output control

2 Check that the device position become close in the given delay

3 Disable synchrocheck module if it was previously enabled

4 Deselect the device if it previously selected

The timing diagram below shows a successful control sequence “close with synchrocheck”.

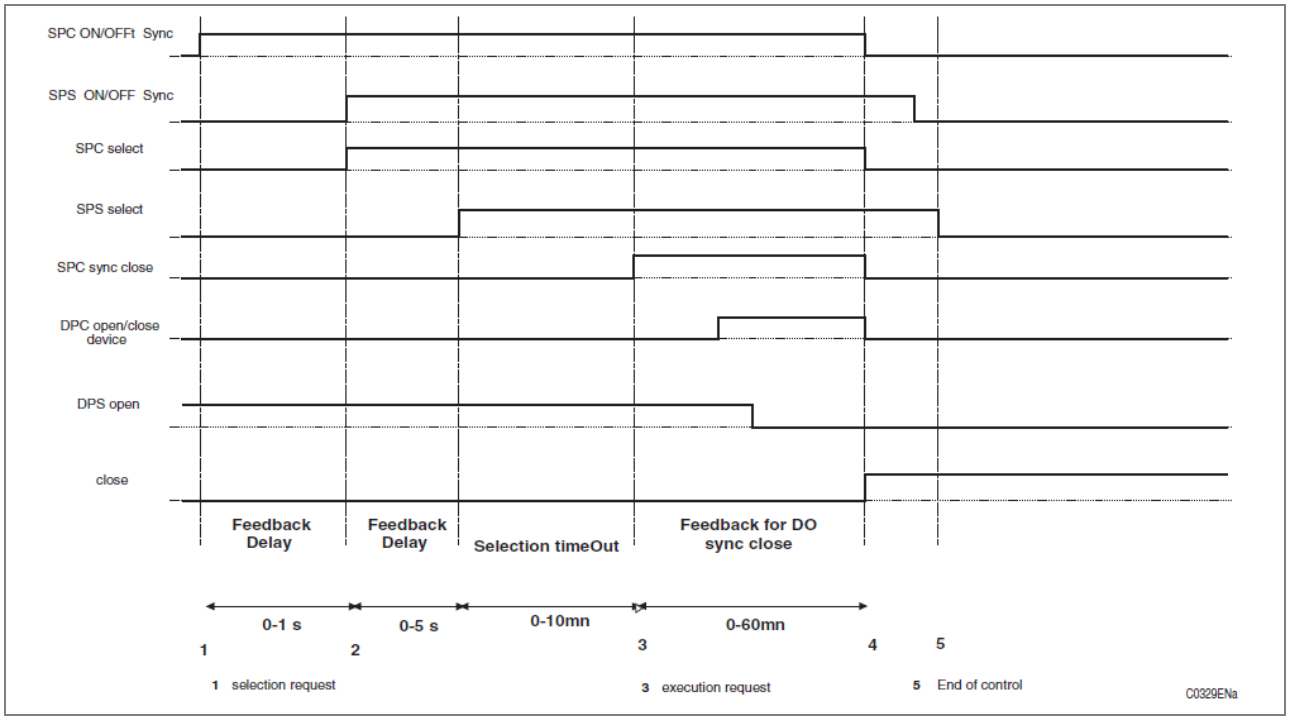


Figure 57: Timing diagram of a successful "close with synchrocheck"

The timing diagram below shows an abnormal termination of control sequence “close with synchrocheck”. The device has not taken the expected position “close” in the given delay. The control sequence is aborted with negative acknowledgement, deselecting previously synchrocheck and device.

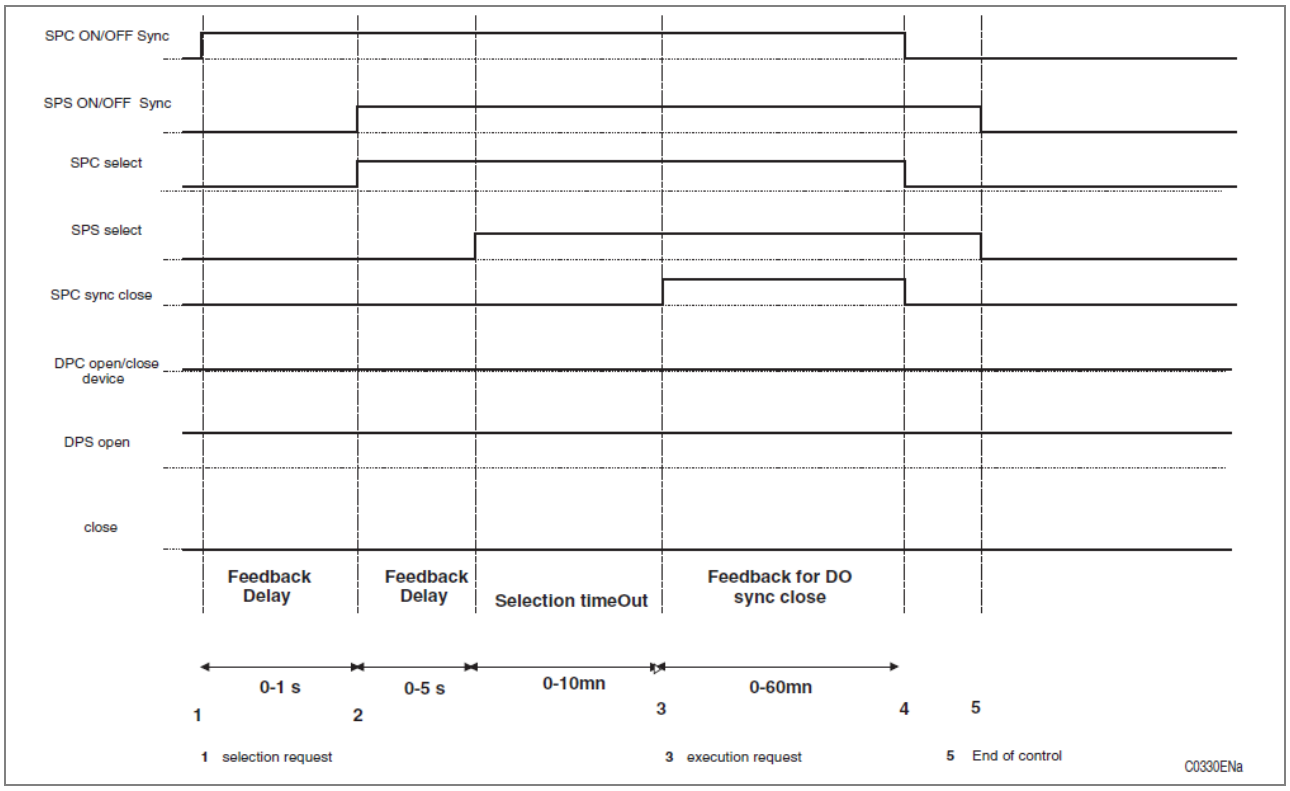


Figure 58: Abnormal termination of "close with synchrocheck"

10.3.2.2 CLOSE CB BY EXTERNAL MANUAL SYNCHROCHECK

By configuration the “close” control of the device may be done in two or three control sequences:

Two sequences

- A “Direct Execute” sequence to put in service the external synchrocheck module
- An SBO once sequence to close the CB by the synchrocheck module and put out of service the synchrocheck module

Three sequences

- A “Direct Execute” sequence to put in service the external synchrocheck module
- An SBO once sequence to close the CB by the synchrocheck module
- A “direct execute” sequence to put out service the external synchrocheck module

The scheme that follows shows a close control request where an operator at the system HMI or gateway manually manages the external synchrocheck module.

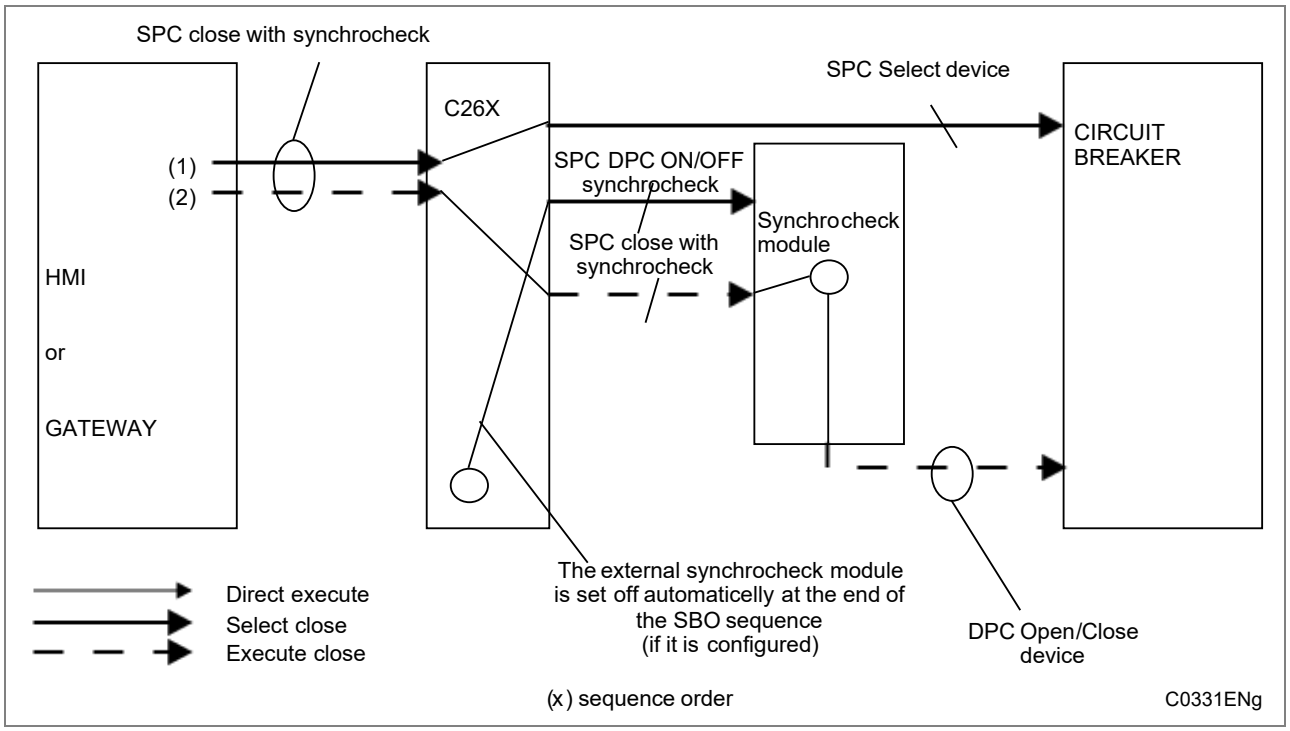


Figure 59: Close control request

First sequence (DIRECT EXECUTE): Enable the external synchrocheck module

1 Close “set on/setoff” output control of the synchrocheck module

2 Check that the synchrocheck module is set (if on/off synchrocheck input information is configured)

In the event of a failure of one of these operations, the sequence ends with a negative acknowledgement

Second sequence (SBO ONCE): Close the device with synchrocheck

Selection phase:

1 Close device selection output to select the device (if is configured)

2 Check selection device input information associated to the output (if is configured)

3 Wait for the execution request or timeout selection

4 In the event of a failure of one of these operations the controls sequence is stopped with a negative acknowledgement

Execution phase:

1 Close the device via the “close with synchrocheck” control

2 Check that the device position becomes closed within the given delay

3 Disable the synchrocheck module if is configured to be disabled automatically

4 Deselect the device if it previously selected

Third sequence (DIRECT EXECUTE): disable the external synchrocheck module

This sequence takes place only if setting the synchrocheck module off is configured to “manual”

1 Open “set on/setoff” output control of the synchrocheck module

2 Check that the synchrocheck module is enabled (if on/off synchrocheck input information is configured)

The timing diagram below shows a successful control sequence “close with synchrocheck” performed in three sequences. In the event of an automatic “setting off” of the synchrocheck module the timing diagram remain identical. It is performed at the end of the SBO sequence.

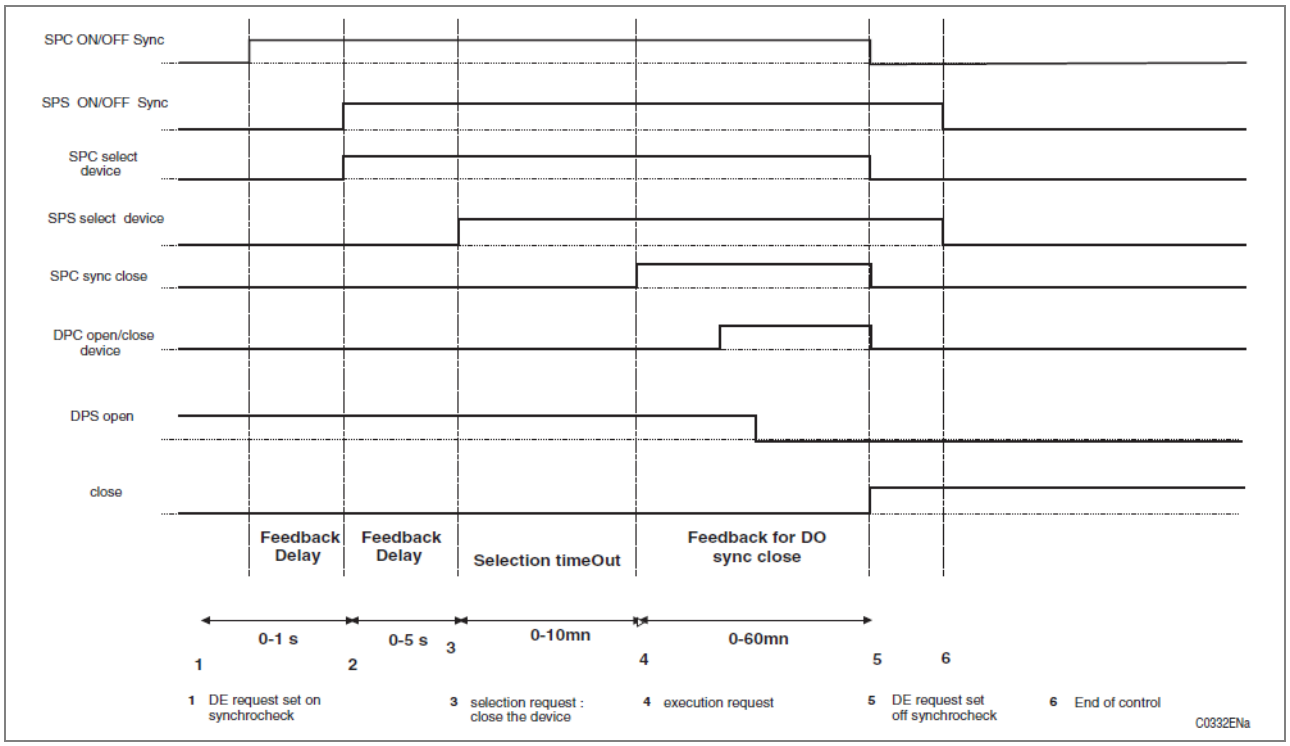


Figure 60: Successful close with synchrocheck

Note:
During SBO sequence after step 5 the initiator of the request may force the closing of the device.

10.3.2.3 CANCEL CLOSE CB WITH EXTERNAL SYNCHROCHECK

While waiting to close the device (0 to 60 mn) by the external synchrocheck module, the initiator of the close request may cancel this one by a “cancel request”.

The timing diagram below shows a cancel close request awaiting to close the device by the external synchrocheck module.

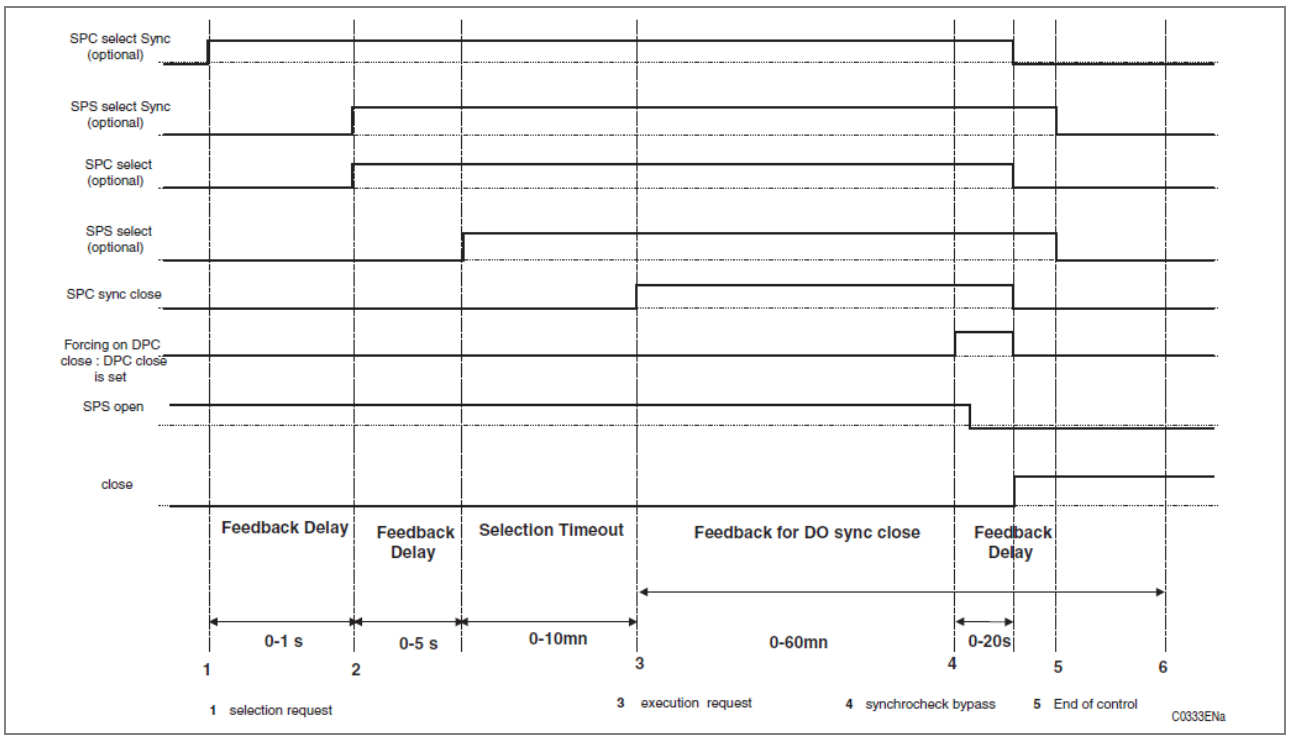


Figure 61: Cancel close request

10.3.3 CIRCUIT-BREAKERS WITH INTERNAL SYNCHROCHECK

On this configuration synchrocheck is assumed by an internal controller automatism, that proceeds to the synchrocheck voltage calculations and gives or not the closing authorisation of the device.

The controls sequence remains similar with the external synchrocheck except for the setting on/off of the synchrocheck and close with synchrocheck output control that do not exist on this configuration

10.3.3.1 CLOSE CB WITH INTERNAL AUTOMATIC SYNCHROCHECK (NOT USED)

The following sequence describes a circuit-breaker “close” request with internal synchrocheck in **“SBO once”** mode. Synchrocheck function is enabled automatically.

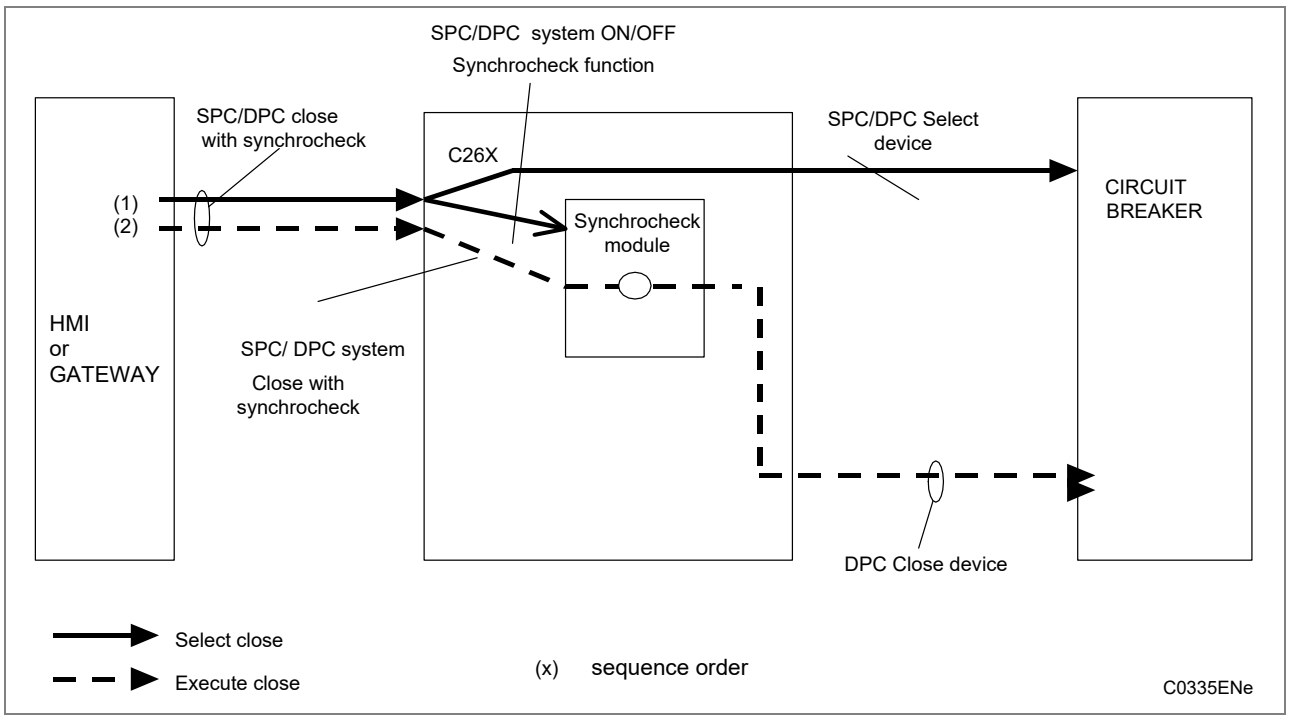


Figure 62: Close CB with internal automatic synchrocheck

Selection phase:

1 Close device selection output to select the device (if is configured)

2 Check selection device input information associated to the output (if is configured)

3 Wait for the execution close request or timeout selection

In the event of a failure of one of these operations, the device is deselected and the controls sequence is aborted with a negative acknowledgement.

Execution phase:

1 Activate the associated internal synchrocheck function for closing authorisation the device

2 Wait closing authorisation

Event 1: Synchrocheck function responds OK before the time-out of the given delay

1 Close the device

2 Deselect the device (if it was previously selected)

3 Send a positive acknowledgement

Event 2: Synchrocheck function responds NO before the time-out of the given delay

1 Deselect the device (if it was previously selected)

2 Send a negative acknowledgement

Event 3: time-out of the given delay without synchrocheck response

1 Stop the synchrocheck function

2 Deselect the device (if it was previously selected)

3 Send a negative acknowledgement

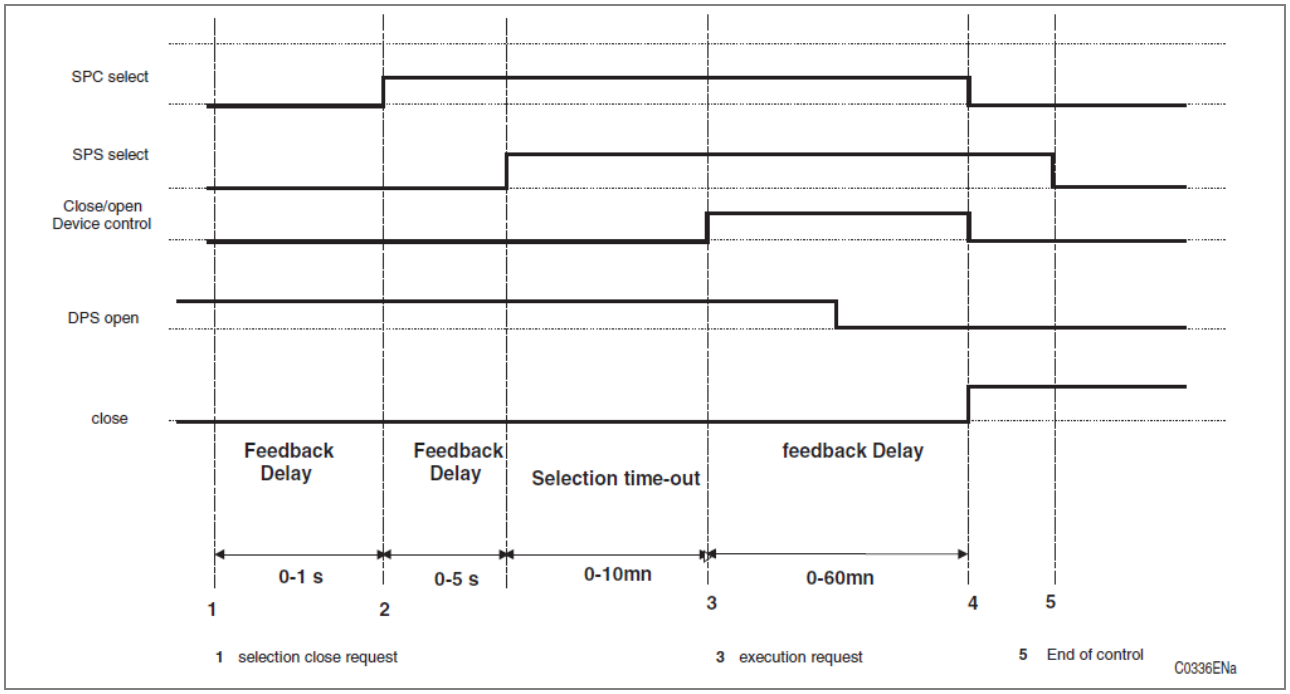
Event 4: reception of cancel request awaiting synchrocheck response

1 Stop the synchrocheck function

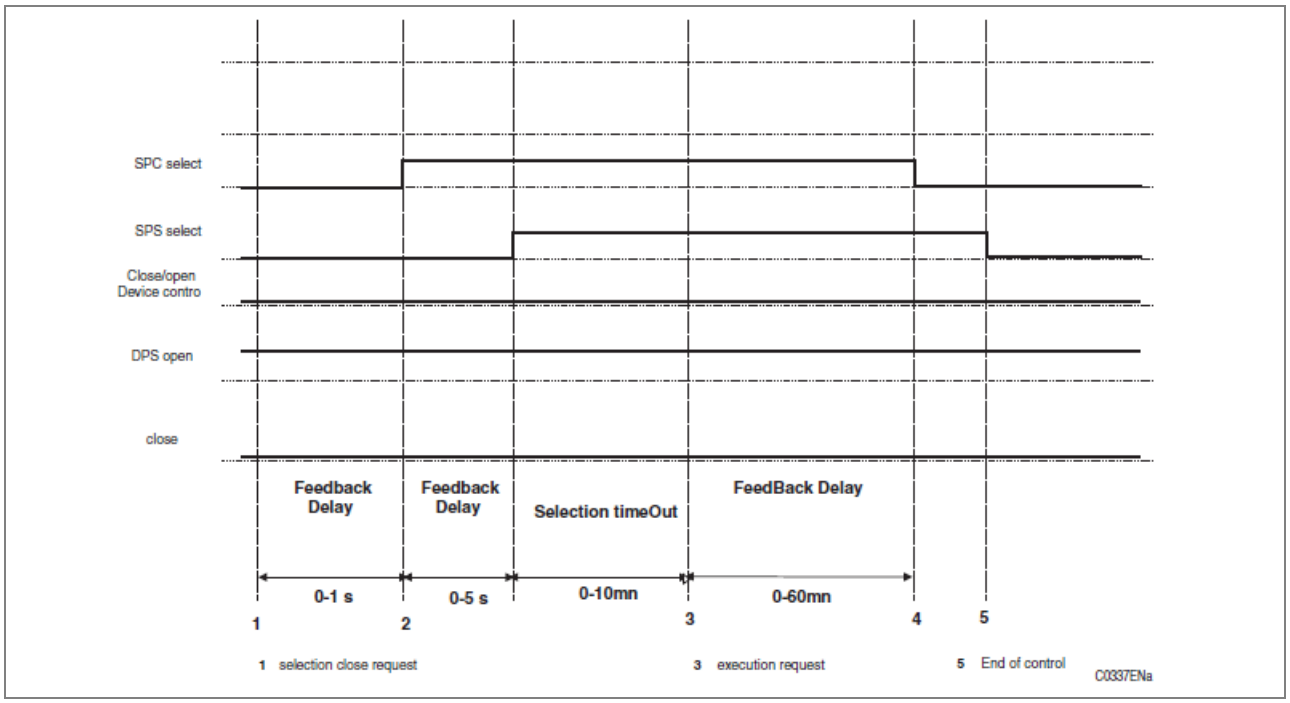
2 Deselect the device (if it was previously selected)

3 Send a negative acknowledgement

The timing diagram below shows a successful control sequence “close with internal synchrocheck”.



The timing diagram below shows an abnormal termination of control sequence “close with internal synchrocheck”.



10.3.3.2 CLOSE CB WITH INTERNAL MANUAL SYNCHROCHECK

The following sequence describes a circuit-breaker “close” request with internal synchrocheck in **“SBO once”** mode. The synchrocheck function is enabled by a separate direct execute control.

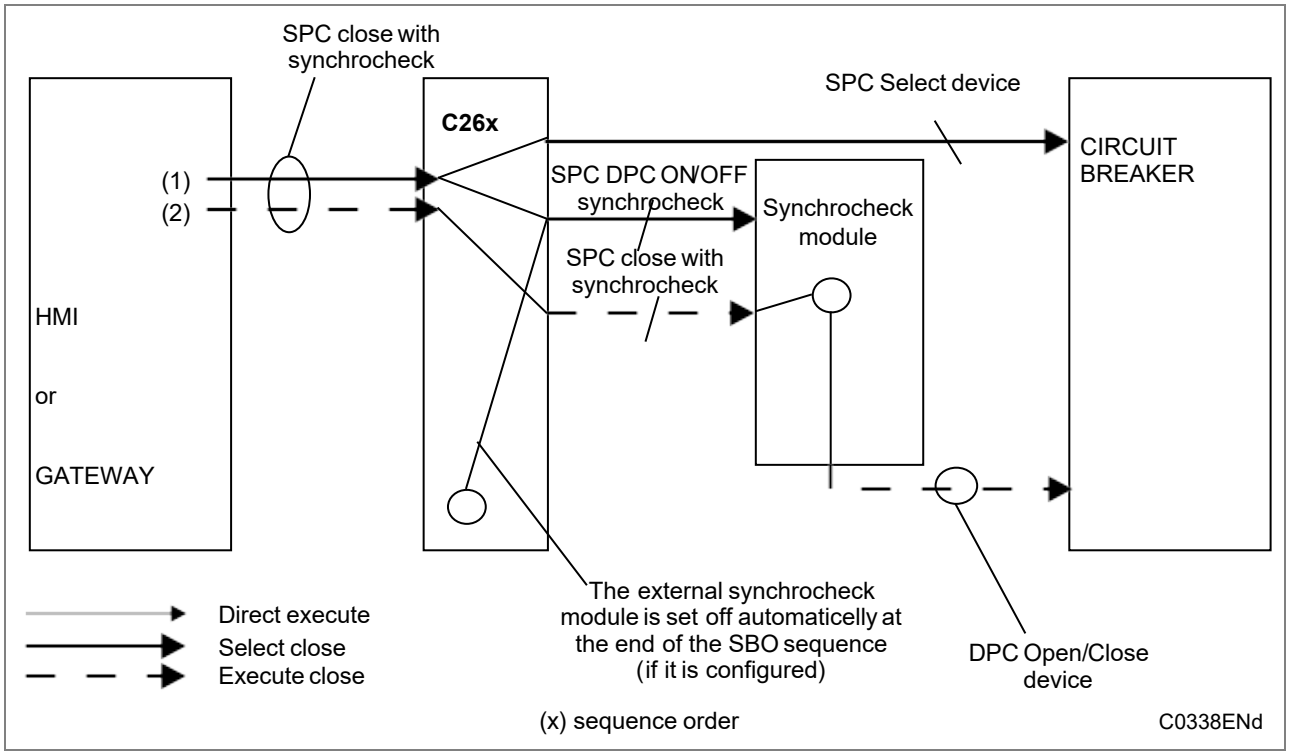


Figure 63: Close CB with internal manual synchrocheck

Selection phase:

1 Close device selection output to select the device (if is configured)

2 Check selection device input information associated to the output (if is configured)

3 Wait for the execution request or timeout selection

4 In the event of a failure of one of these operations the controls sequence is stopped with a negative acknowledgement

Execution phase:

1 Ask to the internal automatism to close the device

Note:
The initiator of the request may force the closing of the device.

2 Check that the device's position becomes closed within the set time-delay

3 Disable the synchrocheck function if is configured to be disabled automatically

4 Deselect the device if it previously selected

10.4 CONTROL OF DISCONNECTORS (SWITCHGEAR)

10.4.1 DISCONNECTOR FEATURES

The C26x manages all types of disconnecting switches such as:

- Disconnectors
- Earthing switches
- Quick break switches

Disconnectors switches		
	Outputs to switchgear	**Inputs from switchgear**
Device control	DPC, control for open/close of device	DPS, physical position of the device
Device selection	SPC (optional), control of device selection	SPS (optional), device selection position information

10.4.2 CONTROL SEQUENCE OF DISCONNECTORS

The control sequence of disconnectors is identical to control sequence of the non-synchronised circuit-breakers.

10.5 CONTROL OF TRANSFORMERS

10.5.1 TRANSFORMER FEATURES

	Outputs	**Inputs**
Transformer control	DPC: raise/lower	TPI value SPS (optional) tap change in progress (TCIP)
Transformer selection	SPC (optional) transformer selection	SPS (optional) selection position information
Transformer type (see note 1)	Double wound or Auto-wound	

Note 1: Transformer type (auto-wound or double-wound) is user selectable.

Double wound (or two winding transformer) is a transformer with galvanic isolation between primary and secondary coil. Tap Changer (with additional winding) is usually located at HV-neutral side for economic reasons. Tapping-up (raise order) reduces primary winding and increases LV tension.

Auto-wound (or auto-transformer or single wound) is a transformer without galvanic isolation between primary and secondary. Secondary coil follows primary coil, (winding are serial). Tap Changer (with tap of additional winding) is serial. Increasing tap position (raise order) acts simultaneously on primary and secondary, it reduces transformer ratio then voltage at LV side.

10.5.2 CONTROL SEQUENCE OF TRANSFORMERS

You can control the transformers in the three modes **“Direct Execute”**, **“SBO once”** and **“SBO many”**.

In addition to the selection and execution checks described in the previous paragraphs the following checks are performed:

- A **“raise”** control is refused if the current tap position value corresponds to the maximum position of the tap.

- A **"lower"** control is refused if the current tap position value corresponds to the minimum position of the tap.
- In the event of a **"go to min"**, **"go to max"** or **"go to position x"** request, an internal automatism (via ISAGRAF) must be added. This automatism generates the desired controls sequences in order to reach automatically the expected position. It may generate "Direct execute", "SBO once" or "SBO many" sequences according the configuration of the device

Note:
If the command of a transformer is configured in SBO many mode, it is impossible to configure the requests "go to min", "go to max"

TCIP feature: The TCIP input information (tap change in progress), is used to confirm the right execution of the low/raise execution. Two delays are given by the configuration for the TCIP management:

- TCIP apparition delay: The TCIP information must appear before the time-out of this delay.
- TCIP disappearance delay: The TCIP information must disappear before the time-out of this delay.

TPI feature: Because the TCIP input information is not always configured, the tap control is performed using only the Tap Position Indication (TPI) value to check the correct execution of the request. The TPI value must change in the given delay.

The following examples are given in **"SBO many"** mode that is the more complex. The main difference with the **"SBO once"** mode remains to the possibility to execute many "raise" or "low" controls before ending the sequence. Moreover, the device is not deselected automatically but only after a cancel order sent by the initiator of the control request.

10.5.2.1 CONTROL OF TRANSFORMER WITH TCIP

In this mode, when the TCIP input information is configured, the selection and execution phase are performed as follows: It is possible by configuration to prevent to have more than one control at a time.

Selection phase:

1 Close device selection output to select the device (if configured)

2 Check selection device input information associated to the output (if is configured)

3 Wait for the execution request (low/raise) or timeout selection

In the event of a failure of one of these operations, the device is deselected, the controls sequence is aborted with a negative acknowledgement.

Execution phase:

1 In agreement with the request "raise or lower" and the type of device, execute the associate control

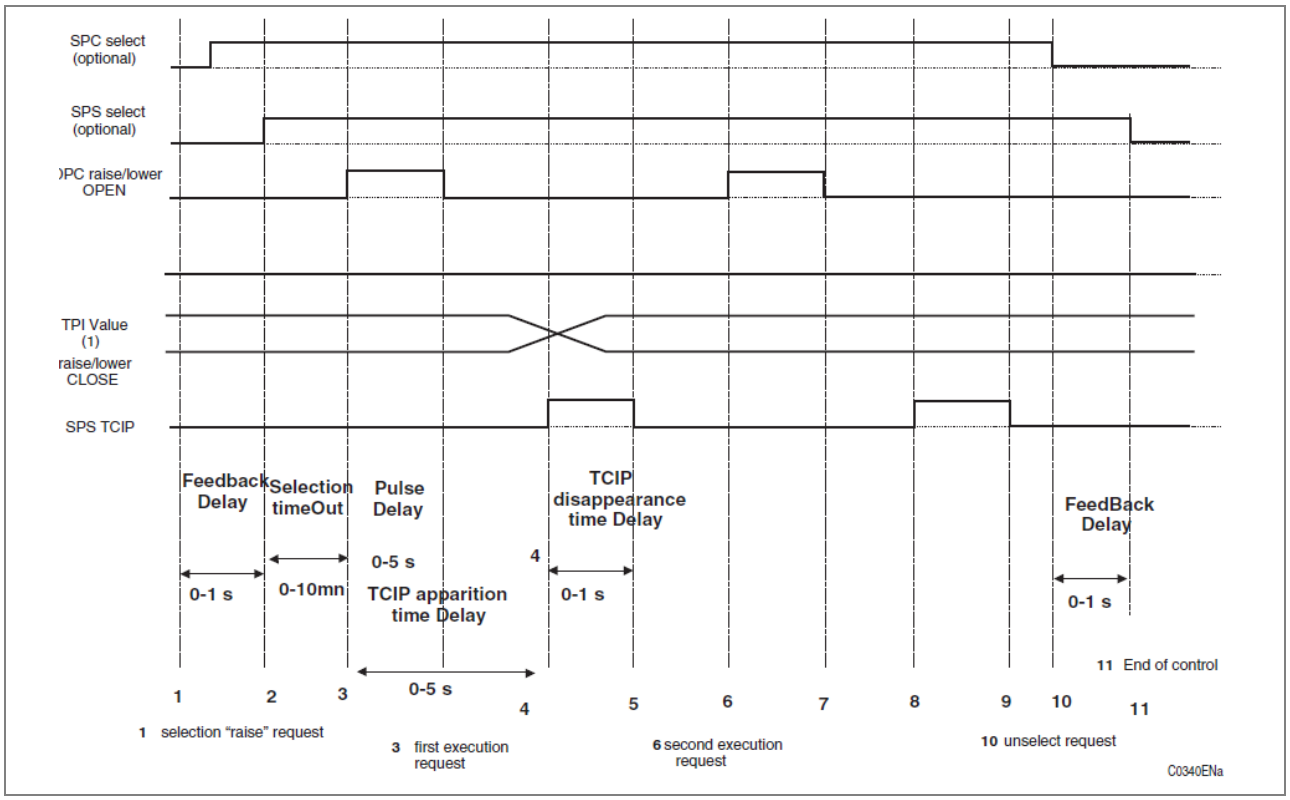
2 Wait for the TCIP data and TIP value to confirm execution. Two events:

- Event 1: The TCIP information appears and is disappears in the given delays, the TPI takes the expected value: The control unit sends a positive acknowledgement and waits a new request (execution or cancellation).
- Event 2: Timeout awaiting the TCIP appearance or disappearance, or the TPI value is wrong: The device is deselected (if it was previously selected), and the sequence is aborted with a negative acknowledgement.

3 Wait for the new execution request or cancellation request to deselect the device

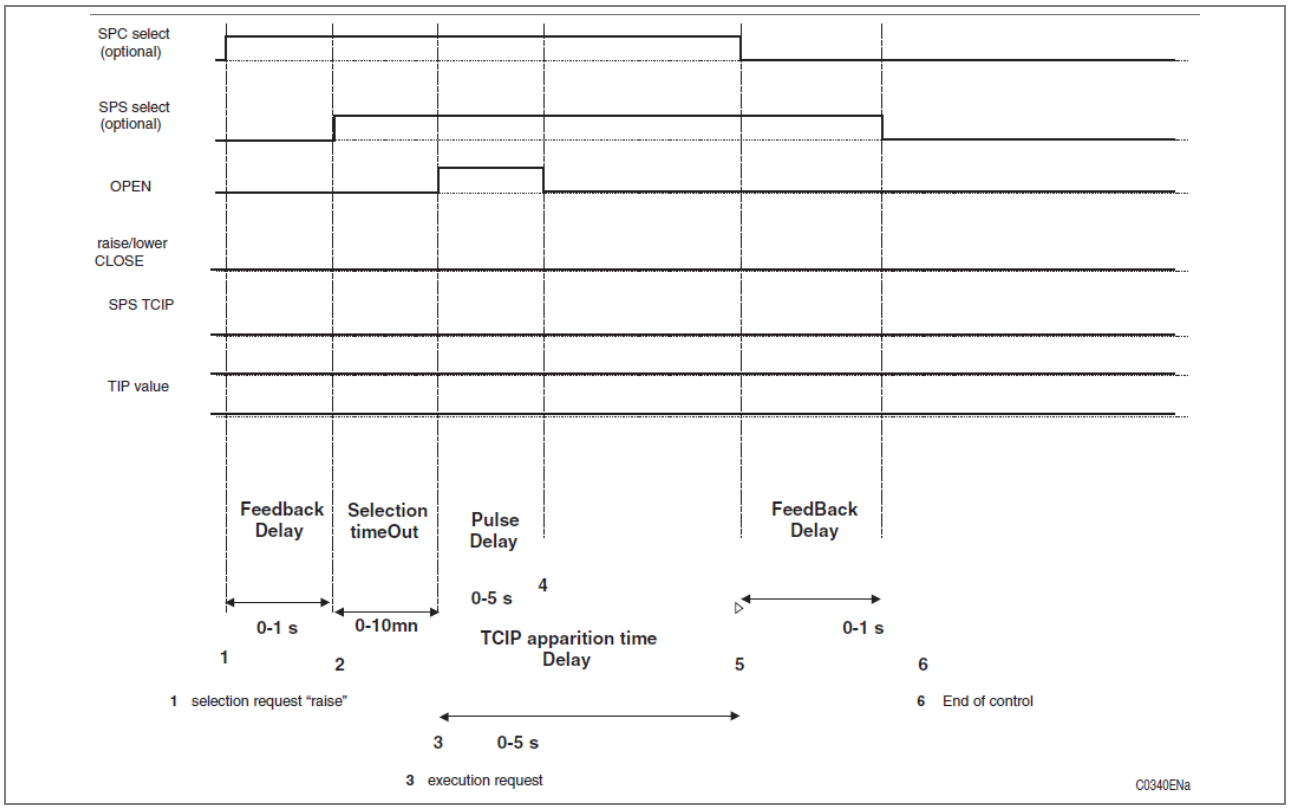
- In the event of a new request the control unit repeat the steps 4 and 5.
- In the event of a cancellation request the control unit deselects the device (if it was previously selected), and ends the sequence with a positive acknowledgement

The timing diagram below shows a successful sequence with device selection, two “raise” controls and device unselection.



Note (1):
The TPI value must be the expected value at least at the end of TCIP disappearance

The timing diagram below shows an abnormal termination of tap changer control sequence due to absence TCIP confirmation. In this event the device is automatically deselected and the sequence ends with a negative acknowledgement.



10.5.2.2 CONTROL OF TRANSFORMER WITHOUT TCIP

In event the TCIP input information is not configured the selection and execution phase are performed as follows:

Selection phase:

1 Close the device selection output to select the device (if configured)

2 Check selection device input information associated to the output (if configured)

3 Wait for the execution close request or timeout selection

In the event of a failure of one of these operations, the device is deselected, the controls sequence is aborted with a negative acknowledgement.

Execution phase:

1 In agreement with the request "raise or lower" and the type of device, execute the related control

2 Wait for the TPI data and compare with the previous value. The difference must confirm the "low" or "raise" execution. Two events:

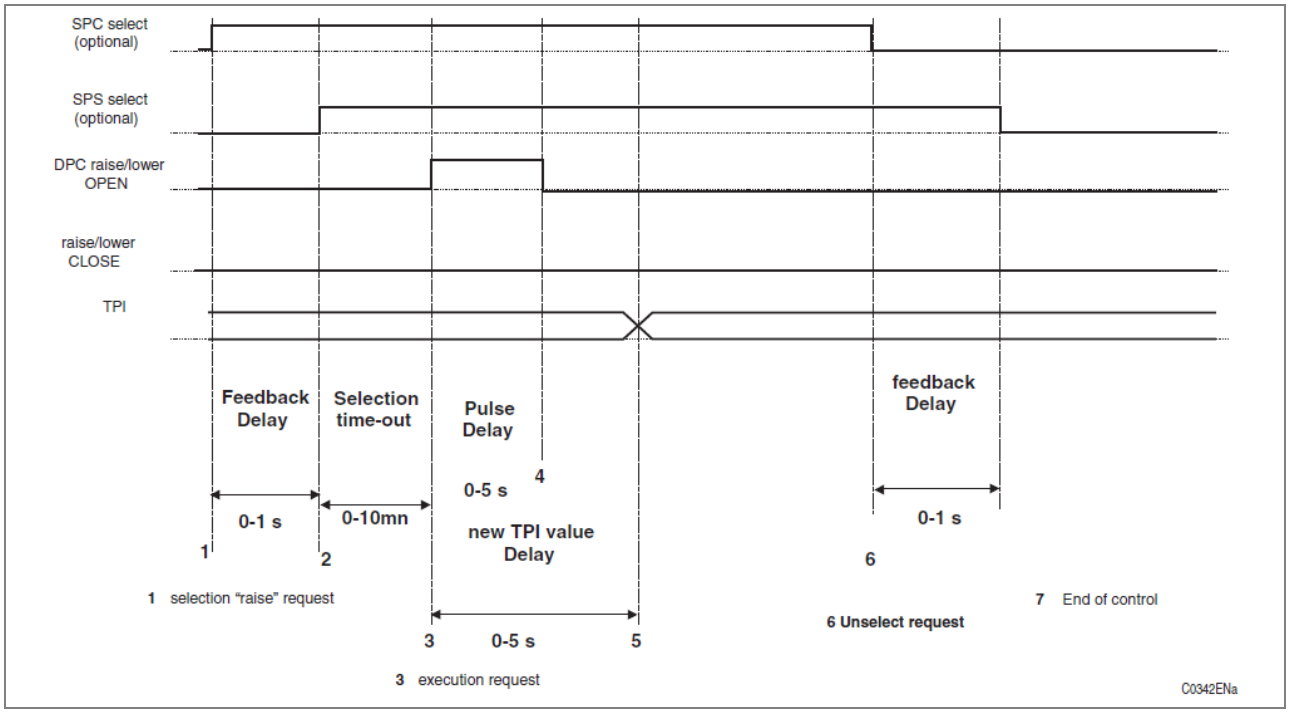
- Event 1: The TPI value confirms in the given delay the execution request: The control unit sends a positive acknowledgement and waits a new request (execution or cancellation) from the initiator.
- Event 2: Timeout awaiting the TPI value or unexpected TPI value: The device is deselected (if it was previously selected), and the sequence is aborted with a negative acknowledgement.

3 Wait for the new execution request or cancellation request to deselect the device

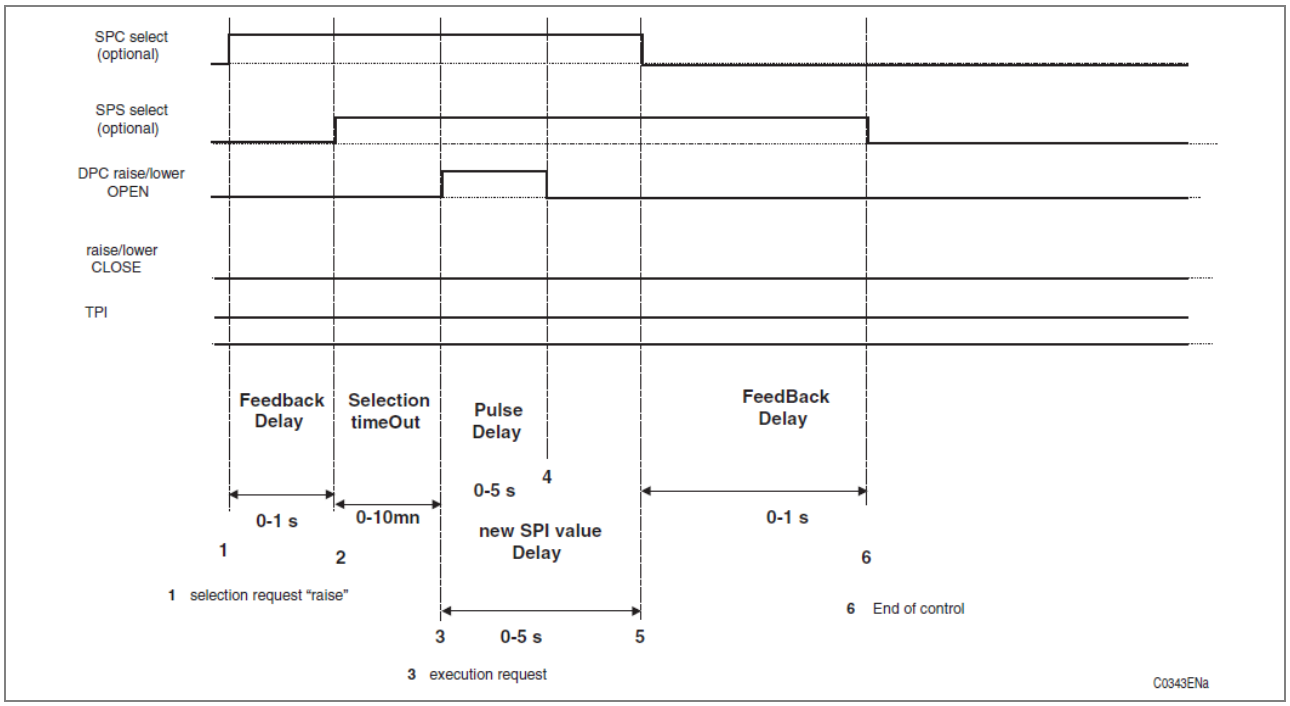
In the event of a new request the control unit repeat the steps 4 and 5.

In the event of a cancellation request the control unit deselects the device (if it was previously selected), and ends the sequence with a positive acknowledgement.

The timing diagram below shows a successful sequence with device selection, a raise control and device unselection



The timing diagram below shows an abnormal termination due to the absence of change of the TPI value in the given delay. The device is automatically deselected, and the sequence is aborted with negative acknowledgement.



10.5.2.3 SUPPRESSION, FORCING OR SUBSTITUTION OF THE TPI

In the event of a suppress or substitution of TPI value the control sequence is aborted with negative Acknowledgement. If the Forcing of the sequence is not aborted but the value of TPI taken into account during the control sequence is the forced value.

10.6 CONTROL OF ANCILLARY DEVICES

Ancillary devices are managed in **"Direct Execute"** or in **"SBO once"** mode. Refer to generic explanations above.

10.7 CONTROL OF INTELLIGENT ELECTRONIC DEVICES (IED)

10.7.1 CONTROL TO IEDS BY XPC

A request to control equipment via IED can be performed in 3 modes: DE, SBO once, SBO many.

10.7.1.1 DIRECT EXECUTE MODE

If execution checks are successful

1 The control unit sends the control (open/close, low/raise, setpoint) via the communication protocol to IED

2 The control unit waits for IED's control acknowledgement in the given delay (if is supported by the protocol)

3 The control unit waits for the reception of the feedback of the request (device position SPS, DPS, TPI) in the given delay (if is configured)

In the event of a failure, in step 2 or 3 the sequence ends with a negative acknowledgement. Otherwise the sequence ends with a positive acknowledgement.

10.7.1.2 SBO ONCE MODE

This mode can be configured only if is supported by the protocol.

Selection phase

After you perform the selection checks

1 The control unit sends a selection request to the IED

2 The control unit waits for a selection acknowledgement from IED in the given delay

3 The control unit generates a positive or negative selection acknowledgement according to the result of the selection phase

4 If positive acknowledgement, the control unit starts selection time-out and waits execution request, otherwise ends the controls sequence

Execution phase

If execution checks are successful

1 The control unit sends the control, such as the open/close, low/raise, setpoint; through the communication protocol to the IED

2 The control unit waits for the IED, if supported by the protocol, to send the control acknowledgement within the given delay

3 The control unit waits for the reception of the feedback of the request, such as the device position SPS, DPS, TPI within the given delay, if it is configured

If successful, the sequence ends with a positive acknowledgement. In the event of a failure in step 6 or 7, the sequence ends with a negative acknowledgement

10.7.1.3 SBO MANY MODE

In comparison with the **SBO once** mode, in this mode, the execution phase is repeated till a cancellation request is sent. This cancellation request allows you to end the sequence in the control unit, and it is not sent to the IED.

10.7.2 CONTROL TO IEDS BY DIGITAL SETTING POINT (SPC)

The available modes include: Direct Execute, Direct Execute with SBO popup (reserved to substation control point usage).

10.8 SYSTEM CONTROLS

System control is used to activate or deactivate automatic functions, change control unit's mode, bay mode, database management, etc.

A system output control remains internal on the control unit (has no digital or IED output) and may generate a system input information. They are managed in **Direct Execute** mode only. A hardware selection has no meaning.

For some uses, such as automatism's activation/deactivation, it is necessary to generate a system input, that gives the state of the controlled function. This system input may be able to be used by the control sequence or enter to an interlocking equation etc. The configuration process allows the user to assign or not a system input, that may include an SPS or DPS. System inputs generated by system outputs are stored in non-volatile memory. In the event of a the control unit's initialisation, they are restored.

10.9 TYPES OF CONTROL SEQUENCES

The control sequences automation receives three kinds of input triggers (as orders from the higher level) with selection, execution and cancellation. Control orders may have a normal or abnormal termination with positive or negative acknowledgement to operator and to communication.

By configuration, each DRC order (close order or open order) and each SPC can activate simultaneously two DO contacts at the same time.

10.10 CONTROL SEQUENCES CHECKS

Receiving control, the control sequence executes configured checks:

Operational conditions

- C26x mode management: Operational (on or on-blocked), Test (test or test/blocked), Maintenance…
- IED connected,
- Substation control mode (Remote/Local),
- Bay control mode,
- SBMC mode,
- Uniqueness of control inside the substation.

Module conditions

- Inter-control delay,
- Status of the device,
- Lock condition,
- Automation already running (AR, AVR, …),
- Interlock equations (substation, bay, local of the module).

Execution conditions

- Delays upon selection feedback, start moving, final position reached.

10.10.1 MODE MANAGEMENT

Control sequences are only performed if the controller mode is in operational mode. In test/blocked and on-blocked modes, control sequences are permitted but digital outputs are not set.

10.10.2 IED CONNECTED

If a control has to be sent to an IED, it is only accepted if this IED is connected to the controller.

10.10.3 CONTROL MODE

This control sequence receives requests from the various control points:

- Automation (Auto Recloser, voltage regulation, PLC),
- C26x Local HMI,
- C26x TBUS communication from SCADA,
- Station BUS (other controller in distributed automation, DS Agile aView, DS Agile Gateway)

To avoid conflict between the control points, substation and bay modes are checked. Each control sequence can be subjected or not to these checks. The switches Remote/Local can be hardware or software (saved in non-volatile memory).

The SBMC Site Based Maintenance Control mode allows controlling one specific bay from the Local HMI or the System HMI (aView) even if the substation is in remote mode. This feature is dedicated to commissioning or maintenance and offers also the possibility to filter data transmitted from the bay to SCADA.

10.10.4 UNIQUENESS OF CONTROL

It is possible by configuration to prevent having more than one control at a time:

- For the whole substation
- Inside a bay

If a device is under control and another control is sent on this device, the second one is ignored.

In the event of a uniqueness of the command at least to one of these levels the selection is refused, with negative acknowledgement.

10.10.5 INTER-CONTROL DELAY

For wired commands only, it is possible by configuration to define a minimum time that must elapse between two consecutive control commands on the same device.

10.10.6 STATUS OF THE DEVICE

If the status of the device is not valid, it is possible by configuration to prevent control.

10.10.7 LOCK DEVICE

Controls are not permitted on a lock device.

10.10.8 RUNNING AUTOMATION

If there is a related automation in operation, controls are not permitted on a device.

For example, controls issued from DS Agile aView or Gateway are not permitted on a transformer controlled by voltage regulation.

10.10.9 INTERLOCKING

The operation of a switching device, such as circuit-breakers; traditional disconnecting switches; disconnecting switches with abrupt loss; and ground disconnecting switches; is directly related to the nature of the switch and to its environment.

To operate these devices, you must respect some conditions. These conditions, called **interlocking**, are managed by **logical equations** within the C26x.

Interlocking prohibits a control sequence that may violate the device operating condition: for example, break capability, isolation, and so on; or plant operating condition.

10.11 HV CONTROL SEQUENCES

10.11.1 CIRCUIT-BREAKER

Several kinds of circuit-breaker can be managed:

- Three phases or single-phase circuit-breaker,
- Synchronised or unsynchronised, with internal or external synchrocheck,
- With and without Auto Recloser.

For three phase breaker each phase DPS is provided separately and it is managed globally by single (grouped) control and global DPS position. Pole Discrepancy management is available.

10.11.2 DISCONNECTOR

The control sequence of disconnectors is identical to single unsynchronised circuit-breakers.

10.11.3 TRANSFORMER

Transformer position is determined using TPI (Tap Position Indication). TPI can be a Digital Measurement or Analogue Measurement (from DC Analogue Input).

The transformer is the only device that supports the SBO Many control sequences. It is linked to voltage regulation, also its Raise and Lower controls are defined for secondary voltage (and not tap position). Except for auto wounded transformer, raise/lower voltage is also a raise/lower tap.

11 AUTOMATIONS

C26x provides three different ways to perform automation functions:

- Programmable Scheme Logic (PSL)
- Programmable Logic Controller (PLC)
- Built-in automation functions

The choice between these three solutions depends on time and complexity.

11.1 BUILT-IN AUTOMATION FUNCTIONS

Within the C26x, some built-in automation functions are available and you can set them directly:

- Auto-Recloser
- xPS/xPC Association
- Pole Discrepancy
- Automatic Voltage Regulation (AVR)
- Synchrocheck

11.1.1 AUTO-RECLOSER (AR)

11.1.1.1 INTRODUCTION

80-90% of faults on the electrical network are transient, such as lightning or insulator flashover. When a fault occurs, the circuit-breaker is tripped to protect the system.

The Auto-Recloser function is then used to close the circuit-breaker after a set time, a time that is long enough to allow the fault to clear. This duration is called cycle delay and is defined in the database during the configuration phase.

But, as permanent fault can occur, an auto-recloser scheme has to be provided in order to allow the elimination of a transient fault by an open/close sequence (auto-reclosing cycle) and the elimination of permanent fault by, after the auto-reclosing cycle, leaving the circuit-breaker in the open state by closing the trip relay.

A transient fault, such as a lightning strike, is one that is cleared by immediate tripping of one or more CB's to isolate the fault and does not recur when the line is re-energized.

This means that in the majority of fault incidents, if the faulty line is immediately tripped out, and if time is allowed for the arc to de-ionise, recloser of the CB will result in the line being successfully re-energized (Closed/Open/Closed cycle).

However, some faults will be permanent (such as a line fallen to earth). In this event the auto-recloser must be able to react to the permanent fault, and on the first reclose and detection of the permanent fault open the CB's (and, if required lock out the auto-reclose functionality). This is a Closed/Open/Closed/Open, 4 cycle system.

Auto-recloser (AR) schemes are implemented to carry out this duty automatically.

11.1.1.2 AR TYPE 1

11.1.1.2.1 Behaviour

The general diagram of the auto-recloser function is as follows:

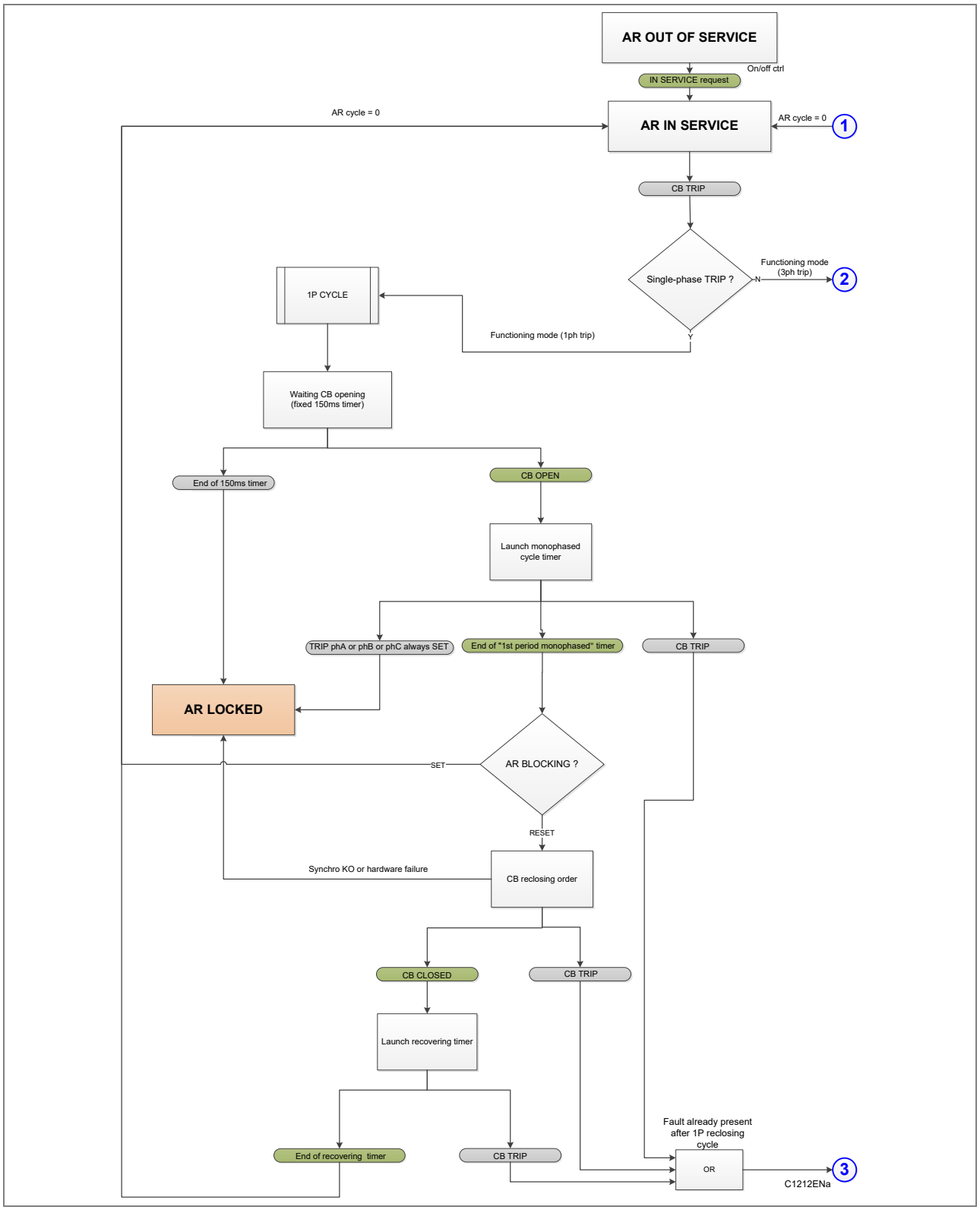


Figure 64: Auto-Recloser scheme logic 1/2

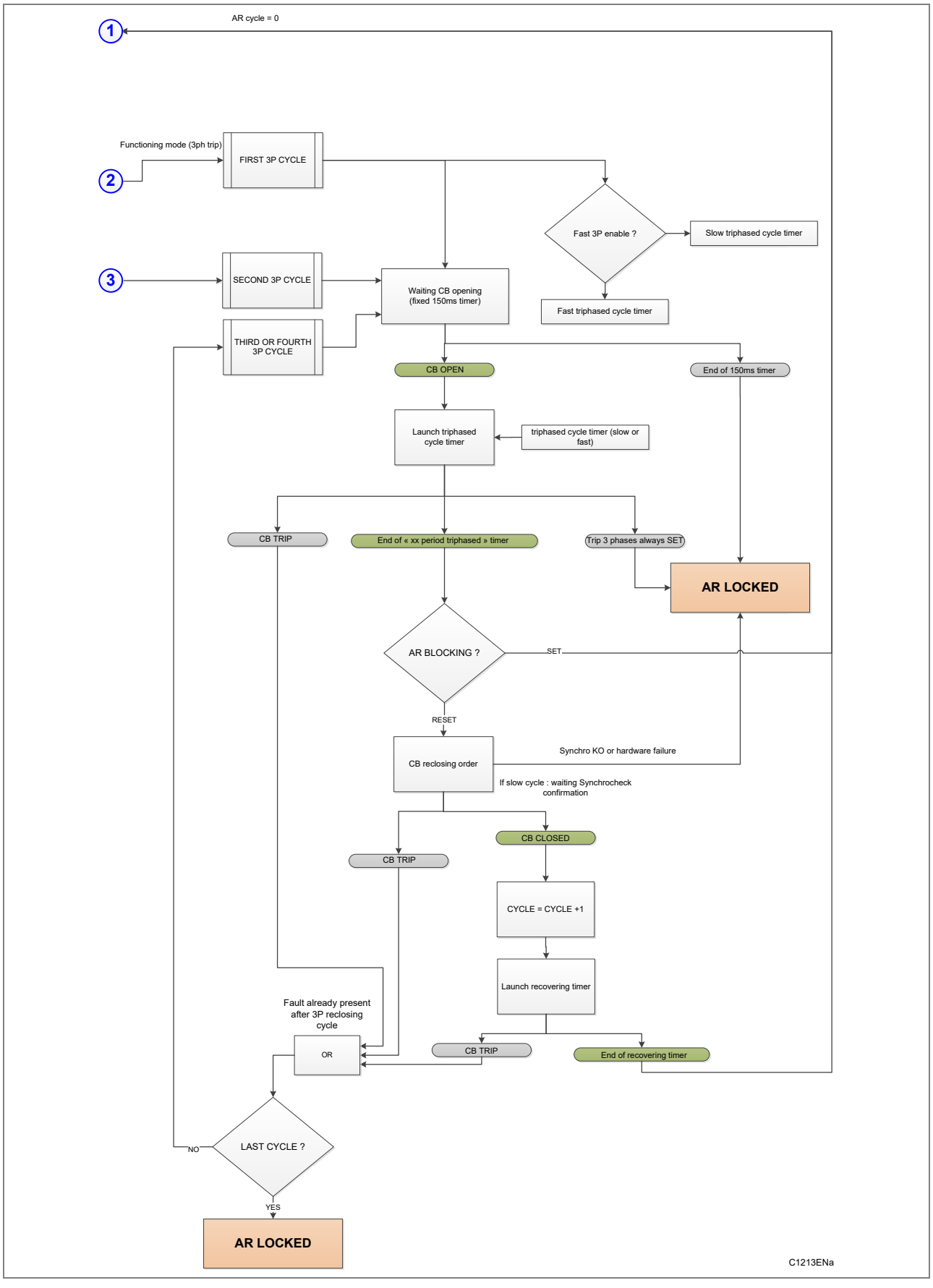


Figure 65: Auto-Recloser scheme logic 2/2

11.1.1.2.2 In Service / Out of service

The auto-recloser function can be in or out of service due to an operator control (through the station bus, the controller's local HMI or a BI).

If the auto-recloser is out of service, no cycle is authorized.

If an out of service request is received during an auto-reclosing cycle, the cycle is immediately stopped.

11.1.1.2.3 Analysis of the received trip

This analysis allows you to detect the type of auto-recloser cycle, that can be:

- The first single-phase cycle
- The first 3-phase fast cycle
- The second 3-phase slow cycle
- The third 3-phase slow cycle
- The fourth 3-phase slow cycle

This detection is done using:

- The current cycle number
- The TRIP_1P_X or TRIP signal sent by the protection relay (single-phase trip / 3-phase trip)
- The configured auto-recloser cycles

11.1.1.2.4 Waiting CB opening

As soon as the trip has been detected, a 150 ms timer is launched to wait for the circuit-breaker opening.

For a single-pole CB

- If the CB position is on a per pole basis:
  - In a single-phase cycle, only one phase position is awaited in the OPEN state (CB_STATE_1P_X)
  - In a 3-phase cycle, each one phase position is awaited in the OPEN state
- If the CB position is given globally:
  - In a single-phase cycle, the position (CB_STATE) is awaited in the MOTION00 state
  - In a 3-phase cycle, the position (CB_STATE) is awaited in the OPEN state

For a three-pole CB

- Whatever was the cycle, the 3-phase position is awaited in the OPEN state (CB_STATE)

For a 3-phase cycle, the DO “AR_TRIP_3P” is closed (if configured) as soon as the CB is detected as open.

The auto-recloser function is locked if the CB is not opened at the end of the timer.

11.1.1.2.5 Launch cycle timer

As soon as the CB is detected as open, the timer associated to the current auto-recloser phase is launched.

During the single-phase cycle, the trip signal must disappear: if not, the auto-recloser function will be locked. Furthermore, a 3-phases trip could appear. In this event, the current cycle is stopped, and the second 3-phases slow cycle is launched.

11.1.1.2.6 Closing the CB

At the end of the cycle timer, the AR_BLOCKING BI is tested: if it is in RESET state, a close order is sent to the circuit-breaker. Note that, if present, the synchrocheck function is used to control the breaker during the second, third and fourth 3-phase slow cycles. The use of the synchrocheck function during the first 3-phase fast cycle is configurable.

If the AR_BLOCKING BI is in another state, the automation is re-initialised to wait for the first cycle.

11.1.1.2.7 Launch recovery time

As soon as all concerned CB phases are closed, the Reclaimmc recovery timer is launched. If the CB remains closed during the timer, the reclosing is considered to be successful and the cycle number is set to 0. The “AR_STATE” signal is set at AR_RECLAIMC state during this timer.

If a new trip occurs during the timer, the next configured cycle is launched. If the trip occurs during the last cycle, the auto-recloser is locked.

11.1.1.2.8 Particular treatments

Reclaim time on manual close

If the CB becomes closed (through an external operation) during an auto-recloser cycle, the Reclaimmc timer is launched during which the auto-recloser function is inhibited and the “AR_STATE” signal is set at the AR_RECLAIMMC state.

CB closing failure

If the CB closing order fails, due to DO hardware failure, interlocking scheme, or synchrocheck inhibition, the AR_FAIL signal is set.

This SI is reset as soon as the CB is closed.

Lock of the auto-recloser

The conditions that lead to an auto-recloser locking are:

- A trip during the last auto-recloser cycle (in this event, the AR_STATE signal is set at the AR_BAR_SHOTS state)
- A lock signal through the AR_LOCK Binary Input at the SET state
- Trip BI state is Invalid (this BI cannot be suppressed, forced or substituted)
- CB position BI(s) state is (are) Invalid
- The Trip BI is always set at the end of the cycle timer
- There is no pole discordance at the end of the single-phase cycle: that is, the three phases are opened
- 2 phases are in an opened state at the end of the single-phase cycle without 3-phase trip signal
- The CB is not opened at the end of the 150 ms timer

The AR_STATE signal is set at the AR_BAR_LOCK state if the auto-recloser function is locked, and the cycle counter is set to 0.

There are two configurable methods to unlock the function. These methods are selected during the configuration phase and can be used separately or together:

1 A manual closing of a circuit-breaker: in this event, the Reclaimmc timer is launched.

2 An “AR_LOCK” signal at the RESET, received either through a BI or an operator order.

If none of these methods are selected, the auto-recloser is automatically unlocked if no lock condition is set and circuit-breaker is closed. In this event, the Reclaimml timer is launched. If the CB is not closed at the end of this timer, the auto-recloser is locked again.

11.1.1.2.9 Information and parameters

Information	Description	Type
CB_STATE_1P_x	CB status, on a per pole basis	BI (DP)
CB_STATE	CB status (global)	BI (DP)
TRIP_1P_x	Trip status, on a per pole basis	BI (SP)
TRIP	3-pole trip status	BI (SP)
AR_IS/OS	Request to put the auto-recloser in / out of service	BI (DP) or operator control
AR_LOCK	Signal to lock / unlock the auto-recloser	BI (SP, Group) or output of a configurable automation or operator control
CB_HEALTHY	Availability of the breaker to be closed	BI (SP)
AR_BLOCKING	Signal to block the closure of the circuit-breaker	BI (SP, Group) or output of a configurable automation
CB_ORDER_1P_x	CB order, on a per pole basis	DO
CB_ORDER	CB order (global)	DO
AR_TRIP_3P	Force 3-pole trip command	This information can be wired to a DO or can be used as an internal signal.
AR_IS/OS	Auto-recloser status: In / Out Of Service	SI (DP)
AR_STATE	Auto-recloser current state	SI (MP)
AR_READY	The auto-recloser is in service, unlocked and no cycle is in progress	State0
AR_WAIT_F/CB_TRP	The auto-recloser is waiting for CB opening	State1
AR_1ST_CYCLE_1P	The first single-pole shot is in progress	State2
AR_1ST_CYCLE_3P	The first 3-pole shot is in progress	State3
AR_2ND_CYCLE_3P	The second 3-pole shot is in progress	State4
AR_3RD_CYCLE_3P	The third 3-pole shot is in progress	State5
AR_4TH_CYCLE_3P	The fourth 3-pole shot is in progress	State6
AR_WAIT_F/CB_CLS	The auto-recloser is waiting for CB closing	State7
AR_RECLAIMC	The Reclaimc timer is launched	State8
AR_BAR_SHOTS	Auto-recloser locked due to reaching the max number of reclosing cycles	State9
AR_BAR_LOCK	Auto-recloser locking	State10
AR_RECLAIMML	The reclaimml timer is launched	State11
AR_RECLAIMMC	The reclaimmc timer is launched	State12
AR_FAIL	Failure of the close command	SI (MP)
AR_SYNC_NOK	Due to the synchrocheck	State0
AR_HARD_ERROR	Due to hardware failure, lock of device or another running automation linked to the device	State1
AR_ILOCK_NOK	Due to interlocking function	State2
AR_NO_FAULT	No failure	State3
AR_TYPE	Auto-recloser type cycle configuration	Mono / Tri
AR_CYCLE_NUMBER	Number of cycles	1, 2, 3 or 4
1P_CYCLE1_TIMER	Timer for the first single-pole shot	From 10 ms to 5 seconds, in steps of 10 ms

Information	Description	Type
3P_CYCLE1_TIMER	Timer for the first 3-pole shot	From 10 ms to 60 seconds, in steps of 10 ms
3P_CYCLE2_TIMER	Timer for the second 3-pole shot	From 1 to 3600 seconds, in steps of 1 s
3P_CYCLE3_TIMER	Timer for the third 3-pole shot	From 1 to 3600 seconds, in steps of 1 s
3P_CYCLE4_TIMER	Timer for the fourth 3-pole shot	From 1 to 3600 seconds, in steps of 1 s
RECLAIM_TIMER	Reclaim timer	From 1 to 600 seconds, in steps of 1 s
RECLAIMMC_TIMER	Reclaimmc timer	From 1 to 600 seconds, in steps of 1 s
RECLAIMML_TIMER	Reclaimml timer	From 1 to 600 seconds, in steps of 1 s
UNLOCKING_METHOD	Method to unlock the auto-recloser	None, manual close, unlock signal, both
SYNC_ENABLE	Use the synchrocheck function during the 3-pole first shot	Yes / No

11.1.1.2.10 Managing Auto-reclosing cycles

The automatic reclosing is triggered by an external trip signal and is managed by the C264 through two functioning modes, depending on the type of circuit breaker:

- **Functioning mode 1 ph trip**: only usable for single-pole circuit-breakers. Up to 4 cycles may be configured where the first cycle is single-pole (“monophased”) and the other ones are three-pole (“triphased”).
- **Functioning mode 3 ph trip**: usable for both single-pole and three-pole circuit-breakers. Up to 4 cycles may be configured where all cycles are three-pole (“triphased”) cycles.

Each auto-reclosing mode is configured in the SCE by selecting the appropriate attributes. These attributes are used by the AR function of the C264 to determine the automatic reclosing cycle, according to the protection fault detection.

The auto-reclosing cycles can be modified either:

- Online via MiCOM S1 (MS1).

  Or,

- At substation HMI level, in DS Agile aView if specific Control (SPC) and Status (SPS) datapoints are set for each auto-reclosing mode (1 ph trip and 3 ph trip). Refer to the **Application** chapter (C26x\EN AP) for configuration details.

11.1.1.3 AR TYPE 3

11.1.1.3.1 Behaviour

The general diagram of the auto-recloser Type 3 function is as follows

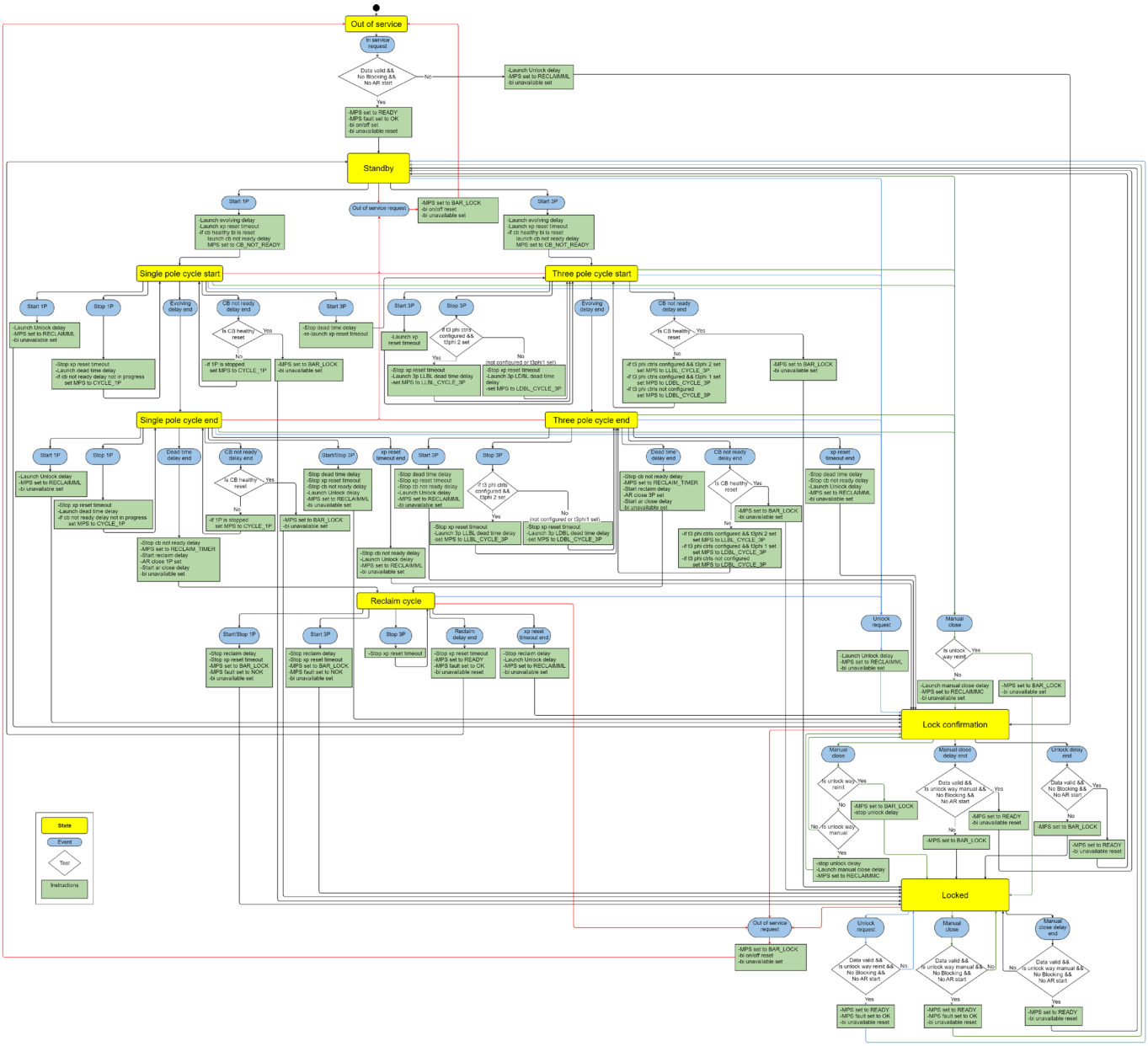


Figure 66: Auto-Recloser Type 3 scheme logic

11.1.1.3.2 Analysis of the received trip

The auto-recloser function is started by the main protection functions of the line (function that determines that a fault is on the protected line and not outside the protected line section).

Depending on the type of the line, the auto-recloser function can be started in a single-phase (**START_1P** SPS signal) or in a three-phase cycle (**START_3P** SPS signal).

11.1.1.3.3 Analysis of the CB status

When the start signal (**START_xP**) is sent by the protection relay (single-phase trip or three-phase trip), the CB status (**CB_HEALTHY**) is checked by the auto-recloser function to start or lock the auto-recloser cycle:

- if the CB_HEALTHY signal is **SET** (CB closed and switch on mechanism armed), the AR cycle (1P or 3P) is started and the evolving fault detection is launched (see section **Detection of evolving fault** below).
- if the CB_HEALTHY signal is **RESET** (CB opened, or switch on mechanism not armed), the **CBNotReady delay (ms)** is started. When this timer has elapsed, the AR cycle is locked (see section **Lock of the auto-recloser**) and the unavailability of the Auto-Recloser function is checked (see section **AR function not available**).

11.1.1.3.4 Detection of evolving faults

An evolving fault is a start signal received although the AR cycle has already started. It may start as a single-phase fault and then involves additional phases during the time that the initial fault is being cleared or during the dead time of the original faulted phase.

In case of evolving faults, the behaviour of the Auto-Recloser function is controlled by the **Evolving fault delay** set at configuration level.

An evolving fault may occur when a single-phase start (**START_1P**) is followed by a three-phase start (**START_3P**) either:

- during the evolving fault delay. In that case, the fault is considered as the same fault, and the **AR cycle 3P** continues (for 3-phase trip start) or goes from **1P** to **3P** (for single-phase trip start).
- after the evolving fault delay. In that case, the fault is considered as an evolving fault and the AR cycle is locked.
- or when a single-phase start (**START_1P**) is followed by another single-phase start (**START_1P**). The fault appears in another phase (*double fault*). The AR cycle is locked.

Detection of evolving faults after a three-phase trip start

If a three-phase start signal is received within the evolving fault delay, the **AR_CYCLE_3P** is started. The **Autorecloser st** (MPS) state is set to **AR_LDBL_CYCLE_3P** or **AR_LLBL_CYCLE_3P** depending on the state of the **t3φ 1** co and **t3φ 2** co datapoint.

If a new **START_3P** signal is received after the evolving fault delay, the **AR_CYCLE_3P** in progress is locked. The AR is unavailable (**AR_UNAVAILABLE** is immediately **SET**) and the unlock delay timer is launched (**Autorecloser st** state is set at **AR_RECLAIMML**).

Detection of evolving faults after a Single-phase trip start

If a single-phase start signal is received within the evolving fault delay, the **AR_CYCLE_1P** is started.

As soon as a new **START_1P** signal is received within or after the evolving fault delay, the **AR_CYCLE_1P** in progress is locked. The **AR UNAVAILABLE** signal is immediately SET and the **Autorecloser st** state is set to **AR_RECLAIMML**.

If a new **START_3P** signal is received:

- within the evolving fault delay:
  - the **AR_CYCLE_1P** in progress is stopped
  - a new **AR_CYCLE_3P** is started,
  - the Autorecloser st state is set to **AR_LDBL_CYCLE_3P** or **AR_LLBL_CYCLE_3P** depending on the line/bus mode at the **RESET** state of **START_3P** signal.
- after the evolving fault delay:
  - the **AR_CYCLE_1P** in progress is locked,
  - the **AR UNAVAILABLE** datapoint is immediately SET
  - the Autorecloser st state is set to **AR_RECLAIMML**.

Note: If the AR_UNAVAILABLE signal is received by the external automation, the circuit breaker will not be reclosed, and the "pole discordance" built-in function will trip the line definitively 2s after the first tripping order.

11.1.1.3.5 Lock of the auto-recloser

The conditions that lead to an auto-recloser locking are:

- **START_1P** or **START_3P** state(s) is/are INVALID (this BI cannot be FORCED, SUPPRESSED, or SUBSTITUED)
- **CB_HEALTHY** state is INVALID
- **Evolving fault detection** during the AR cycle
- **Blocking** datapoint at SET state (see section **Auto-recloser blocking**)
- **Manual close** order (see section **Reclaim time on manual closing**)

When the auto-recloser function is locked, the AR cycle in progress is inhibited and the **unlock delay** timer (RECLAIMML) is started.

When the RECLAIMML has elapsed, if the condition that lead to the auto-recloser locking is:

- not present, then the AR is re-initialised to wait for a new cycle.
- still present, then the AR is locked.

11.1.1.3.6 Dead time management

After the start signal (**START_xP**) is sent, a time interval, that is, the **dead time**, is necessary between initiation of the Auto-Reclose operation and the attempt to close the CB.

The **dead time** of each start signal can be independently adjusted at configuration level.

For a **START_1P** signal, only one dead time is available.

For a **START_3P** signal, two different dead times are possible. The relevant dead time is selected automatically by the AR function depending on the state of the **t3φ 1** co and/or **t3φ 2** co datapoint. Only one control datapoint is active at a time.

Dead time selection

Start signal (SPS)	AR Cycle	Mode used	t3φ1 co	t3φ2 co	Dead time	Default value	"Autorecloser st" MPS state
Single phase (**START_1P**)	Single-phase cycle	N/A			Dead time for 1P reclosing cycle (ms)	1000ms	AR_CYCLE_1P
Three-phases (**START_3P**)	Three-phase cycle	Dead Line and Live Bus (DL/LB)	SET	RESET	Dead time for 3P reclosing cycle on DL/LB mode (ms)	500ms	AR_LDBL_CYCLE_3P
		Live Line and Live Bus (LL/LB) Live Line and Dead Bus (LL/DB)	RESET	SET	Dead time for 3P reclosing cycle on LL/LB mode (ms)	10 000ms	AR_LLBL_CYCLE_3P

If another start signal occurs during the dead time, the AR is blocked. At the end of the relevant dead time, the CB close signal sent by the AR function is blocked temporarily (refer to " AR function not available" description below).

Downgraded mode

- If **t3φ 1** co (SPC) and/or **t3φ 2 co** (SPC) datapoints is/are INVALID, or not configured, the default dead time is "dead time for 3P reclosing cycle on LDBL mode (ms)".
- In case of C264 reboot, the last deadtime control is saved and restored as active dead time 3P.
- After a DB switch, the dead time 3P selection is reset. The default dead time is "dead time for 3P reclosing cycle on LDBL mode (ms)".

11.1.1.3.7 Auto-Recloser function Inputs

11.1.1.3.7.1 In service / Out of service

The AR function can be "In service" (ON) or "Out of service" (OFF) according to the state of control datapoints (**on/off ctrl**, **AR ON req** or **AR OFF req**) or due to an operator control (through the station bus, the controller's local HMI or a BI).

If the auto-recloser function is out of service, no cycle is authorized (the AR is locked).

If an out of service request is received during an auto-reclosing cycle, the cycle is immediately stopped.

In case of C264 reboot, the last **on/off ctrl** (DPS) status value saved in the database is restored as the active function status (ON or OFF).

After a DB switch, the last **on/off ctrl** (DPS) status value saved in the database is reset. The function status is set at ON by default.

Note: if the function activation control datapoints are INVALID, the AR function will be locked.

11.1.1.3.7.2 Circuit breaker status

The CB mechanism provides a Boolean signal called **CB_READY**. This signal is a unique physical input for single-pole or three-pole CB.

The **CB_READY** automation logic relies on the following information:

- the "spring charged" (or "remaining energy" in case of oil-mechanism) status set to TRUE (CB mechanism capable of carrying out a complete O-C-O cycle at the time the fault occurred),
- the circuit breaker detected as **CLOSED** (by the CB mechanism auxiliary switches position)

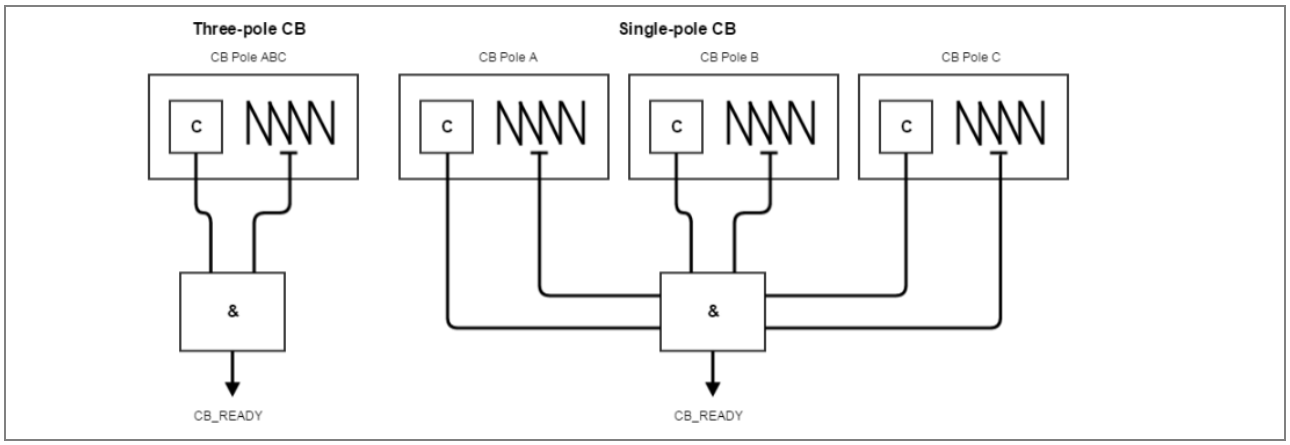


Figure 67: CB status

To use the CB status as an input of the Auto-recloser function, the **CB_HEALTHY** datapoint is taken into account. Refer to the AR behaviour description, in section 7.1.1.2.1 for more details on the use of this input.

11.1.1.3.7.3 Auto-recloser blocking

To block the AR cycle in progress, the **Blocking** datapoint is checked: if it is in RESET state, the AR cycle is started and a reclose order is sent to the circuit-breaker.

If the Blocking datapoint is in another state, the AR cycle is locked and the unlock delay (RECLAIMML) is started.

Once the RECLAIMML has elapsed:

- If the Blocking datapoint is at **RESET** state, the AR is re-initialized to wait for a new cycle. The **Autorecloser st** state is set at **AR_READY**.
- If the **Blocking** datapoint is in another state (**SET** or **INVALID**), the AR cycle is locked until the **Blocking** signal is **SET**. The **Autorecloser st** state is set at **AR_BAR_LOCK**. When the **Blocking** signal is RESET, the AR remains at the **AR_BAR_LOCK** state.

When the reclosing order is transmitted (**AR_CLOSE_xP**), the reclaim delay timer is launched. The Autorecloser st state is set to AR_RECLAIMC. During this time, the AR is inhibited, and no start is possible.

At the end of the reclaim delay timer, the AR is re-initialized to wait for a new cycle. The **Autorecloser st** state is set to **AR_READY**.

11.1.1.3.7.4 Protection start information

The start signal (**START_xP**) sent by the protection relay can be a single-phase trip or a three-phase trip. When the datapoint state is SET, the **Start_Timeout(ms)** delay is launched.

If the **START_xP** signal is set at the **RESET** state before the end of the **Start_Timeout(ms)** delay, the timer is stopped, and the AR cycle continues. At the end of the **Start_Timeout(ms)** delay, if the **START_xP** signal is set at the **SET** state, the AR cycle is locked.

11.1.1.3.8 Auto-Recloser function Outputs

11.1.1.3.8.1 AR function not available

The unavailability of Auto-Recloser function is transmitted by the **AR_UNAVAILABLE** datapoint to external automation (FBD, PLC).

The AR function may result unavailable in the following cases:

- CB is not ready (**CB_HEALTHY** at **RESET** state). In that event, the **Autorecloser st** state is set at **CB_NOT_READY** and the **CBNotReady delay (ms)** timer is started.

  At the end of the timer:

  - if **CB_HEALTHY** is at **RESET** state (CB opened, or switch on mechanism not armed), the **AR_UNAVAILABLE** datapoint is **SET** and the **Autorecloser st** state is set at **AR_BAR_LOCK**.
  - if **CB_HEALTHY** is at **SET** state (CB closed and switch on mechanism armed), the AR is available. The **AR_UNAVAILABLE** datapoint remains at **RESET** state and the **Autorecloser st** state is set at AR_READY.
- AR function is out of service. In that event, the **AR_UNAVAILABLE** state is immediately **SET**.
- AR function is blocked. In that event, the **AR_UNAVAILABLE** state is immediately **SET**.
- During the reclaim time

11.1.1.3.8.2 CB reclosing order status

The **AR_CLOSE_xP** output datapoint is used by external automations (FBD, PLC) to control the automatic reclosing cycle of a circuit breaker, installed on the bay managed by the bay controller.

- **AR_CLOSE_3P** SPS controls the CB state by a three-phase reclosing order,
- **AR_CLOSE_1P** SPS controls the CB state by a single-phase reclosing order.

By default, the **AR_CLOSE_xP** signal is RESET. At the end of the **dead time** (AR cycle not locked by blocking signal or evolving fault), the **AR_CLOSE_xP** signal is SET.

When **AR_CLOSE** signal is **SET**, the **reclosing delay(ms)** is launched, during which the **AR_CLOSE_xP** signal is maintained. At the end of the timer, the signal **AR_CLOSE** is RESET.

11.1.1.3.9 Particular treatments

Reclaim time on manual closing

If the CB becomes closes (through a manual closing operation) during an auto-recloser cycle, the **RECLAIMMC** timer (manual close delay) is launched during which the auto-recloser function is inhibited. The **AR_UNAVAILABLE** state is immediately SET and the **Autorecloser st** (MPS) state is set at the **AR_RECLAIMMC** state.

CB closing failure

If the CB closing order fails, the **Autorecloser flt** (MPS) sends the auto-recloser status:

- if no start signal is received during the reclaim time:
  - the **Autorecloser flt** (MPS) is set at the **AR_OK** state
  - the **Autorecloser st** (MPS) is set at the **AR_READY** state
- if a start signal is received during the reclaim time:
  - the **Autorecloser flt** (MPS) is set at the **AR_NOK** state
  - the **Autorecloser st** (MPS) is set at the **AR_BAR_LOCK** state

Auto-recloser unlocking methods

There are three configurable methods to unlock the AR function. These methods are selected during the configuration phase and can be used separately or together:

- **Manual closing**: In this event, the manual close delay timer (**RECLAIM_MC**) is launched. At the end of the timer, the AR function is reinitialized, whether it is in standby mode, locked or a reclosing cycle is in progress.
- **Reinitialization**: the AR function is locked by a manual closing order and unlocked by a reinitialization signal (**unlock req**) received either through an automation or an operator order (**unlock ctrl**).
  - If a manual closing order is received while the AR function is in standby mode or a reclosing cycle is in progress, the AR function is locked (**AR_BAR_LOCK**).
  - If a manual closing order is received while the AR function is locked, the function remains locked. When the **unlock req** signal is **SET** then the function is reinitialized immediately.
- **Both ways**: Both methods are applied in the same time.

If the **Unlock req** or **Unlock ctrl** datapoint is **INVALID**, the AR function is locked.

11.1.1.3.10 AR type 3 Limitations

- The **AR type 3** is dedicated to conventional architectures only;
- The **AR type 3** function is not managed in case of DS Agile system redundancy;
- The number of automatic reclosing cycles is fixed to **1**.

11.1.1.3.11 Information and parameters

Information	Description	Type
AR UNAVAILABLE	Output status for unavailability of the Auto-recloser function	Output SPS status
Autorecloser flt	Auto-recloser failure status	MPS
AR_OK	Auto-recloser failed	State0
AR_NOK	No failure	State2
Autorecloser st	Auto-recloser status	MPS
AR_READY	Auto-recloser in service, unlocked and no cycle in progress	State0
AR_CYCLE_1P	1-phase cycle is in progress	Status1
AR_LDBL_CYCLE_3P	3-phases cycle on D-L/L-B mode is in progress	Status2
AR_LLBL_CYCLE_3P	3-phases cycle on L-L/L-B mode is in progress	Status3
CB_NOT_READY	CB not ready	Status4
AR_RECLAIMC	Reclaim delay timer launched	Status5
AR_BAR_LOCK	Auto-recloser locking	Status6
AR_RECLAIMML	Unlock delay timer is launched	Status7
AR_RECLAIMMC	Manual close delay timer is launched	Status8
AR_BLOCKING	Signal to block the closure of the circuit-breaker	BI (SP, Group) or output of a configurable automation
AR_CLOSE_1P	Reclosing order after a 1P cycle	SPS
AR_CLOSE_3P	Reclosing order after a 3P cycle	SPS
on/off st	Auto-recloser IN/OUT status	DPS
on/off ctrl	Auto-recloser IN/OUT of service ctrl	DPC
AR ON req	Request to set the auto-recloser in service (AR_IS)	SPS
AR OFF req	Request to set the auto-recloser out of service (AR_OS)	SPS
START_1P	Protection start signal for single phase AR cycle	SPS
START_3P	Protection start signal for three-pole or single-pole CB	SPS
CB_HEALTHY	Availability of the breaker to be closed	BI (SP)
CBNotReady delay	Delay used to test the CB_Healthy input during the protection start	From 0 to 100 ms, in steps of 1 ms
Dead time for 1P reclosing cycle	Time interval between the start of the 1P reclosing cycle and the time when the closing order is given	From 1000 ms to 10 000 ms, in steps of 100 ms

Information	Description	Type
Dead time for 3P reclosing cycle on LDBL mode	Dead time for 3P reclosing cycle on DL/LB scheme	From 100 ms to 6000 ms, in steps of 10 ms
Dead time for 3P reclosing cycle LLBL mode	Dead time for 3P reclosing cycle on LL/LB or LL/DB mode	From 1000 ms to 60 000 ms, in steps of 100 ms
Evolving fault delay	Delay used to treat evolving faults in 1P cycle	From 0 to 100 ms, in steps of 1 ms
RECLAIM_TIMER	Reclaim delay timer	From 1000 ms to 600 000 ms, in steps of 1000 ms
RECLAIMML	Auto-recloser unlock delay	From 1000 ms to 600 000 ms, in steps of 1000 ms
RECLAIMMC	Manual reclosing time	From 1000 ms to 600 000 ms, in steps of 1000 ms
Reclosing delay	Delay used to maintain the AR_CLOSE_xP order	From 0 to 3000 ms, in steps of 10 ms
Start_Timeout	Delay used to wait the protection start signal fallout	From 0 to 10000 ms, in steps of 10 ms
t3 phi 1 st	Short 3P cycle time status	SPS
t3 phi 2 st	Long 3P cycle time status	SPS
t3 phi 1 co	Allows to set a short 3P cycle time	SPC
t3 phi 2 co	Allows to set a long 3P cycle time	SPS

11.1.2 TRIP CIRCUIT SUPERVISION (TCS)

The Trip Circuit Supervision function monitors the trip circuit wiring continuity irrespective of the position of the CB contacts but only when the trip relay is not activated. This information is received through a separate input and it inhibits the detection of continuity.

The DS Agile C26x supports two Trip Circuit Supervision schemes:

- Trip Circuit Supervision using one Digital Input and an external resistor
- Trip Circuit Supervision using two Digital Inputs and no external resistor

Both schemes are based on digital inputs being kept energised as long as the trip circuit is healthy. These inputs can then be configured to issue alarms when they are reset.

Note: The Trip Circuit Supervision is not a dedicated feature in System Configuration Editor. It is configured by engineering from generic datapoints. To implement this feature, a DIU or a CCU input board can be used. Moreover, there is no constraint with PBUS architecture usage.

Trip Circuit Supervision using one Digital Input and an external resistor

The value of the resistor in the TCS scheme (R) should be:

- High enough, so that once the CB is open and if the protection device's trip contact is latched, the trip coil powered via this resistor is no longer submitted to a magnetic effect and the tripping mechanism can be released (within a possible delay due to inductive effect of the coil).
- Low enough, so that the DS Agile C26x's digital input powered through the resistor (and the tripping coil) is seen energised.

Therefore:

- It is estimated that the magnetic effect is low enough to allow the release of the tripping mechanism when the applied voltage is equal to 0.1 Vn. Taking into account usual tolerances for the power supply, this leads to the minimum value of R being approximately 10 to 12 times the resistance of the tripping coil.
- The DS Agile C26x's digital input was tested to operate with a series resistor of up to 40 kOhm, still leaving voltage through the input above the minimum. Taking into account tolerances, this defines a maximum value for the resistor of 20 kOhm.

The recommended value is in the middle of the range (geometrically):

$R / 12 \times Rc = 20kOhm / R$

Where Rc = resistance of the tripping coil.

The power rating of the resistor must be such that it withstands permanent application of the maximum trip circuit voltage. Therefore:

$P = (1.2 \times Vx)^2 / R$

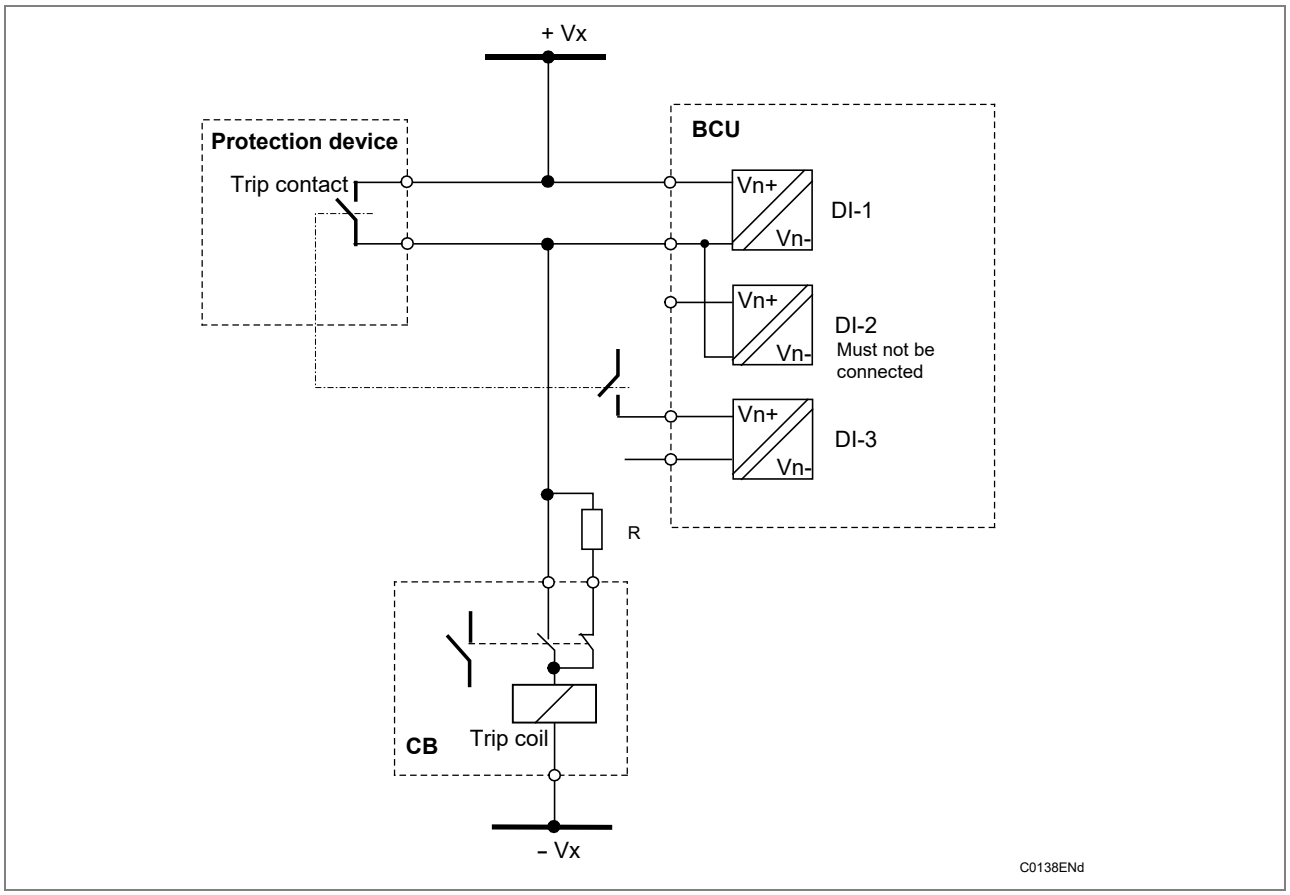


Figure 68: Trip circuit supervision using one digital input and an external resistor

Trip Circuit Supervision using two Digital Inputs and no external resistor

- When the CB is open, DI-3 is energised (SPS state: SET) while DI-1 is de-energised (SPS state: RESET).
- When the CB is closed, DI-1 is energised (SPS state: SET) while DI-3 is de-energised (SPS state: RESET).

Thus, if the trip circuit is healthy, the DPS status resulting from the two SPS datapoints is either ON (10) or OFF (01). If the trip circuit is faulty (open circuit), the DPS status is "jammed" (00).

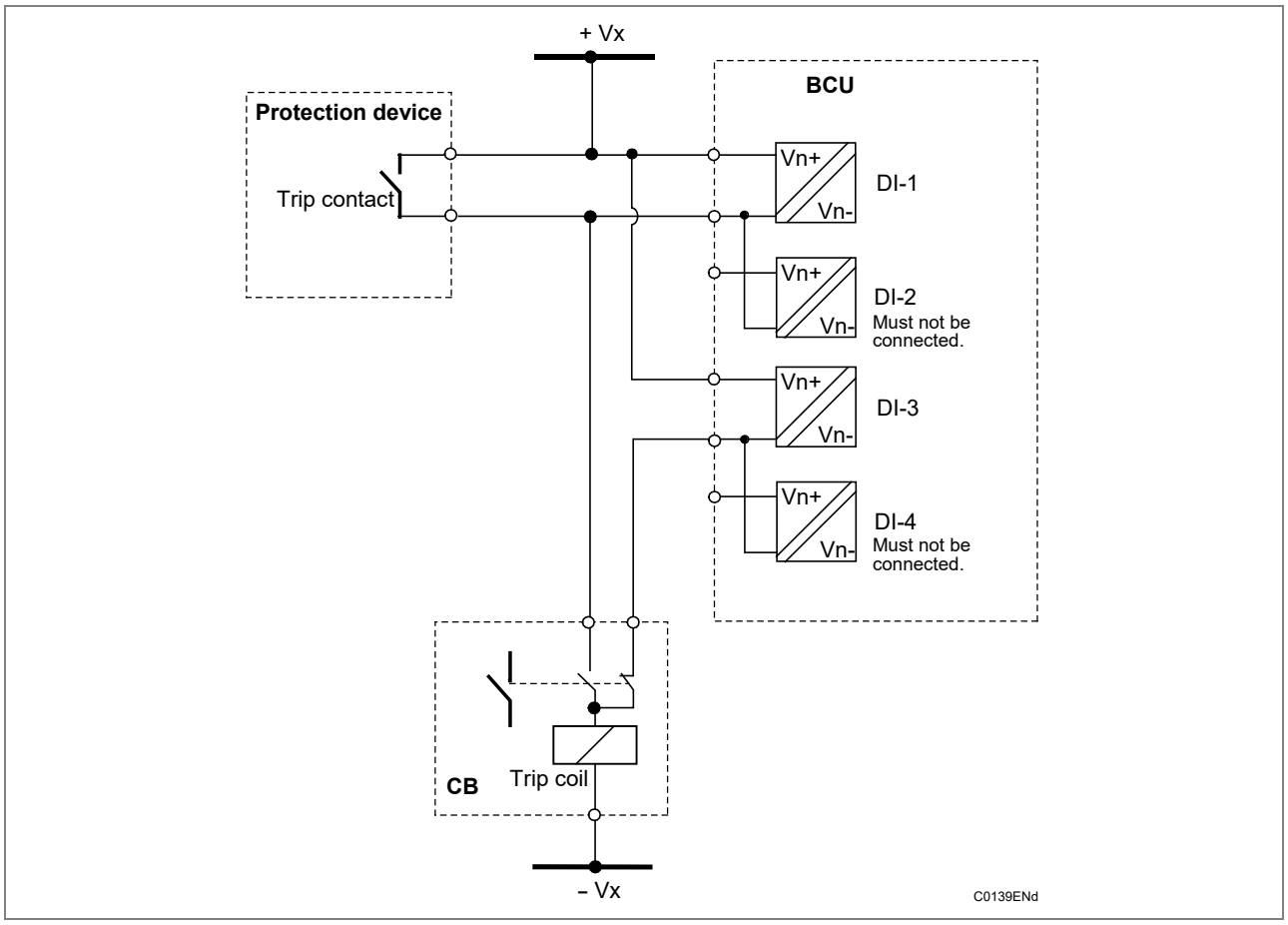


Figure 69: Trip circuit supervision using two digital inputs

Note: This scheme can be used with inputs for which the detection threshold of the "set" state is > 55% Vn (e.g. CCU200 A07).

11.1.3 AUTOMATIC VOLTAGE REGULATION–AVR

Automatic voltage regulation is used to regulate the voltage. It takes the fluctuate voltage and changes them into a constant voltage. The fluctuation in the voltage mainly occurs due to the variation in load on the supply system. The variation in the voltage can be controlled by the DS Agile C26x controller.

The Automatic Voltage Regulation (AVR) function operates in conventional or digital BCU (coupled with SCU for DI/DO), in combination with ISAGRAF or FBD user-functions, and built-in functions, such as Auto-Recloser and Synchrocheck.

In the case of multi-bays managed by the same BCU, the AVR function can be instantiated in only one of them (only 1 AVR per C264).

11.1.3.1 PRESENTATION

11.1.3.1.1 Role

DS Agile C26x with AVR is a compact Voltage Regulation solution for Electrical Substations; it automatically regulates the voltage level on the secondary side of HV/MV and/or MV/MV transformers.

It can automatically send secured commands (Raise, Lower) to the Tap Changer, fully aware of the transformer characteristics (voltage,), the Tap Changer characteristics (position number, inter tap timers…), the voltage targets and the various transformer or tap changer alarms.

11.1.3.1.2 Hardware

The DS Agile C26x includes:

- A BIU2xx board and a CPU4 board
- An LCD screen (optional) with predefined AVR panel
- A DIU2xx board to acquire 16 Digital Inputs:
  - Tap Position Indications (typically on 6 bits with BCD encoding, up to 64 bits with BCD, Gray, binary codes,)
  - 2 CB positions
  - 1 VT Fuse
  - 1 Tap Changer fault (option)
  - +7 customisable DIs (Bay L/R, AVR Auto/Manu, AVR on/off, alarms, external lock, voltage target selection)
- A DOU20x board to control Digital Output relays:
  - 2 Raise/Lower controls
  - 1 AVR fault (Watchdog)
  - 1 AVR Mode Auto/Manu
  - 1 AVR ON/OFF
  - 1 circulating current signal
  - other optional customisable digital outputs (I>, V>, alarms, locking, …)

Note: Digital inputs and outputs can be located at BCU or SCU level, according to the type of DCS architecture (conventional or digital).

- A TMU220 board (4 CTs / 5 VTs) for direct acquisition of currents and voltages. Sampled values (IEC 61850-9-2LE) are also used for direct acquisition of currents and voltages.
- An AIU board (option) to acquire Tap positions, voltages…(4-20 mA)
- An AOU board (option) for analogue outputs (4-20 mA) to repeat the Tap changer positions or measurement values (voltages, circulating currents…)

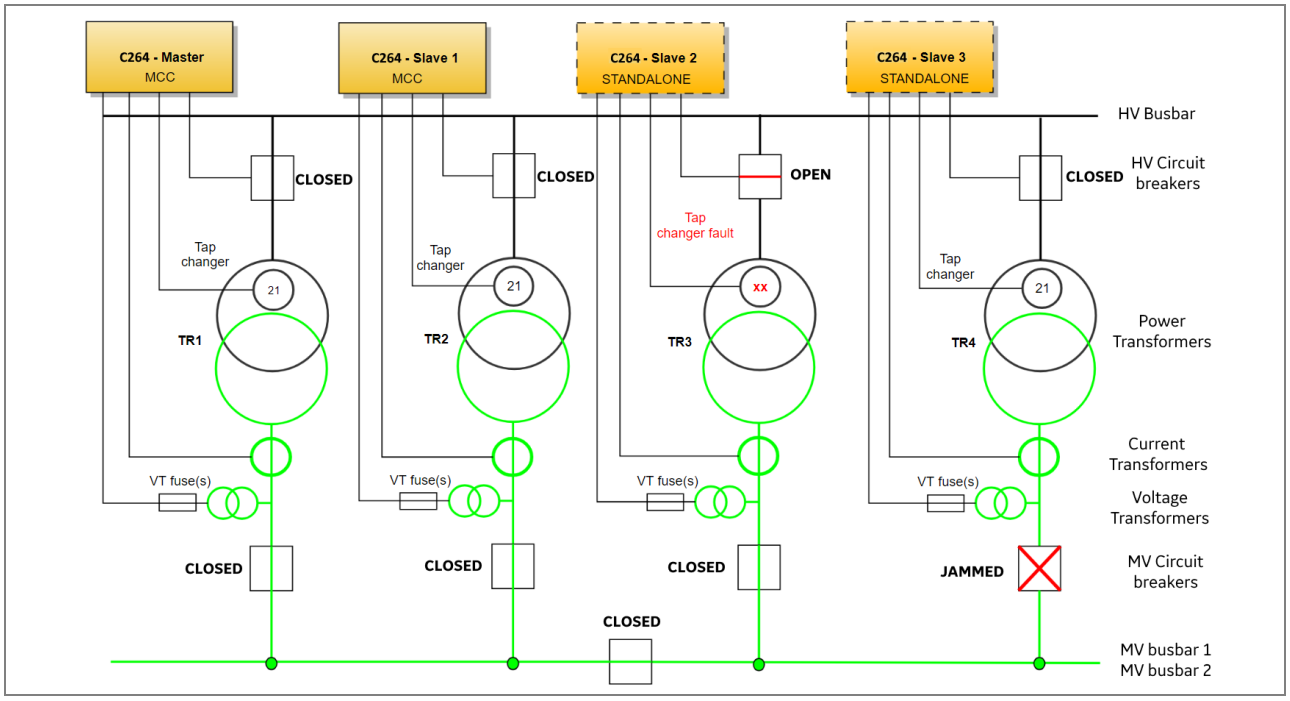
11.1.3.1.3 Exchanges over the bus

The IEC 61850-8-1 bus can convey additional data:

- TPI and Tap changer status, “tap pulse duration”
- power factor
- target voltages and target voltage setpoint, compounding method
- topology information from IEDs (in place of serial bus) or other C26x
- settings from DS Agile S1
- measurements and commands when several transformers are involved:
  - each transformer is controlled by one controller, but the “master” role is defined on one controller among the group of transformers in parallel.

The figure illustrates an example of architecture that controls three transformers:

- the AVR function is activated on C264 TR1. This controller gets analogue values through the station bus from C264 TR2 and TR3, and issues tap changer commands through the station bus:



11.1.3.1.4 Topologies

DS Agile system manages 3 types of Automatic Voltage Regulations:

- **Standalone**: **voltage regulation for a single transformer:**
  - **Standard application**: based on remote/local voltage target
  - **ARU application**: based on local voltage reference and defined controls

In case of transformers in parallel:

- **Master/follower**: tap changers follow a Master tap changer with up to 4 C26x followers with AVR;
- **Minimize Circulating Currents**: computes circulating reactive current, and internal voltage difference between transformers secondary windings.

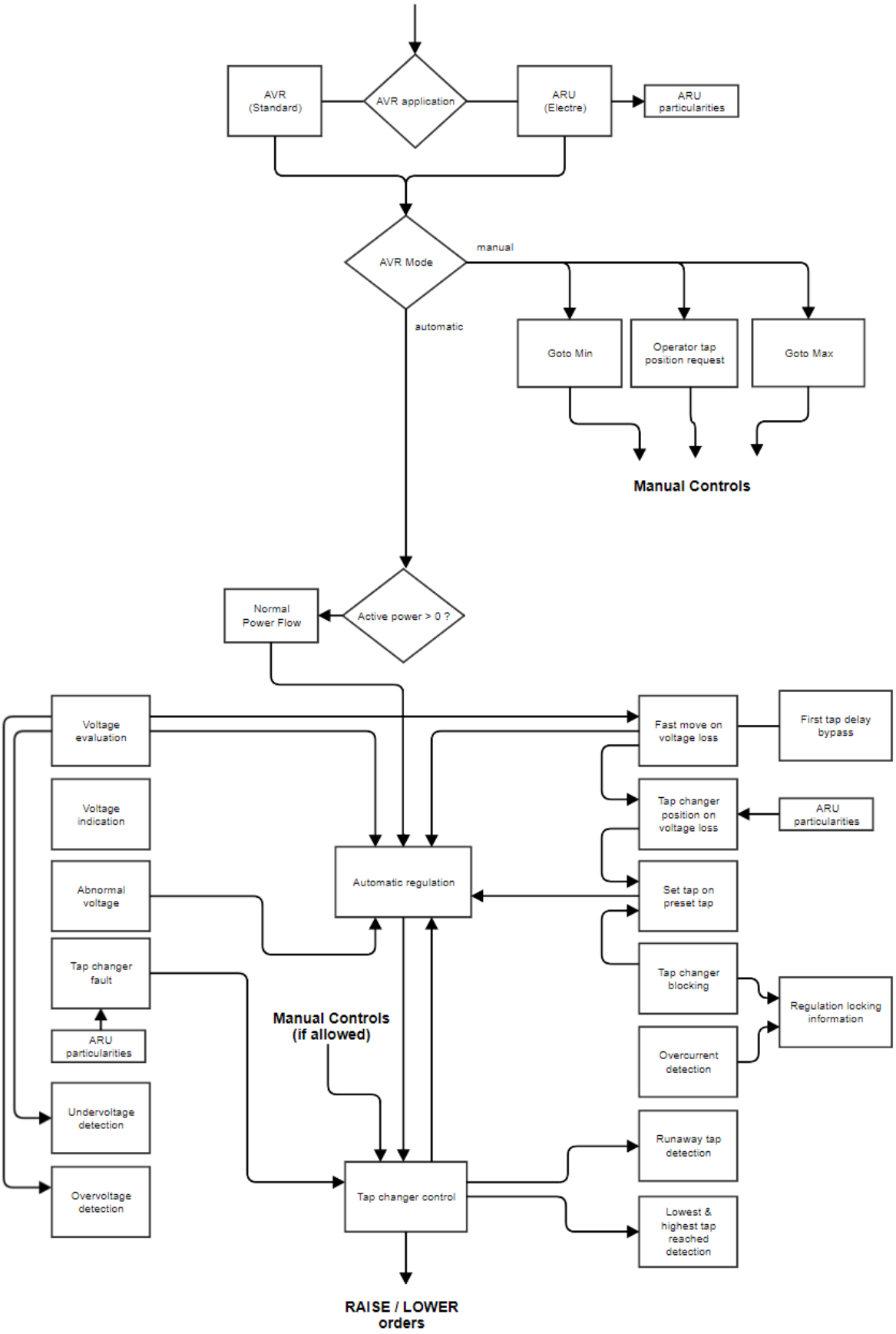
Note: the "Master/Follower" method requires an external automation (PLC) to manage substation topology. The topology management is integrated into the "Minimization of circulating currents" method.

11.1.3.2 AVR STANDALONE MODE

The AVR function manages two modes of voltage regulation:

- **Manual** (open loop): the operator forcefully issues Raise/Lower commands to the tap changer from the LHMI to adjust the secondary power transformer voltage to the desired value;
- **Automatic** (closed loop):
  - **Remote/Local target voltage**: the AVR algorithm issues Raise/Lower commands to the tap changer when the voltage is outside limits and tap changer conditions permit to adjust the secondary power transformer voltage according to the remote or local target voltage; the operator can still deactivate the algorithm from the LHMI.
  - **Controls**: the AVR algorithm issues Raise/Lower commands to the tap changer to adjust the secondary power transformer voltage according to operator or automation controls; the operator can still deactivate the algorithm from the LHMI.

The AVR Standalone method is processed as follows:



By default, the AVR function starts according to the **AVR Mode** (automatic or manual), defined at configuration level (SCE).

If **AVR Mode** is changed by an operator action (HMI) or from online parameters (DS Agile S1), the new **AVR Mode** is saved and the next AVR start is done in this mode.

11.1.3.2.1 Manual Regulation mode

The manual regulation mode is set by an operator control (HMI) or through DS Agile S1 by modifying the dedicated parameter.

When the **Manual** AVR mode is activated, if a Tap operation is in progress, the **TCIP** signal is SET. The manual mode will be set at the end of the tap operation, when TCIP is RESET.

In manual mode, the AVR does not react at any change of analogue inputs (voltage or current).

When the operator issues a **Raise** command, if the highest tap is not reached, the control is sent to the tap changer;

When the operator issues a **Lower** command, if the lowest tap is not reached, the control is sent to the tap changer.

The operator (HMI) can activate the **Tap changer on a preset tap** function. In this case, **Raise** or **Lower** orders are sent to the tap changer, until the preset tap is reached.

For each tap control, when the **TCIP** is RESET, a defined **Preset tap delay** is started. At the end of this delay, the next tap control is activated. If the current **TPI** value is not valid, this function cannot be activated.

The control activation is held until the **TCIP** is SET.

11.1.3.2.2 Automatic Regulation mode

The automatic regulation mode can be set from an operator control (HMI) or through DS Agile S1 by modifying the dedicated parameter.

When the **Automatic** AVR mode is activated, if a Tap operation is in progress, the **TCIP** signal is SET. At the end of the tap operation, when **TCIP** is RESET, the automatic control is set.

Automatic regulation occurs only if the following conditions prevail:

- The AVR mode is automatic;
- The “Topology Status” (circuit-breaker position on the primary side of the transformer) is set to CLOSED;
- VT fuse information (**VT.Fuse.Set**) is RESET;
- **Voltage present** signal is SET (voltage on secondary winding is in the range);
- Regulation locking signal is RESET.

If one or more of these conditions is missing, no automatic regulation is performed.

Moreover, before sending an automatic tap changer control, the following conditions are also required:

- **TCIP** is RESET (no tap changer in progress)
- For a **Raise** control: no **High.Tap.Reached** indication is SET
- For a **Lower** control: no **Low.Tap.Reached** indication is SET

The HMI signalisations are:

- If the “Topology Status” (circuit-breaker position on the primary side of the transformer) is set to OPEN, the **Noregul.Topology.Status** signal is SET
- If **Voltage present** signal is RESET, the **Noregul.voltage** signal is SET
- If VT fuse information is SET, the **Noregul.VT.Fuse** signal is SET

11.1.3.2.2.1 Voltage Evaluation

Depending on the type of transformer and configuration attributes, the automatic voltage regulation may apply to:

- voltage and current of one winding (voltage 1)
- voltage and current of the other winding (voltage 2)
- average voltage and current of the 2 windings (average voltage)

11.1.3.2.2.2 Voltage indication

In the voltage evaluation, the target voltage (with its possible correction) set by configuration, setting or operator control, is compared to the acquired voltage (with its possible correction).

Three voltage indications are used in the automatic regulation process:

1 **Voltage.State**: MPS indicating whether the actual voltage is higher or lower than the target voltage, for the defined **Regulation deadband**:

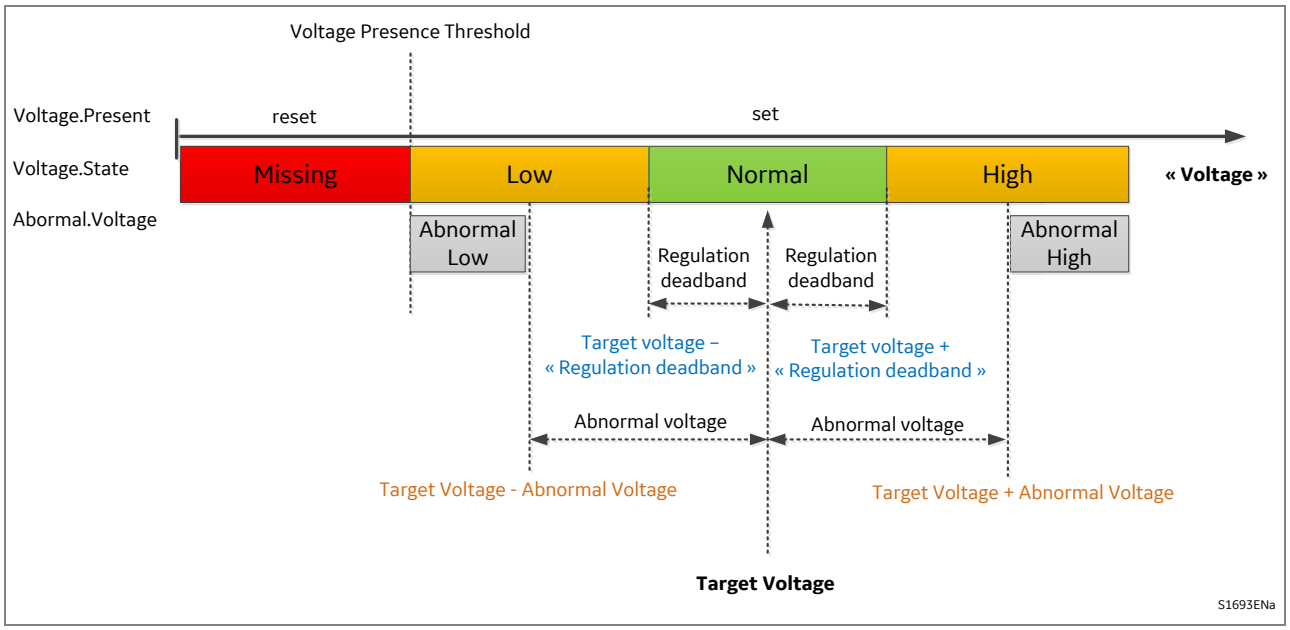
- **Missing**: the voltage is lower than the **Voltage presence threshold**;
- **Normal**: the voltage is within the **Regulation deadband**;
- **High**: the voltage is higher than the **Target Voltage** ⊕ the **Regulation deadband**, for a period longer than the “**Voltage Confirmation delay**”;
- **Low**: the voltage is lower than the **Target Voltage** ⊖ the **Regulation deadband**, for a period longer than the “**Voltage Confirmation delay**”;
- **No Conditions**: one or more condition is missing for evaluating the voltage, notably when the C264 is Follower and does not manage voltage regulation.

2 **Voltage.Present:** SPS indicating whether the actual voltage is higher than a defined **Voltage presence threshold**:

- **Set**: the voltage is above the “voltage presence threshold”, for a period longer than the **Voltage present delay**;
- **Reset**: the voltage is below the voltage presence threshold, for a period longer than the **Voltage missing delay**.

3 **Abnormal.Voltage:** SPS indicating whether the actual voltage is outside a defined **Abnormal voltage threshold**:

- **Set**: the voltage is higher than the **Target Voltage** ⊕ **Abnormal voltage threshold** parameter OR is lower than **Target Voltage** ⊖ **Abnormal voltage threshold** parameter, for a period longer than the defined **Abnormal voltage delay**;
- **Reset**: the voltage value is within the defined voltage zone.



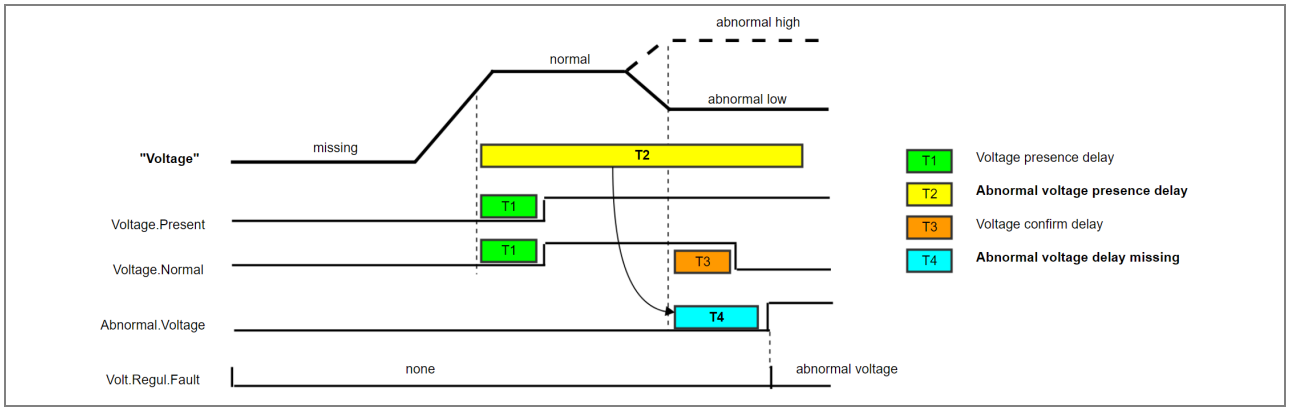
11.1.3.2.2.3 Abnormal Voltage

The **Abnormal voltage** signal is SET only if:

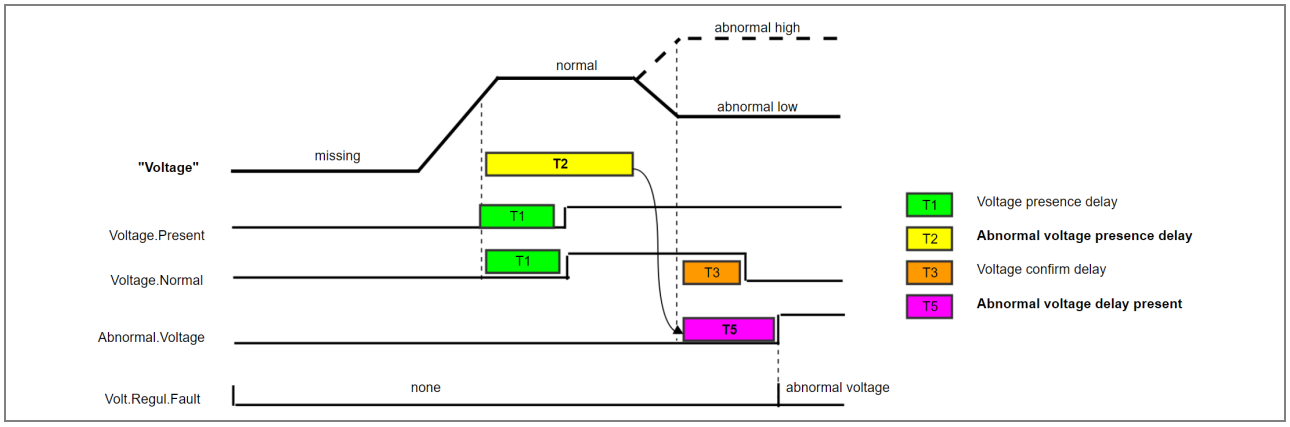
- **AVR Mode** is "automatic"
- **Topology.Status** is SET (valid topology automation)
- VT fuse information is RESET (no VT fuses blown)

The abnormal voltage signal is SET after a defined delay:

- When the abnormal voltage signal is issued before the **Abnormal voltage presence delay** has elapsed, **Abnormal voltage delay missing** indication is set:



- When the abnormal voltage signal is issued after the **Abnormal voltage presence delay** has elapsed, the **Abnormal voltage delay present** indication is set:



When the "Voltage" value is back to normal, the **Abnormal voltage** signal is RESET immediately.

11.1.3.2.2.4 Activate Control on Tap

In case of high voltage

If the voltage state indicates a “high” voltage, a **First tap delay** (TA1) is started. Once the TA1 delay has elapsed, a “Lower tap” control is activated until the TCIP indication is SET. As soon as the TCIP is SET, the control is de-activated (tap changer in progress). When the TCIP is RESET, if the voltage value is still high, then, the **Next tap delay** (TA2) is launched. At the end this delay, a “Lower tap” control is activated until the TCIP indication is SET. And so on, until the voltage value returns to normal.

In case of low voltage

If the voltage state indicates a low value, a **First tap delay** (TA1) is started. Once the TA1 delay has elapsed, a “Raise tap” control is activated until the TCIP indication is SET. As soon as the TCIP is SET, the control is de-activated (tap changer in progress). When the TCIP is RESET, if the voltage value is still low, then the **Next tap delay** (TA2) is launched. At the end of this delay, a “Raise tap” control is activated until the TCIP indication is SET. And so on, until the voltage value returns to normal.

When the **First tap delay** or **Next tap delay** is started, if one of the delay conditions is cleared off (voltage value back to normal, for instance), the delay is RESET, and no control is activated.

11.1.3.2.2.5 First tap delay bypass

The first tap delay can be bypassed if the "**Fast Tap Changer Move after Voltage Loss**" function is set.

When the **first tap delay bypass delay** is SET (TA3), The first tap delay is replaced by the next tap delay.

11.1.3.2.2.6 Set tap changer on a preset tap

When the "**Tap Changer Position on Voltage Loss**" function is active, the "**Set the tap changer on a preset tap**" function can be set to raise, lower or raise and lower the tap changer to the “preset tap”.

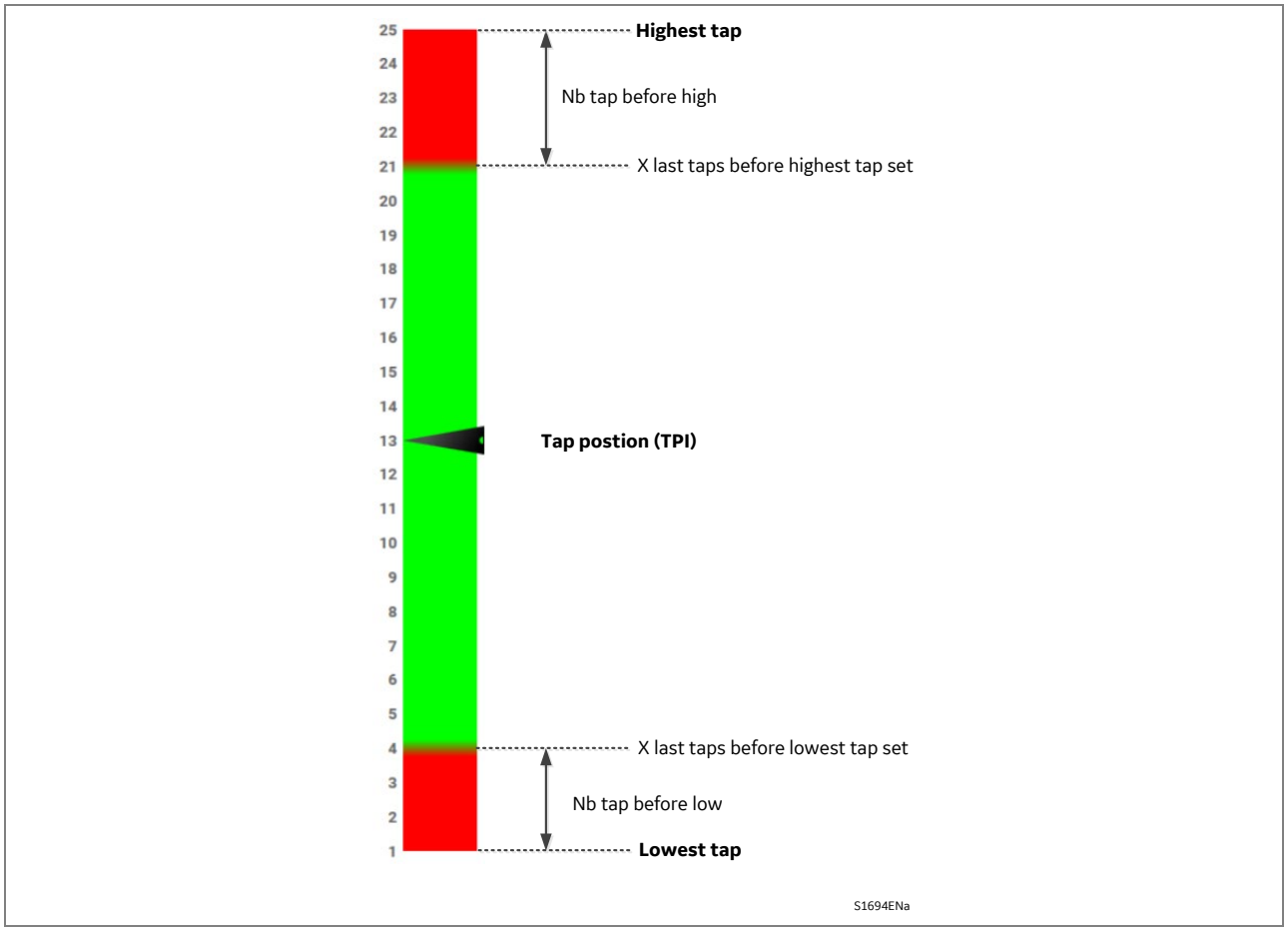
The "**Set the Tap changer on a preset Tap**" function is used only if the current ta position indication (TPI) is valid.

For each tap control, when the **TCIP** is RESET, the **next tap delay** is started. At the end of this delay, the next tap control is activated. As long as the "**Set the Tap changer on a preset Tap**" function is active, the **Preset.Tap.Run** signal is SET. When the "**Set the Tap changer on a preset Tap**" function is deactivated, the automatic regulation mode is resumed.

11.1.3.2.2.7 Detection of lowest & highest tap reached

DS Agile C26x with AVR monitors the pair **Tap Changer Lowest/Highest reached position** based on the **High.End.Stop** and **Low.End.Stop** tap control inputs:

- When the current Tap Position Indication equals or is higher than the “highest tap value”, the **Highest Tap reached** signal is positioned. Inversely, when the current Tap Position Indication equals or is lower than the “lowest tap value”, the **Lowest Tap reached** signal is positioned.
- When the current TPI value is equal or higher than the **Highest Tap Value** − **Nb tap before high**, the **Xtap.before.high** signal is SET
- When the current TPI value is equal or lower than the **Lowest Tap Value** + **Nb tap before low**, the **Xtap.before.low** indication is SET



Note:

- If the Tap Position Indication value is not valid, a "Tap Changer Fault" is raised.
- If **High.End.Stop** input is not valid, the Tap Changer function is considered as **High tap reached**.
- If **Low.End.Stop** digital input is not valid, the Tap Changer function is considered as **Low tap reached**.
- If both **High.End.Stop** or **Low.End.Stop** inputs are SET simultaneously, a "Tap Changer Fault" is raised.

11.1.3.2.2.8 Tap Changer Fault

The Tap Position Indication value may be wired on digital inputs (or optional analog inputs).

If the TPI value is not valid, all the functions using this information are locked.

The signal indicates the kind of problem on the tap changer.

A tap changer fault may be detected by:

- an external signal (**External only**)
- an internal tap changer fault signal (**Internal only**)
- either by an external signal, or by an internal tap changer fault signal (**Internal and External)**

Tap Changer fault conditions

Depending on the AVR application type (Standard or Electre), the Tap Changer Fault signal may result from different conditions:

"Standard" AVR application type	"ARU" AVR application type (Electre)
The Tap Changer Fault signal is **immediately set** if one of these conditions prevails: • the TPI value is undefined (coding error); • after the TCIP delay, the TCIP (Tap Changer In Progress) signal is not set (on tap control sequence); • after the TCIP end delay, the TCIP signal is not reset (on tap control sequence); • after the TCIP signal reset, the tap has not the expected TPI value; • if the "tap changer fault function" is on, an external signal indicates a tap changer fault. A Tap Changer Fault signal may also be issued after **Tap changer fault delay** (temporization launched after the first RAISE or LOWER command) if the voltage state indication is not back to normal.	The Tap Changer Fault signal is issued **after the Tap Changer Fault Delay**, if one of these conditions prevails: • the TPI value is undefined (coding error); • after the TCIP delay, the TCIP (Tap Changer In Progress) signal is not set (on tap control sequence); • after the TCIP end delay, the TCIP signal is not reset (on tap control sequence); • after the TCIP signal reset, the tap has not the expected TPI value • an external signal indicates a tap changer fault. • the voltage state indication is not back to normal.

When the Tap Changer Fault signal is positioned, the tap control or the sequence of tap controls in progress is cancelled, and no more tap control is accepted (whether it is manual or automatic).

Tap Changer fault behaviour

According to the defined “tap changer fault behaviour”, when a tap changer fault occurs, the AVR function can:

- position the Tap Changer Fault signal, and automatically reset it when none of the faulty condition prevail (**Automatic reset**);
- position the Tap Changer Fault signal, and keep it set until an operator deactivates the automatic regulation and activates it again (**Manual reset**);
- position the Tap Changer Fault signal and switch the automatic regulation mode to manual (**Manual mode**).

A Voltage Regulation Fault signal is positioned with the corresponding status, when:

- a VT fuse is detected;
- an abnormal voltage is detected;
- a voltage or current acquisition failure is detected;
- a Tap Changer fault occurs (tap position not valid, tap changer blocked, TCIP positioned before control, transient…).

When none of the above problems is detected, the signal Voltage Regulation Fault status is OK.

11.1.3.2.2.9 Regulation Locking Information

The regulation locking indication can be set by:

- a dedicated external input;
- the "**Overcurrent detection**" AVR function;
- the "**Tap changer blocking**" AVR function.

When the regulation locking indication is set, automatic regulation is deactivated. Even if the AVR mode is automatic, manual controls are accepted and managed as in manual mode.

The behavior of manual controls allowed is settable in the AVR attributes.

Automatic regulation is activated again when the regulation locking indication is reset.

11.1.3.2.3 Additional Functions (automatism)

Additional functions may be used in "automatic" or "manual" regulation modes to manage tap changer operations.

11.1.3.2.3.1 Tap changer position on voltage loss

The "**Tap changer position active**" function is settable but can also be defined by an operator control.

The function sets the tap changer on the "defined tap" position, only if the following conditions prevail:

- The AVR mode is automatic
- Tap changer position active function is active (defined at configuration level)
- The "Topology Status" (circuit-breaker position on the primary side of the transformer) is set to OPEN or CLOSED
- No other regulation locking information is set
- No VT fuse information positioned

If all the above conditions prevail, the AVR function may operate differently depending on the AVR application type (Standard or Electre):

"Standard" AVR application type	"ARU" AVR application type (Electre)
If the voltage signal is missing (**Voltage.Present** RESET), for a defined **Voltage missing delay**, the AVR can: • either move the tap changer "on a defined tap"; • or "lock the automatic" regulation as long as the voltage is missing.	If the voltage signal is missing (**Voltage.Present** RESET), the AVR function can immediately: • either move the tap changer "on a defined tap"; • or "lock the automatic" regulation as long as the voltage is missing. In this case, the **Voltage missing delay** is by-passed.

In both cases, the "tap changer position (on voltage loss) behaviour" can be set to:

- keep the tap changer on the "current tap" (no tap control performed)
- move the tap changer to the "preset tap"
- move the tap changer to the "lowest tap"

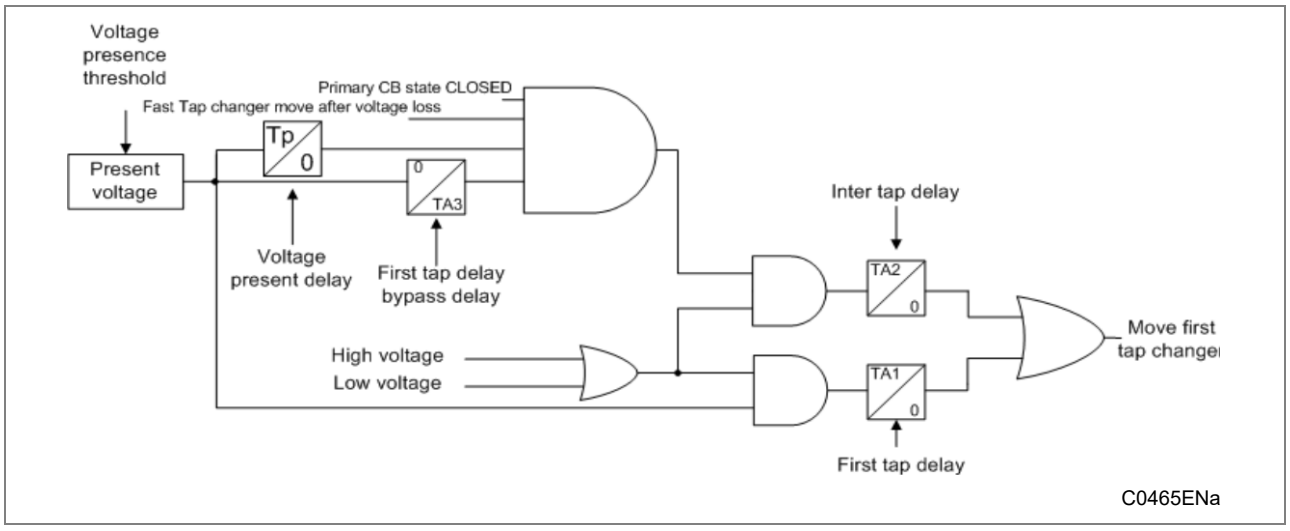
11.1.3.2.3.2 Tap changer fast move AFTER voltage loss

When the "tap changer fast move after voltage loss" function is set, the AVR allows tap changing fast regulation when the **Voltage.Present** signal is set.

The command occurs only if the following conditions prevail:

- The AVR mode is automatic
- "**Tap changer fast move active**" attribute is ON (in the SCE)
- The "Topology Status" (circuit-breaker position on the primary side of the transformer) is set to CLOSED
- No VT fuse information positioned
- No regulation locking signal positioned

If all the above conditions prevail, and the voltage is present for a defined "voltage present delay" (Ta), the first tap delay is bypassed for TA3 (first tap delay bypass delay). The first tap control activation is delayed by TA2.



If the "**Tap changer fast move active**" function is NOT active, when the voltage is detected, the first tap control activation is delayed by the **First tap delay** TA1.

11.1.3.2.3.3 Operator tap position request

When the **Operator.Tap** setpoint is received (HMI), **Raise** or **Lower** commands are sent to the tap changer, until the requested tap position is reached. The tap changer can be moved to the Lowest Tap Value (Goto Min) or to the Highest Tap Value (Goto Max).

For each tap control, when the **TCIP** is RESET, a defined **Preset tap delay** is started. When the delay elapses, the next tap control is activated. If the current **TPI** value (or the TCIP) is not valid, this function cannot be used.

The tap control is immediately cancelled if any other function is activated while this operation is in progress.

11.1.3.2.3.4 Runaway tap detection

DS Agile C26x with AVR checks if the Tap changer operates without valid commands or if tap changer operation causes Tap Changer to move further away from the set values.
If it occurs, after the “runaway tap delay”, an alarm is raised and the AVR can be blocked

11.1.3.2.3.5 Overcurrent detection

“Line overcurrent detection” activation is settable through the **Overcurrent detect active** attribute, through an operator control (**OverCurrent.SPC**) or from DS Agile S1.

If the value of the current is larger than the “overcurrent threshold” for more than the “overcurrent delay”, the Overcurrent signal is positioned.

If the value of the current becomes lower than the “overcurrent threshold”, the Overcurrent signal is reset.

The regulation locking information can be set/reset following the line overcurrent signal.

If the line current value is not valid, the line overcurrent detection is not running.

Depending on the “Overcurrent detection behaviour” value configured in the SCE, the AVR can:

- set/reset the Overcurrent signal
- set/reset the Overcurrent signal AND the Regulation Locking information

11.1.3.2.3.6 Overvoltage detection

“Overvoltage detection” activation is settable through the **OverVoltage detect active** attribute, through an operator control (**OverVoltage.SPC**) or from DS Agile S1.

If the voltage value is greater than the “overvoltage threshold” for a time longer than the “overvoltage delay”, the Overvoltage signal is set.

If the voltage value becomes lower than the “overvoltage threshold”, the Overvoltage signal is immediately reset.

The regulation locking information can be set/reset depending on the Overvoltage signal.

If the voltage value is not valid, the overvoltage detection is not running.

Depending on the Overvoltage detection “behaviour” value, the AVR function can:

- set/reset the Overvoltage signal
- set/reset the Overvoltage signal AND the Regulation Locking information

11.1.3.2.3.7 UnderVoltage detection

“Undervoltage detection” activation is settable through the **UnderVoltage detect active** attribute, via an operator control (**UnderVoltage.SPC**) or from online parameters via DS Agile S1.

If the voltage value is lower than the “undervoltage threshold” for a time longer than the “undervoltage delay”, the Undervoltage signal is set.

If the voltage value becomes larger than the “undervoltage threshold”, the Undervoltage signal is reset.

The regulation locking information can be set /reset depending on the Undervoltage signal.

If the voltage value is not valid, the undervoltage detection is not running.

Depending on the “Undervoltage detection behaviour” defined at configuration level, the AVR function can:

- set/reset the Undervoltage signal
- set/reset the Undervoltage signal AND the Regulation Locking information

11.1.3.2.3.8 Tap Changer blocking

“Tap Changer Blocking” activation is settable through the **Tap Changer blocking** attribute or via an operator control (**Tap.Blocking**).

When the Tap Changer Blocking control is on, then:

- the "Set the tap changer on a preset tap" function is activated;
- the **Fct.Tap.Blocking** signal is positioned;
- the regulation locking information is set;
- no tap control from automatic voltage regulation can be performed;
- the **Tap changer blocking delay** is started.

As soon as the **Preset tap** is reached:

- the "Tap Changer blocking OK" signal is set;
- the Tap changer blocking delay is reset.

When the **Tap changer blocking delay** elapses, if the **Preset tap** has not been reached, the "**Tap Changer blocking NOK**" signal is set.

When the **Tap.Blocking** activation control is reset, then:

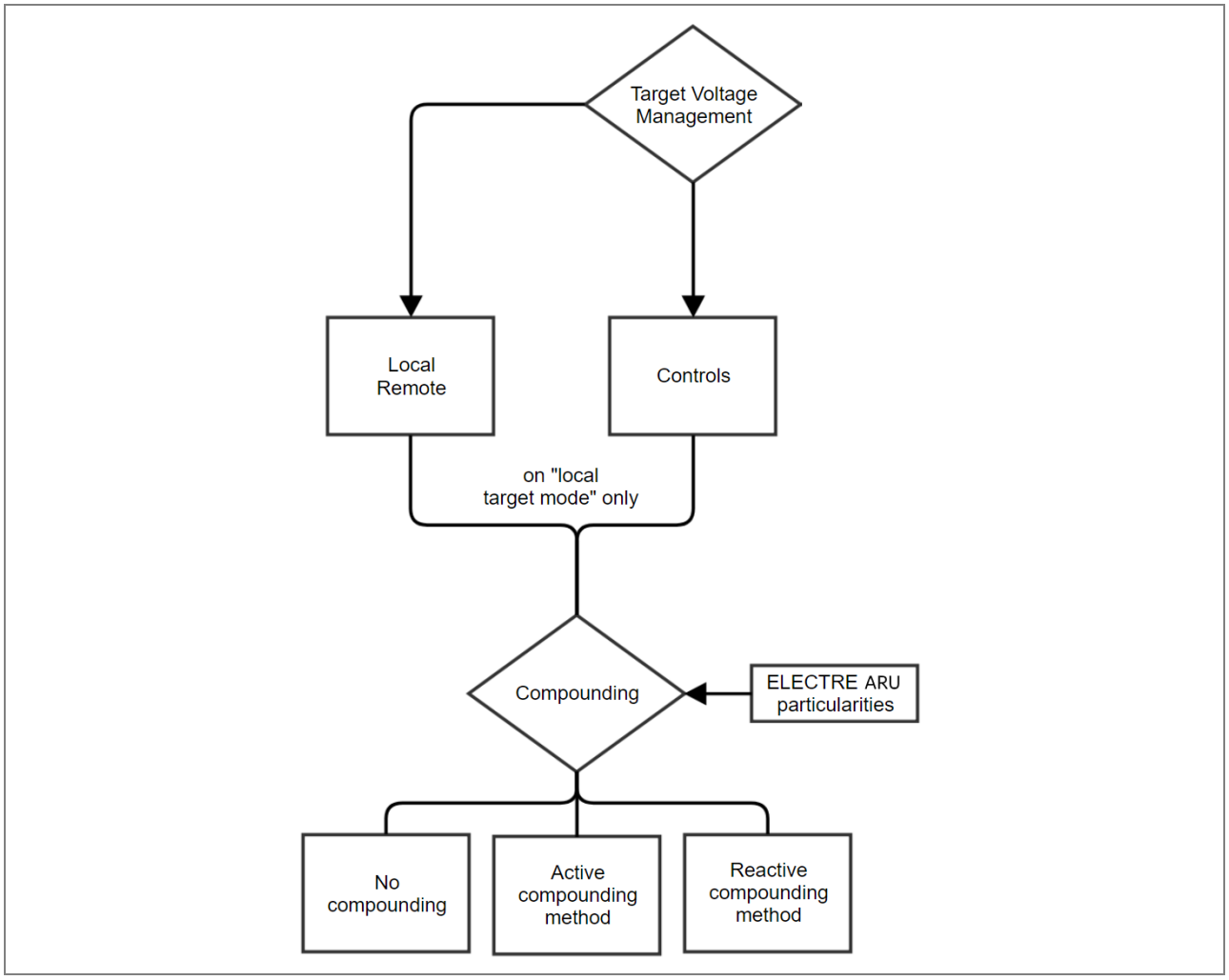
- the "Set the tap changer on a preset tap" function is disabled;
- the **Fct.Tap.Blocking** indication is reset;
- the regulation locking information is reset;
- the automatic voltage regulation is allowed.

11.1.3.2.4 Target Voltage Management

Depending on the “Target voltage management”, the target voltage can be:

- **Locally** or **remotely defined**; the AVR must be in automatic mode; and the **Target Voltage Management** attribute configured as **Remote-Local mode**.
- **Controlled**: the value is one the two above, selected through controls.

11.1.3.2.4.1 Process



11.1.3.2.4.2 Local / Remote

11.1.3.2.4.2.1 Setting the target voltage management mode

The target value can be set at remote or local mode.

Remote mode:

- The **remote target** voltage comes from a remote-control point (setpoint). To be valid, it is subjected to min, max, max difference. Until the end of the confirmation delay, the latest valid remote target voltage value is used,

Local mode:

- In the event of a confirmed loss of remote target voltage (invalidity, loss of connection with RCP), the **local target** voltage takes over;
- The operator can also use the **Target voltage -5%** control to urgently reduce the target value to 95% of the configured value.

11.1.3.2.4.2.2 Managing remote target voltage

The remote target value is used as the received remote target voltage is valid.

To be valid:

- The first remote target value received must be contained between the minimum and maximum remote target parameters (in % of Vn).
- The next remote value must also be contained between the minimum and maximum remote target values **and** the difference with the previous valid value must be lower than the value specified in the **Remote target maximum difference between 2 target voltages** parameter (in V).

When the above-mentioned conditions are met, the remote target value is saved as the actual value and the "remote target voltage mode" is automatically set. It will be compared with the next incoming remote target value and used as a first value in the case of an AVR restart.

If the remote target value is invalid:

- The **End remote target delay** is started. At the end of this delay, if the remote target value is still invalid, the **Local Target Voltage** value becomes the new target voltage. Until the end of the delay, the latest valid remote voltage value is used.

11.1.3.2.4.2.3 Managing local target voltage

The local target voltage value is used as long as the remote target value is invalid.

The local target value is used as the AVR target voltage.

It is set at configuration level and can be modified through DS Agile S1. When it is active, the "target voltage mode" is automatically set to "local target voltage mode".

In local target voltage mode, the AVR can treat an incoming remote target voltage value (in order to return to the remote target voltage mode).

11.1.3.2.4.2.4 Transition to target voltage

When the received remote target voltage value is valid, the remote target voltage becomes the new target voltage mode, following the transition conditions below:

From Local to Remote target voltage

- At AVR start up, the local target voltage mode is active for a defined delay (end of local target voltage delay).
- If a valid remote target voltage value is received before the end of the delay, the remote target voltage mode is set at the end of the delay.

- If a valid remote target voltage value is received after the end of the delay, the remote target voltage mode is set immediately.

When the target voltage mode changes from remote to local, the same delay is launched, and the behavior is identical.

Force to Local target voltage

The operator can use a dedicated control **(ForceLocalTarget)** to forcefully put the target voltage mode to Local target voltage. In this event, the mode is set immediately.

From Automatic to Manual mode

When the **AVR Mode** is **manual**, the target voltage mode management mode (Remote or Local) is disabled, but the current "target voltage mode" is memorised. When the **AVR Mode** is set back to **automatic** mode, the last saved valid "target voltage mode" is resumed.

Compounding

The received remote target value (which is already compounded) is compared to the acquired voltage value.

When the **Local Target Voltage** value is active, the acquired voltage value is compounded first, and then compared to the target voltage value.

The "Control -5%" SPC can also be used to reduce the target voltage value (HMI or automation). When the control is activated, the target voltage value moves from 100% to 95% of its current value.

11.1.3.2.4.3 Controls

Managing target voltage through controls is possible when the **Target voltage management** attribute is set to **Controls**.

Up to 5 controls (**Target.Voltx.SPC**) can be are sent to move the target voltage value from one range to another.

The current target voltage value is saved and restored when activating the AVR function.

The current target voltage can be disabled. If no active target voltage value is set for the **No Target Voltage Active Delay**, the **Target.Missing** alarm is set.

11.1.3.2.4.4 Compounding

The **AVR** function provides a compounding method to correct the measured voltage value, before comparing it to the target voltage value.

Compounding activation is settable at configuration level or at HMI level via an operator request and may be changed from DS Agile S1.

The Compounding method may be:

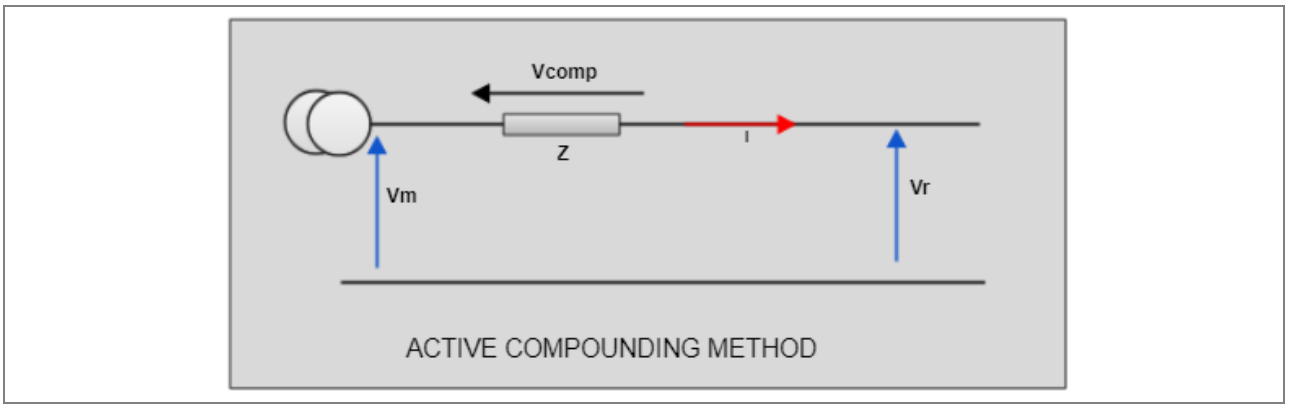
- Active
- Reactive

11.1.3.2.4.4.1 No compounding

If no compounding is performed, the measured voltage value is directly compared to the target voltage value.

11.1.3.2.4.4.2 Active compounding

The **active compounding** method is used to balance the loss of voltage in the transformer link impedance.



With active compounding, the voltage to be regulated (Vr) is evaluated as follows:

Vr = Vm – Vcomp, where:

- Vr: real voltage to regulate
- Vm: measured voltage
- Vcomp: compounding voltage ((depending on complex load of feeder)

Vcomp = Z.I where complex active load: Z = R1 + jX1

The active compounding results in: **Vr = Vm - I * (R1 + jX1)**

When Application type is Standard

Active compounding parameters are:

- **A1** = R1, % of Vn/In (nominal voltage and current)
- **B1** = X1, % of Vn/In (nominal voltage and current)

When Application type is Electre (ARU)

The Active compounding parameters **A1** and **B1** and computations are identical to **Standard** case.

The value of **A1** and **B1** parameters can be doubled at configuration level (SCE), or through online parameters (DS Agile S1)

- if **Double a1** is equal to **Yes**, the parameter value **A1** is immediately doubled in the above calculation;
- if **Double b1** is equal to **Yes**, the parameter value **B1** is immediately doubled in the above calculation;
- If **Double a1** becomes to **No**, the parameter value **A1** becomes immediately to its value set;
- If **Double b1** becomes to **No**, the parameter value **B1** becomes immediately to its value set.

11.1.3.2.4.4.3 Reactive compounding

Reactive compounding method is used to balance the loss of voltage due to the circulating current between transformers in parallel.

With reactive compounding, the voltage to be regulated (Vr) is evaluated as follows:

Vr = Vm – Vcomp, where:

- Vr: real voltage to regulate
- Vm: measured voltage
- Vcomp: compounding voltage (depending on complex load of feeder)

Vcomp = Z.I where complex reactive load: Z = R2 + jX2

The reactive compounding results in: **Vr = Vm - I * (R2 + jX2)**

When Application type is Standard

Reactive compounding parameters are:

- **A2** = R2 in % of Vn/In (nominal voltage and current)
- **B2** = X2 in % of Vn/In (nominal voltage and current)

When Application type is Electre (ARU)

Reactive compounding parameters **A2** and **B2** are identical to **Standard** case.

The values of **A2** and **B2** parameters can be doubled at configuration level (SCE), or through online parameters (DS Agile S1).

- if **Double a2** is equal to **Yes**, the parameter value **A2** is immediately doubled in the above calculation;
- if **Double b2** is equal to **Yes**, the parameter value **B2** is immediately doubled in the above calculation;
- If **Double a2** becomes to **No**, the parameter value **A2** becomes immediate to its value set;
- If **Double b2** becomes to **No**, the parameter value **B2** becomes immediate to its value set.

11.1.3.2.5 Additional measurements

11.1.3.2.5.1 Transformer Double-Wound voltage management

The AVR function can manage Double Wound Transformers. Double-wound transformers have 1 primary winding, 2 secondary windings and possibly a tertiary winding (not managed by the AVR MCC).

For regulation, the automatic voltage regulation function takes into account the following measurements:

- **Voltage 1:** the voltage measured on the secondary winding N°1,
- **Voltage 2:** the voltage measured on the secondary winding N°2,
- **Average voltage:** average voltage value of the 2 windings (calculated based on measured value from Voltage1 and Voltage2).

The limitation of the circulating current at the transformer's secondary side is unavailable on this type of transformer.

The AVR function also calculates the difference value between **Voltage1** and **Voltage2** values.

- If the difference between the 2 voltages is greater than the defined “double wound voltage difference” value (in % of Vn) then, the double wound voltage difference signal is set
- If the difference between the 2 voltages is lower than the defined “double wound voltage difference” value (in % of Vn) then, the double wound voltage difference signal is reset.

Note: The **voltage1** value (measured at secondary winding #1) may be different from the **voltage2** value (measured at secondary winding #2) due to instrument transformer accuracy, or MV busbar impedance difference. In this event, a static voltage correction can be made to **voltage 2**.

The **Voltage correction** value can be set at configuration level or modified by online parameter (MiCOM S1).

11.1.3.2.6 AVR standalone limits

- C26X can manage only 1 tap changer per power transformer bay;
- "Online parameters" modifications can be done for only 1 transformer bay at the same time, not for all transformer bays of a busbar;
- The Automatic Voltage Regulation is realized on three-phase systems, with a voltage and current measurements realized on one phase;
- The load of three-phase is considered as symmetrical.

11.1.3.3 PARALLEL OPERATIONS

For the right performance of power transformers in parallel, the coordination between AVR is essential.

Two methods can be used whether the transformers are identical and work together or not:

- **Master-follower method**: for power transformers with identical or very similar characteristics (rated power, voltage difference per tap changer position, …)
- **Circulating current method**: for power transformers with different characteristics, creating circulating current between the secondary of transformers

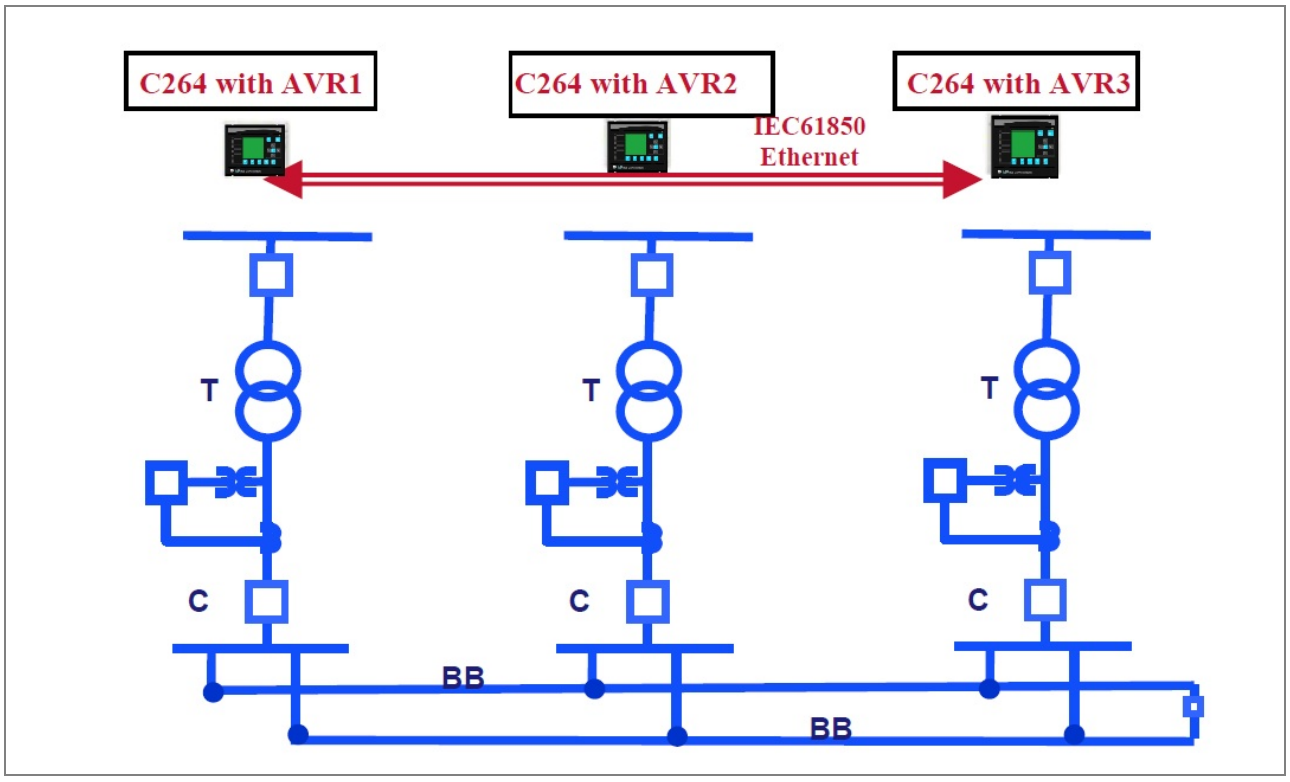
11.1.3.3.1 Master Follower method

The C264 AVR feature can operate parallel transformers according to the **Master/Follower** principle.

With this technique, in a group of transformers, one C26x AVR takes on a master function. This controller is assigned overall control (master), while the other C26x (followers) execute its control commands.

Master AVR controls the busbar voltage with traditional criteria of this function. It can either use automatic or manual modes to regulate voltage. In both cases, it activates "**raise**" or "**lower**" tap controls, as it does it in the **standalone** mode.

The master transmits its TPI to the followers over the Station Bus and elaborates the commands for all the transformers.



If the tap changer has the Follower role (or Follower Master backup role), it receives the tap position indication of the master.

The Master compares the tap position of the followers with its own tap position. If a tap position deviation is detected, the master put commands to ensure that the followers are brought to the same tap position.

No circulation currents (MCC) are evaluated; this imposes severe limitations on the network operation:

- Master and Follower transformers identical, with the same impedance, rated power …
- same number of taps
- transformers on the same tap position

11.1.3.3.1.1 Master/Follower function activation

The **Master/Follower** function activation is settable at configuration level (SCE), at HMI level via an operator control or through an automation.

When enables, the followers start their "**Follower**" process.

The "**Master/Follower**" function can be disabled via an operator control (HMI) or through an automation.

When disabled, the Followers stop their "**Follower**" process.

When the "**Backup mode delay**" has elapsed, the transformer bay managed by the MF follower(s) switch(es) to a "**standalone**" AVR regulation either "manual" or "automatic" depending on the **AVR mode** configuration attribute.

11.1.3.3.1.2 Master/Follower Management

The Master tap position signal (MasterTap) is sent through SBUS, to all the "Followers".

The Master compares the tap position of the followers with its own tap position and if deviations are detected, tap changer controls are activated and the master sends commands to bring them to its own position.

If the **MasterTap** is not valid, the tap changer control is not activated.

Note: In "Follower(s)" mode, all manual controls (HMI) and settings (DS Agile S1) are allowed. Be aware to the impact of settings transmitted.

11.1.3.3.1.3 Master failure management

In the event of a Master failure (C264 reboot, SBUS network disconnection, switching to maintenance mode), the AVR function must continue and backup solutions are possible.

For a follower, a master failure involves an “Unknown” tap position indication quality. The MasterTap (TPI) with quality Unknown is sent to all followers.

When a master failure is detected, each "Follower" sets its “**Master failure**" indication after a defined **backup mode time out delay**. When the **Master failure** indication is set, the "Master" is disabled.

According to the configured backup mode, the followers have two possible fallback behaviors:

- **Backup mode #1**: **the “Follower Master Backup" becomes "Master”**

  A follower, among all others C264, has a **Follower/Master backup** role configured. In case of master failure, this C264 becomes the new "Master". All the followers receive the TPI from the new master (**FollowTap**).

  During this fallback operation, if the "Master" recovers, an automatic **Reset Process** is realized so that all Follower(s) and “Follower Master Backup” follow the "Master".

  Note: this backup mode requires a good health network. In the event of a faulty network, the TPI indication (**MasterTap** or **FollowTap**) is sent with “Unknown” quality to the followers.

  After the “**Backup mode time out delay**”, all the followers switch to a standalone mode (backup mode #2). If this backup mode switches automatically to standalone mode, returning to Backup mode #1 requires a manual reset operation (described below), in which the master will restart all the followers.

- **Backup mode #2**: **Follower(s) become(s) standalone**

  If no C264 is configured as "**Follower/Master backup**", all followers switch to standalone mode automatically to ensure a continuous service. During this fallback operation, if the "Master" recovers, an automatic **Reset Process** is realized so that all Follower(s) follow the "Master".

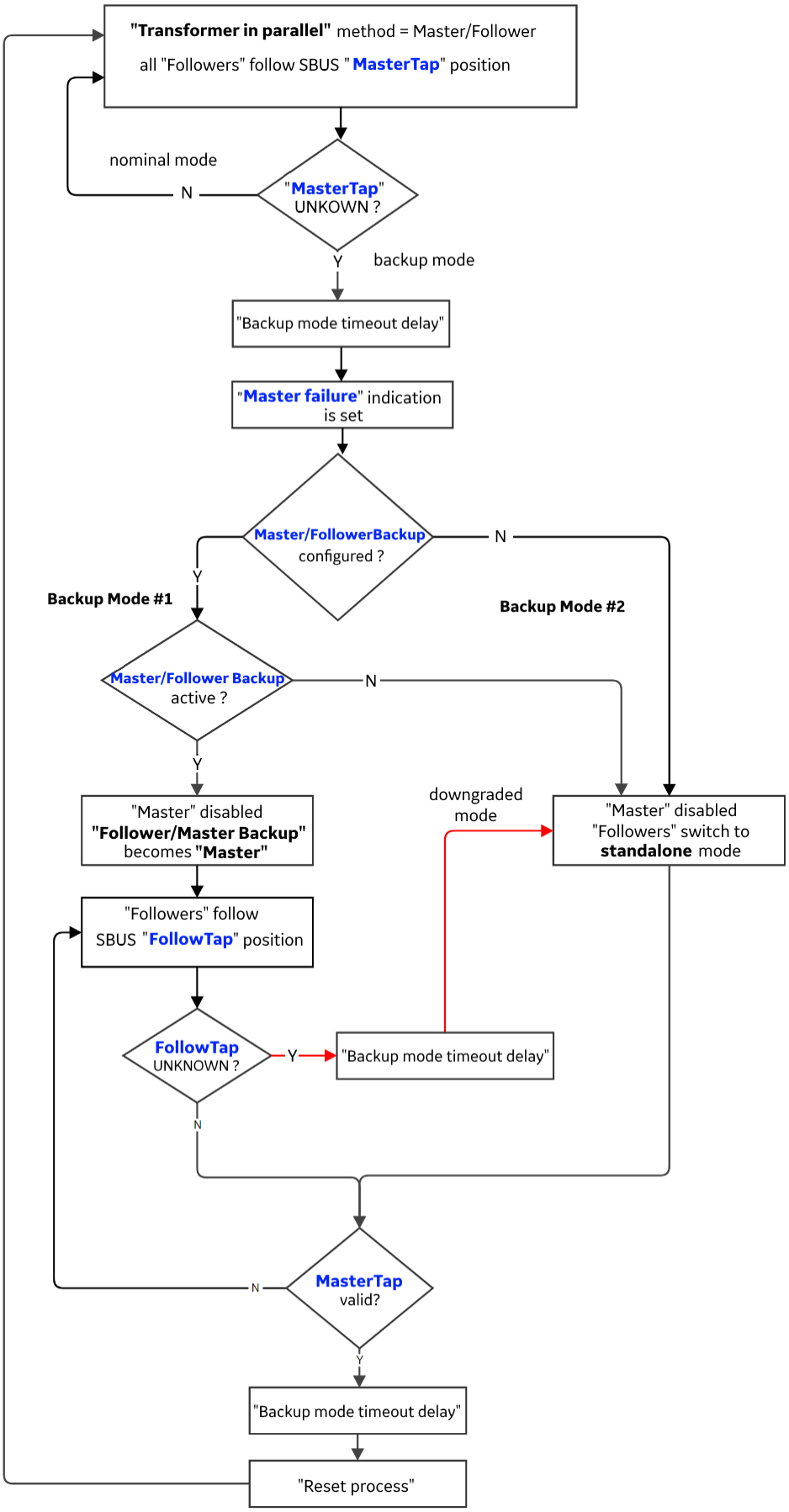
Reset process

After a defined **backup mode time out delay**, if the "**MasterTap**" is valid, the "Master" becomes automatically active.

The Master may also be manually activated in the following cases:

- a manual operation (HMI) on **Reset process** SPC is set
- a manual operation (HMI) on **Master.FollowSPC** is reset, and after a **Master.FollowSPC** activation is set
- on restart sequence ("Followers", including "Follower/Master backup")

All "Followers", including "Follower/Master backup", are activated on Master/Follower nominal mode, and receive a valid **MasterTap** indication.


"Transformer in parallel" method = Master/Follower
all "Followers" follow SBUS "MasterTap" position
nominal mode
"MasterTap" UNKOWN ?
N
Y
backup mode
"Backup mode timeout delay"
"Master failure" indication is set
Master/FollowerBackup configured ?
N
Y
Backup Mode #1
Backup Mode #2
Master/Follower Backup active ?
N
Y
"Master" disabled "Follower/Master Backup" becomes "Master"
downgraded mode
"Master" disabled "Followers" switch to standalone mode
"Followers" follow SBUS "FollowTap" position
FollowTap UNKNOWN ?
Y
"Backup mode timeout delay"
N
MasterTap valid?
N
Y
"Backup mode timeout delay"
"Reset process"

Limits

- When configured as “Master”, a C264 can lead up to **3** followers;
- Up to **4** power transformers can be managed by the AVR-MF method. The AVR-MF method works only with measurement of secondary side of transformers. There is no assumption that the primary voltages of transformers are identical. AVR-MF method does not manage a substation topology and requires an automation (PLC) to handle target voltage values according to secondary busbar topology;
- **1** and only **1** Master/Follower group can be configured as per the substation voltage level;
- Master/Follower(s) operate only on an **IEC61850.8-1** station bus (SBUS). "MasterTap" and "FollowTap" signals are transmitted by reports;
- For transformers in parallel, when the **AVR mode** is "automatic" and "target voltage management" is **Local/remote**, the **target voltage** can be estimated by "compounding" if **Remote.target** is invalid. This "compounding" method is only available for a unique electrical node on secondary side of transformer bay;
- The "transformer in parallel” methods (Master/follower and Minimization of Circulating Currents) are limited to AVR Standard application (Not ARU application).
- If the C264 manages several bays, only **1** AVR-MF (Master or Follower) can be instantiated.

11.1.3.3.2 Minimizing Circulating Current Method

Unequal tap positions between parallel transformers creates a circulating current. Parallel operations require special control measures for minimizing circulating current between the transformers.

The C264 AVR can operate parallel transformers according to the Minimizing Circulating Current principle.

The minimizing circulating current principle, also called **MCC** or **Isinφ,** is the optimal solution for controlling parallel transformers of different ratings or step voltages in substations with varying reactive loads:

- maximum difference of tap changer position in operation
- voltage difference per tap changer position
- rated power
- relative short-circuit voltages

This method is used to

- **regulate voltage** into a defined deadband (by local or remote target voltage value)
- **limit the reactive current circulating** between parallel transformers, created by the voltage difference due to the transformer characteristics.

The limitation of the reactive current is possible if the absolute value of voltage difference between two secondary windings of transformers is equal or greater than 90% of voltage difference between two tap changer positions.

The regulation of transformers relies on the position of the circuit breakers and the switchgears of each transformer bay. The MCC method integrates a **topology scheme monitoring**, which can detect a change event into the transformer group managed by the MCC method.

The positions of the tap changers of transformers are controlled **individually** by the MCC method.

Since this control scheme allows exchange of data between the regulators, the circulating current can be calculated more exactly than with other schemes.

11.1.3.3.2.1 MCC method selection

The MCC method applies if the "**Transformer in parallel**" attribute is set to **Yes** and the "**Used Parallel method**" is set to "**Minimize circulating current method**" in the configuration.

11.1.3.3.2.2 MCC method activation

11.1.3.3.2.2.1 Automatic (at C264 boot)

The MCC method can be started at C264 boot, according the "**Initial state"** attribute defined in the configuration:

- **OFF:** the MCC method is not started at C26X boot
- **ON:** the MCC method is started at C26X boot

11.1.3.3.2.2.2 Manual

The regulation by MCC method can be activated/deactivated at HMI level (aView) through the **MCC.active** (SPC) datapoint.

The MCC method is activated only if no fault is detected among transformers constituting the MCC group (refer to "**MCC method behaviour in case of error**" chapter below).

At master level, when the **MCC.Active** (SPC) is SET, the MCC calculation is started and the slave tap positions **Master.Tap.SlvX** (X = 1 for slave1, 2 for slave2, 3 for slave3) are transmitted as VALID over the Station Bus (SBUS) network. The MCC.Error.Mode signal indicates that the MCC method is in service

For each MCC slave(s) present into the MCC group, the **Master.Tap.SlvX** is received as VALID (X = 1 for slave1, 2 for slave2, 3 for slave3) and the "Backup mode delay" is started. When the "Backup mode delay" has elapsed, if no fault is detected at transformer bays managed by the MCC master and the MCC slave(s), the tap changer position(s) of each transformer follow the tap position transmitted by the MCC master and the Mode.Indication of each slave is set to Follower.

MCC Method Deactivation

When the **MCC.Active** (SPC) is RESET, the MCC calculation is stopped, and the slave tap position(s) **Master.Tap.SlvX** (X = 1 for slave1, 2 for slave2, 3 for slave3) are transmitted as INVALID over the Station Bus (SBUS) network. The **MCC.Error.Mode** (MPS) of the master indicates that the MCC method is out of service.

For each MCC slave(s) present into the MCC group, the **Master.Tap.SlvX** is received as INVALID (X = 1 for slave1, 2 for slave2, 3 for slave3) and the "Backup mode delay" is started. When the "Backup mode delay" has elapsed, the transformer bay managed by the MCC slave(s) switch to a "standalone" AVR regulation either "manual" or "automatic" depending on the **AVR mode** configuration attribute.

Whenever the C264 is rebooted, the AVR function starts according to the **MCC.State** status saved in the C264 memory.

When the database is switched (AVR is configured with the same attributes in the new database), the AVR function starts according to the **MCC.State** state saved in the C264 memory**.**

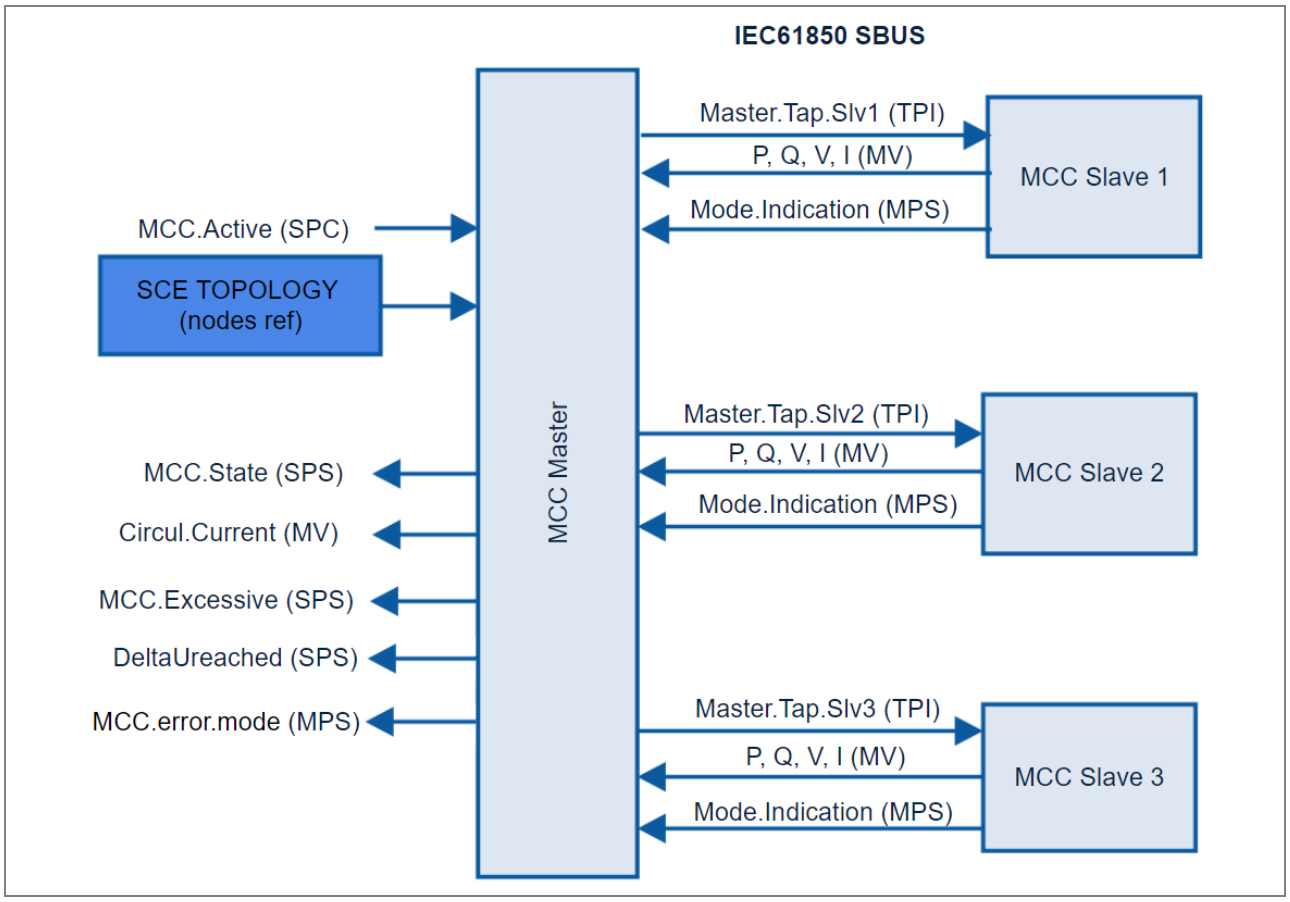
11.1.3.3.2.3 MCC group management

The "MCC group" consists of the **MCC Master** and at least one **MCC Slave**.

The “role” of the C264 within the MCC group is settable for each transformer bay:

- **MCC Master** (function of the C264 assigned to TR1);
- **MCC slave1** (function of the C264 assigned to TR2);
- **MCC slave2** (function of the C264 assigned to TR3);
- **MCC slave3** (function of the C264 assigned to TR4).

The topology nodes (i.e. which transformers are interconnected) is dynamically evaluated by the C264 **MCC Master**. It computes the U, I, P, Q values for all C264 **MCC slaves** that control transformers (up to 4) and transmits the values over the Station Bus.



If no MCC slave follow an MCC master tap, no MCC group can be defined. In that event, the **MCC.Error.Mode** (MPS) signal indicates that no MCC group(s) are present.

If one or more MCC Slave(s) follow the MCC Master, the **MCC.Error.Mode** (MPS) signal indicates that the MCC method is in service.

11.1.3.3.2.4 MCC behaviour in case of error

11.1.3.3.2.4.1 Type of detected faults

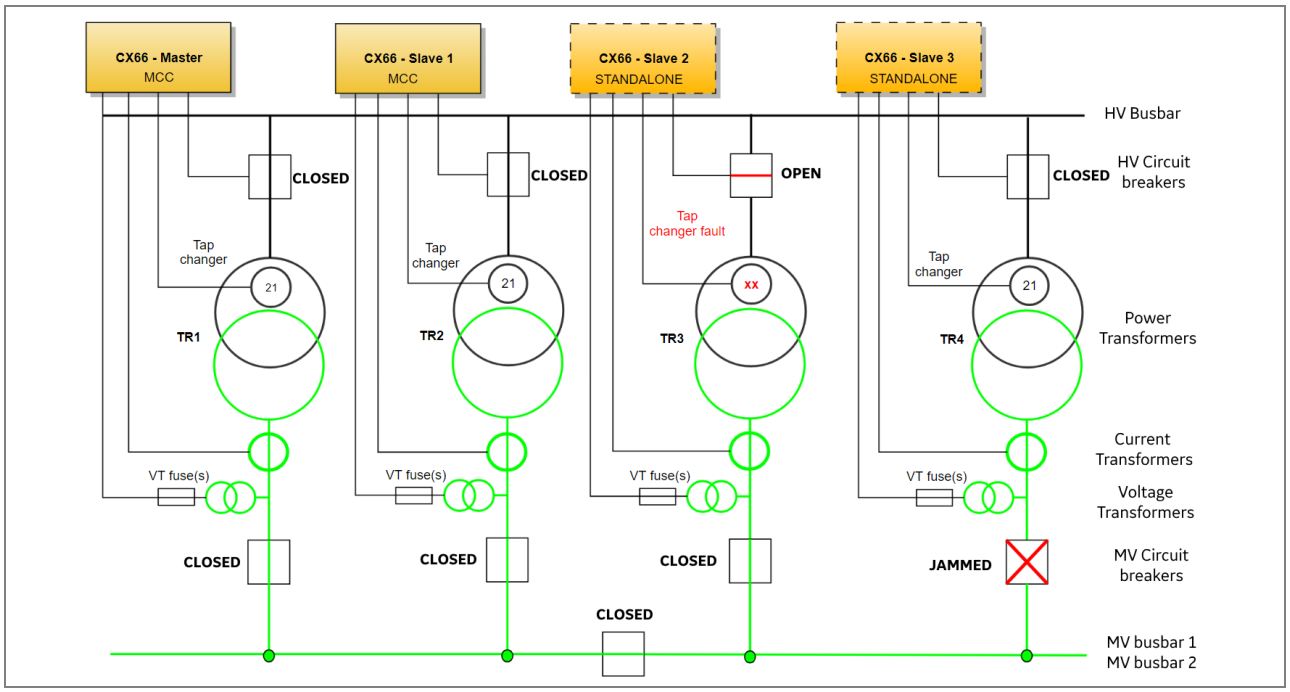
The following fault(s) may occur on a transformer managed by MCC method (MCC group):

1. Topology error

A topology error may be detected in a transformer group regulated by the MCC method.

At configuration level, each primary device position (transformer, switchgear, CB) may have **3** states

- **Connected**: the device state is CLOSED
- **Not connected**: the device state is OPEN
- **Uncertain**: the device state is JAMMED



In MCC method, the electrical scheme topology is automatically managed for each transformer in parallel. Different states are possible:

Transformer primary side	Transformer secondary side	MCC method
Connected	Connected	Authorized
Connected	Not connected	MCC group exclusion => **standalone**
Connected	Uncertain	Stopped
Not connected	Connected	MCC group exclusion => **standalone**
Not connected	Not connected	MCC group exclusion => **standalone**
Not connected	Uncertain	Stopped
Uncertain	Connected	Stopped
Uncertain	Not connected	Stopped
Uncertain	Uncertain	Stopped

2. Measurement invalidity

In case of **standard** power transformer, the following measurements may turn to INVALID state:

- **Voltage1**
- **Current1**
- **Active.Power**
- **Reactive.Power**

This information is provided by the C264, through the **Mode.Indication** (MPS) signal.

3. Tap changer fault

The **tap changer indication** (TPI) is in INVALID state.

This information is provided by the C264, through the **Mode.Indication** (MPS) signal.

4. VT fuse (detected at secondary VT transducer)

If a Voltage Transducer (VT), at secondary side of power transformers managed by the MCC method, indicates a "VT fuse" blown indication, the AVR function cannot manage the transformer since the voltage measure is missing (0.0 V) and its status is VALID.

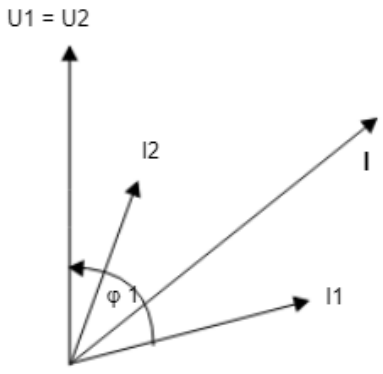
This information is provided to the AVR-MCC by the C264, through the **VT.Fuse.Set** (SPS) and the **Voltage.Regul.Fault** (MPS) signals.

5. Difference of sign between the active power of Master and a Slave x

The sign of **φ** is determined according to the **Active power** values.

According to the signs of Pi and Qi: **Qi**: **$-\pi < \varphi i < \pi$**

For parallel transformers, if **$\varphi 1 > \varphi 2$**, a "Circulating Current" signal is SET to indicate that there is a circulating current from transformer 1 to transformer 2.



The same function is applied to other transformers for instance for TR2 to TR3, TR3 to TR4, TR4 to TR1

11.1.3.3.2.4.2 Fault management

The MCC method behavior differ whether the fault is detected at Master or Slave level.

At master level, the MCC.Error signal is immediately SET and the MCC calculation is stopped. The slave tap positions **Master.Tap.SlvX** (X = 1 for slave1, 2 for slave2, 3 for slave3) are transmitted as INVALID over the Station Bus (SBUS) and the "Backup mode delay" is started.

If errors are detected on each MCC slave(s) present into the MCC group, the **Master.Tap.SlvX** signal (X = 1 for slave1, 2 for slave2, 3 for slave3) is received as INVALID state and the "Backup mode delay" is started.

If the fault is **present** once the timer has elapsed:

- The **MCC.State** and **MCC.Excessive** SPS signals are RESET at MCC master level.
- The **Circul.Current** value is set to **0.0** and its quality is set to "Faulty" at master and slave(s) level.

The transformer bay, managed by the MCC master and the MCC slave(s), switch to a "Standalone" AVR regulation, either "manual" or "automatic" depending on the **AVR mode** configuration attribute.

If the fault disappears **before** the end of the "Backup mode delay" timer:

At master level:

- the MCC.Error signal is immediately RESET and the MCC calculation is restarted.
- The slave tap positions **Master.Tap.SlvX** (X = 1 for slave1, 2 for slave2, 3 for slave3) are transmitted as VALID state over the Station Bus (SBUS) network and the "Backup mode delay" timer is stopped

On each MCC slave(s) present into MCC group:

- the **Master.Tap.SlvX** signal is received as VALID (X = 1 for slave1, 2 for slave2, 3 for slave3) and the "Backup mode delay" is stopped.

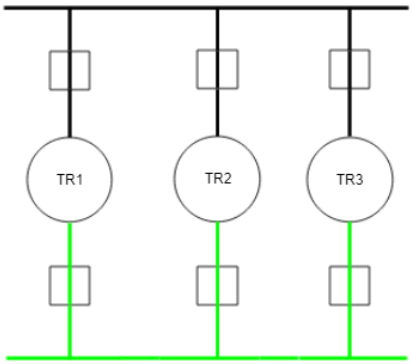
The transformer bay, managed by the MCC master and the MCC slave(s), continues to regulate the voltage and limit the circulating current by applying the MCC method.

11.1.3.3.2.5 MCC Group segmentation

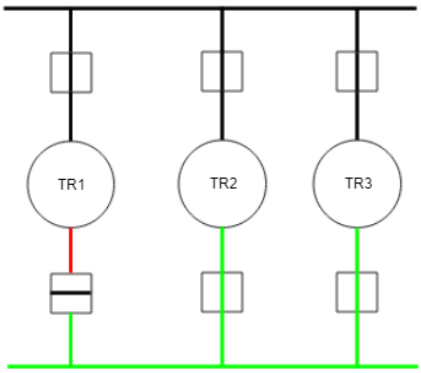
MCC groups are segmented with the different rules of each transformer:

- For **2 transformers in parallel**, if the topology changes at primary or secondary sides (no circulating current between both transformers), the MCC method is stopped.
- For **3 transformers in parallel**, the transformer exclusion behaviour is the same whether the topology changes at primary or secondary side. The "MCC master" continues to compute tap positions for the other transformer bays according to their different power values, whatever their topology.

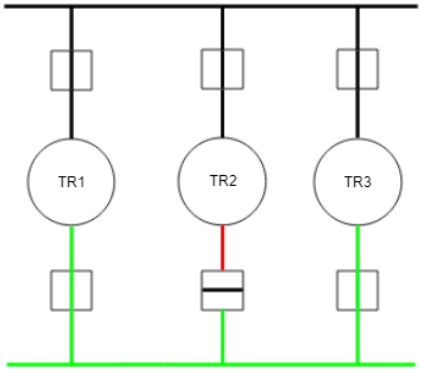
Few examples:



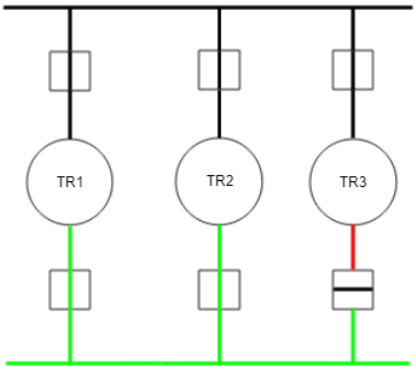
Case #1



Case #2



Case #3

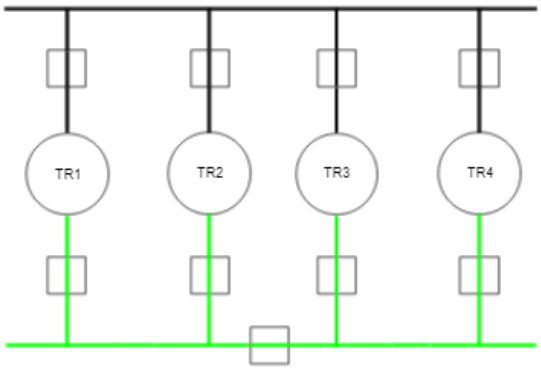


Case #4

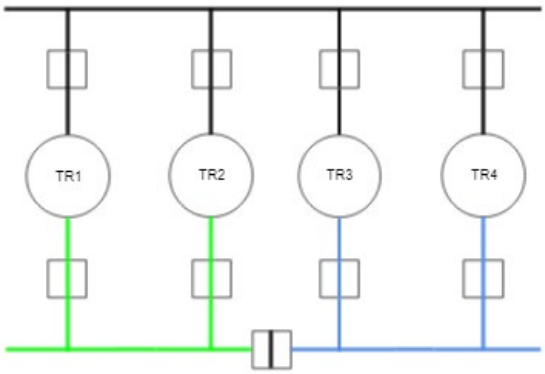
Transformer	MCC Rule	Case #1	Case #2	Case #3	Case #4
TR1	MCC Master	Group#1	**Standalone**	Group#1	Group#1
TR2	MCC Slave1	Group#1	Group#1	**Standalone**	Group#1
TR3	MCC Slave2	Group#1	Group#1	Group#1	**Standalone**

- **For 4 transformers in parallel**, the "MCC master" continues to compute tap positions for the other transformer bays according to their different power values, whatever their topology.

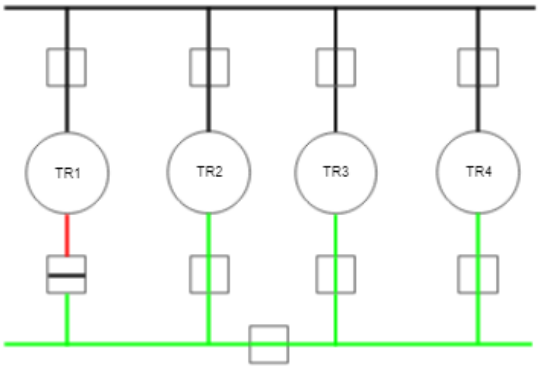
Few examples:



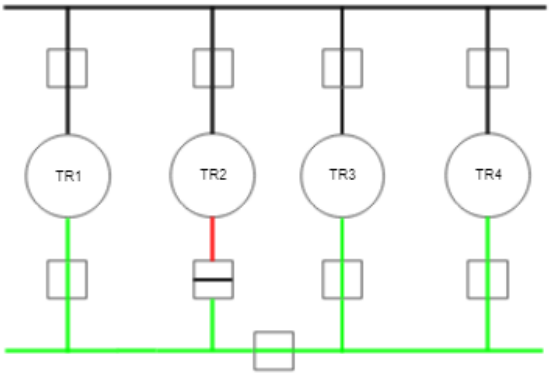
Case #1



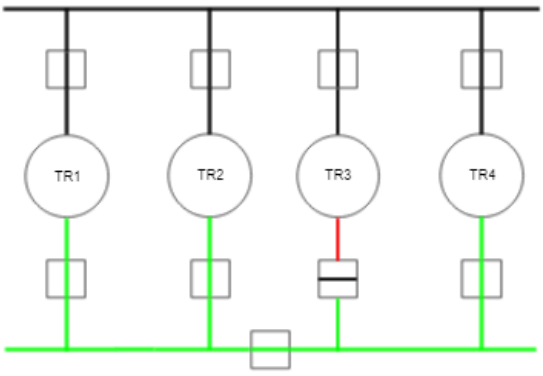
Case #2



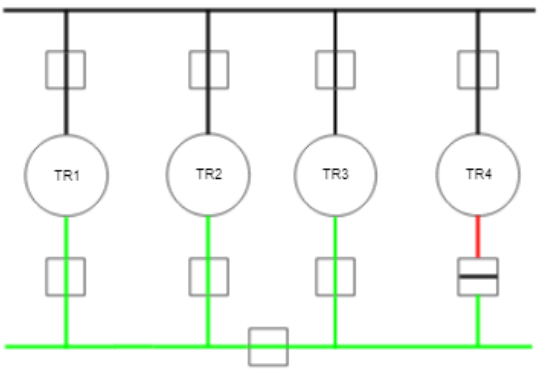
Case #3



Case #4



Case #5



Case #6

Transformer	MCC Rule	Case #1	Case #2	Case #3	Case #4	Case #5	Case #6
TR1	MCC Master	Group#1	Group#1	**Standalone**	Group#1	Group#1	Group#1
TR2	MCC Slave1	Group#1	Group#1	Group#1	**Standalone**	Group#1	Group#1
TR3	MCC Slave2	Group#1	Group#2	Group#1	Group#1	**Standalone**	Group#1
TR4	MCC Slave3	Group#1	Group#2	Group#1	Group#1	Group#1	**Standalone**

11.1.3.3.2.6 Voltage regulation on MCC method

11.1.3.3.2.6.1 Voltage out of the deadband

If the voltage of secondary side of transformer is out of the regulation deadband (High or Low states according to target voltage value), the MCC controls the tap changer through the "Active control on tap" function, in **standalone** mode.

If a circulating current is detected, the MCC adapts the tap control according to the **φ** value.

No circulating current is detected:

- If the voltage is under the target **(Low)**, a Raise order is launched on all the transformers in parallel simultaneously;
- If the voltage is over the target (**High**), a Lower order is launched on all the transformers in parallel simultaneously.

A circulating current is detected:

When the voltage is out of the deadband and active power > 0 ($|\varphi| < \pi/2$) then:

- If the voltage is under the target (Low); the transformer with highest $|\varphi|$ is tapped UP
- If the voltage is over the target (High); the transformer with lowest $|\varphi|$ is tapped DOWN

When the voltage is out of the deadband and active power **<** 0 ($|\varphi| > \pi/2$), then:

- If the voltage is under the target (Low); the transformer with lowest $|\varphi|$ is tapped UP
- If the voltage is over the target (High); the transformer with highest $|\varphi|$ is tapped DOWN

11.1.3.3.2.6.2 Voltage inside the deadband

If the voltage is into the deadband then the circulating current value must be checked to know if it is possible to reduce it by changing the tap changer position of one transformer among the MCC group.

- **deltaU**: difference of voltage between the secondary side of transformer in parallel ($|\Delta U|$)
- **deltaU1tap**: variation of secondary voltage value as per tap position ($|\Delta U1tap|$)

An automatic regulation is launched by MCC method when the "Voltage" value is within the **Regulation deadband** and the "**Delta_U_Reached"** signal is SET.

The **DeltaUreached** SPS is a computed information used by the MCC method to determine whether it is possible to reduce the circulating current in a group of transformers in parallel, by changing the tap changer position of one transformer among that group. It is SET when the difference of voltage between the secondary side of transformers connected in parallel is over 90% of the tap changer voltage pitch. When the difference of voltage is less than or equal to 90%, the DeltaUreached signal is RESET and no voltage regulation is performed.

If the value "0.9 * $|\Delta U1tap|$" becomes lower than $|\Delta U|$, the DeltaUreached signal is RESET and the voltage regulation is performed into the regulation deadband. Refer to the computation of Δ**U** and Δ**U1tap** for more information.

Active power is positive:

If **Active.Power** > 0 (|**φ**| < π/2) then:

- If the "Voltage" value is under the target voltage, then, the transformer with lowest **|φ|** is tapped UP (RAISE);
- If the "Voltage" is over the target voltage, then, the transformer with highest **|φ|** is tapped DOWN (LOWER).

Active power is negative:

If **Active.Power** < 0 (|**φ**| > π/2) then:

- If the voltage is under the target voltage then, the transformer with lowest |**φ**| is tapped UP (RAISE)
- If the voltage is over the target then, the transformer with highest |**φ**| is tapped DOWN (LOWER)

11.1.3.3.2.7 MCC calculations

11.1.3.3.2.7.1 Measurements per Transformer

For each transformer within an MCC group, the following values are used by the MCC method:

- S: Rated power value (ex: 100 MVA)
- z: Transformer impedance value (in % on "Sbase": e.g.100 MVA)
- Sbase: equivalent value of Rated power value
- Unom: Rated voltage value of secondary side of transformer
- LDC R value: Line Drop Compensation - active load (in Ohms)
- LDC X value: Line Drop Compensation - reactive load (in Ohms)
- U: "Voltage" value measured on secondary side of transformer
- I: "Current" value measured on secondary side of transformer
- P: Active.Power value
- Q: Reactive.Power value
- TPI: Current tap position

11.1.3.3.2.7.2 Excessive circulating current detection

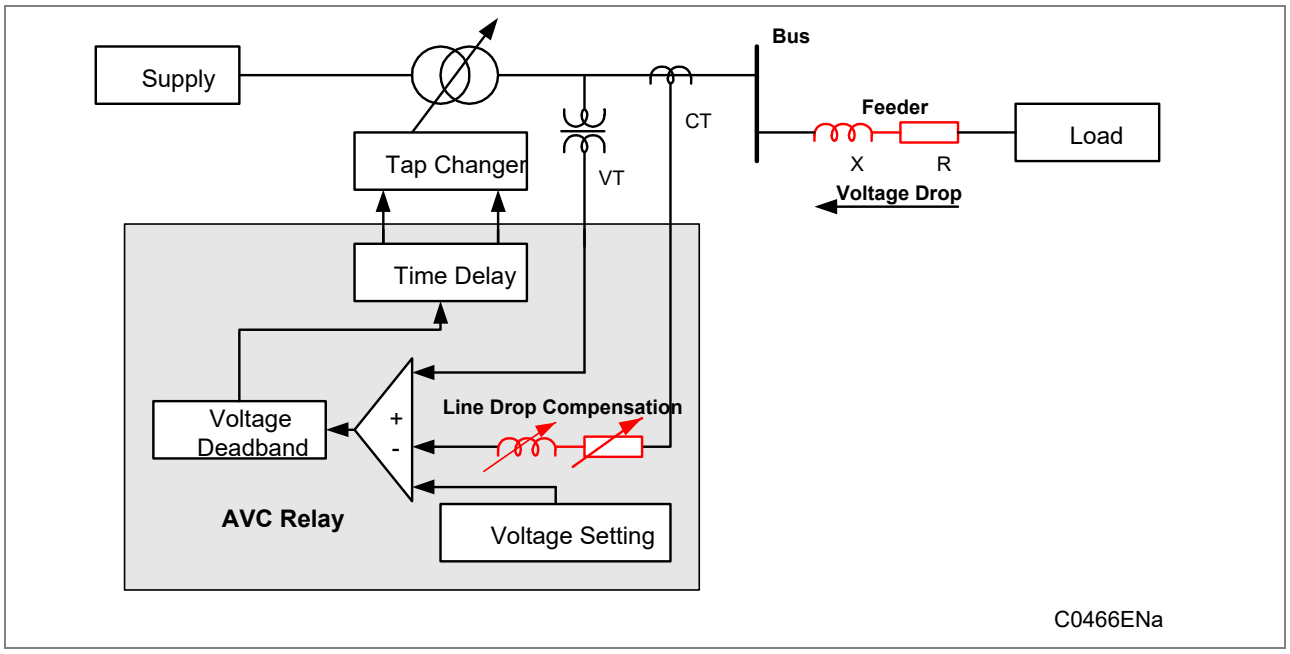
To detect excessive circulating current, the **MCC.Excessive** signal is used in the AVR module of transformers in parallel.

This signal is SET when **Circul.Current** > **Current1** * (**Excessive circ. current threshold** / 100) and RESET when **Circul.Current** ≤ **Current1** * (**Excessive circ. current threshold** / 100).

11.1.3.3.2.7.3 Line drop compensation

To regulate the voltage at a remote point on the feeder, the LDC simulates voltage drop of the line and artificially boosts transformer voltage at times of high load.

The LDC is validated by the “compounding activation” and ruled by the active “compounding method”.



Vr = Vm - Vcomp

Z = R + jX, R and X are % of Vn/In

R = “Active compounding method parameter A1”, % of Vn/In (nominal voltage and current)

X = “Active compounding method parameter B1”, % of Vn/In (nominal voltage and current)

The reactive “compounding method” is used only when two transformers are in parallel.

11.1.3.3.2.8 Performance & limits

MCC information (tap positions, circulating currents, delta voltages...) is updated every 1**0s** by the MCC calculation method hosted in the **MCC master**.

Limits

- The MCC method can manage up to **4** power transformers.
- The MCC method works only with measurement from secondary side of transformers. There is no assumption that transformer primary voltages are identical.
- For reactance calculation, the transformer rated base power value (Sbase), used to calculate the impedance value (in % of Sbase), is considered as being identical to the transformer rated power (S).
- Only **1** MCC group can be configured per substation voltage level.
- If the C264 manages several bays, only **1** AVR-MCC (**MCC Master** or **MCC Slave**) can be instantiated per C264.

Note: The MCC method can be used only within substation equipped with standard power transformers. Double-wound power transformers (with 2 windings at secondary side) are not managed.

11.1.3.3.3 Tap Changer Maintenance: Tap Counting

The numbers of automatic + manual tap changes are counted as follows:

Number	On the “slipping period for counting”	since C26x init	since last operator reset
Overall changes	x	up to 6 000 000	x
Raise	x	up to 3 000 000	x
Lower	x	up to 3 000 000	x
Limits reached	x	–	–
Time of use	–	For each tap as long as voltage is present	

- The date of the latest operator reset is also recorded.

Note 1: On operator reset

- the partial number of “tap changes”, “raise” and “lower” controls are reset
- the partial time of use with voltage present of each tap is reset
- the current date becomes the new “last reset date”

Note 2: The time of use is recorded, only if the voltage is present, and the Tap Position Indication and the TCIP signal are valid.

11.2 SYNCHROCHECK

11.2.1 GENERAL

The DS Agile C26x synchrocheck function is designed to measure voltages with respect to phase angle, frequency and magnitude on the line and on the busbar in order to safeguard against the interconnection of unsynchronised systems.

It is impossible to connect the C26x to the high voltage electrical network directly or through merging units on the Process Bus. The C26x receives the data from the Current Transformers (CT) and from Voltage Transformers (VT) connected to the TMU2xx board or as sampled values from the merging units.

The C26x BCU can manage only one synchrocheck function per electrical bay. If it manages two bays, the BCU can manage two synchrocheck functions of the same type, either type 1 or type 4. Mixes are not supported.

The purposes of the CTs and VTs include:

- Delivering current and voltage data that give a reliable picture of in the phenomena occurring on the high voltage side of an electrical substation
- Providing galvanic insulation between the high voltage side and the measurement circuits,
- Protecting the measurement circuits against damage when a fault occurs in the high voltage network.

The voltage measurements used by the internal synchrocheck function are provided by VTs. These measurements are used for the Internal Synchrocheck.

The synchrocheck function makes it possible to couple together 2 electrical networks that can be connected to different sources (generators) and therefore not synchronised with each other:

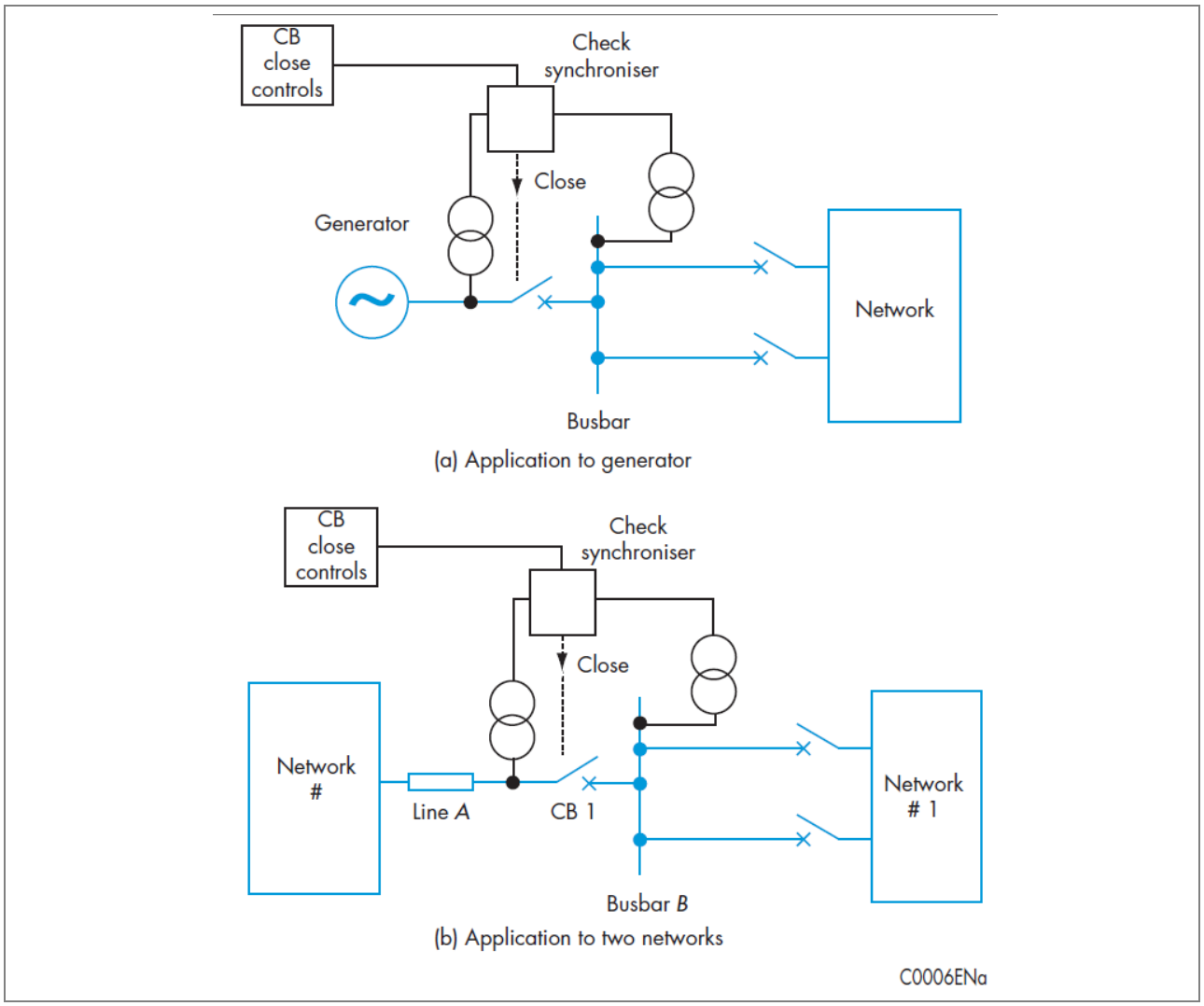


Figure 71: Synchrocheck single-breaker application examples

The Synchrocheck function measures two voltages with respect to phase angle, frequency and magnitude to safeguard the electrical network against the interconnection of two unsynchronised systems.

Synchrocheck functions types 1 and 4 can manage only 1 circuit-breaker at a time.

When 2 electrical networks are synchronised with each other:

- Voltages are identical (plus or minus a dispersion)
- Frequencies are identical (plus or minus a dispersion)
- Phases are identical (plus or minus a dispersion)

ΔV, $\Delta\varphi$ and ΔF are calculated. Their values are available through the measurement module.

ΔV is derived from the RMS values of the voltages on both busbar and line side.

The value of ΔF is assumed to be constant across the period. As a result, the $\Delta\varphi$ measurement makes it possible to determine whether the synchrocheck conditions are met (the circuit-breaker operating time can be taken into account).

time_synchro = 2 * pi *ΔF / $\Delta\varphi$

For more details, refer to section *7.2.4 Focus 3: TMU2XX - CT/VT measurement processing up to Threshold Detection*.

The 3 phase voltages of the line and one phase of the busbar are provided to the synchrocheck function.

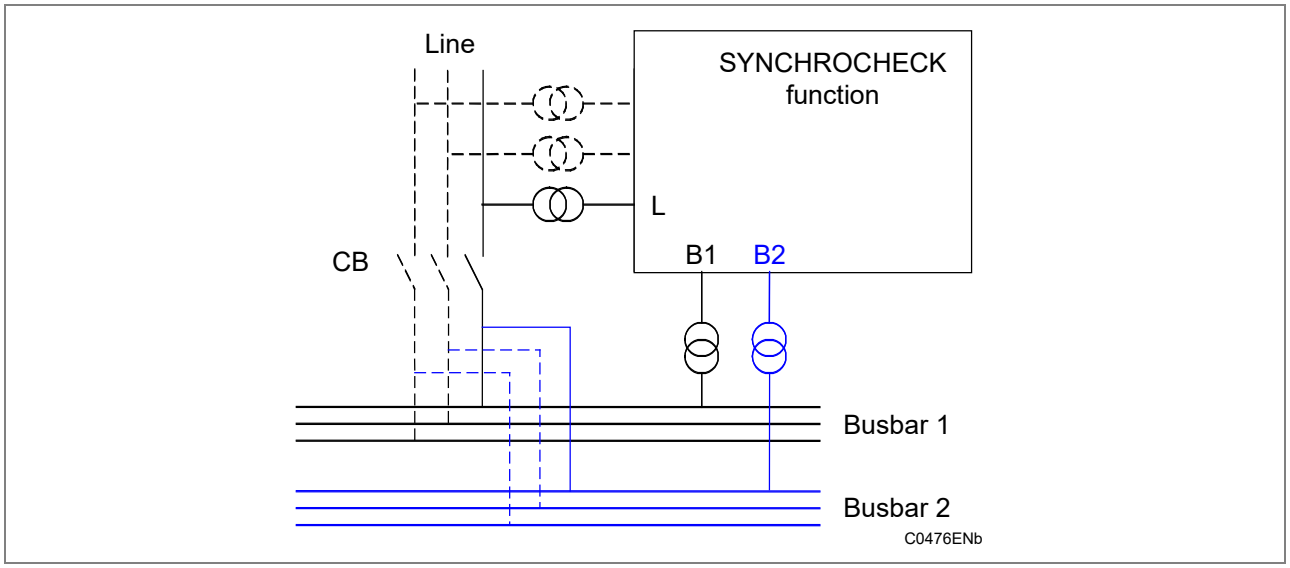


Figure 72: Standard Type1 synchrocheck scheme

The busbar reference phase is settable. If there are two busbars, the reference phase must be the same for both. The synchronism check will be applied between the line and the selected busbar. They are listed later in this section.

11.2.2 FUNCTIONAL DESCRIPTION

The synchrocheck diagram will vary depending on the type of synchrocheck, on the type of close request, on the locking/coupling management mode, and on the configured schemes. Nevertheless, the C26x always executes the scheme checks in the same order:

- Locking
- Coupling (this step can be skipped for a manual close command)
- Voltage presence check

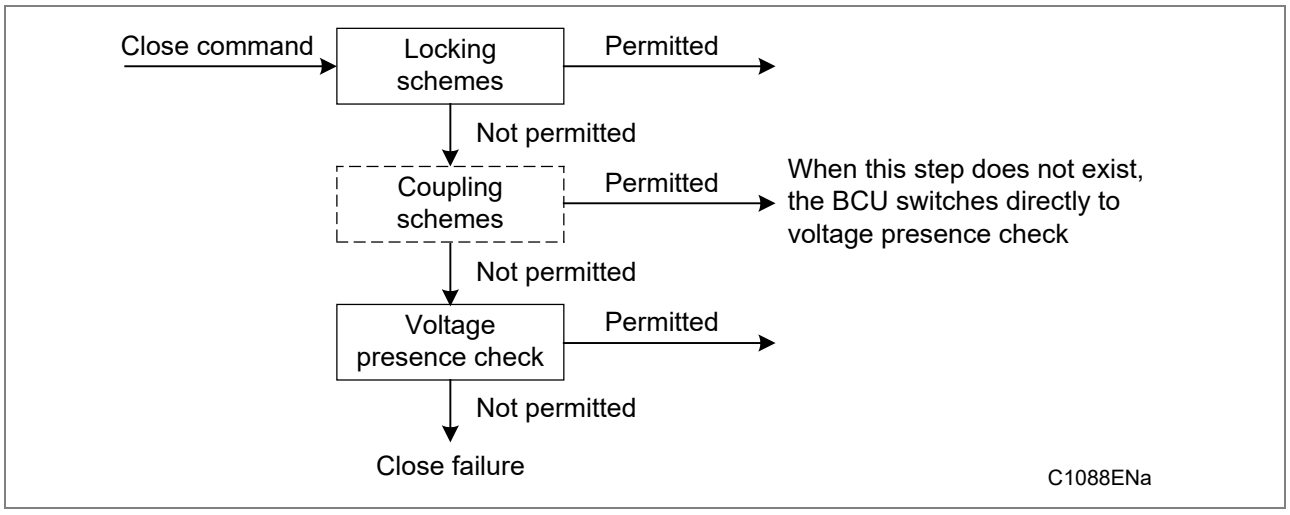


Figure 73: Synchrocheck sequence

11.2.2.1 MODES

Check synchronising (locking)

It is performed if the ΔF value is lower than a user-defined threshold (generally less than 0.1 Hz). If so, ΔV and Δφ are calculated. If these values are under a user-defined threshold, a close command is sent to the circuit-breaker.

On the other hand, closure of the circuit-breaker is prevented if system synchronising is not activated and one of the above conditions is not met.

System synchronising (coupling)

When a close request is received and if the ΔF value is outside of a user-defined range, coupling is activated.

The system synchronising function has a predictive role. This means that it calculates the time to wait before initiating the CB closure authorization by taking into account the complete command line, including the mechanical characteristics of the circuit-breaker. This time should be user-defined.

Note:
After a user-defined delay, the system synchronising mode is reset.

Voltage presence Check

Voltage presence is checked if locking is not permitted by the set schemes or has failed, and if coupling is not permitted. The role of the voltage presence check is to control if the line and/or the busbar are “Dead” (voltage under the **line/bus voltage under threshold (%)** setting), or “Live” (voltage higher than the **line/bus voltage over threshold (%)** setting). There are four possible cases:

- Live Line and Live Bus: LL/LB
- Live Line and Dead Bus: LL/DB
- Dead Line and Live Bus: DL/LB
- Dead Line and Dead Bus: DL/DB

In the LL/DB, DL/LB, and DL/DB cases, a close command is sent to the circuit-breaker according to the configured scheme.

There are three ways to manage Locking and Coupling (LL/LB):

- **Exclusive mode**

  No locking is performed, only coupling. If that fails, then the closing operation is aborted.

- **Evolutive mode**

  This is the default mode: locking is tried first, and if it fails, then coupling is tried. If that fails too, then the closing operation is aborted.

- **Split mode**

  Locking is tried first, and if it fails, then coupling is tried according to special split conditions. If that fails too, then the closing operation is aborted.

The availability of these modes depends on the type of Synchrocheck: Details are provided later in this chapter.

11.2.2.2 DIFFERENT TYPES OF CLOSE REQUESTS

There are several types of circuit-breaker close requests:

- **Close with synchro** Close request with synchrocheck: Locking, coupling and voltage presence check will be performed, according to the user configuration and selected schemes
- **Manual Close** Close request without synchrocheck: Only locking and voltage presence check will be performed, according to the user configuration and selected schemes
- **Automatic Close** Close request from auto-recloser: It is managed like a manual close but has a separate and different set of schemes (not available with Synchrocheck Type 3)

The Synchrocheck process replies with a positive (closing is possible) or negative (closing is not possible) acknowledgement.

11.2.2.3 SYNCHROCHECK SCHEMES

The synchrocheck function manages several scheme conditions s as shown in the table below.

Schemes	Scheme conditions	Manual close	Synchrocheck closure	Automatic close (AR)
Voltage Control (Energising Synchronising)	DLDB (Dead Line – Dead Bus)	Authorized	Authorized	Authorized*
	DLLB (Dead Line - Live Bus)	Authorized	Authorized	Authorized*
	LLBL (Line Live - Bus Live	Authorized	Authorized	Authorized*
Locking (Check Synchronising)	LLLB (Live Line – Live Bus) ΔV, ΔF, Δφ	Authorized	Authorized	Authorized
Coupling (Power System Synchronising)	LLLB (Live Line - Live Bus) ΔV, ΔF, Δ(Δφ)	not authorized	Authorized	not authorized

** Not recommended*

Locking (check synchronising) is defined by specific requirements: frequency difference, etc. If the corresponding values are all below the set thresholds, closing is immediately accepted.

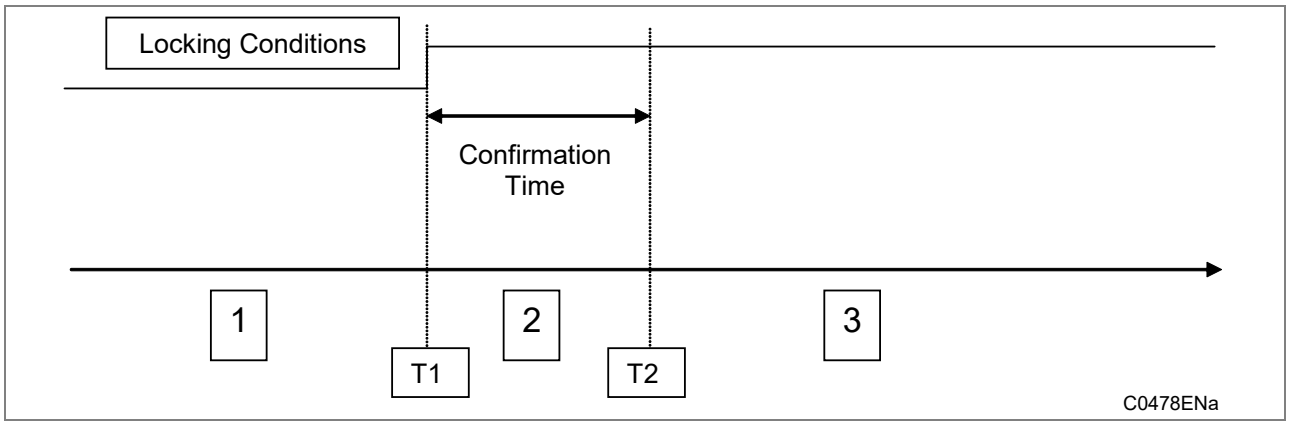
Generally, these requirements are very restrictive: for example, Delta F < 0.1 Hz

Coupling (system synchronising is also defined by specific requirements: frequency difference, etc. This has a predictive mode: the C26x includes a timer "T" and calculates whether the coupling conditions will be met t seconds later. This timer is settable.

Schemes are the general SC attributes defined at configuration level (SCE). They are authorized or not according to the needs.

Locking permitted / coupling NOT permitted by configuration

Example



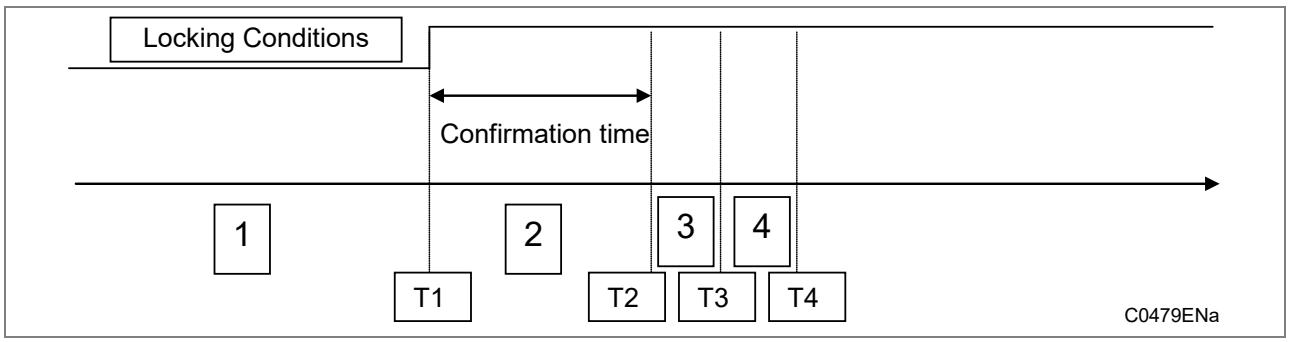
1: If a close command is received before T1 elapses, it is rejected.

2: If a close command is received after T1 has elapsed but while T2 is still running, it is executed when T2 elapses if the locking conditions are still present. If the locking conditions are lost before T2 elapses, then the command is rejected

3: If a close command is received after T2 has elapsed, it is accepted.

Locking permitted / coupling permitted by configuration

Example 1

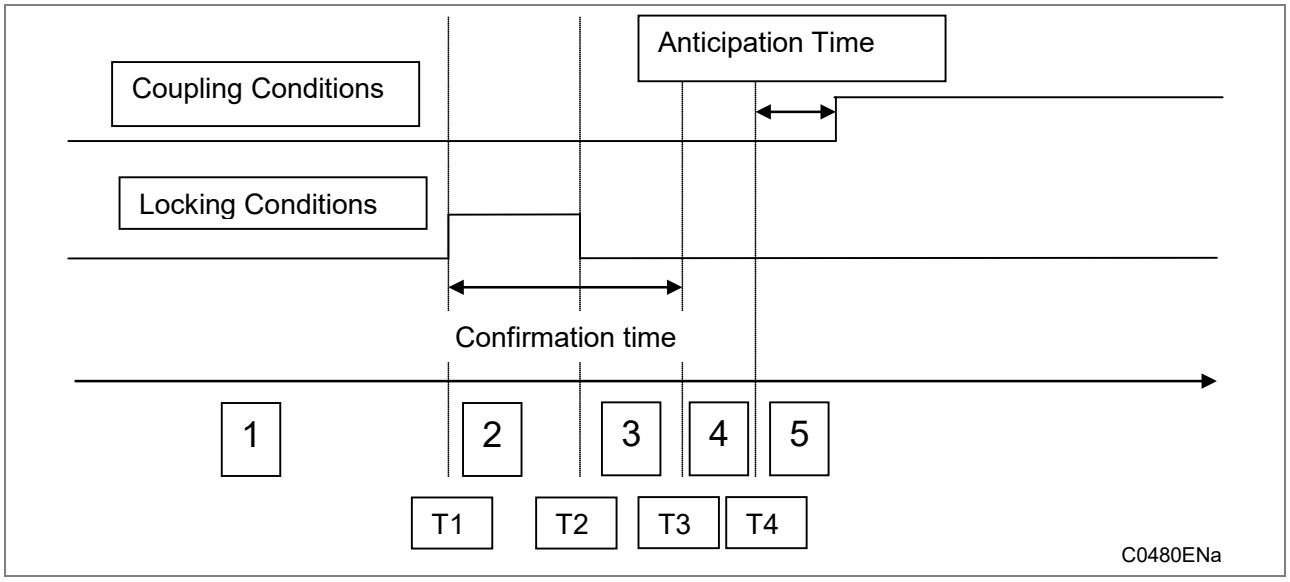


1: If a close command is received before T1 elapses, the control is executed when T2 elapses.

2: If a close command is received after T1 has elapsed but while T2 is still running, it is buffered until T2 elapses if the locking conditions are still present. If the locking conditions are lost before T2 elapses, then the command is rejected.

3: If a close command is received after T2 has elapsed, it is accepted.

Example 2



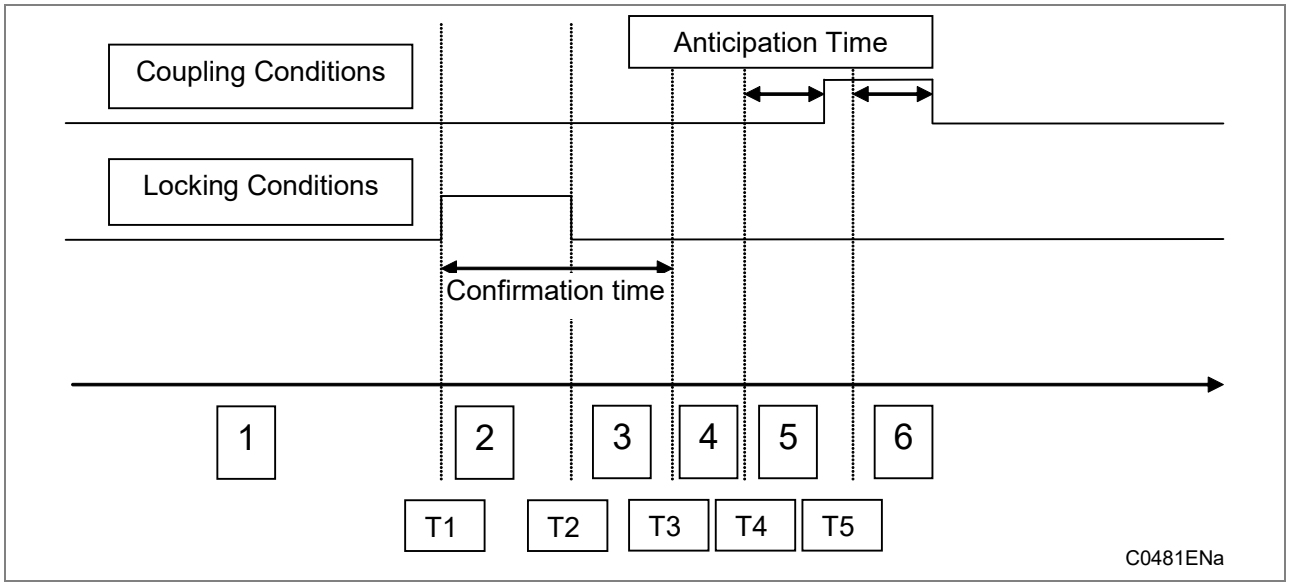
1: If a close command is received before T1 elapses, the control is executed when T4 elapses.

2: If a close command is received after T1 has elapsed but while T2 is still running, it is buffered. As the locking conditions are lost, the command is executed when T4 elapses.

3, 4: If a close command is received after T2 has elapsed but while T4 is still running, the control is executed when T4 elapses.

5: If a close command is received after T4 elapses, the control is immediately executed.

Example 3



1: If a close command is received before T1 elapses, the control is executed when T4 elapses.

2: If a close command is received after T1 has elapsed but while T2 is still running, it is buffered. As the locking conditions are lost, the command is executed at T4.

3, 4: If a close command is received after T2 has elapsed but while T4 is still running, the control is executed when T4 elapses.

5: If a close command is received after T4 has elapsed but while T5 is still running, the control is immediately executed.

6: If a close command is received after T5 has elapsed, the control is rejected after the synchrocheck waiting time (not shown in the above drawing).

11.2.2.4 SYNCHROCHECK CLOSE REQUEST

When a close request is received, the schemes are tested, and the close command is sent with the answer:

- OK: closing is possible
- KO: closing is impossible

When the LL/LB scheme is valid, the synchronisation conditions between the 2 voltages must be checked in order to allow the breaker to close.

The locking mode is the default synchronising mode. If the requirements are valid, at least during a delay T1, closing is immediate. Otherwise the coupling mode is tried. The different coupling modes are defined according to the type of synchrocheck.

The following authorized schemes are defined during the configuration process. The synchrocheck function operates for these schemes:

	Operator manual closure	Operator Synchrocheck closure	Auto-recloser
Network locking on both voltages presence and test of deltas Automatic and manual network locking on live line / live bus	X	X	X
Network coupling on both voltages presence and test of deltas Automatic and manual network coupling on live line / live bus		X	
Presence of only the line voltage Automatic and manual network connection on live line / dead bus	X	X	X
Presence of only the busbar voltage Automatic and manual network connection on dead line / live bus	X	X	X
Absence of both voltages Automatic and manual network connection on dead line / dead bus	X	X	X

11.2.2.5 COMMANDS RECEIVED FROM A CONTROL SEQUENCE

A synchronism check is initiated when a close command is received for a synchronised circuit-breaker.

Depending on the configuration of the circuit-breaker and the synchrocheck, the type of request and the state of the built-in synchrocheck, the requests received and managed by the synchrocheck function are:

Synchrocheck Type	Synchrocheck "on/off main" state(1)	Synchrocheck "on/off sec" state(2)	Control command	Origin	Request received by the synchrocheck function
Automatic	N/A	OFF	Close	Operator	Manual close
		ON	Close	Operator	Synchro close
		ON or OFF	Close	Auto-Recloser	Automatic close
		ON	Cancel	Operator	Abort
		ON	Force	Operator	Abort
Manual	ON	OFF	Close	Operator	Manual close
	ON	ON	Close	Operator	Synchro close
	ON	ON or OFF	Close	Auto-Recloser	Automatic close
	ON	ON	Cancel	Operator	Abort
	OFF	N/A	Close	N/A	Close without Synchrocheck

The requests received and managed by the synchrocheck function do not depend on whether it is automatic or manual.

(1) The "on/off main" SPC can be interpreted as "Synchrocheck activation ON/OFF"

(2) The "on/off sec" SPC can be interpreted as "Close with synchro ON/OFF"

If the CLOSE control sequence is issued by the **AutoRecloser** function, the request is transmitted to the Synchrocheck (external or internal) as "Automatic Close".

11.2.2.6 WIRING MODE

The synchronism check is calculated by comparing the comparing voltage modules, frequencies and phase acquired on voltages transformers (VT) installed at Line and Busbar sides.

A voltage input on the C26x's TMU2xx, or on the merging unit(s), can be wired to a on Ph-N (**Phase-to-Neutral**) voltage, or Ph-Ph (**Phase-to-Phase**) voltage.

Wiring topology must be configured according to the physical VT connections:

VT connections	Synchrocheck Wiring Modes
Ph-N line side and **Ph-N busbar** side	*star on both sides*
Ph-Ph line side and **Ph-Ph busbar** side	*delta on both sides*
Ph-N line side and **Ph-Ph busbar** side	*star on line - delta on busbar*
Ph-Ph line side and **Ph-N** busbar side	*delta on line - star on busbar*

The default wiring mode is "**star on both sides**".

11.2.2.7 REFERENCE PHASE

The reference phase (or circuit) must be configured in either the TMU board's or the SampleValueGroup's attributes, whatever the type of wiring on the line side:

- If on the line side, the VT wiring is in a star configuration, AN, BN or CN can be chosen as reference.
- If on the line side, the VT wiring is in a delta configuration, AB, BC or CA can be chosen as reference.

On the TMU210 board

The Synchrocheck reference phase is determined by the connection type (Line VTs and Busbar VT):

- **3Vpn + Vb** is equivalent to "**Star on both sides**" SC wiring mode.
- **3Vpp + Vb** is equivalent to "**Delta on both sides**" SC wiring mode.

The reference phase may be:

- Phase A or AB
- Phase B or AB
- Phase C or CA

The reference phase side may be:

- Phase A, B, C wired line side
- Phase A, B, C wired busbar side

On the TMU220 board

The Synchrocheck reference phase is determined by the **electrical network topology** (Line side VTs):

- star (or Ph-N wiring) equivalent to "Star on Line" SC wiring mode.
- delta (or Ph-Ph wiring) equivalent to "Delta on Line" SC wiring mode.

The reference phase may be:

- Phase A or AB
- Phase B or AB
- Phase C or CA

The reference phase side may be:

- Phase A, B, C wired line side
- Phase A, B, C wired busbar side

Note: Busbar VT connection not defined at TMU220 level.

On IEC61850-9.2LE Sampled Value

The Synchrocheck phase reference is determinate by the reference phase (Ph-N only) A, B or C.

The reference phase side may be:

- Phase A, B, C wired line side
- Phase A, B, C wired busbar side

Note: in case of IEC61850-9.2LE SampleValue, electrical network topology is not defined. "Star" topology is selected by default for "Line" and "Busbar" VTs.

Earth factor

The earth factor K_0 (**earth phase factor**) must be configured as it is needed in the calculation to derive the phase-phase voltages from the phase-neutral voltages and vice-versa where there are different VT topologies on the line side and on the busbar side.

Frequency

The frequency is not affected by the calculation to derive the line V_{PN} from the measured line V_{PP}. It is identical for both.

11.2.2.8 SC AQUISISITION

Depending on the number of busbar voltages and features required, the following acquisition modules may be used:

Acquisition module	Number of wired Busbar voltage	Protection features	Busbar selection	SC type
TMU210 board	1	Yes	External (1)	1 or 4
TMU220 board	1 or 2 (2)	No	Internal (3)	1 or 4
IEC61950-9.2LE	1 or dynamically (4)	Yes (4)	Dynamically (5)	1 or 4

(1) the TMU210 board can connect 3 phase voltages from the line, and 1 phase voltage from the busbar. Selecting a different busbar voltage is possible using an external relay switch automation.

(2) TMU220 can connect 3 phase voltages from the line, 1 phase voltage from "busbar1", and 1 phase voltage from "busbar2" (or "busbar bis").

(3) The busbar is automatically selected by the **Internal Synchrocheck** function.

(4) if the Merging Unit installed on line side is a "protection class" MU.

(5) if the "**Sample Values dynamic arrangement**" feature is configured with analogue acquisition.

11.2.3 SYNCHROCHECK COMPUTATION

11.2.3.1 STANDARD WIRING MODE

- If wiring mode is "**star on both sides**":

The measured line V_{PN} depends on the **reference phase** setting (A or B or C). The Ph-N wiring is selected (ex: Phase A for an "A or AB" selection).

The voltage is acquired on one phase (phase A or B or C).

- If wiring mode is "**delta-on-both-side**":

Measured line V_{PP} depends on the **reference phase** setting (AB or BC or CA). The Ph-Ph wiring is selected (ex: Phase AB for an "A or AB" selection).

The voltage is acquired on one phase (phase AB or BC or CA).

11.2.3.2 "STAR ON BOTH SIDES" WIRING MODE

11.2.3.2.1 "Line" reference phase side

The synchronism check is calculated using:

- ΔV = | Acquired line V_{PN} – Acquired busbar V_{PN} |
- ΔF = | Frequency of acquired line V_{PN} - Frequency of acquired busbar V_{PN} |
- $\Delta\varphi$ = | Phase angle of acquired line V_{PN} – Phase angle of acquired busbar V_{PN} |

11.2.3.2.2 “Busbar” reference phase side

The synchronism check is calculated using:

- ΔV = | Acquired busbar V_{PN} – Acquired line V_{PN} |
- ΔF = | Frequency of acquired busbar V_{PN} - Frequency of acquired line V_{PN} |
- Δφ = | Phase angle of acquired busbar V_{PN} – Phase angle of acquired line V_{PN} |

11.2.3.3 “DELTA ON BOTH SIDES” WIRING MODE

11.2.3.3.1 “Line” reference phase side

The synchronism check is calculated using:

- ΔV = | Acquired line V_{PP} – Acquired busbar V_{PP} |
- ΔF = | Frequency of acquired line V_{PP} – Frequency of acquired busbar V_{PP} |
- Δφ = | Phase angle of acquired line V_{PP} – Phase angle of acquired busbar V_{PP} |

11.2.3.3.2 “Busbar” reference phase side

The synchronism check is calculated using:

- ΔV = | Acquired busbar V_{PP} – Acquired line V_{PP} |
- ΔF = | Frequency of acquired busbar V_{PP} – Frequency of acquired line V_{PP} |
- Δφ = | Phase angle of acquired busbar V_{PP} – Phase angle of acquired line V_{PP} |

11.2.3.4 HYBRID WIRING MODES

In case of **hybrid wiring modes** (**"Star on Line, delta on Busbar" or "Delta on Line, star on Busbar"**), computations are performed on the "Line" phase voltages in order to have the same **wiring mode** than the "Busbar" side. No computation is possible on "busbar".

- **If the "Line" side is acquired in Ph-N and the "Busbar" side is acquired in Ph-Ph**:

The acquired "line" V_{PN} depends on the **reference phase** setting (A or B or C). The Ph-N wiring is selected (ex: Phase A for an "A or AB" selection).

The "Busbar" voltage is acquired on one phase (phase AB or BC or CA).

The "line" V_{PN} is converted to "line" V_{PP}.

- **If the "Line" side is acquired in Ph-Ph and the "Busbar" side is acquired in Ph-N**:

For TMU2xx only, the acquired "line" V_{PP} depends on the **reference phase** (AB or BC or CA).

The "Busbar" voltage is acquired on one phase (phase A or B or C).

The "line" V_{PP} is converted to "line" V_{PN}.

11.2.3.4.1 "Star on line, delta on busbar" ("Line" reference phase side)

The synchronism check is calculated using:

- ΔV = | Computed line V_{PP} – acquired busbar V_{PP} |
- ΔF = | Frequency of computed line V_{PP} – Frequency of acquired busbar V_{PP} |
- $\Delta\varphi$ = | Phase angle of computed line V_{PP} – Phase angle of acquired busbar V_{PP} |

11.2.3.4.1 "Star on line, delta on busbar" (Busbar reference phase side)

The synchronism check is calculated using:

- ΔV = | Computed busbar V_{PP} – acquired line V_{PP} |
- ΔF = | Frequency of computed busbar V_{PP} – Frequency of acquired line V_{PP} |
- $\Delta\varphi$ = | Phase angle of computed busbar V_{PP} – Phase angle of acquired line V_{PP} |

11.2.3.4.2 "Delta on line, star on busbar" ("Line" reference phase side)

The synchronism check is calculated using:

- ΔV = | Computed line V_{PN} – acquired busbar V_{PN} |
- ΔF = | Frequency of computed line V_{PN} – Frequency of acquired busbar V_{PN} |
- $\Delta\varphi$ = | Phase angle of computed line V_{PN} – Phase angle of acquired busbar V_{PN} |

11.2.3.4.1 "Delta on line, star on busbar" ("Busbar" reference phase side)

The synchronism check is calculated using:

- ΔV = | Computed busbar V_{PN} – acquired line V_{PN} |
- ΔF = | Frequency of computed busbar V_{PN} – Frequency of acquired line V_{PN} |
- $\Delta\varphi$ = | Phase angle of computed busbar V_{PN} – Phase angle of acquired line V_{PN} |

11.2.3.5 TMU210 SPECIFICITIES

11.2.3.5.1 Synchrocheck Ph-Ph wiring with TMU210

DS Agile makes it possible to configure a Synchrocheck function with Phase-to-Phase voltages, using a "Delta on both side" **wiring mode**.

This configuration is done in the SCE at "C26X\Hardware\TMU210" level, with the attributes **type of connection,** and **reference phase**.

To implement a Phase-to-Phase synchrocheck, the configuration must be as follows:

- **Type of connection**: "3 Vpp + Vb (delta)"
- **reference phase:** AB, BC or CA

The "Busbar" voltage will be compared by the Synchrocheck function to the Phase-to-Phase "Line" voltage defined as reference (AB, BC or CA). This reference voltage (AB, BC or CA) must be the same as the Phase-to-Phase "Busbar" voltage (wired on TMU210 channel VI#4).

In this configuration, calculation of Phase-to-Phase voltage, angle and frequency are the same as for Phase-to-Neutral.

For example: if the **reference phase** configured at TMU210 level is voltage "AB", then "Busbar" voltage must be wired on voltage "AB" (Ph-Ph).

Note: No check of the configuration is done at C264 or SCE level. It is highly recommended to verify that the configuration matches the VTs and TMU210 physical wiring.

11.2.4 SYNCHROCHECK TYPE 1

11.2.4.1 DESCRIPTION

SC	Control	Specificity	Synchronised CB	Set of parameters (MICOM S1)
Type 1	manual SET ON or automatic SET ON	CB closure, with additional features: • exclusive mode • evolutive mode • split mode • CS lock input	1 CB	1 set of parameters

11.2.4.2 MANUAL CLOSE CONDITIONS (LOCKING LOGIC)

Voltage conditions for manual and automatic requests are checked during a set time-delay.

Voltage conditions

The voltage conditions are:

Voltage present:

- V_{line}: On the line VT, the voltage of the set reference circuit is higher than the set threshold **line voltage over threshold**.
- V_{busbar}: On the busbar VT, the voltage (only one circuit available) is higher than the set threshold **bus voltage over threshold**.

Voltage missing:

- Not(V_{line}): On the line VT, the voltage of the set reference circuit is lower than the set threshold **line voltage under threshold**.
- Not(V_{busbar}): On the busbar VT, the voltage (only one circuit available) is lower than the set threshold **bus voltage under threshold**.

Permitted voltage delta:

- $\Delta V \leq \Delta V_{locking}$: The difference between the line voltage and the busbar voltage is lower than the set threshold **voltage delta threshold for locking**.

Permitted frequency delta:

- $\Delta f \leq \Delta f_{locking}$: The difference between the line frequency and the busbar frequency is lower than the set threshold **frequency delta threshold for locking**.

Permitted frequency range:

- $f_{min\ locking} \leq f_{line} \leq f_{max\ locking}$: The line voltage frequency is comprised between the set thresholds **minimum frequency for locking** and **minimum frequency for locking**.
- $f_{min\ locking} \leq f_{busbar} \leq f_{max\ locking}$: The busbar voltage frequency is comprised between the set thresholds **minimum frequency for locking** and **maximum frequency for locking**.

Permitted phase angle delta:

- $\Delta\varphi \leq \Delta\varphi_{locking}$: the difference between the line voltage phase angle (for the configured reference circuit) and the busbar voltage phase angle is lower than the set threshold **phase delta threshold for locking**.

Dead Line / Dead Bus

The Dead Line / Dead Bus (DLDB) closing conditions are met if:

- Line = Voltage missing
- Busbar = Voltage missing

for the duration of the T3 time-delay at the end of which the absence of both voltages is confirmed.

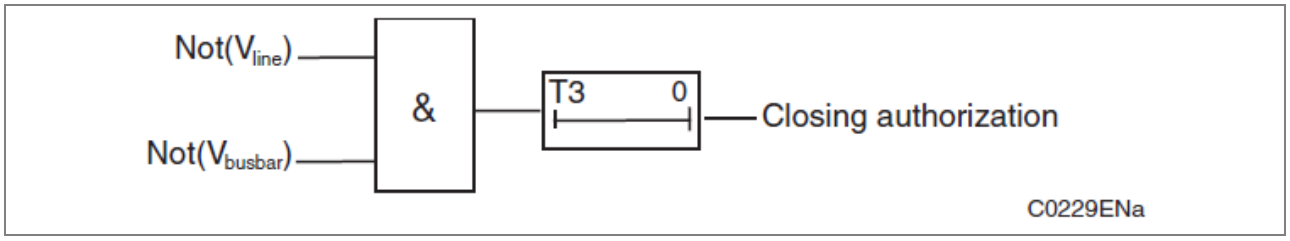


Figure 74: Not(V_{line}) and not(V_{busbar}) voltage check

When the Dead Line / Dead Bus (DLDB) closing conditions are met, CB closure is authorised.

If either DLDB condition criterion is lost while T3 elapses, the DLDB condition is no longer verified and T3 is reset. It will be restarted only upon the reappearance of both criteria.

Dead Line / Live Bus

The Dead Line / Live Bus (DLLB) closing conditions are met if:

- Line = Voltage missing
- Busbar = Voltage present

for the duration of the T2 time delay at the end of which the presence of only one voltage is confirmed.

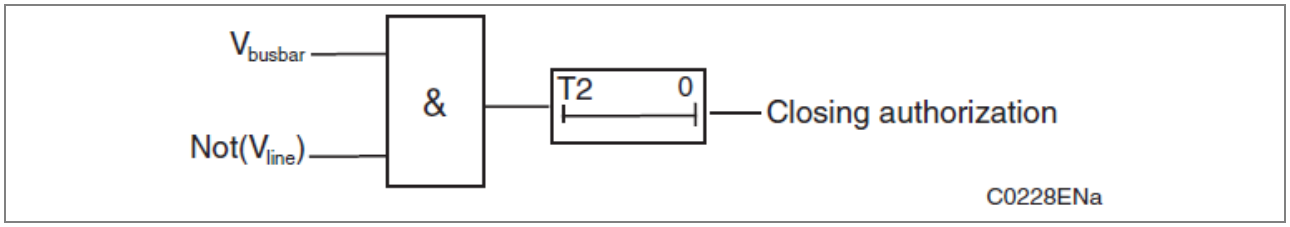


Figure 75: not(V_{line}) and V_{busbar} voltage check

When the Dead Line / Live Bus (DLLB) closing conditions are met, CB closure is authorised.

If either DLLB condition criterion is lost while T2 elapses, the DLLB condition is no longer verified and T2 is reset. It will be restarted only upon the reappearance of both criteria.

Live Line / Dead Bus

The Live Line / Dead Bus (LLDB) closing conditions are met if:

- Line = Voltage present
- Busbar = Voltage missing

for the duration of the T2 time delay at the end of which the presence of only one voltage is confirmed.

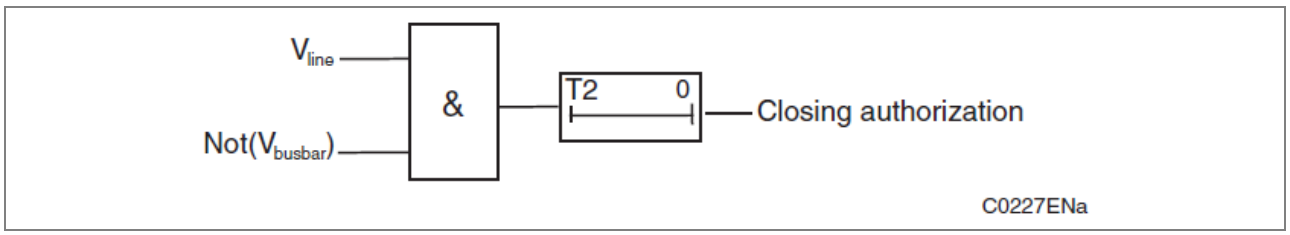


Figure 76: V_{line} and not(V_{busbar}) voltage check

When the Live Line / Dead Bus (LLDB) closing conditions are met, CB closure is authorised.

If either LLDB condition criterion is lost while T2 elapses, the LLDB condition is no longer verified and T2 is reset. It will be restarted only upon the reappearance of both criteria.

Live Line / Live Bus

The Live Line / Live Bus (LLLB) closing conditions are met if:

- Line = Voltage present
- Busbar = Voltage present
- Voltage Delta = OK
- Frequency Delta = OK
- Phase Delta = OK

for the duration of the T1 time-delay at the end of which the presence of both voltages is confirmed and so are the locking conditions.

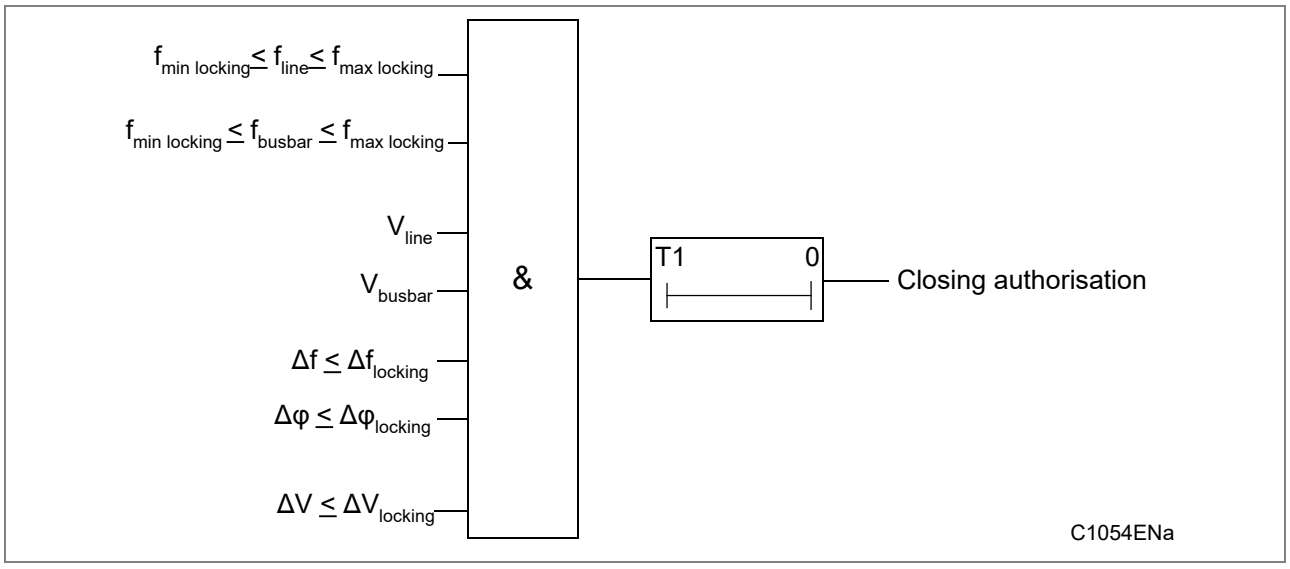


Figure 77: Locking scheme for type 1 synchrocheck

When the Live Line / Live Bus (LLLB) closing conditions are met, CB closure is authorised.

If any LLLB condition criterion is lost while T1 elapses, the LLLB condition is no longer verified and T1 is reset. It will be restarted only upon the reappearance of all the criteria.

11.2.4.3 SYNCHRO CLOSE CONDITIONS (COUPLING LOGIC)

Voltage conditions for synchro close requests are checked during a set time-delay.

Voltage conditions

The voltage conditions are:

Voltage present:

- V_{line}: On the line VT, the voltage of the set reference circuit is higher than the set threshold **line voltage over threshold**.
- V_{busbar}: On the busbar VT, the voltage (only one circuit available) is higher than the set threshold **bus voltage over threshold**.

Permitted voltage delta:

- $\Delta V < \Delta V_{locking}$: The difference between the line voltage and the busbar voltage is lower than the set threshold **voltage delta threshold for coupling**.

Permitted frequency delta range:

- $\Delta f_{min\ locking} < \Delta f < \Delta f_{max\ locking}$: The difference between the line frequency and the busbar frequency is comprised between the set thresholds **minimum frequency delta threshold for coupling** and **maximum frequency delta threshold for coupling**.

Permitted frequency range:

- $f_{min\ locking} < f_{line} < f_{max\ locking}$: The line voltage frequency is comprised between the set thresholds **minimum frequency for coupling** and **minimum frequency for coupling**.
- $f_{min\ locking} < f_{busbar} < f_{max\ locking}$: The busbar voltage frequency is comprised between the set thresholds **minimum frequency for coupling** and **maximum frequency for coupling**.

Live Line / Live Bus

The Live Line / Live Bus (LLLB) closing conditions are met if:

- Line = Voltage present
- Busbar = Voltage present
- Voltage Delta = OK
- Frequency Delta = OK

for the duration of the T1 time-delay at the end of which the presence of both voltages is confirmed and so are the coupling conditions.

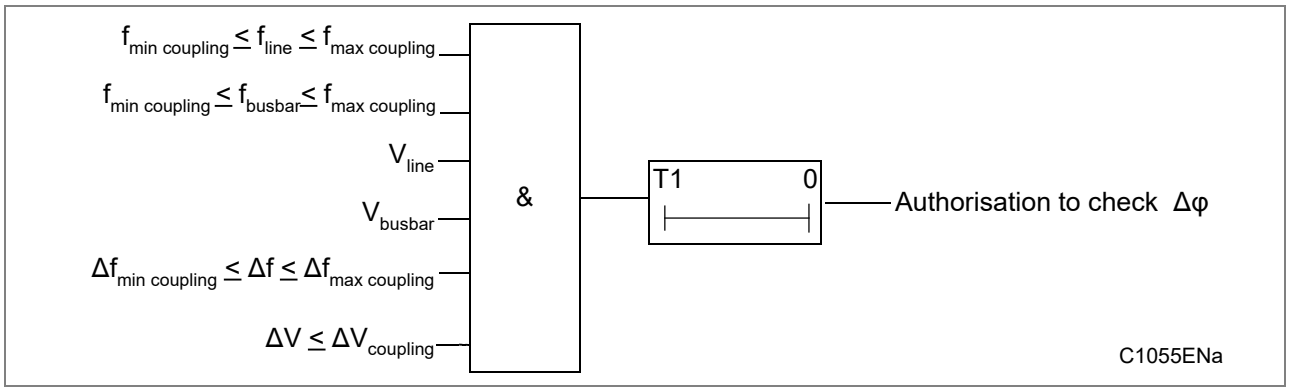


Figure 78: Coupling scheme for type 1 synchrocheck

When the Live Line / Live bus (LLLB) closing conditions are met, a synchro close request will authorise searching for min(Δφ).

If any LLLB condition criterion is lost while T1 elapses, the LLLB condition is no longer verified and T1 is reset. It will be restarted only upon the reappearance of all the criteria.

The search for min(Δφ) is launched, in order to find the optimal phase difference between line and busbar to close the circuit-breaker. In the min(Δφ) search, the circuit-breaker's operating time must be taken into account.

min(Δφ) is reached when $\Delta\varphi = \Delta f * 360 * Ta$

If min(Δφ) cannot be reached due to Δf being close to 0, then closing is permitted when this condition is met:
$-\ \Delta\varphi_{coupling} \leq \Delta\varphi \leq +\ \Delta\varphi_{coupling}$

where:

- Ta = circuit-breaker operating time
- $\Delta\varphi_{coupling}$ = setting for **phase delta threshold for coupling** attribute

Locking mode vs. Coupling mode

In order to discriminate between the locking and coupling modes, 2 separate ranges for frequency differences are configured.

- Locking range: $[0 \ldots \Delta f_{max\ locking}]$
- Coupling range: $[\Delta f_{min\ coupling} \ldots \Delta f_{max\ coupling}]$

The 2 ranges may overlap but the following condition must be met:

- $\Delta f_{max\ coupling} > \Delta f_{max\ locking}$

11.2.4.4 CLOSING SCHEMES

In order to enable closing only when the required voltage conditions are met, separate closing schemes are configured for each type of close request:

Manual close

For the manual close request, and for each voltage condition, a closing scheme is defined as shown below:

Voltage Conditions	Close Authorisation
Dead Line / Dead Bus	YES / NO
Dead Line / Live Bus	YES / NO
Live Line / Dead Bus	YES / NO
Live Line / Live Bus (locking)	YES / NO

Depending on the configuration, the following checks are performed for manual close requests:

Voltage Conditions	Closing Authorisation	Verified Voltage Conditions	Close request result
Dead Line / Dead Bus	YES	DLDB	Accepted
Dead Line / Dead Bus	YES	DLDB in progress*	Delayed
Dead Line / Dead Bus	YES	≠ DLDB	Rejected
Dead Line / Dead Bus	NO	Any condition	Rejected
Dead Line / Live Bus	YES	DLLB	Accepted
Dead Line / Live Bus	YES	DLLB in progress*	Delayed
Dead Line / Live Bus	YES	≠ DLLB	Rejected
Dead Line / Live Bus	NO	Any condition	Rejected
Live Line / Dead Bus	YES	LLDB	Accepted
Live Line / Dead Bus	YES	LLDB in progress*	Delayed
Live Line / Dead Bus	YES	≠ LLDB	Rejected
Live Line / Dead Bus	NO	Any condition	Rejected
Live Line / Live Bus (Locking)	YES	LLLB	Accepted
Live Line / Live Bus (Locking)	YES	LLLB in progress*	Delayed
Live Line / Live Bus (Locking)	YES	≠ LLLB	Rejected
Live Line / Live Bus (Locking)	NO	Any condition	Rejected

* the voltage condition check is in progress when the manual close request is received.

Automatic close (reclosing cycle after a protection trip)

For the automatic close request, and for each voltage condition, a closing scheme is defined as shown below:

Voltage Conditions	Close Authorization
Dead Line / Dead Bus	YES / NO
Dead Line / Live Bus	YES / NO
Live Line / Dead Bus	YES / NO
Live Line / Live Bus (Locking)	YES / NO

Depending on the configuration, the following checks are performed for automatic close requests:

Voltage Conditions	Close Authorisation	Verified Voltage Conditions	Close request result
Dead Line / Dead Bus	YES	DLDB	Accepted
Dead Line / Dead Bus	YES	DLDB in progress*	Delayed
Dead Line / Dead Bus	YES	≠ DLDB	Rejected
Dead Line / Dead Bus	NO	Any condition	Rejected
Dead Line / Live Bus	YES	DLLB	Accepted
Dead Line / Live Bus	YES	DLLB in progress*	Delayed
Dead Line / Live Bus	YES	≠ DLLB	Rejected
Dead Line / Live Bus	NO	Any condition	Rejected
Live Line / Dead Bus	YES	LLDB	Accepted
Live Line / Dead Bus	YES	LLDB in progress*	Delayed
Live Line / Dead Bus	YES	≠ LLDB	Rejected
Live Line / Dead Bus	NO	Any condition	Rejected
Live Line / Live Bus (Locking)	YES	LLLB	Accepted
Live Line / Live Bus (Locking)	YES	LLLB in progress*	Delayed
Live Line / Live Bus (Locking)	YES	≠ LLLB	Rejected
Live Line / Live Bus (Locking)	NO	Any condition	Rejected

* the voltage condition check is in progress when the automatic close request is received.

Synchro close

For the synchro close request, and for each voltage condition, a close scheme is defined as shown below:

Voltage Conditions	Close Authorisation
Dead Line / Dead Bus	YES / NO
Dead Line / Live Bus	YES / NO
Live Line / Dead Bus	YES / NO
Live Line / Live Bus (Locking)	YES / NO
Live Line / Live Bus (Locking and Coupling)	YES / NO

Depending on the configuration, the following checks are performed for synchro close requests:

Voltage Conditions	Close Authorisation	Verified Voltage Conditions	Close Request Result
Dead Line / Dead Bus	YES	DLDB	Accepted
Dead Line / Dead Bus	YES	DLDB in progress*	Delayed
Dead Line / Dead Bus	YES	≠ DLDB	Rejected
Dead Line / Dead Bus	NO	Any condition	Rejected
Dead Line / Live Bus	YES	DLLB	Accepted
Dead Line / Live Bus	YES	DLLB in progress*	Delayed
Dead Line / Live Bus	YES	≠ DLLB	Rejected
Dead Line / Live Bus	NO	Any condition	Rejected
Live Line / Dead Bus	YES	LLDB	Accepted
Live Line / Dead Bus	YES	LLDB in progress*	Delayed
Live Line / Dead Bus	YES	≠ LLDB	Rejected
Live Line / Dead Bus	NO	Any condition	Rejected
Live Line / Live Bus (Locking)	YES	LLLB (locking)	Accepted

Voltage Conditions	Close Authorisation	Verified Voltage Conditions	Close Request Result
Live Line / Live Bus (Locking)	YES	LLLB (locking) in progress*	Delayed
Live Line / Live Bus (Locking)	YES	≠ LLLB (locking)	Rejected
Live Line / Live Bus (Locking)	NO	Any condition	Rejected
Live Line / Live Bus (Locking and Coupling)	YES	LLLB (locking)	Accepted
Live Line / Live Bus (Locking and Coupling)	YES	LLLB (locking) in progress*	Delayed
Live Line / Live Bus (Locking and Coupling)	YES	≠ LLLB (locking and coupling)	Rejected
Live Line / Live Bus (Locking and Coupling)	YES	LLLB (coupling only)	Search for min(Δφ)
Live Line / Live Bus (Locking and Coupling)	NO	Any condition	Rejected

* the voltage condition check is in progress when the synchro close request is received.

11.2.4.5 CLOSING SCENARIOS

Request accepted

According to the configured closing scheme, if the close request is accepted, a close command is sent to the circuit-breaker.

Request rejected

According to the configured closing scheme, if the close request is rejected, a negative acknowledge (*KO-Synchrocheck*) is sent and no close command is sent to the circuit-breaker.

Request delayed

According to the configured closing scheme, if the close request result is delayed, a configured time-delay is started (**delay (ms)**):

- When the voltage condition check is complete, if the close scheme issues a close authorization:
  - a close command is sent to the circuit-breaker
  - and the time-delay is reset.
- When the voltage condition check is complete, if the close scheme does not give a close authorization:
  - a negative acknowledge (KO-Synchrocheck) is sent,
  - no close command is sent to the circuit-breaker,
  - and the time-delay is reset.
- If the time-delay elapses with no voltage conditions having been checked:
  - a negative acknowledge (KO-Synchrocheck) is sent,
  - and no close command is sent to the circuit-breaker.

11.2.4.6 CLOSE WITH LOCKING / COUPLING

Synchro close requests can be managed according to three management modes combining Locking and Coupling logics.

The synchro close request Locking/Coupling management mode is defined in the configuration and cannot be changed without reloading a new database.

The 3 available modes are:

- Exclusive mode
- Evolutive mode
- Split mode

Exclusive mode

When a synchro close request is received and coupling conditions are verified ($\Delta f_{min\ coupling} \leq \Delta f \leq \Delta f_{max\ coupling}$) the search for min(Δφ) is started and a time-delay is launched (**delay for coupling (s)**).

If min(Δφ) is found, a positive acknowledge is sent to close the circuit-breaker, and the time-delay is reset.

If the time-delay elapses without min(Δφ) being found, a negative acknowledge (*KO-Synchrocheck*) is sent and no close command is sent to the circuit-breaker.

When a synchro close request is received while Δf is not within the range [$\Delta f_{min\ coupling}$ ... $\Delta f_{max\ coupling}$], a negative acknowledge (*KO-Synchrocheck*) is immediately sent and no close command is sent to the circuit-breaker.

If Δf drifts outside of the range [$\Delta f_{min\ coupling}$ ... $\Delta f_{max\ coupling}$] during the search for min(Δφ) a negative acknowledge (*KO-Synchrocheck*) is sent when **delay for coupling (s)** elapses and no close command is sent to the circuit-breaker.

Evolutive mode

When a synchro close request is received, if Δf is within the range [0 ... $\Delta f_{max\ locking}$] and the locking condition is met, a positive acknowledge is immediately sent to close the circuit-breaker.

When a synchro close request is received, if Δf is within the range [0 ... $\Delta f_{max\ locking}$] and the locking condition check is in progress, the LLLB locking logic is applied.

When a synchro close request is received, if Δf is within the range [$\Delta f_{min\ coupling}$ ... $\Delta f_{max\ coupling}$], the search for min(Δφ) is started and a time-delay is launched (**delay for coupling (s)**).

When a synchro close request is received, if Δf is within neither of the ranges [0 ... $\Delta f_{max\ locking}$] and [$\Delta f_{min\ coupling}$ ... $\Delta f_{max\ coupling}$], a negative acknowledge (*KO-Synchrocheck*) is immediately sent and no close command is sent to the circuit-breaker.

If Δf drifts from the Coupling range to the Locking range (outside of any overlap) during the search for min(Δφ), the search is aborted, the time-delay is reset and a synchro close request is sent according to the locking logic.

If Δf drifts outside of both the Coupling and Locking ranges during the search for min(Δφ), the search is aborted, the time-delay is reset, a negative acknowledge (*KO-Synchrocheck*) is immediately sent and no close command is sent to the circuit-breaker.

The drift of Δf during the search for min(Δφ) is confirmed after a fixed time-delay of 5 s.

If Δf drifts outside of the Coupling range, the 5 s Δf drift time-delay is started. If Δf returns into the Coupling range, the Δf drift time-delay is reset.

If, when the Δf drift time-delay elapses, Δf is inside the Locking range, the search is aborted, the time-delay is reset and a synchro close request is sent according to the locking logic. If Δf is outside the Locking range, the search is aborted, the search for min(Δφ) time-delay is reset, a negative acknowledge (*KO-Synchrocheck*) is immediately sent and no close command is sent to the circuit-breaker.

If the Evolutive mode for synchro close request management is defined in the configuration, a SPS “Delta drift” can be defined. Whenever Δf drifts from the Coupling range to the Locking range (outside of any overlap) during the search for min(Δφ), the SPS “Delta drift” is transmitted in the SET state. As soon as the Δf drift during the search for min(Δφ) is over, whatever the resulting acknowledgement: OK or *KO-Synchrocheck*, the SPS “Delta drift” is transmitted in the RESET state.

Split mode

When a synchro close request is received, if Δf is within the range [0 ... $\Delta f_{max\ locking}$] and the locking condition is met, a positive acknowledge is immediately sent to close the circuit-breaker.

When a synchro close request is received while the locking conditions are not met, the **SBO timeout (s)** time-delay configured in the *Switch Ctrl DPC* profile table (0 to 600 s, step 1 s) is started and the following condition checks are performed:

- $\Delta V_{min\ split} \leq \Delta V \leq \Delta V_{max\ split}$
- $\Delta f_{min\ split} \leq \Delta f \leq \Delta f_{max\ split}$
- $\Delta\varphi \leq \Delta\varphi_{min\ split}$ (negative value) or $\Delta\varphi \geq \Delta\varphi_{max\ split}$ (positive value)

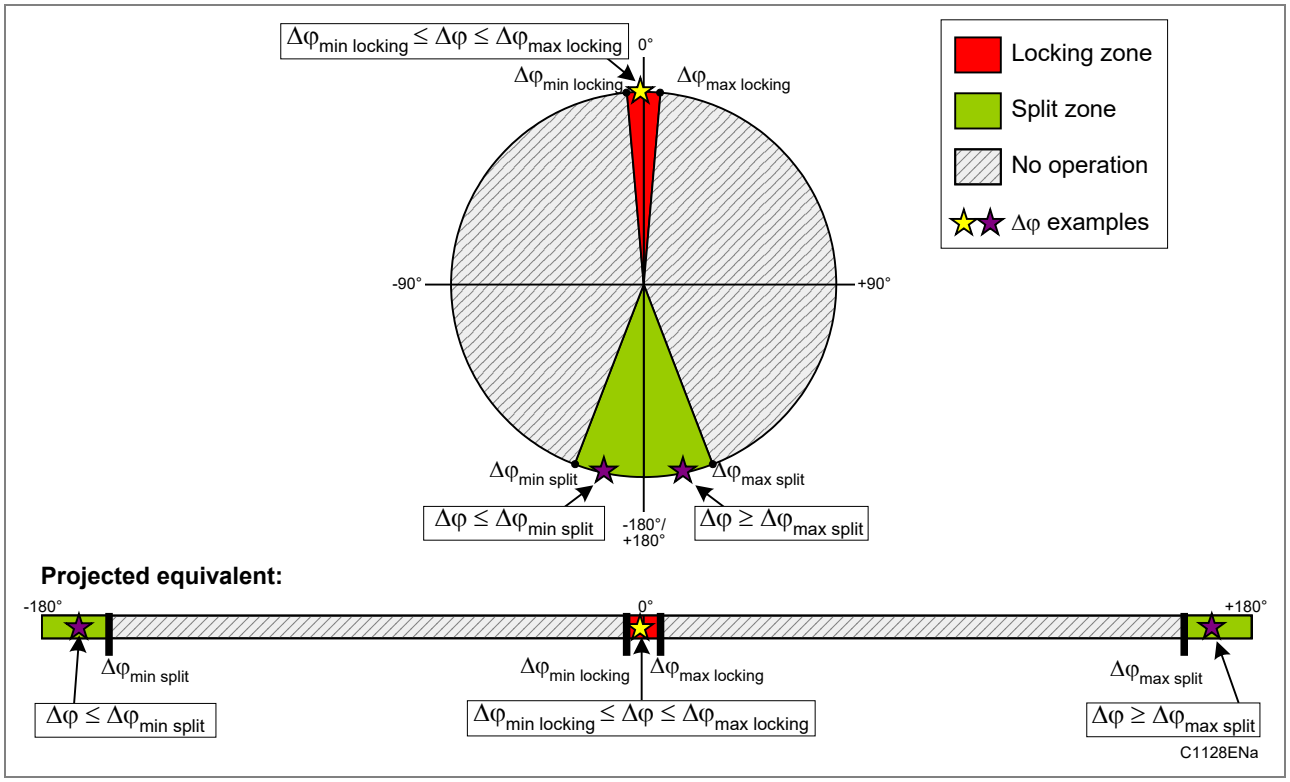


Figure 79: Angle conditions for split and locking zones

If the above split condition checks are verified, the search for min($\Delta\varphi$) is started, **SBO timeout (s)** is reset and the coupling process is started:

- if
  - Δf is in the range [$\Delta f_{min\ coupling}$ .. $\Delta f_{max\ coupling}$]

  and
  - $\Delta V \leq \Delta V_{max\ coupling}$

  and
  - the coupling mode T1 time-out has elapsed,

  the search for min($\Delta\varphi$) is started and another time-delay is launched (**delay for coupling**).
- if Δf is not in the range [$\Delta f_{min\ coupling}$ .. $\Delta f_{max\ coupling}$], a negative acknowledge (*KO-Synchrocheck*) is sent immediately.
- if $\Delta V > \Delta V_{max\ coupling}$, a negative acknowledge (*KO-Synchrocheck*) is sent immediately.

When **SBO timeout (s)** elapses while the split conditions are not met, a negative acknowledge (*KO-Synchrocheck*) is sent and no close command is sent to the circuit-breaker.

When **SBO timeout (s)** elapses while the coupling mode is still not confirmed (T1 is running), the search for min(Δφ) is started when T1 elapses and another time-delay is launched (**delay for coupling**).

Note:
If the three condition checks are verified when the CB close request is received, the search for min(Δφ) time-delay is started immediately.

If min(Δφ) is found, a positive acknowledge is sent to close the circuit-breaker and the time-delay is reset.

If the time-delay elapses without min(Δφ) having been found, a negative acknowledge (*KO-Synchrocheck*) is sent and no close command is sent to the circuit-breaker.

If the **Split mode** is configured, 2 SPS datapoints: "**Locking mode**" and **"Split sync mode"** can be defined.

The SPS **"Locking mode"** is SET as soon as Δf is within the range [0 ... $\Delta f_{max\ locking}$] and the locking condition is met.

The SPS **"Locking mode"** is RESET as soon as Δf is outside the range [0 ... $\Delta f_{max\ locking}$] or the locking condition is not met.

The SPS **"Split sync mode"** is SET as soon as the split conditions are verified.

The SPS **"Split sync mode"** is RESET as soon as the split conditions are not verified.

"Locking mode" and **"Split sync mode"** are managed even if there is no close request received by the synchrocheck.

11.2.5 SYNCHROCHECK TYPE 4

Synchrocheck Type 4 is a variant of Type 1. The differences are:

- No Split mode.
- Addition of a settable overvoltage threshold, over voltage threshold (% of Vn): Closing is not permitted if the line voltage, the busbar voltage, or both, are higher than this threshold.
- Addition of a settable “retry” timeout, **control rejection time out** (s): Starting when the close or reclose command is issued, this timer allows the C26x to continue trying to reach synchronising conditions until it expires.
- In addition to preventing the S/C function from starting when it is SET, if the datapoint CS Locked becomes SET while a check is in progress, it is terminated with a negative acknowledge.

11.2.5.1 MANUAL CLOSE CONDITIONS (LOCKING LOGIC)

Voltage conditions for manual and automatic requests are checked during a set time-delay.

Voltage conditions

The voltage conditions are:

Voltage present:

- V_{line}: On the line VT, the voltage of the set reference circuit is higher than the set threshold **line voltage over threshold**.
- V_{busbar}: On the busbar VT, the voltage (only one circuit available) is higher than the set threshold **bus voltage over threshold**.

Overvoltage threshold:

- V>: On both the line VT and the busbar VT, the voltage is lower than or equal to the set threshold **over voltage threshold**.

Voltage missing:

- Not(V_{line}): On the line VT, the voltage of the set reference circuit is lower than the set threshold **line voltage under threshold**.
- Not(V_{busbar}): On the busbar VT, the voltage (only one circuit available) is lower than the set threshold **bus voltage under threshold**.

Permitted voltage delta:

- $\Delta V \leq \Delta V_{locking}$: The difference between the line voltage and the busbar voltage is lower than the set threshold **voltage delta threshold for locking**.

Permitted frequency delta:

- $\Delta f \leq \Delta f_{locking}$: The difference between the line frequency and the busbar frequency is lower than the set threshold **frequency delta threshold for locking**.

Permitted frequency range:

- $f_{min\ locking} \leq f_{line} \leq f_{max\ locking}$: The line voltage frequency is comprised between the set thresholds **minimum frequency for locking** and **minimum frequency for locking**.
- $f_{min\ locking} \leq f_{busbar} \leq f_{max\ locking}$: The busbar voltage frequency is comprised between the set thresholds **minimum frequency for locking** and **maximum frequency for locking**.

Permitted phase angle delta:

- $\Delta\varphi \leq \Delta\varphi_{locking}$: the difference between the line voltage phase angle (for the configured reference circuit) and the busbar voltage phase angle is lower than the set threshold **phase delta threshold for locking**.

Dead Line / Dead Bus

The Dead Line / Dead Bus (DLDB) closing conditions are met if, before **control rejection time out (s)** expires:

- Line = Voltage missing
- Busbar = Voltage missing

for the duration of the T3 time-delay at the end of which the absence of both voltages is confirmed.

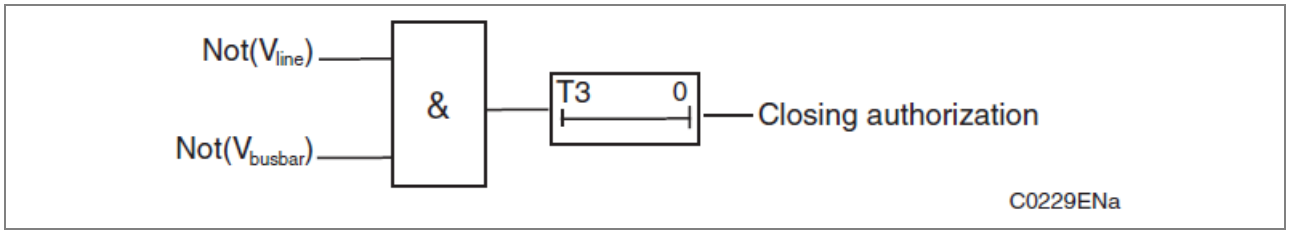


Figure 80: Not(V_{line}) and not(V_{busbar}) voltage check

When the Dead Line / Dead Bus (DLDB) closing conditions are met, CB closure is authorised.

If either DLDB condition criterion is lost while T3 elapses, the DLDB condition is no longer verified and T3 is reset. It will be restarted only upon the reappearance of both criteria.

Dead Line / Live Bus

The Dead Line / Live Bus (DLLB) closing conditions are met if:

- Line = Voltage missing
- Busbar = Voltage present
- Busbar voltage ≤ V> (overvoltage threshold)

for the duration of the T2 time delay at the end of which the presence of only one voltage not exceeding the overvoltage threshold is confirmed.

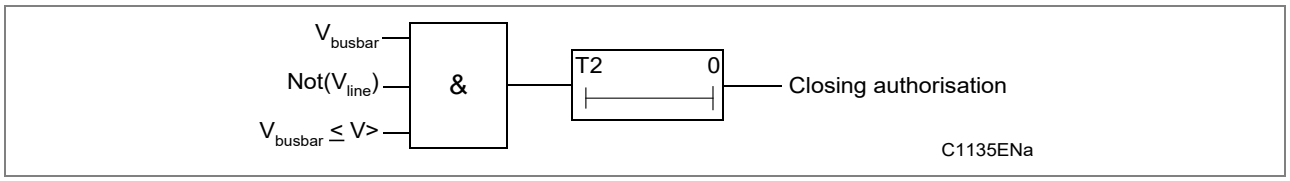


Figure 81: not(V_{line}) and V_{busbar} and not(V>) voltage check

When the Dead Line / Live Bus (DLLB) closing conditions are met, CB closure is authorised.

If either DLLB condition criterion is lost while T2 elapses, the DLLB condition is no longer verified and T2 is reset. It will be restarted only upon the reappearance of all the criteria.

Live Line / Dead Bus

The Live Line / Dead Bus (LLDB) closing conditions are met if, before **control rejection time out (s)** expires:

- Line = Voltage present
- Busbar = Voltage missing
- Line voltage ≤ V> (overvoltage threshold)

for the duration of the T2 time delay at the end of which the presence of only one voltage not exceeding the overvoltage threshold is confirmed.

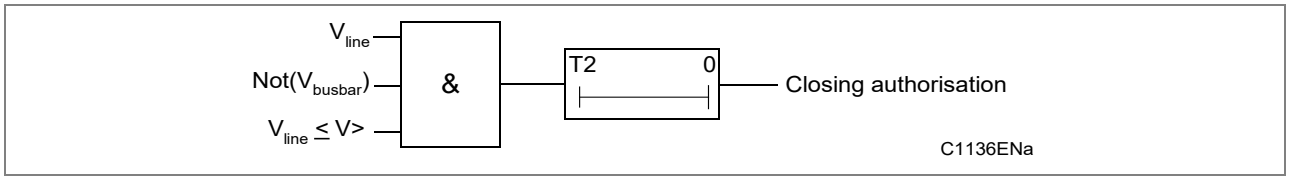


Figure 82: V_{line} and not(V_{busbar}) and not(V>) voltage check

When the Live Line / Dead Bus (LLDB) closing conditions are met, CB closure is authorised.

If either LLDB condition criterion is lost while T2 elapses, the LLDB condition is no longer verified and T2 is reset. It will be restarted only upon the reappearance of all the criteria.

Live Line / Live Bus

The Live Line / Live Bus (LLLB) closing conditions are met if, before **control rejection time out (s)** expires:

- Line = Voltage present
- Busbar = Voltage present
- Voltage Delta = OK
- Frequency Delta = OK
- Phase Delta = OK
- Line voltage ≤ V>
- Busbar voltage ≤ V>

for the duration of the T1 time-delay at the end of which the following conditions are confirmed:

- both the line and the busbar voltages are present,
- neither voltage exceeds the overvoltage threshold,
- the locking conditions are met.

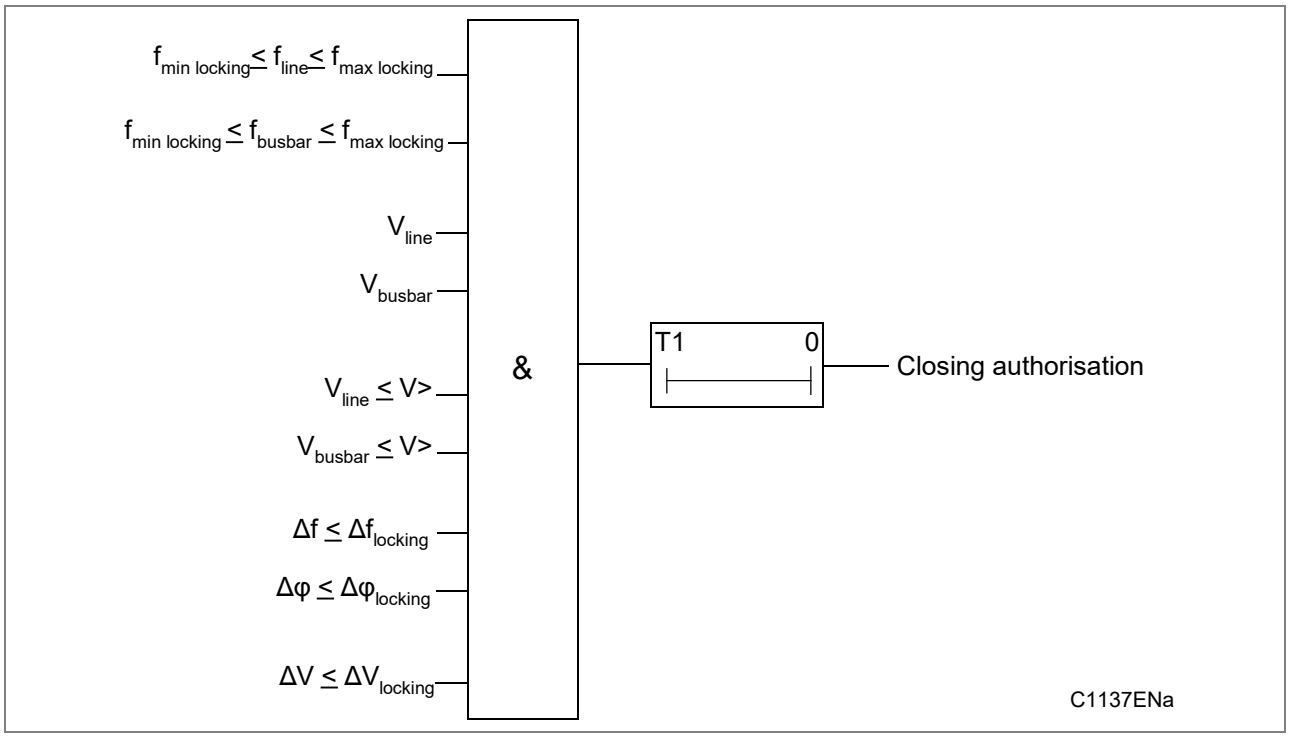


Figure 83: Locking scheme for type 4 synchrocheck

When the Live Line / Live Bus (LLLB) closing conditions are met, CB closure is authorised.

If any LLLB condition criterion is lost while T1 elapses, the LLLB condition is no longer verified and T1 is reset. It will be restarted only upon the reappearance of all the criteria.

11.2.5.2 SYNCHRO CLOSE CONDITIONS (COUPLING LOGIC)

Voltage conditions for synchro close requests are checked during a set time-delay.

Voltage conditions

The voltage conditions are:

Voltage present:

- V_{line}: On the line VT, the voltage of the set reference circuit is higher than the set threshold **line voltage over threshold**.
- V_{busbar}: On the busbar VT, the voltage (only one circuit available) is higher than the set threshold **bus voltage over threshold**.

Overvoltage threshold:

- V>: On both the line VT and the busbar VT, the voltage is lower than or equal to the set threshold **over voltage threshold**.

Permitted voltage delta:

- $\Delta V < \Delta V_{locking}$: The difference between the line voltage and the busbar voltage is lower than the set threshold **voltage delta threshold for coupling**.

Permitted frequency delta range:

- $\Delta f_{min\ locking} < \Delta f < \Delta f_{max\ locking}$: The difference between the line frequency and the busbar frequency is comprised between the set thresholds **minimum frequency delta threshold for coupling** and **maximum frequency delta threshold for coupling**.

Permitted frequency range:

- $f_{min\ locking} < f_{line} < f_{max\ locking}$: The line voltage frequency is comprised between the set thresholds **minimum frequency for coupling** and **minimum frequency for coupling**.
- $f_{min\ locking} < f_{busbar} < f_{max\ locking}$: The busbar voltage frequency is comprised between the set thresholds **minimum frequency for coupling** and **maximum frequency for coupling**.

Live Line / Live Bus

The Live Line / Live Bus (LLLB) closing conditions are met if, before **control rejection time out (s)** expires:

- Line = Voltage present
- Busbar = Voltage present
- Voltage Delta = OK
- Frequency Delta = OK
- Line voltage ≤ V>
- Busbar voltage ≤ V>

for the duration of the T1 time-delay at the end of which the following conditions are confirmed:

- both the line and the busbar voltages are present,
- neither voltage exceeds the overvoltage threshold,
- the coupling conditions are met.

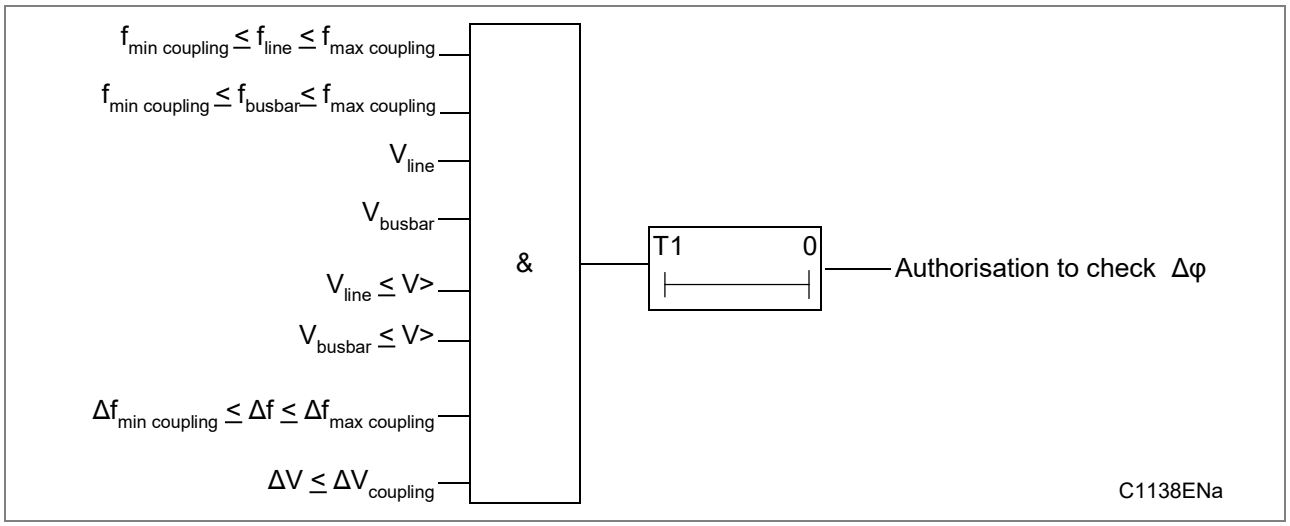


Figure 84: Coupling scheme for type 4 synchrocheck

When the Live Line / Live bus (LLLB) closing conditions are met, a synchro close request will authorise searching for min(Δφ).

If any LLLB condition criterion is lost while T1 elapses, the LLLB condition is no longer verified and T1 is reset. It will be restarted only upon the reappearance of all the criteria.

The search for min(Δφ) is launched, in order to find the optimal phase difference between line and busbar to close the circuit-breaker. In the min(Δφ) search, the circuit-breaker's operating time must be taken into account.

min(Δφ) is reached when Δφ = Δf*360*Ta

If min(Δφ) cannot be reached due to Δf being close to 0, then closing is permitted when this condition is met:
$-\Delta\varphi_{coupling} \leq \Delta\varphi \leq +\Delta\varphi_{coupling}$

where:

- Ta = circuit-breaker operating time
- $\Delta\varphi_{coupling}$ = setting for **phase delta threshold for coupling** attribute

Locking mode vs. Coupling mode

In order to discriminate between the locking and coupling modes, 2 separate ranges for frequency differences are configured.

- Locking range: $[0 \ldots \Delta f_{max\ locking}]$
- Coupling range: $[\Delta f_{min\ coupling} \ldots \Delta f_{max\ coupling}]$

The 2 ranges may overlap but the following condition must be met:

- $\Delta f_{max\ coupling} > \Delta f_{max\ locking}$

11.2.5.3 CLOSING SCHEMES

In order to enable closing only when the required voltage conditions are met, separate closing schemes are configured for each type of close request:

Manual close

For the manual close request, and for each voltage condition, a closing scheme is defined as shown below:

Voltage Conditions	Close Authorisation
Dead Line / Dead Bus	YES / NO
Dead Line / Live Bus	YES / NO
Live Line / Dead Bus	YES / NO
Live Line / Live Bus (locking)	YES / NO

Depending on the configuration, the following checks are performed for manual close requests:

Voltage Conditions	Closing Authorisation	Verified Voltage Conditions	Close request result
Dead Line / Dead Bus	YES	DLDB	Accepted
Dead Line / Dead Bus	YES	DLDB in progress*	Delayed
Dead Line / Dead Bus	YES	≠ DLDB	Rejected
Dead Line / Dead Bus	NO	Any condition	Rejected
Dead Line / Live Bus	YES	DLLB	Accepted
Dead Line / Live Bus	YES	DLLB in progress*	Delayed
Dead Line / Live Bus	YES	≠ DLLB	Rejected
Dead Line / Live Bus	NO	Any condition	Rejected
Live Line / Dead Bus	YES	LLDB	Accepted
Live Line / Dead Bus	YES	LLDB in progress*	Delayed
Live Line / Dead Bus	YES	≠ LLDB	Rejected
Live Line / Dead Bus	NO	Any condition	Rejected
Live Line / Live Bus (Locking)	YES	LLLB	Accepted
Live Line / Live Bus (Locking)	YES	LLLB in progress*	Delayed
Live Line / Live Bus (Locking)	YES	≠ LLLB	Rejected

Voltage Conditions	Closing Authorisation	Verified Voltage Conditions	Close request result
Live Line / Live Bus (Locking)	NO	Any condition	Rejected

* the voltage condition check is in progress when the manual close request is received.

Automatic close (reclosing cycle after a protection trip)

For the automatic close request, and for each voltage condition, a closing scheme is defined as shown below:

Voltage Conditions	Close Authorization
Dead Line / Dead Bus	YES / NO
Dead Line / Live Bus	YES / NO
Live Line / Dead Bus	YES / NO
Live Line / Live Bus (Locking)	YES / NO

Depending on the configuration, the following checks are performed for automatic close requests:

Voltage Conditions	Close Authorisation	Verified Voltage Conditions	Close request result
Dead Line / Dead Bus	YES	DLDB	Accepted
Dead Line / Dead Bus	YES	DLDB in progress*	Delayed
Dead Line / Dead Bus	YES	≠ DLDB	Rejected
Dead Line / Dead Bus	NO	Any condition	Rejected
Dead Line / Live Bus	YES	DLLB	Accepted
Dead Line / Live Bus	YES	DLLB in progress*	Delayed
Dead Line / Live Bus	YES	≠ DLLB	Rejected
Dead Line / Live Bus	NO	Any condition	Rejected
Live Line / Dead Bus	YES	LLDB	Accepted
Live Line / Dead Bus	YES	LLDB in progress*	Delayed
Live Line / Dead Bus	YES	≠ LLDB	Rejected
Live Line / Dead Bus	NO	Any condition	Rejected
Live Line / Live Bus (Locking)	YES	LLLB	Accepted
Live Line / Live Bus (Locking)	YES	LLLB in progress*	Delayed
Live Line / Live Bus (Locking)	YES	≠ LLLB	Rejected
Live Line / Live Bus (Locking)	NO	Any condition	Rejected

* the voltage condition check is in progress when the automatic close request is received.

Synchro close

For the synchro close request, and for each voltage condition, a close scheme is defined as shown below:

Voltage Conditions	Close Authorisation
Dead Line / Dead Bus	YES / NO
Dead Line / Live Bus	YES / NO
Live Line / Dead Bus	YES / NO
Live Line / Live Bus (Locking)	YES / NO
Live Line / Live Bus (Locking and Coupling)	YES / NO

Depending on the configuration, the following checks are performed for synchro close requests:

Voltage Conditions	Close Authorisation	Verified Voltage Conditions	Close Request Result
Dead Line / Dead Bus	YES	DLDB	Accepted
Dead Line / Dead Bus	YES	DLDB in progress*	Delayed
Dead Line / Dead Bus	YES	≠ DLDB	Rejected
Dead Line / Dead Bus	NO	Any condition	Rejected
Dead Line / Live Bus	YES	DLLB	Accepted
Dead Line / Live Bus	YES	DLLB in progress*	Delayed
Dead Line / Live Bus	YES	≠ DLLB	Rejected
Dead Line / Live Bus	NO	Any condition	Rejected
Live Line / Dead Bus	YES	LLDB	Accepted
Live Line / Dead Bus	YES	LLDB in progress*	Delayed
Live Line / Dead Bus	YES	≠ LLDB	Rejected
Live Line / Dead Bus	NO	Any condition	Rejected
Live Line / Live Bus (Locking)	YES	LLLB (locking)	Accepted
Live Line / Live Bus (Locking)	YES	LLLB (locking) in progress*	Delayed
Live Line / Live Bus (Locking)	YES	≠ LLLB (locking)	Rejected
Live Line / Live Bus (Locking)	NO	Any condition	Rejected
Live Line / Live Bus (Locking and Coupling)	YES	LLLB (locking)	Accepted
Live Line / Live Bus (Locking and Coupling)	YES	LLLB (locking) in progress*	Delayed
Live Line / Live Bus (Locking and Coupling)	YES	≠ LLLB (locking and coupling)	Rejected
Live Line / Live Bus (Locking and Coupling)	YES	LLLB (coupling only)	Search for min(Δφ)
Live Line / Live Bus (Locking and Coupling)	NO	Any condition	Rejected

* the voltage condition check is in progress when the synchro close request is received.

11.2.5.4 CLOSING SCENARIOS

Request accepted

According to the configured closing scheme, if the close request is accepted, a close command is sent to the circuit-breaker.

Request rejected

According to the configured closing scheme and when **control rejection time out (s)** expires, if the close request is rejected, a negative acknowledge (KO-Synchrocheck) is sent and no close command is sent to the circuit-breaker.

Request delayed

According to the configured closing scheme, if the close request result is delayed, a configured time-delay is started (**delay (ms)**):

- When the voltage condition check is complete, if the close scheme issues a close authorization:
  - a close command is sent to the circuit-breaker
  - and the time-delay is reset.
- When the voltage condition check is complete, if the close scheme does not give a close authorisation, the process is repeated until **control rejection time out (s)** expires.
  If, when **control rejection time out (s)** expires there is still no close authorisation:
  - a negative acknowledge (KO-Synchrocheck) is sent,
  - no close command is sent to the circuit-breaker,
  - and the time-delay is reset.
- If the time-delay elapses with no voltage conditions having been checked, the process is repeated until **control rejection time out (s)** expires.
  If, when **control rejection time out (s)** expires there is still no close authorisation:
  - a negative acknowledge (KO-Synchrocheck) is sent,
  - and no close command is sent to the circuit-breaker.

11.2.5.5 CLOSE WITH LOCKING / COUPLING

Synchro close requests can be managed according to three management modes combining Locking and Coupling logics.

The synchro close request Locking/Coupling management mode is defined in the configuration and cannot be changed without reloading a new database.

The 2 available modes are:

- Exclusive mode
- Evolutive mode

Exclusive mode

When a synchro close request is received, if $\Delta f_{min\ coupling} \leq \Delta f \leq \Delta f_{max\ coupling}$ the search for min($\Delta\varphi$) is started and a time-delay is launched (**delay for coupling (s)**).

- If min($\Delta\varphi$) is found, a positive acknowledge is sent to close the circuit-breaker, and the time-delay is reset.
- If **delay for coupling (s)** elapses without min($\Delta\varphi$) being found:
  - a negative acknowledge (KO-Synchrocheck) is sent
  - and no close command is sent to the circuit-breaker.

When a synchro close request is received while Δf is not within the range [$\Delta f_{min\ coupling}$ … $\Delta f_{max\ coupling}$], the C26x waits for Δf to shift into the range [$\Delta f_{min\ coupling}$ ... $\Delta f_{max\ coupling}$] until **control rejection time out (s)** expires.
If, when **control rejection time out (s)** expires there is still no close authorisation:

- a negative acknowledge (KO-Synchrocheck) is immediately sent
- and no close command is sent to the circuit-breaker.

If Δf drifts outside of the range [Δ $f_{min\ coupling}$ ... Δ $f_{max\ coupling}$] during the search for min(Δφ:

- a negative acknowledge (KO-Synchrocheck) is sent
- and no close command is sent to the circuit-breaker.

Evolutive mode

When a synchro close request is received, if Δf is within the range [0 ... $\Delta f_{max\ locking}$] and the locking condition is met, a positive acknowledge is immediately sent to close the circuit-breaker.

When a synchro close request is received, if Δf is within the range [0 ... $\Delta f_{max\ locking}$] and the locking condition check is in progress, the LLLB locking logic is applied.

When a synchro close request is received, if Δf is within the range [$\Delta f_{min\ coupling}$ ... $\Delta f_{max\ coupling}$], the search for min(Δφ) is started and a time-delay is launched (**delay for coupling (s)**).

When a synchro close request is received, if Δf is within neither of the ranges [0 ... $\Delta f_{max\ locking}$] and [$\Delta f_{min\ coupling}$ ... $\Delta f_{max\ coupling}$], the C26x waits for Δf to shift into either range until **control rejection time out (s)** expires.
If, when **control rejection time out (s)** expires there is still no close authorisation:

- a negative acknowledge (KO-Synchrocheck) is immediately sent
- and no close command is sent to the circuit-breaker.

If Δf drifts from the Coupling range to the Locking range (outside of any overlap) during the search for min(Δφ), the search is aborted, the time-delay is reset and a synchro close request is sent according to the locking logic.

If Δf drifts outside of both the Coupling and Locking ranges during the search for min(Δφ), the search is aborted, the time-delay is reset, and:

- a negative acknowledge (KO-Synchrocheck) is immediately sent
- and no close command is sent to the circuit-breaker.

The drift of Δf during the search for min(Δφ) is confirmed after a fixed time-delay of 5 s.

If Δf drifts outside of the Coupling range, the 5 s Δf drift time-delay is started. If Δf returns into the Coupling range, the Δf drift time-delay is reset.

If, when the Δf drift time-delay elapses,

- Δf is inside the Locking range, the search is aborted, the time-delay is reset and a synchro close request is sent according to the locking logic.
- Δf is outside the Locking range, the search is aborted, the search for min(Δφ) time-delay is reset:
  - a negative acknowledge (KO-Synchrocheck) is immediately sent
  - and no close command is sent to the circuit-breaker.

If the Evolutive mode for synchro close request management is defined in the configuration, a SPS “Delta drift” can be defined. Whenever Δf drifts from the Coupling range to the Locking range (outside of any overlap) during the search for min(Δφ), the SPS “Delta drift” is transmitted in the SET state. As soon as the Δf drift during the search for min(Δφ) is over, whatever the resulting acknowledgement: OK or KO-Synchrocheck, the SPS “Delta drift” is transmitted in the RESET state.

11.2.5.6 MANAGEMENT OF THE 5TH VT INPUT ON THE TMU220 BOARD

The fifth VT input allows using 2 different synchrocheck voltages: $V_{busbar1}$ and $V_{busbar2}$

This feature is also available with sampled values, but a second merging unit is required for $V_{busbar2}$.

An internal SPS, defined in the SCE configuration, allows choosing either voltage to close the circuit-breaker with synchrocheck. This SPS can be directly measured or derived using a programmable scheme logic (PSL). Depending on its state, the selected busbar voltage is:

- $V_{busbar1}$ if the SPS is RESET (or FORCED RESET or SUBSTITUTED RESET)
- $V_{busbar2}$ if the SPS is SET (or FORCED SET or SUBSTITUTED SET)

If the state of this SPS changes during a synchrocheck closure, the operation is aborted, a negative acknowledgement (*KO-Synchrocheck*) is sent and the system waits for a new command.

If the SPS is SELFCHECK FAULTY (or TOGGLING or UNKNOWN or SUPPRESSED), no busbar voltage can be used (automatic forcing can be used on this SPS to pre-define a behaviour in case of invalid state)

This SPS is optional: if it is not configured, $V_{busbar1}$ is used.

The 5th voltage input is associated to an RMS measurement and can be used in the same way as the other voltage inputs. This new measurement is defined using the SCE with the TMU220 board.

Samples from the fifth voltage channel can be included in fast waveform records.

The RMS value of $V_{busbar2}$ can be included in a slow waveform record.

11.2.6 CONFIGURATION AND SETTINGS

11.2.6.1 PARAMETERS OF THE TMU2XX BOARD

- Reference phase: definition of the voltage reference phase for comparison
- Reference phase side: definition of the energised reference voltage

11.2.6.2 CONFIGURATION

The table below lists all the parameters that can only be set in the SCE configuration (not in S1).

Configuration / Label in SCE	Setting range
SC type	type 1 or type 4
Check voltage	Yes or No
drift Management	Exclusive mode Evolutive mode Split mode (1)
wiring mode	star on both side delta on both side star on line - delta on busbar (2) delta on line - star on busbar(2)
Earth to Phase Coefficient	0 to 2, in steps of 0.01

(1) Split mode is available only for type 1 synchrocheck.

(2) for Type 1, mixed wiring (star on line - delta on busbar / delta on line - star on busbar) is available only if the acquisition board is a TMU220.

11.2.6.3 SETTINGS

The table below lists all the parameters that can be set in both the SCE configuration and using the setting software S1.

Setting name	Setting range	Type 1	Type 4	Comments
Timers				
T1: presence deltas test duration	From 20 ms to 10 s, in steps of 10 ms	✓	✓	
T2: presence test duration	From 200 ms to 10 s, in steps of 20 ms	✓	✓	
T3: absence deltas test duration	From 200 ms to 10 s, in steps of 20 ms	✓	✓	
Ta: close time of the Circuit-Breaker	0 to 1 s, in steps of 10 ms	✓	✓	For optimal performances, Ta must be greater than or equal to 50 ms
Control rejection time out	0 to 60 s, in steps of 1 s		✓	Must be greater than T1, T2 and T3.
Voltage presence conditions / Thresholds				
Line voltage over threshold	0 to 100% Vn, in steps of 1% Vn	✓	✓	
Line voltage under threshold	0 to 100% Vn, in steps of 1% Vn	✓	✓	
Bus voltage over threshold	0 to 100% Vn, in steps of 1% Vn	✓	✓	
Bus voltage under threshold	0 to 100% Vn, in steps of 1% Vn	✓	✓	
over voltage threshold	100% to 150% Vn, in steps of 1% Vn		✓	
Locking and Coupling				
Locking parameters				
Voltage delta threshold for locking	0 to 100% Vn, in steps of 1% Vn	✓	✓	
Minimum frequency for locking	45 to 59.5 Hz, in steps of 0.1 Hz	✓	✓	
Maximum frequency for locking	50.5 to 66 Hz, in steps of 0.1 Hz	✓	✓	
Frequency delta threshold for locking	0 to 1 Hz, in steps of 0.01 Hz	✓	✓	
Phase delta threshold for locking	0 to 90°, in steps of 1°	✓	✓	
Split parameters				
Voltage diff. drift management split mode	No or Yes	✓		Only used if drift management=Split mode
Min voltage diff. (%)	0 to 100% Vn, in steps of 1% Vn	✓		Only used if drift management=Split mode
Max voltage diff.(%)	0 to 100% Vn, in steps of 1% Vn	✓		Only used if drift management=Split mode
Frequency diff. drift management split mode	No or Yes	✓		Only used if drift management=Split mode
Min frequency diff. (Hz)	0 to 1 Hz, in steps of 0.01 Hz	✓		Only used if drift management=Split mode

Setting name	Setting range	Type 1	Type 4	Comments
Max frequencydiff. (Hz)	0 to 1 Hz, in steps of 0.01 Hz	✓		Only used if drift management=Split mode
Phase diff. drift management split mode	No or Yes (Yes must be selected if Split mode is used)	✓		Only used if drift management=Split mode
Min phase diff.	-180° to 0, in steps of 1°	✓		Only used if drift management=Split mode
Max phase diff.	0 to 180°, in steps of 1°	✓		Only used if drift management=Split mode
Time out drift management split mode	0 to 10 s, in steps of 0.1 s	✓		Only used if drift management=Split mode
Coupling parameters				
Voltage delta threshold for coupling	0 to 100% Vn, in steps of 1% Vn	✓	✓	
Minimum frequency for coupling	45 to 59.5 Hz, in steps of 0.1 Hz	✓	✓	
Maximum frequency for coupling	50.5 to 66 Hz, in steps of 0.1 Hz	✓	✓	
Maximum frequency delta threshold for coupling	0 to 1 Hz, in steps of 0.01 Hz	✓	✓	
Minimum frequency delta threshold for coupling	0 to 1 Hz, in steps of 0.01 Hz	✓	✓	
Phase delta threshold for coupling	0 to 90°, in steps of 1°	✓	✓	
Delay for coupling	1 to 3600 s, in steps of 1 s	✓	✓	
Schemes				
Close with synchro schemes				
Coupling and locking	No or Yes	✓	✓	
Locking	No or Yes	✓	✓	
Line Dead and Bus Live	No or Yes	✓	✓	
Line Live and Bus Dead	No or Yes	✓	✓	
Line Dead and Bus Dead	No or Yes	✓	✓	
Delay (ms)	From 200 ms to 10 s, in steps of 10 ms	✓	✓	
Close schemes				
Locking	No or Yes	✓	✓	
Line Dead and Bus Live	No or Yes	✓	✓	
Line Live and Bus Dead	No or Yes	✓	✓	
Line Dead and Bus Dead	No or Yes	✓	✓	
Delay (ms)	From 200 ms to 10 s, in steps of 10 ms	✓	✓	
AutoRecloser schemes				
Locking	No or Yes	✓	✓	
Line Dead and Bus Live	No or Yes	✓	✓	
Line Live and Bus Dead	No or Yes	✓	✓	
Line Dead and Bus Dead	No or Yes	✓	✓	

Setting name	Setting range	Type 1	Type 4	Comments
Delay (ms)	From 200 ms to 10 s, in steps of 10 ms	✓	✓	

11.2.6.4 THRESHOLD HYSTERESIS

A hysteresis is built into each threshold calculation in order to avoid multiple state changes for values close to the threshold (toggling):

- High ('over' / '>' / 'max') thresholds:

  The thresholds pick up at their set value and drop off at their set value minus the hysteresis.

- Low ('under' / '<' / 'min') thresholds:

  The thresholds pick up at their set value and drop off at their set value plus the hysteresis.

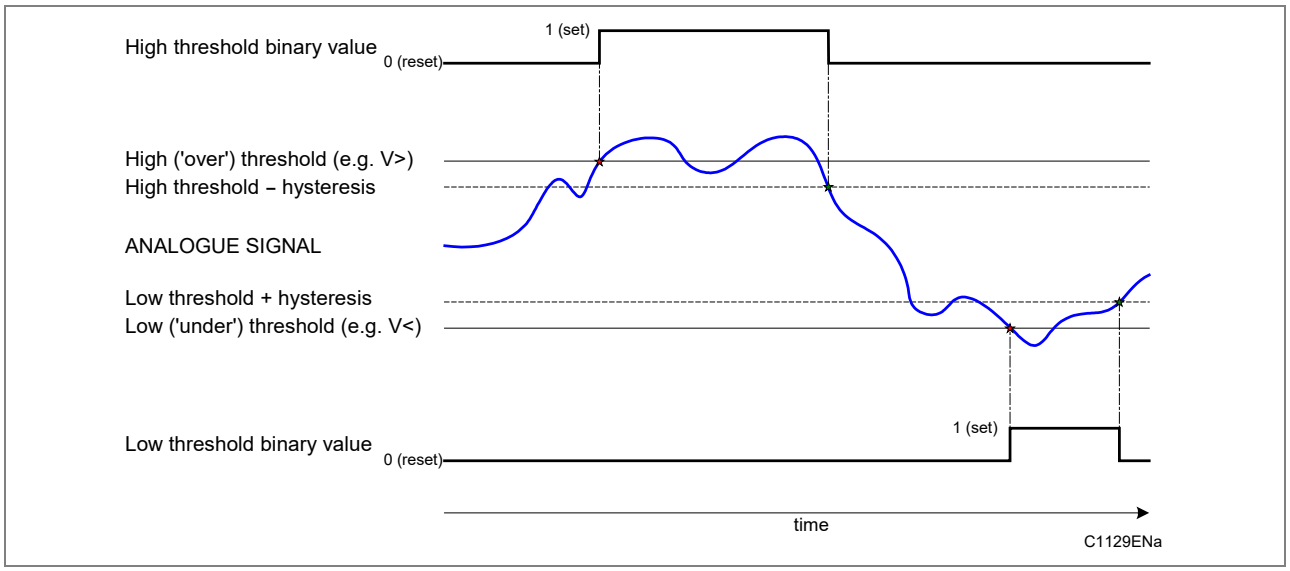


Figure 85: Pick-up/drop-off characteristics for high/low thresholds according to the relevant signal's variations

Values

- voltage thresholds: 5% of set value
- voltage delta threshold for locking and coupling:
  - 2% of nominal voltage for TMU220
  - 2% of delta voltage for TMU210
- frequency delta threshold for locking: 0.014 Hz
- frequency delta threshold for coupling: 0.014 Hz
- frequency delta threshold for split: 0.014 Hz
- over- and under-frequency thresholds: 0.1 Hz
- phase delta threshold for locking
  - +/– 1° for synchrocheck type 1/4

11.2.7 DIGITAL OUTPUT (DO) OF THE CIRCUIT-BREAKER

The DPC of the circuit-breaker can be configured on a DOU/HBU board of the BCU.

There are only 2 choices for the DPC type:

- Transient
- Permanent until feedback

If an SCU is used, intermediate SPCs must be used. See *Application chapter (C26x/EN AP)* for configuration information.

Note:
The check sequence is detailed at the end of the Interlocking section.

11.2.8 SYNCHROCHECK TYPE 5

11.2.8.1 TERMS USED IN THIS MANUAL

This section contains the lexical description of terms and definitions used in DS Agile system:

Terminology used in DS Agile system	Third party terminology
Coupling	Couplage asynchrone
Locking	Rebouclage synchrone
LDBD (Line Dead - Bus Dead)	Enclenchement hors tension
LDBL (Line Dead - Bus Live)	Renvoi tension - ligne
LLBD (Line Live - Bus Dead)	Renvoi tension - barre
LLBL (Line Live - Bus Live	Réseau sain
Voltage control	Contrôle tension

11.2.8.2 INTRODUCTION

The Synchrocheck type 5 built-in function is used in **conventional DCS architectures** and runs on an electrical bay managed by the Bay Controller Unit (BCU). This function checks the voltages upstream and downstream of a circuit breaker and allows closing when the differences in amplitude, frequency and phase are within authorized limits.

The Synchrocheck type 5 controls the CB reclosing synchronism schemes conditions with a permanent mode and reacts on-demand to a manual closing order transmitted by the operator, or to an automatic order of CB reclosing sent by the automatic recloser function.

The Synchrocheck feature can be used with Synchrocoupler function depending on configuration.

Analog measurements (VT) for this function are done through the TMU220 module only.

11.2.8.3 DATA USED

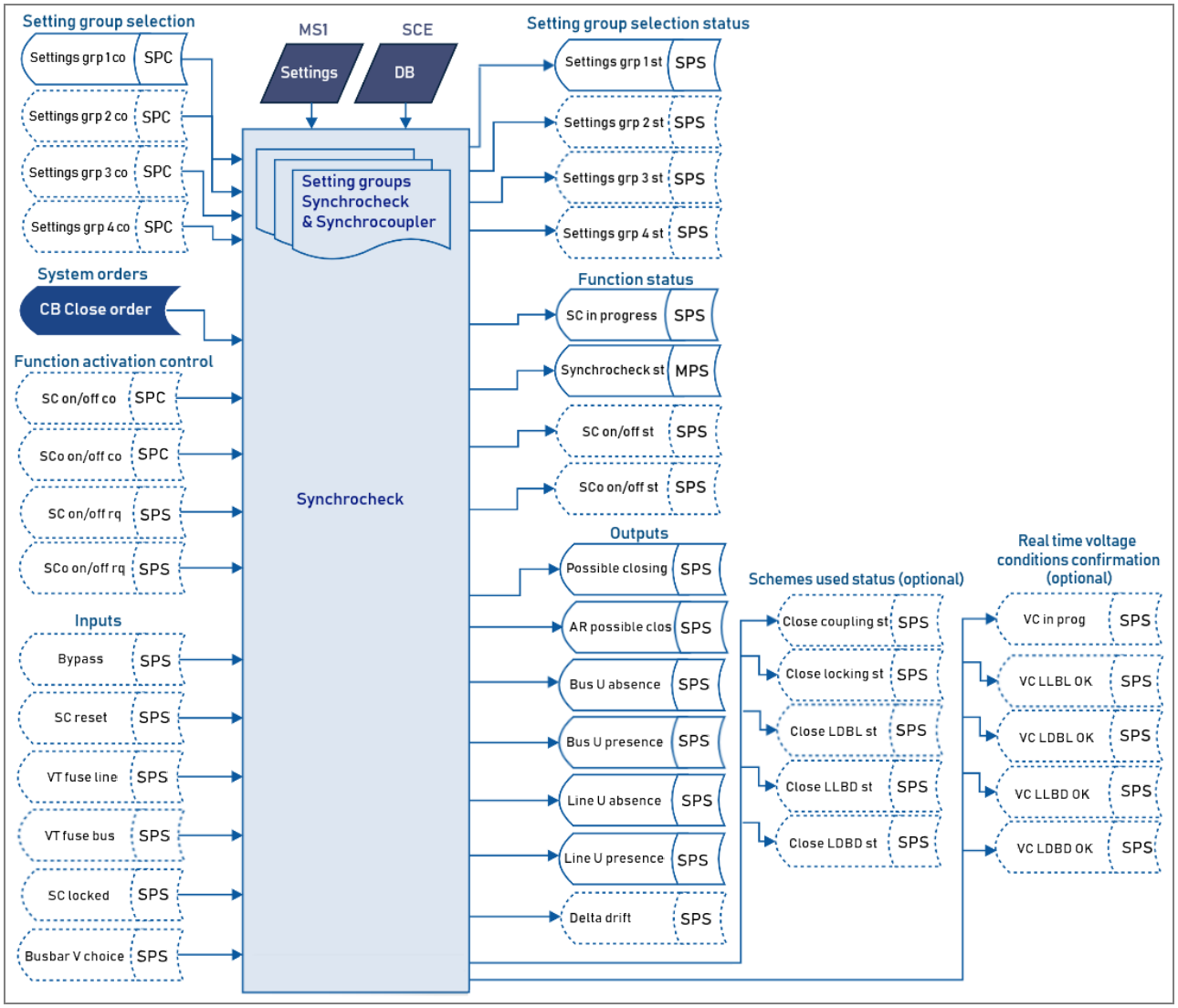


Figure 86: Synchrocheck Type 5 Data

11.2.8.4 SYNCHROCHECK TYPE

The built-in function is running on an electrical bay managed by the Bay Controller Unit (BCU). Two types of SC are possible:

- **Internal Synchrocheck only**:
  The Synchrocheck available schemes conditions shall be "manual close" and "autorecloser" (no "coupling" scheme conditions). The drift management can be configured to "Exclusive mode".

  When receiving an automatic reclosing order, if the scheme is confirmed by permanent mode, the reclosing of CB acknowledgement is immediately transmitted to control system, with bypass of interlock(s), and without confirmation timer. If a confirmation timer was in progress on permanent mode, it is stopped.

- **Internal Synchrocheck & Synchrocoupler**:
  The Synchrocheck schemes conditions used shall be "manual close" only and "autorecloser" scheme. The Synchrocoupler schemes conditions used shall be "manual close" only. The drift management can be configured to "Exclusive mode" or “Evolutive mode”.

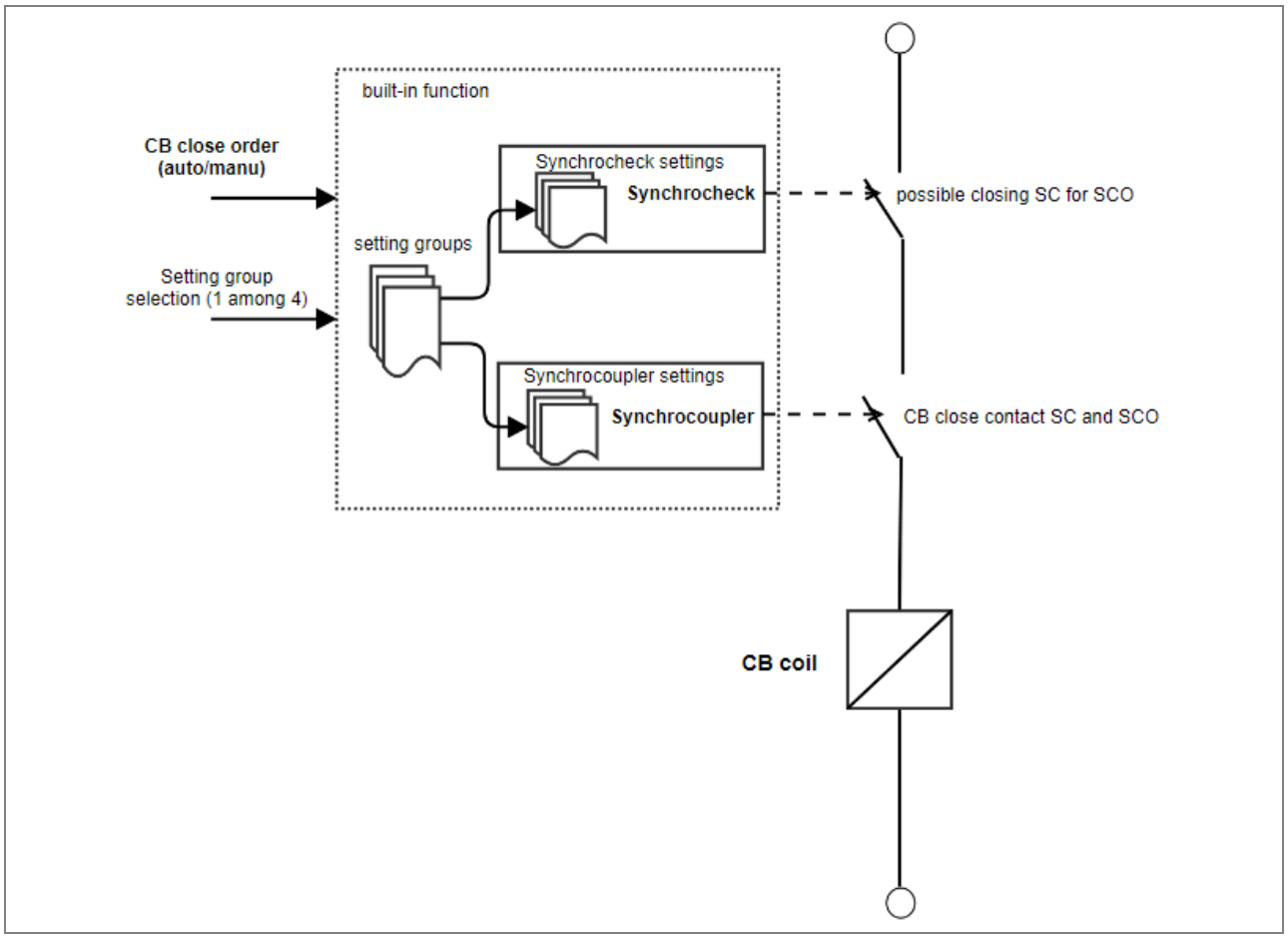


Figure 87: Synchrocheck / Synchrocoupler function

11.2.8.5 WIRING MODES

Standard wiring mode

- "Line" and "Busbar" sides are acquired in Ph-N (**star-on-both side**):
  - Acquired Ph-N "Line" voltage depends on the setting **reference phase** (A or B or C). The Ph-N wiring is selected (ex: Phase A for "A or AB" selection). Voltage is acquired in one phase (phase A or B or C).
- "Line" and "Busbar" sides are acquired in Ph-Ph (**delta-on-both-side**):
  - Acquired Ph-Ph "Line" voltage depends on the setting **reference phase** (AB or BC or CA). The Ph-Ph wiring is selected (ex: Phase AB for "A or AB" selection). Voltage is acquired in one phase (phase AB or BC or CA).

Star/Star wiring mode

LINE reference phase side:

If the **reference phase side** setting is "Phase A, B, C wired line side" AND If the **wiring mode** is “Star on both side”, the synchrocheck computation is performed as follows:

- **dV** = Acquired Ph-N "Line" voltage - Ph-N "Busbar" voltage
- **dF** = | Frequency of acquired Ph-N "Line" voltage - Freq of Ph-N "Busbar" voltage|
- **dΦ** = |Φ of acquired Ph-N "Line" voltage - Φ of Ph-N "Busbar" voltage|

BUSBAR reference phase side:
If the **reference phase side** setting is "Phase A, B, C wired busbar side" AND If the **wiring mode** is “Star on both side”, the synchrocheck computation is performed as follows:

- **dV** = Acquired Ph-N "Busbar" voltage - Ph-N "Line" voltage
- **dF** = | Freq of acquired Ph-N "Busbar" voltage - Freq of Ph-N "Line" voltage|
- **dΦ** = |Φ of acquired Ph-N "Busbar" voltage - Φ of Ph-N "Line" voltage|

Delta/Delta wiring mode

LINE reference phase side:
If the setting **reference phase side** is "Phase A, B, C wired line side" AND If the **wiring mode** is “Delta on both side”, the synchrocheck computation is performed as follow:

- **dV** = Acquired Ph-Ph "Line" voltage - Ph-Ph "Busbar" voltage
- **dF** = | Freq of acquired Ph-Ph "Line" voltage - Freq of Ph-Ph "Busbar" voltage|
- **dΦ** = |Φ of acquired Ph-Ph "Line" voltage - Φ of Ph-Ph "Busbar" voltage|

BUSBAR reference phase side:
If the setting **reference phase side** is "Phase A, B, C wired busbar side" AND If the **wiring mode** is “Delta on both side”, the synchrocheck computation is performed as follow:

- **dV** = Acquired Ph-Ph "Busbar" voltage - Ph-Ph "Line" voltage
- **dF** = | Freq of acquired Ph-Ph "Busbar" voltage - Freq of Ph-Ph "Line" voltage|
- **dΦ** = |Φ of acquired Ph-Ph "Busbar" voltage - Φ of Ph-Ph "Line" voltage|

11.2.8.6 FUNCTION ACTIVATION / DEACTIVATION

The Synchrocheck and Synchrocoupler function can be activated and deactivated using specific datapoints:

- **SC on/off co** and **SCo on/off co** SPC control datapoints are used to enable or disable a synchrocheck or **synchrocoupler** cycle.
- **SC on/off rq** and **SCo on/off rq** SPS request datapoints are used to enable or disable a local function

while status datapoints (**SC on/off st** and **SCo on/off st) monitor the function status.**

The last status of **SC on/off st** and **SCo on/off st** are saved and restored upon the C264 reboot or DB switch.

11.2.8.7 SETTING GROUP(S)

Up to 4 setting groups can be defined at configuration level (SCE) and activated through dedicated datapoints. Only one setting group is active at a time.

The **SetGroup X ctrl** (SPC) datapoint can be:

- set from the SCADA through the Gateway
- set from the DS Agile Operator Interface (aView)
- set from the C26X Control panel (LHMI)
- set by activating a wired BI
- activated by an FBD or an automation (PLC)

The active setting group is saved at DB level and overwrites the previous default setting group value.

If no CB close command occurs:

- if the SC function receives a valid setting group control, the function is reset, and the new setting group values are taken into account.

When a CB close command is received:

- if the SC function receives a new valid setting group control, the function returns a negative acknowledgement to the setting group control and keeps on checking the CB close command in progress.

Note:

The “Default setting group” value is restored upon the C264 reboot or DB switch as the active setting group.

If a **SetGroup X ctrl** (SPC) datapoint used in the function becomes INVALID, the "Default setting group" stored at C264 level is then used as the active setting group.

11.2.8.8 INPUT DATAPOINTS

11.2.8.8.1 Function Bypass

In some cases, bypassing the SC function may be necessary to switch on the circuit breaker when the bay is out of service.

To do so, the optional **Bypass** (SPS) datapoint can be added to the Synchrocheck function. This datapoint can be wired, managed by an automation or associated with a control.

The **Bypass** (SPS) datapoint is RESET by default.

If the **Bypass** (SPS) datapoint goes and remains at the SET state:

- when a "close order" is received, the control unit generates a positive acknowledgement whatever the synchronism conditions status (voltage conditions and locking/coupling modes)
- The **possible closing** (SPS) datapoint status is forced to SET state
- The **AR possible clos** (SPS) datapoint is forced to SET state

When the BYPASS (SPS) datapoint goes to RESET, the Synchrocheck function is reinitialized.

Downgraded mode:

If the function is locked (**VT FUSE LINE** SPS information positioned and/or **VT FUSE BUSBAR** (SPS) datapoints in SET state:

- the function is immediately unlocked when the BYPASS (SPS) switches to SET state
- when a "close order" is received, the control unit generates a positive acknowledgement, even if the VTs MCBs are tripped (refer to "VT MCB TRIP" description).

When the BYPASS (SPS) is RESET (with VT fuse datapoint(s) already in SET state), the function is immediately locked.

11.2.8.8.2 Function Reset

An optional datapoint "**SC reset**" (transient SPS) can be added to the Synchrocoupler configuration to stop the function.

This datapoint can be wired to an operator control:

- at bay level: push-button control, bay controller LCP (LHMI)
- at substation level: substation control point (SCP)
- at SCADA level: remote control point (RCP)

By default, the "**SC reset**" (SPS) datapoint is in RESET state with a VALID quality.

When the **"SC reset"** (SPS) datapoint switches to SET state:

- if the Synchrocoupler runs a scheme confirmation or a min($\Delta\varphi$) search, the temporization is stopped
- a negative acknowledgement (*KO-Synchrocheck*) is sent and no close command is sent to the circuit-breaker
- the function is reset

If the "**SC reset**" (SPS) datapoint changes when the Synchrocoupler is in standby mode, the function is reset.

11.2.8.8.3 Function Locked

The Synchrocheck/Synchrocoupler function can locked and unlocked using the optional **"SC locked"** (SPS) datapoint.

When the **"SC locked"** (SPS) datapoint is SET, the synchrocheck process currently running is aborted and the control unit generates a negative acknowledgement (KO Device Lock).

If the **"SC locked"** (SPS) is SET before the search for closing is started, then:

- the timer to start the voltage condition search is not started (T1, T2...)
- a negative acknowledgement (*KO-Synchrocheck*) is sent and no close command is sent to the circuit-breaker.

11.2.8.8.4 VT Fuse Line & VT Fuse Busbar

If a miniature circuit breaker (MCB) placed on the secondary side of VT circuits is tripped, the synchrocheck/Synchrocoupler functions can be locked using two optional datapoints:

- **VT FUSE LINE** (SPS): MCB trip on the secondary side of VT transducer located at LINE side of circuit breaker
- **VT FUSE BUS** (SPS): MCB trip on the secondary side of VT transducer located at BUSBAR side of circuit breaker

These datapoints are received either through a BI or an automation (PLC, FBD).

By default, the **"VT fuse line"** (SPS) and **"VT fuse bus"** (SPS) datapoints are in a RESET state with a VALID quality.

When this/these SPS is/are in SET state, the synchrocheck/Synchrocoupler function is locked. When the VT fuse information is RESET, the function is reinitialized.

11.2.8.8.5 VT Transformer Ratio

The synchrocheck/Synchrocoupler function uses the transformer ratio, and the possible phase displacement to compare the voltages when VTs are placed on either side of a transformer (Line/Bus).

At Synchrocheck configuration level, when the “**with transfo ratio**” setting is set to **Yes**:

- The attributes "Voltage ratio (V)" shall define the secondary voltage of VT located at secondary side of power transformer / the secondary voltage of VT located at primary side of power transformer.
- The attribute "Secondary HV phase shift" defines the phase shift (leading=positive, lagging=negative) of voltage vectors, between VT located at secondary side of power transformer vs voltage of VT located at primary side of power transformer.
- By convention, the primary vector is taken as reference (phase = 0°)

The Synchrocheck or Synchrocheck & Synchrocoupler functions control the CB synchronism according to:

- the primary voltage magnitude, compared to the secondary voltage magnitude, in %Un defined at configuration level.
- the primary voltage phase, compared to the secondary voltage phase, modified statically by the phase shift value defined at configuration level.

11.2.8.8.6 Input Datapoint Invalidity

If one of the optional datapoints (**SC on/off co / SCo on/off co** / **SC Reset** / **Bypass / VT fuse line** / **VT fuse bus**) is received with an INVALID quality, the Synchrocheck/Synchrocoupler function is locked

As soon as the datapoint quality is VALID again, the Synchrocheck/Synchrocoupler function is reinitialized and waits for a new close order.

11.2.8.8.7 Voltage Check

The "voltage present" and "voltage missing" conditions (used for "voltage conditions" results) are tested by the SC type 5 function one phase of the busbar and on one or three phases of the Line depending on the **Check 3P voltage** attribute set in the SC type 5 configuration.

The "line voltage over threshold(%)" and "**line voltage under threshold(%)**" must also be defined at the SC type 5 function level.

If the "**Check 3P voltage**" is set to "**No**":

- the “Line” voltage conditions are checked on the TMU220 "reference phase" (A or B, or C), with the over and under voltage thresholds defined at function level.

If the "**Check 3P voltage**" is set to "**Yes**":

the “Line” voltage conditions are checked over the three phases (A and B and C), with the over and under voltage thresholds defined at function level.

11.2.8.9 OUTPUT DATAPOINTS

11.2.8.9.1 Possible Closing

To authorize synchronised closing, the **Possible closing** (SPS) datapoint is present at Synchrocheck function level. By default, the datapoint is VALID with RESET state.

On permanent mode, the **Possible closing** (SPS) is SET when the voltage condition (VC xxxx OK) authorized by the active setting group is confirmed.

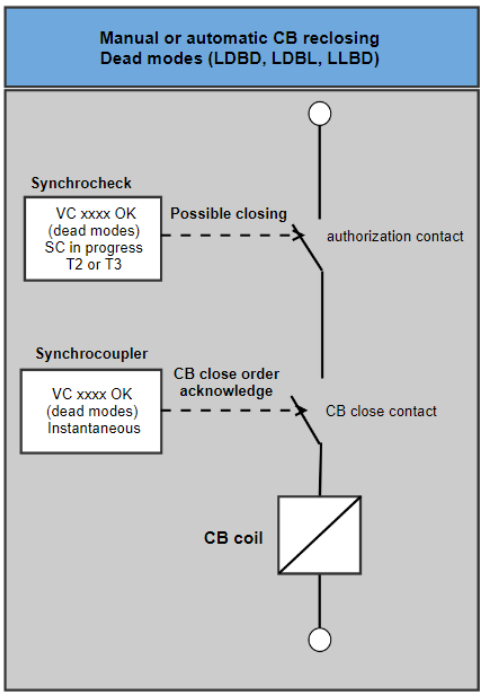
The **Possible closing** (SPS) is updated whatever the manual or automatic valid schemes:

- LLLB (locking mode) OR LLLB close scheme (coupling mode)
- LL/DL
- DB/LL
- DB/DL

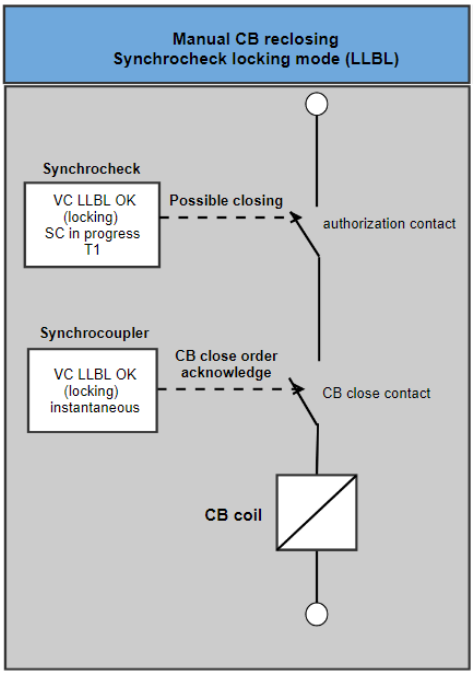
Voltage Conditions	Permanent mode	On-demand mode (manual order received)	On-demand mode (automatic order received)
Not present (steady state)	Possible closing (SPS) is RESET	Possible closing (SPS) is RESET KO acknowledgement is sent not to close the circuit breaker	Possible closing (SPS) is RESET KO acknowledgement is sent, not to close the circuit breaker.
become present	Possible closing (SPS) is RESET state until the confirmation timeout (T1 or T2 or T3) expires. After confirmation, Possible closing (SPS) is SET	Possible closing (SPS) is RESET until the confirmation timeout (T1, T2, T3) expires. Possible closing (SPS) is SET Temporization started to synchronise the "authorization contact" closure and the "CB close order" relays OK acknowledgement is sent to close the circuit breaker.	Confirmation timeout (T1, T2, T3) is stopped Possible closing (SPS) is immediately SET Temporization started to synchronise the "authorization contact" closure and the "CB close order" relays OK acknowledgement is sent, to close the circuit breaker.

Synchrocheck/Synchrocoupler function can manage the following closing use cases:

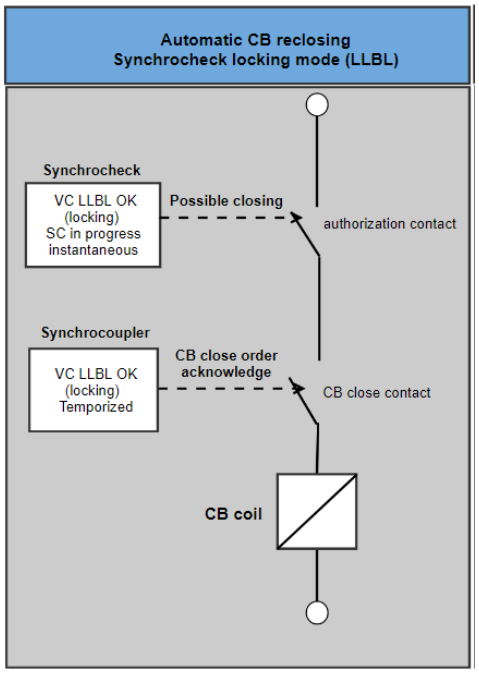
Manual or automatic CB reclosing - Dead modes (LDBD, LDBL, LLBD)



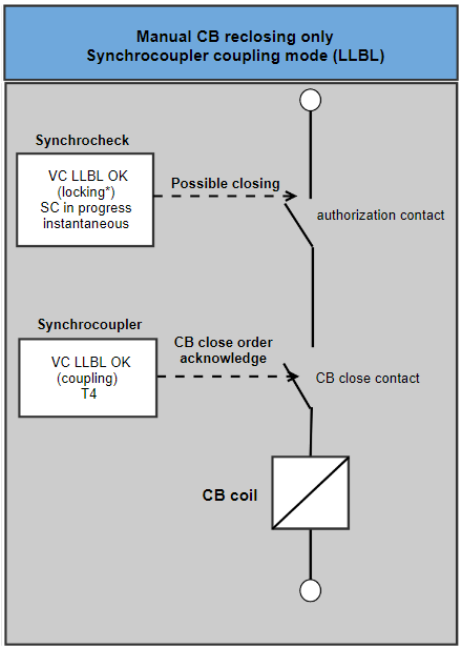
Manual CB reclosing - Synchrocheck locking mode (LLBL)



Automatic CB reclosing - Synchrocheck locking mode (LLBL)



Manual CB reclosing only - Synchrocoupler coupling mode (LLBL)



Notes:

* To authorize a CB closure in an asynchronous network (coupling mode), the "ΔF" range checked by the Synchrocheck relay (authorization contact) is a combination of the "ΔF locking" and "ΔF coupling" ranges.

For locking and coupling conditions description, refer to:

- Line Live Bus Live (LLBL) close scheme (locking mode) description
- Line Live Bus Live (LLBL) close scheme (coupling mode) description

11.2.8.9.2 AR Possible closing

To authorize automatic CB reclosing, the **AR possible clos** (SPS) datapoint is present at Synchrocheck function level.

By default, the datapoint is VALID with RESET state and remains at RESET state whatever the **manual valid** schemes.

The **AR possible clos** (SPS) is updated whatever the **automatic valid** schemes:

- LLLB close scheme (locking mode)
- LB/DL
- DB/LL
- DB/DL

Voltage Conditions	Permanent mode with automatic valid scheme	On-demand mode (manual order received)	On-demand mode (automatic order received)
Not present (steady state)	**AR Possible clos** (SPS) is RESET	**AR possible clos** (SPS) is RESET	**AR possible clos** (SPS) is RESET
become present	**AR possible clos** (SPS) is RESET state until the confirmation timeout (T1 or T2 or T3) expires. After confirmation, **AR possible clos** (SPS) is SET	**AR possible clos** (SPS) is RESET	**AR possible clos** (SPS) is RESET until the confirmation timeout (T1 or T2 or T3) expires. After confirmation, **AR possible clos** (SPS) is SET

11.2.8.9.3 Setting Group Activation Status

The setting groups activation status can be monitored through dedicated **SetGroup X st** (SPC) datapoints as described in the C26x_AP/EN chapter.

These datapoints can be:

- sent to the SCADA through the Gateway
- displayed on the DS Agile Operator Interface (aView)
- displayed in the C26X States panel (LHMI)
- input into an FBD or an automation (PLC)

11.2.8.9.4 Synchrocheck in progress Status

The Synchrocheck status **SC in progress** (SPS) is present by default at Synchrocheck function level.

By default, this SPS is in RESET state with a VALID quality and goes to SET state:

- when a "close order" is received by the function
- during the confirmation delay (voltage control, locking or coupling)
- until a positive or negative acknowledgement is sent

Independently of the result, the datapoint is RESET after the acknowledgement transmission.

11.2.8.9.5 Used Schemes Status

Optional datapoints can be configured at Synchrocoupler/Synchrocheck function to monitor the manual close schemes status:

- **Close coupl st** (SPS): SET when the "Coupling" Synchrocoupler scheme is used
- **Close LDBD st** (SPS): SET when the " Dead Line / Dead Bus " manual scheme is used
- **Close LDBL st** (SPS): SET when the " Dead Line / Live Bus " manual scheme is used
- **Close LLBD st** (SPS): SET when the " Live Line / Dead Bus " manual scheme is used
- **Close locking st** (SPS): SET s when the "Locking" manual scheme is used

By default, these SPS are RESET with a VALID quality.

11.2.8.9.6 Voltage Condition Status

To monitor the confirmed schemes status, optional datapoints can be configured at Synchrocoupler/Synchrocheck function level:

- **VC in prog** (SPS): SET as long as voltage conditions are being confirmed. RESET when voltage conditions in progress are confirmed.
- **VC LLBL ok** (SPS): SET as long as the "Live Line / Live Bus" close scheme is confirmed. RESET if one condition is not met.
- **VC LDBL ok** (SPS): SET as long as the "Dead Line / Live Bus" close scheme is confirmed. RESET if one condition is not met.
- **VC LLBD ok** (SPS): SET as long as the "Live Line / Dead Bus" close scheme is confirmed. RESET if one condition is not met.
- **VC LDBD ok** (SPS): SET as long as the " Dead Line / Dead Bus " close scheme is confirmed. RESET if one condition is not met.

By default, these SPS are RESET with a VALID quality.

Only one datapoint can be in the SET state at the same time. During the confirmation delay, the **VC in prog** (SPS) is in the SET state. At the end of confirmation timer, one of the voltage conditions is at the SET state.

11.2.8.9.7 Synchrocheck Status

A multiple state datapoint **Synchrocheck st** (MPS) can be used at Synchrocheck function level to get the real time status of the SC function if the command is issued at bay level, from IEC 61850, from an automation (FBD) or (IEC61131-3) or, from substation HMI (DS Agile aView).

The possible states are:

- 0: synchrocheck-ready
- 1: synchrocheck-bypass
- 2: synchrocheck-in-progress
- 3: synchrocheck-ok
- 4: synchrocheck-ko
- 5: synchrocheck-locked

11.2.8.9.8 Voltage Status

Voltage status can be monitored at Synchrocheck function level using the following datapoints. These SPS are updated continuously to provide the Line and Busbar voltage status according to the predefined thresholds.

Datapoint	Description	Threshold	SET	RESET
Bus U absence (SPS)	Busbar voltage absence status	Busbar voltage under threshold	Voltage < threshold	Voltage ≥ threshold
Bus U presence (SPS)	Busbar voltage presence status	Busbar voltage over threshold	Voltage ≥ threshold	Voltage < threshold
Line U absence (SPS)	Line voltage absence status	Line voltage under threshold	Voltage < threshold	Voltage ≥ threshold
Line U presence (SPS)	Line voltage presence status	Line voltage over threshold	Voltage ≥ threshold	Voltage < threshold

11.2.8.9.9 Frequency Drift Status

The optional **"Delta drift"** (SPS) optional datapoint can be added to the Synchrocheck function level to get the frequency drift status.

When a frequency drift of Δ**f** during the "min($\Delta\varphi$) search" occurs in evolutive mode, the **"Delta drift"** (SPS) is sent in the SET state. As soon as the drift of Δf during the "min($\Delta\varphi$) search" is over, the "**Delta drift**" (SPS) is sent in the RESET state.

11.2.8.9.10 CB Control for Synchrocheck-Synchrocoupler

For Synchrocheck/Synchrocoupler use case, 2 physical relay contacts are put in serial with circuit breaker coil circuitry, to reinforce the reclosing order security.

The physical contact of Synchrocheck relay (**SC**) is linked to the **Possible closing** (SPS) and the **SC in progress** (SPS) datapoints.

To limit the current switched by the contact (**DOU20x**), the SC relay shall be CLOSED when the control positive acknowledgement is sent by the function.

The physical contact of Synchrocoupler relay (**SCO**) is linked to the Circuit Breaker **Switch Ctrl** (DPC). The relay contact energizes the CB coil circuitry.

In case of indirect CB coil release circuitry (conventional substation, with intermediate relays into CB marshalling boxes), the **DOU20x** contact can be used.

In case of direct CB coil release circuitry, the **HBU20x** contact is recommended.

11.2.8.9.11 Synchrocheck or Synchrocoupler Measurement

The measurements used by the Synchrocheck and the Synchrocoupler functions (voltage, frequency, phase difference between line and busbar and value) are configured through the "is computed by:<TMU220>"" relation at MV modules level and transmitted to the supervision level (aView):

- **voltage_difference**: voltage difference between line and busbar
- **frequency_difference**: frequency difference between line and busbar
- **phase difference**: phase difference between line and busbar
- **RMS value of the voltage phase A, B or C**: voltage value at line side
- **Vbusbar 1**: Voltage value at busbar side
- **network frequency**: frequency value at line side
- **Frequency busbar1**: frequency value at busbar1
- **frequency busbar2**: frequency value at busbar2

Note: The busbar voltage is a Ph-N voltage, in a STAR wiring mode, with external electro-mechanical switchover for two busbar topologies.

11.2.8.10 MANUAL CLOSE AND AUTO-RECLOSER CONDITIONS (LOCKING LOGIC)

Voltage conditions are the same for manual close and auto-recloser requests and are checked during a set time-delay.

Voltage conditions

The voltage conditions are:

Voltage present

- Vline: On the line VT, the voltage of the set reference circuit is higher than the set threshold **line voltage over threshold(%)**.
- Vbusbar: On the busbar VT, the voltage is higher than the set threshold **bus voltage over threshold(%)**

Voltage missing:

- Not(V_{line}): On the line VT, the voltage of the set reference circuit is lower than the set threshold **line voltage under threshold (%)**.
- Not(V_{busbar}): On the busbar VT, the voltage is lower than the set threshold (**bus voltage under threshold(%)**.

Permitted voltage delta

- $\Delta V < \Delta V_{locking}$: the difference between the line voltage and the busbar voltage is lower than the set threshold **voltage delta threshold for locking(%)**.

Permitted Frequency Delta

- $\Delta f < \Delta f_{locking}$: the difference between the line frequency and the busbar frequency is lower than the set threshold **frequency delta threshold for locking (Hz)**

Permitted frequency range

- $f_{min\ locking} < f_{line} < f_{max\ locking}$: the line voltage frequency is comprised between the set thresholds **minimum frequency for locking(Hz)** and **maximum frequency for locking(Hz)**
- $f_{min\ locking} < f_{busbar} < f_{max\ locking}$: the busbar voltage frequency i is comprised between the set thresholds **minimum frequency for locking(Hz)** and **maximum frequency for locking(Hz)**

Permitted phase angle delta

- $\Delta\varphi \leq \Delta\varphi_{locking}$: the difference between the line voltage phase angle (for the configured reference circuit) and the busbar voltage phase angle is lower than the set threshold **phase delta threshold for locking(°)**.

Dead Line / Dead Bus

The Dead Line / Dead Bus (DLDB) voltage conditions are met if:

- Line = Voltage missing
- Busbar = Voltage missing
- During the T3 or **absence test duration** (*total time-delay during which the absence of both voltages is confirmed*).

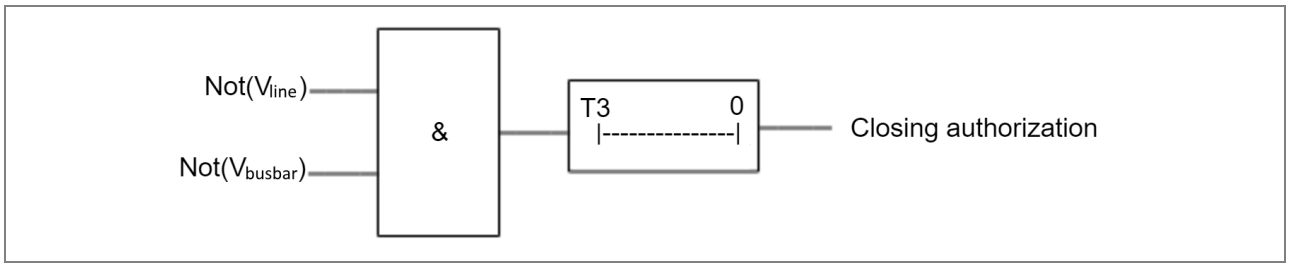


Figure 88: Not(Vline) and not(Vbusbar) voltage check

When the Dead Line / Dead Bus (DLDB) voltage conditions are met, CB closure is authorized (in the case of manual/automatic close request).

If either DLDB condition criterion is lost during T3, the DLDB voltage condition is no longer verified and T3 is reset. T3 will be restarted only upon the reappearance of all criteria.

note: this scheme is also used in case of **Synchrocoupler** scheme.

Dead Line / Live Bus

The Dead Line / Live Bus (DLLB) voltage conditions are met if:

- Line = Voltage missing
- Busbar = Voltage present
- during T2 or p**resence test duration** (*time delay during which, the presence of only one voltage is confirmed*).

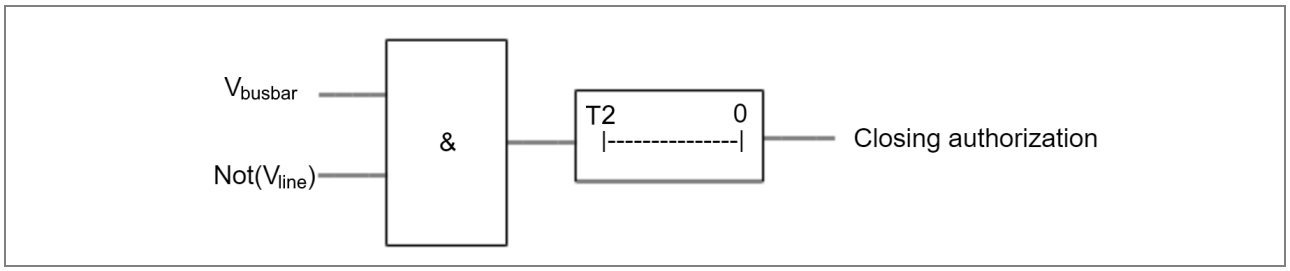


Figure 89: not(Vline) and Vbusbar voltage check

When the Dead Line / Live Bus (DLLB) voltage conditions are met, CB closure is authorized (in case of manual/automatic close request).

If either DLLB condition criterion is lost while T2 elapses, the DLLB condition is no longer verified and T2 is reset. T2 is restarted only upon the reappearance of all the criteria.

Note: this scheme is also used in case of **Synchrocoupler** scheme.

Live Line / Dead Bus

The Live Line / Dead Bus (LLDB) voltage conditions are met if:

- Line = Voltage present
- Busbar = Voltage missing
- During T2 or **presence test duration** (*total time delay during which the presence of only one voltage is confirmed*).

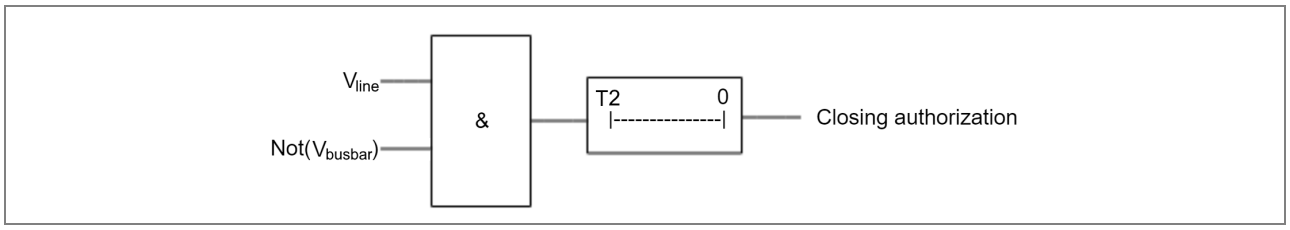


Figure 90: not(Vbusbar) and Vline voltage check

When the Live Line / Dead Bus (LLDB) closing conditions are met, CB closure is authorized (in case of manual/automatic close request).

If either LLDB condition criterion is lost while T2 elapses, the LLDB voltage condition is no longer verified and T2 is reset. T2 is restarted only upon the reappearance of all the criteria.
Note: this scheme is also used in case of **Synchrocoupler** scheme.

Live Line / Live Bus

The Live Line / Live Bus (LLLB) voltage conditions are met if:

- Line = Voltage present
- Busbar = Voltage present
- Voltage Delta (locking) = OK
- Frequency Delta (locking) = OK
- Phase Delta locking) = OK
- during T1 (confirmation timer for manual synchrocheck) or T1' (confirmation timer for automatic synchrocheck) or **presence delta test duration** (total time delay during which the presence of both voltages is confirmed). Note: this voltage condition is currently called "**locking mode**".

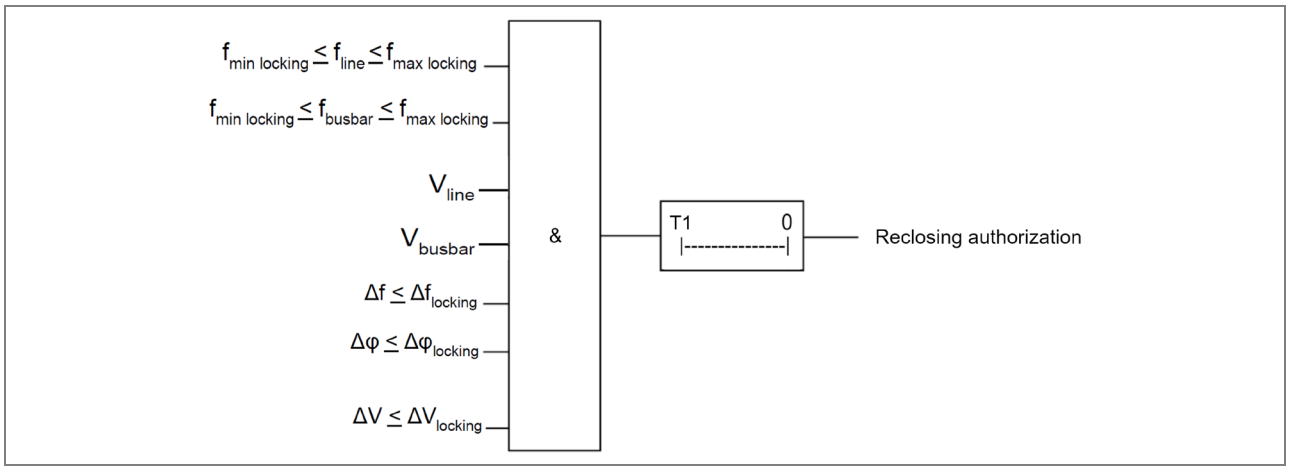


Figure 91: Locking scheme for type 5 synchrocheck

When the Live Line / Live Bus (LLLB) voltage conditions are met, CB closure is authorized.

If any LLLB condition criterion is lost during T1 or T1', the LLLB condition is no longer verified and T1 or T1' is reset. It will be restarted only upon the reappearance of all the criteria.

11.2.8.11 SYNCHRO CLOSE CONDITIONS (COUPLING LOGIC)

Voltage conditions for synchro close requests are checked during a set time-delay.

Voltage conditions

The voltage conditions are:

Voltage present:

- V_{line}: On the line VT, the voltage of the set reference circuit is higher than the set threshold **line voltage over threshold**.
- V_{busbar}: On the busbar VT, the voltage (only one circuit available) is higher than the set threshold **bus voltage over threshold**.

Voltage missing:

- Not(V_{line}): On the line VT, the voltage of the set reference circuit is lower than the set threshold **line voltage under threshold (%)**.
- Not(V_{busbar}): On the busbar VT, the voltage is lower than the set threshold (**bus voltage under threshold(%)**.

Permitted voltage delta:

- The difference between the line voltage and the busbar voltage is lower than the set threshold **voltage delta threshold for coupling**.

Permitted frequency delta range:

- $\Delta f_{min\ locking} < \Delta f < \Delta f_{max\ locking}$: The difference between the line frequency and the busbar frequency is comprised between the set thresholds **minimum frequency delta threshold for coupling** and **maximum frequency delta threshold for coupling**.

Permitted frequency range:

- $f_{min\ locking} < f_{line} < f_{max\ locking}$: The line voltage frequency is comprised between the set thresholds **minimum frequency for coupling** and **maximum frequency for coupling**.
- $f_{min\ locking} < f_{busbar} < f_{max\ locking}$: The busbar voltage frequency is comprised between the set thresholds **minimum frequency for coupling** and **maximum frequency for coupling**.

Live Line / Live Bus

The Live Line / Live Bus (LLLB) voltage conditions are met if:

- Line = Voltage present
- Busbar = Voltage present
- Voltage Delta (coupling) = OK
- Frequency Delta (coupling) = OK
- during T4 or **presence delta test duration** (*total time-delay during which the presence of both voltages is confirmed*).

Note: this voltage condition is currently called "**coupling mode**".

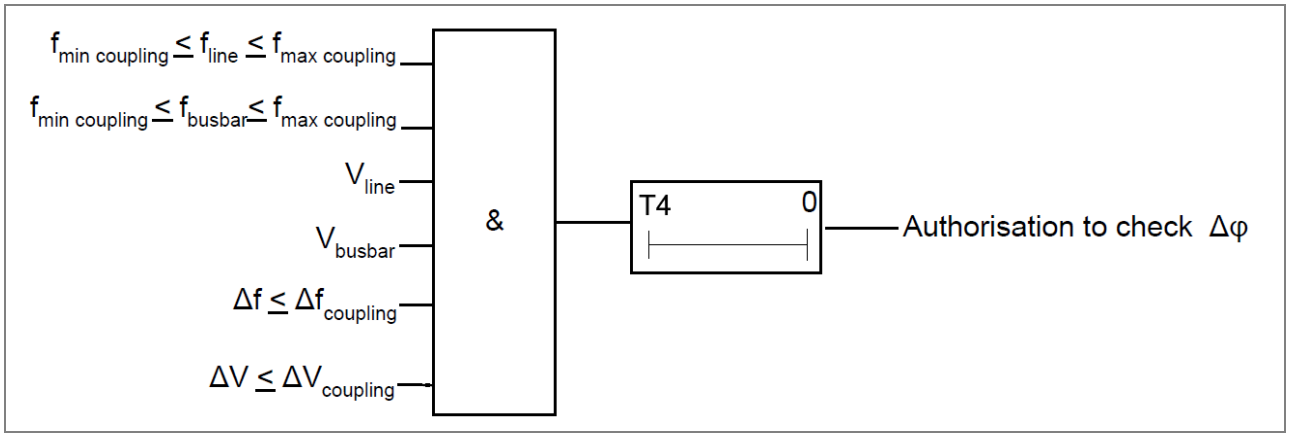


Figure 92: Coupling scheme for type 5 synchrocheck

When the Live Line / Live bus (LLLB) voltage conditions are met, a synchrocoupler close request will authorize searching for min(Δφ).

If any LLLB condition criterion is lost during T4, the LLLB voltage condition is no longer verified and T4 is reset. It will be restarted only upon the reappearance of all the criteria.

The search for min(Δφ) is launched, in order to find the optimal phase difference between line and busbar to close the circuit-breaker. In the min(Δφ) search, the circuit-breaker's operating time (Ta) must be taken into account.

Phase delta condition

In an asynchronous network, the synchrocoupler relay (SCO) tries to close the circuit breaker when the phase reference is **0°**.

The min(Δφ) is reached when Δφ = Δf*360*Ta

where:

- Δφ = computed phase difference (°)
- Δf = frequency delta for coupling (mHz)
- Ta = circuit-breaker operating time

Phase Delta for coupling:

If min(Δφ) cannot be reached due to Δf being close to 0, then closing is permitted when the following condition is met:

$-\Delta\varphi_{coupling} \leq \Delta\varphi \leq +\Delta\varphi_{coupling}$

Where:

- Δφ: computed phase difference (°)
- Δφcoupling = setting for **phase delta threshold for coupling(°)** attribute

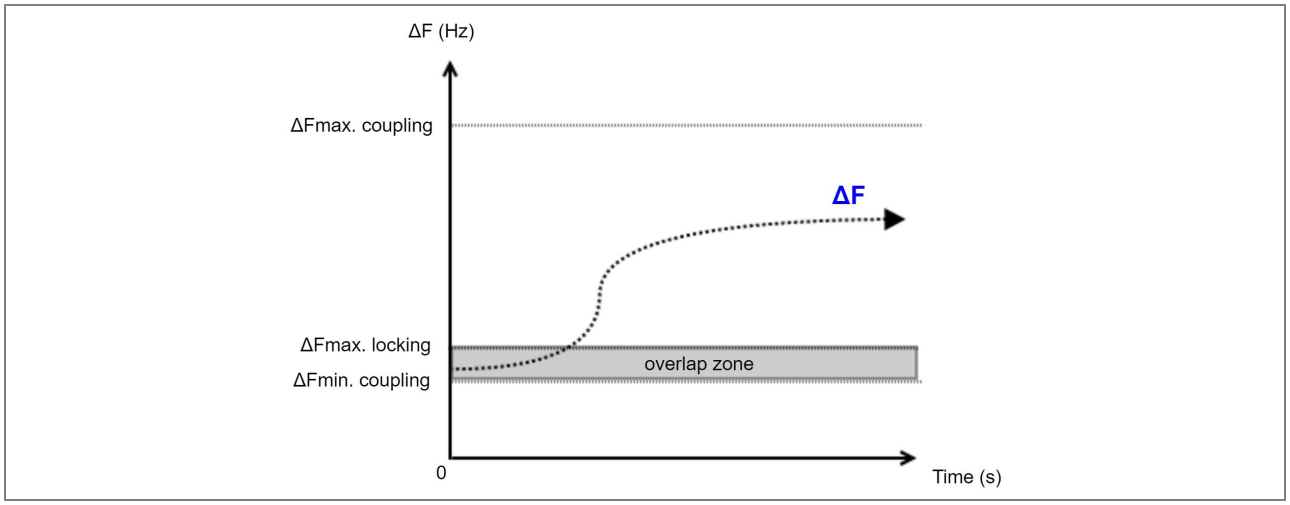
Frequency range definition (Locking mode vs. Coupling mode)

In order to discriminate between the locking and coupling modes, 2 separate ranges for frequency differences are defined in the configuration.

- Locking range: [0 … $\Delta f_{max\ locking}$]
  - **frequency delta threshold for locking (Hz)**: from 0.0 to 1.0 Hz, by step of 0.01 (default value 0.1
- Coupling range: [$\Delta f_{min\ coupling}$ … $\Delta f_{max\ coupling}$]
  - **minimum frequency delta threshold for coupling (Hz)**: from 0.0 to 1.0 Hz, by step of 0.01, (default value 0.1)
  - **maximum frequency delta threshold for coupling (Hz)**: from 0.0 to 1.0 Hz, by step of 0.01, (default value 0.1)

The 2 ranges may overlap but the following condition must be met:

- Δf_{max} coupling > Δf_{max} locking



11.2.8.12 CLOSING SCHEMES

To enable closing only when the required voltage conditions are met, separate closing schemes are configured for each type of close request:

Manual close

For the manual close request, and for each voltage condition, closing schemes are defined at SCE level and modified by setting groups changeover, as shown below:

Voltage Conditions	Close Authorisation
Dead Line / Dead Bus	YES / NO
Dead Line / Live Bus	YES / NO
Live Line / Dead Bus	YES / NO
Live Line / Live Bus (locking)	YES / NO

If the **Close authorization** is set to "NO", the Scheme Control result is set to "Rejected".

If the **Close authorization** configured to "YES", the following checks are performed for manual close requests:

Voltage Conditions	Closing Authorisation	Verified Voltage Conditions	Close request result
Dead Line / Dead Bus	YES	DLDB	Accepted
Dead Line / Dead Bus	YES	DLDB in progress*	Delayed
Dead Line / Dead Bus	YES	≠ DLDB	Rejected
Dead Line / Live Bus	YES	DLLB	Accepted
Dead Line / Live Bus	YES	DLLB in progress*	Delayed
Dead Line / Live Bus	YES	≠ DLLB	Rejected
Live Line / Dead Bus	YES	LLDB	Accepted
Live Line / Dead Bus	YES	LLDB in progress*	Delayed
Live Line / Dead Bus	YES	≠ LLDB	Rejected
Live Line / Live Bus (Locking)	YES	LLLB	Accepted
Live Line / Live Bus (Locking)	YES	LLLB in progress*	Delayed
Live Line / Live Bus (Locking)	YES	≠ LLLB	Rejected

* the voltage condition check is in progress when the manual close request is received.

Automatic close (reclosing cycle after a protection trip)

For the automatic close request, and for each voltage condition, the following Auto-Recloser schemes are defined at SCE level and modified by settings groups changeover:

Voltage Conditions	Close Authorization
Dead Line / Dead Bus	YES / NO
Dead Line / Live Bus	YES / NO
Live Line / Dead Bus	YES / NO
Live Line / Live Bus (Locking)	YES / NO

If the Close authorization is set to "NO", the Scheme Control result is set to "Rejected".

If the **Close authorization** configured to "YES", the following checks are performed for manual close requests:

Voltage Conditions	Closing Authorisation	Verified Voltage Conditions	Close request result
Dead Line / Dead Bus	YES	DLDB	Accepted
Dead Line / Dead Bus	YES	DLDB in progress*	Delayed
Dead Line / Dead Bus	YES	≠ DLDB	Rejected
Dead Line / Live Bus	YES	DLLB	Accepted
Dead Line / Live Bus	YES	DLLB in progress*	Delayed
Dead Line / Live Bus	YES	≠ DLLB	Rejected
Live Line / Dead Bus	YES	LLDB	Accepted
Live Line / Dead Bus	YES	LLDB in progress*	Delayed
Live Line / Dead Bus	YES	≠ LLDB	Rejected
Live Line / Live Bus (Locking)	YES	LLLB	Accepted
Live Line / Live Bus (Locking)	YES	LLLB in progress*	Delayed
Live Line / Live Bus (Locking)	YES	≠ LLLB	Rejected

* the voltage condition check is in progress when the autorecloser request is received.

Synchrocoupler schemes

For the "Synchrocoupler" request and for each voltage condition, a **Synchrocoupler Schemes** are defined at configuration level, and modified by setting groups changeover:

Voltage Conditions	Close Authorization
Live Line / Live Bus (Locking)	YES / NO
Live Line / Live Bus (Locking and Coupling)	YES / NO

If the **Close authorization** is set to "NO", the **Scheme Control result** is set to "Rejected".

If the **Close authorization** configured to "YES", the following checks are performed:

Voltage Conditions	Verified Voltage Conditions	Close request result
Live Line / Live Bus (Locking*)	LLLB	Accepted
Live Line / Live Bus (Locking*)	LLLB in progress**	Delayed
Live Line / Live Bus (Locking*)	≠ LLLB	Rejected
Live Line / Live Bus (Coupling)	LLLB	Accepted
Live Line / Live Bus (Coupling)	LLLB in progress**	Delayed
Live Line / Live Bus (Coupling)	≠ LLLB	Rejected
Live Line / Live Bus (Coupling)	LLLB	Search for min(Δφ)

* with deltaF for locking & coupling range

** the voltage condition check is in progress when the "Synchrocoupler" request is received.

11.2.8.13 CLOSING SCENARIOS

Request accepted

According to the configured closing scheme, if the close request is accepted, a close command is sent to the circuit-breaker.

Request rejected

According to the configured closing scheme, if the close request is rejected, a negative acknowledge (KO-Synchrocheck) is sent and no close command is sent to the circuit-breaker.

Request delayed

According to the configured closing scheme, if the close request result is delayed, a configured time-delay is started:

Close order	Delay selected
Manual synchrocheck	**manual close time (ms)**
Manual synchrocoupler	**synchrocoupler close time (s)**
Automatic synchrocheck	**automatic close time (ms)**

During the time-delay, if the voltage condition is verified:

- if the close scheme issues a close authorization:
  - a close command is sent to the circuit-breaker
  - and the time-delay is cancelled.
- if the close scheme does not give a close authorization:
  - a negative acknowledgement (*KO-Synchrocheck*) is sent,
  - no close command is sent to the circuit-breaker,
  - and the time-delay is cancelled.

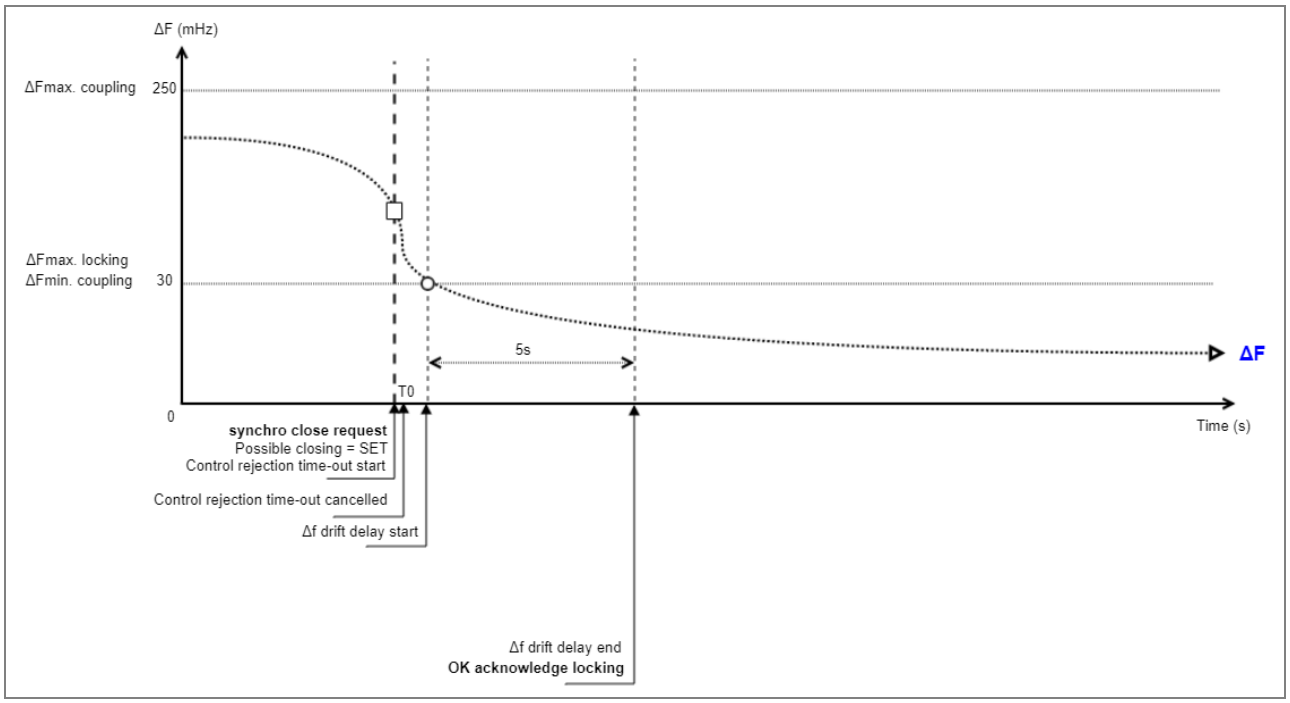
If the time-delay elapses with no voltage conditions having been checked:

- a negative acknowledgement (*KO-Synchrocheck*) is sent,
- and no close command is sent to the circuit-breaker.

Particularities of Timers in drift management

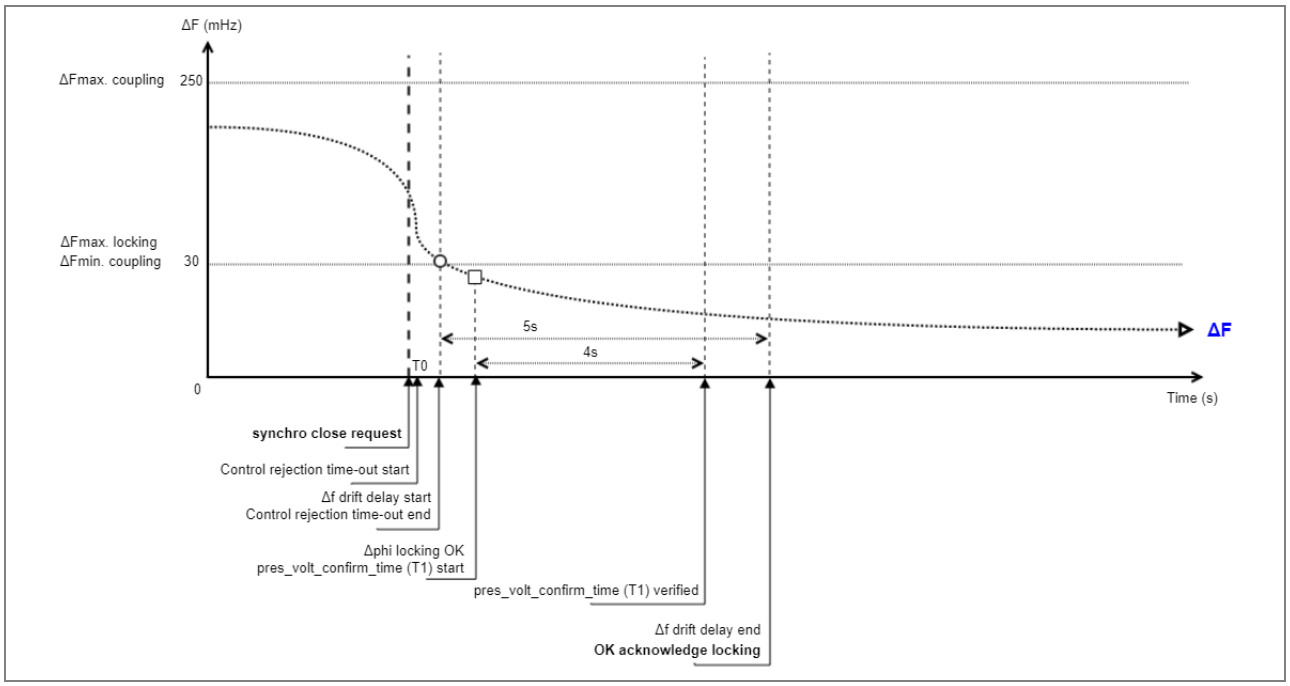
To manage frequency drift, different types of timers are used depending on whether Δf locking is confirmed before or after locking conditions:

- **Δphi is confirmed before locking condition confirmation**
  - Synchro close request is launched upon coupling conditions.
  - Locking conditions are validated ("possible closing" at SET state).
  - Delta frequency drifts from coupling conditions to locking conditions.
  - The locking confirmation timer (T1) is not relaunched upon locking conditions. The rejection timeout is cancelled immediately.
  - Locking condition acknowledgement is sent at the end of delta drift delay.



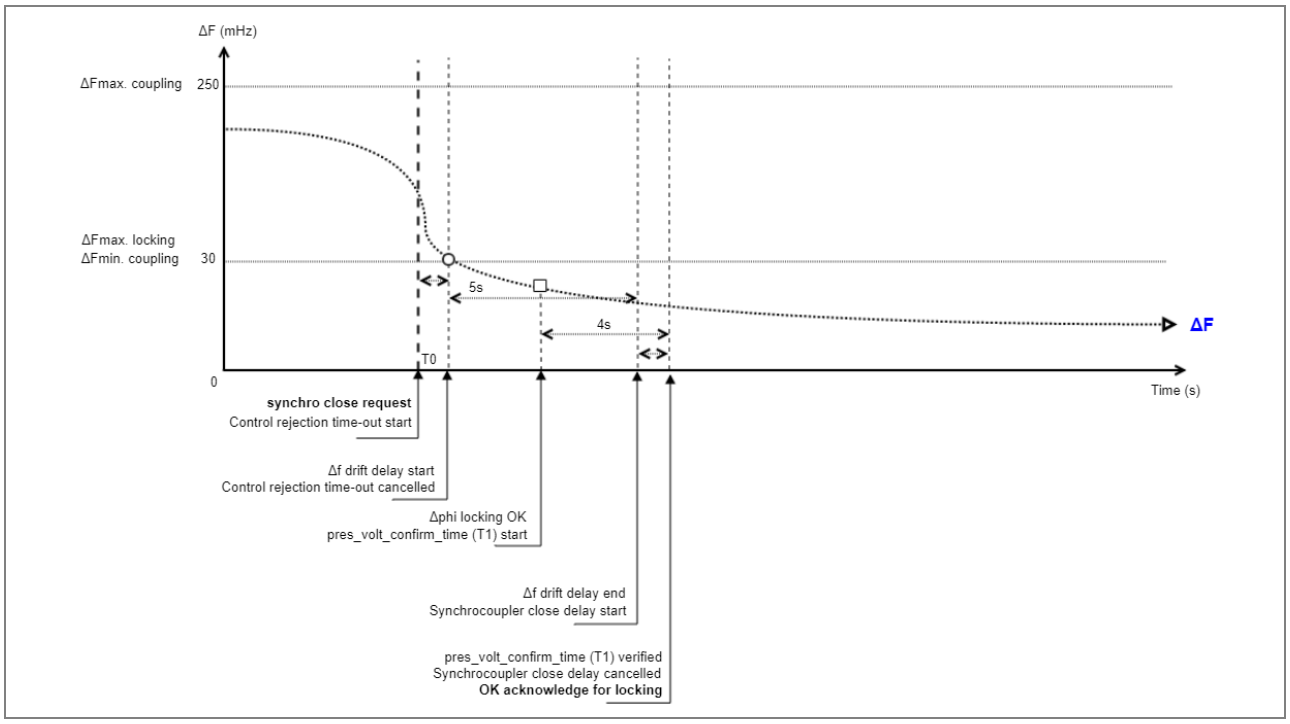
- **Δphi is confirmed after locking condition confirmation**

The confirmation timer (T1) is shorter than the delta drift delay. The positive acknowledgement is sent at the end of delta drift delay.

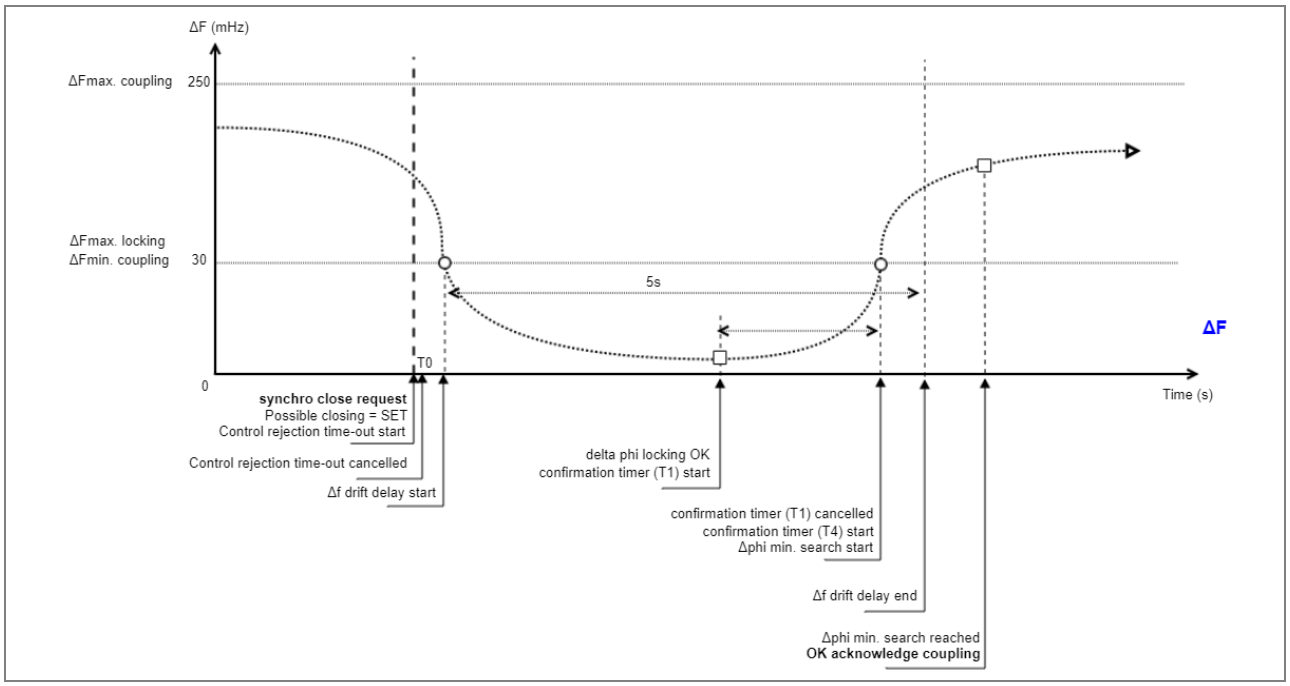


- **Δphi is confirmed after locking conditions confirmation (bis)**

Same drift as in the previous case but the positive locking acknowledgement is sent at the end of the locking conditions confirmation (T1).



- **Δphi is confirmed before coupling condition confirmation**



Locking and Coupling drift management

Synchrocoupler close requests can be managed according to modes combining Locking and Coupling logics. The Locking or Coupling management mode is defined in the configuration and cannot be changed without reloading a new database.

For the **Synchrocoupler** scheme, configured with "Synchrocoupler: locking and coupling" scheme, **2** request management modes are available:

- Exclusive mode
- Evolutive mode

Exclusive mode

When a synchrocoupler close request is received, if $\Delta\mathbf{f}_{min}$ coupling ≤ $\Delta\mathbf{f}$ ≤ $\Delta\mathbf{f}_{max}$ coupling, the search for min(Δφ) is started and a time-delay is launched (**delay for coupling (s)**).

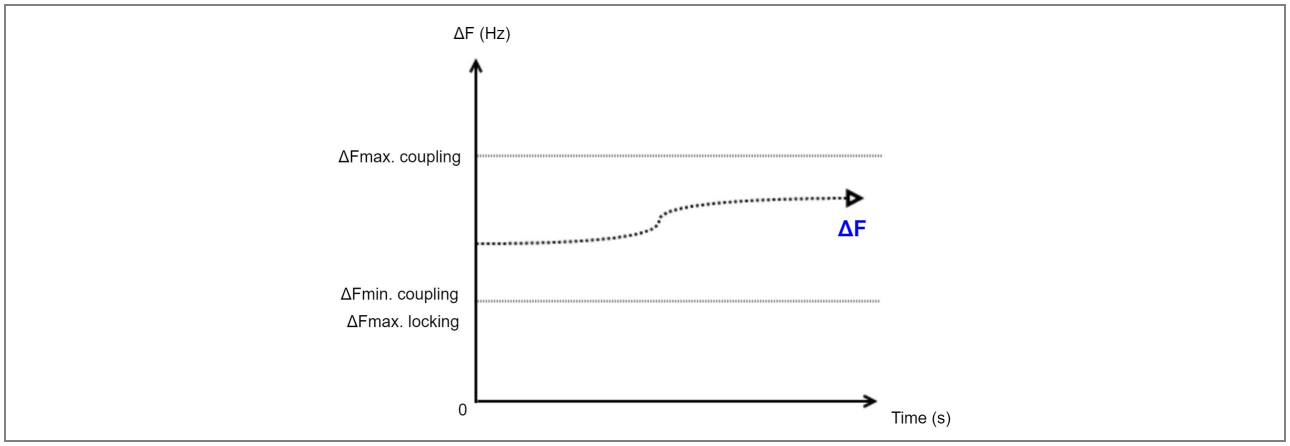
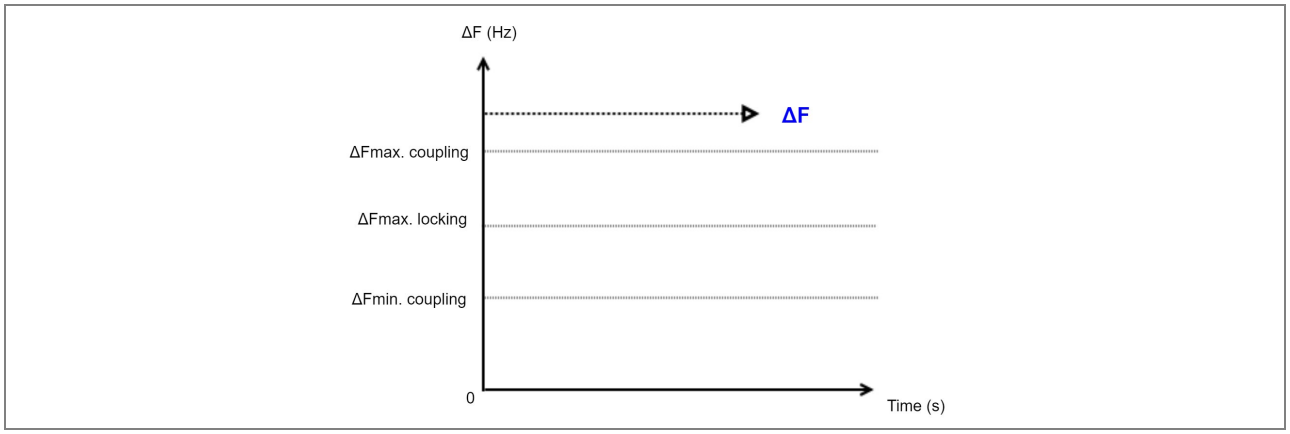


Figure 75: Locking and Coupling drift management in Exclusive mode

- If min(Δφ) is found, a positive acknowledge is sent to close the circuit-breaker, and the time-delay is reset.
- If **delay for coupling (s)** elapses without min(Δφ) being found:
  - a negative acknowledgement (*KO-Synchrocheck*) is sent
  - and no close command is sent to the circuit-breaker.

When a synchrocoupler close request is received while Δf is not within the range [$\Delta\mathbf{f}_{min\ coupling}$ ... $\Delta\mathbf{f}_{max\ coupling}$]:



- a negative acknowledgement (*KO-Synchrocheck*) is immediately sent
- and no close command is sent to the circuit-breaker.

The drift management into Exclusive mode is limited for "Synchrocheck only" use case, when the Δ**f** value goes outside the locking range.

Evolutive mode

When a synchrocoupler close request is received, if Δf is within the range [0 ... $\Delta f_{max\ locking}$] and the locking condition is met, a positive acknowledge is immediately sent to close the circuit-breaker.

When a synchrocoupler close request is received, if Δf is within the range [0 ... $\Delta f_{max\ locking}$] and the locking condition check is in progress, the LLLB locking logic is applied.

When a synchrocoupler close request is received, if Δf is within the range [$\Delta f_{min\ coupling}$ ... $\Delta f_{max\ coupling}$], the search for min(Δφ) is started and a time-delay is launched (**delay for coupling (s)**).

When a synchrocoupler close request is received, if Δf is within neither of the ranges [0 ... $\Delta f_{max\ locking}$] and [$\Delta f_{min\ coupling}$ ... $\Delta f_{max\ coupling}$]:

- a negative acknowledgement (*KO-Synchrocheck*) is immediately sent
- and no close command is sent to the circuit-breaker.

If Δf drifts from the Coupling range to the Locking range (outside of any overlap) during the search for min(Δφ), a "Δf drift delay" is started.

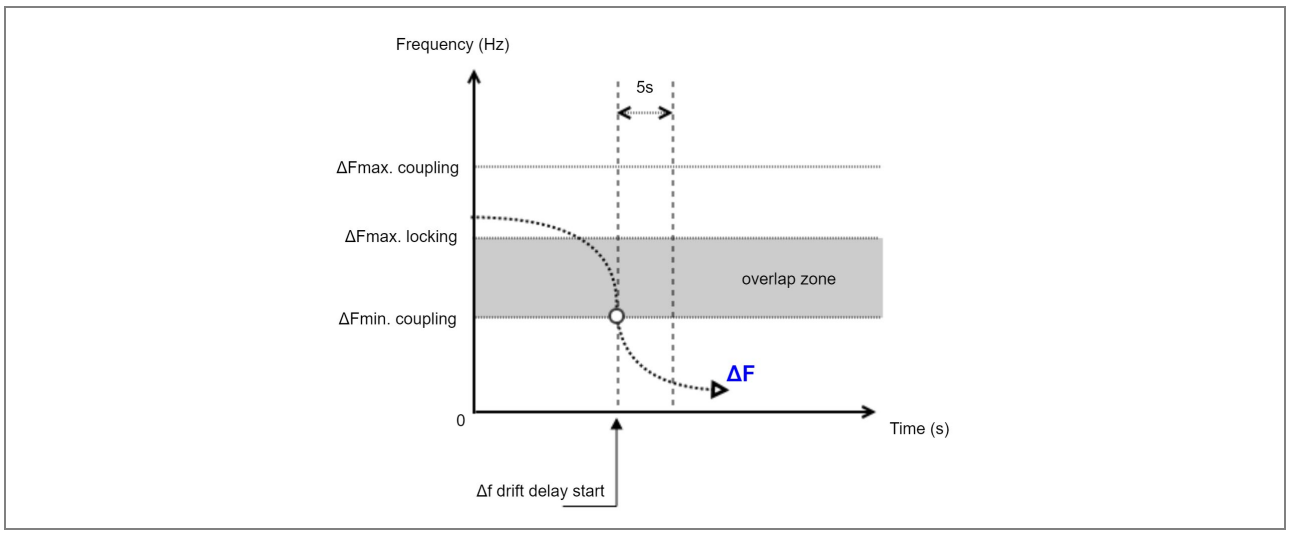
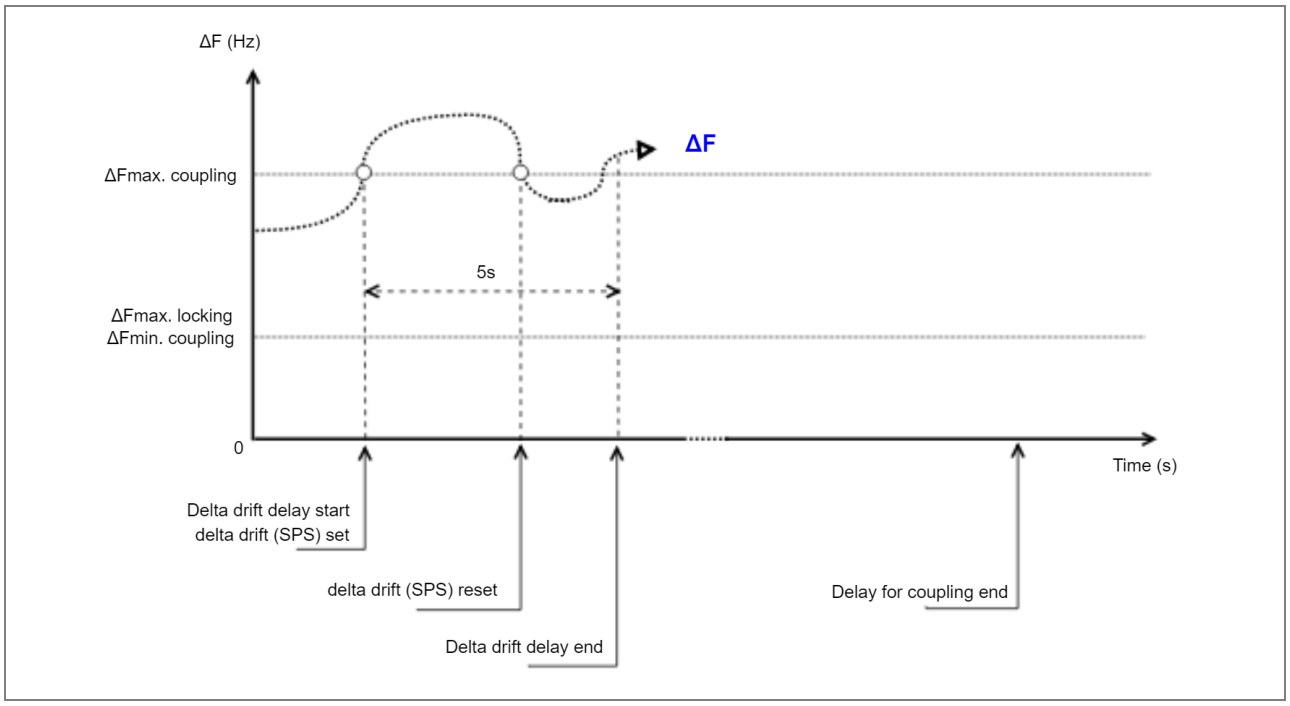


Figure 93: Locking and Coupling drift management in Evolutive mode

At the end of the "Δf drift delay", if Δf is inside the **Locking** range, then:

- the min(Δφ) search is aborted,
- the time-delay is reset and a synchrocoupler close request is sent according to the locking logic.

If Δf drifts outside of the Coupling ranges [**Δf_{min} coupling... Δf_{max} coupling**], during the search for min(Δφ), the "delta drift delay" is started and the min(Δφ) search is aborted.



Before the Δf drift time-delay elapses if Δf is inside the Coupling range, the "delta drift delay" continues to the end of delay and the "min(Δφ) search" is relaunched at the end of "delta drift delay".

When the Δf drift time-delay elapses, if Δf is outside the Coupling range, the min(Δφ) search is aborted. A negative acknowledgement (*KO-Synchrocheck*) is immediately sent and no close command is sent to the circuit-breaker.

11.2.8.14 ADDITIONAL SYNCHROCHECK / SYNCHROCOUPLER FEATURES

Overvoltage threshold

When Line or Busbar voltage goes over the set threshold **over voltage threshold (% of Vn):**

- Before control rejection time out (s) expires:
  - The "synchro close" scheme conditions are lost
  - the time-delay T1 is stopped (presence of both voltages is confirmed for locking mode) or T2 is stopped (presence of only one voltage is confirmed).

- During the min(Δφ) search:
  - the time-delay T4 is stopped (presence of both voltages is confirmed and so are the coupling conditions)
  - a negative acknowledgement (synchrocheck-ko) is sent immediately and no close command is sent to the circuit-breaker

Blocking condition: control rejection timeout

When a synchro close request is received, if no scheme conditions are valid, the **control rejection time out (s)** is started to wait for a valid close scheme.

During the **control rejection time out (s)**, if close scheme conditions are met, before the confirmation timer expires (T1, T4 depending on the scheme), the min(Δφ) search is launched for the Coupling scheme. For other schemes, the **rejection time out (s)** is stopped and a close command is sent to the circuit-breaker.

When the **control rejection time out (s)** expires, if no close scheme conditions are valid or, if the confirmation timer (T1, T4 depending on the scheme) is still running, a negative acknowledgement (synchrocheck-ko) is sent immediately and no close command is sent to the circuit-breaker.

When a synchro close request is received while no DLDB, LLDB or DLLB closing condition scheme is selected for the active setting group:

- a negative acknowledgement (synchrocheck-ko) is sent when **control rejection time out (s)** expires
- no close command is sent to the circuit-breaker

11.2.8.15 ANALOG VOLTAGE ACQUISITION OPTIONS

Double-busbar management with TMU220

The TMU220 allows using 2 different synchrocheck voltages: $V_{busbar1}$ and $V_{busbar2}$.

The **busbar V choice** internal SPS, defined in the SCE configuration, allows choosing either voltage to close the circuit-breaker with synchrocheck. This SPS can be directly acquired or generated using an internal automation (PLC, FBD).

Depending on its state, the selected busbar voltage is:

- $V_{busbar1}$ if the SPS is RESET (or FORCED RESET or SUBSTITUTED RESET)
- $V_{busbar2}$ if the SPS is SET (or FORCED SET or SUBSTITUTED SET)
- Not connected: The "Bus" is considered as "Dead" by the Synchrocheck. The ΔV, Δf, $\Delta \varphi$ measurements are set to 0.0 with a VALID quality, either if voltage(s) is/are present at Bus level. the DLDB and LLDB schemes are authorized by the Synchrocheck function if these schemes are allowed in Synchrocheck settings.

If the state of this SPS changes during a synchrocheck closure, the operation is aborted, a negative acknowledgement (*KO-Synchrocheck*) is sent and the system waits for a new CB close command.

If the SPS is INVALID (SELFCHECK FAULTY or TOGGLING or UNKNOWN or SUPPRESSED), no busbar voltage can be used as Synchrocheck reference (automatic forcing can be used on this SPS to pre-define a behaviour in case of invalid state). The busbar is considered as "not connected" by the SC function.

This SPS is optional: if it is not configured, $V_{busbar1}$ is used.

11.2.8.16 PERFORMANCE

11.2.8.16.1 Frequency Difference for Locking and Coupling Modes

The limit between locking and coupling modes is less or equal to **30mHz**. The Synchrocheck setting values are naturally set higher than the Synchrocoupler settings.

The **frequency delta threshold for locking (Hz)** value must be higher than the **Hysteresis value of frequency delta threshold for locking.**

With TMU220 board as analog acquisition device, the **frequency delta threshold for locking (Hz)** must configured higher than **15mHz**.

11.2.8.16.2 Circuit Breaker Closing Time

The constant value **Ta**, defined to anticipate the inertia of circuit breaker mechanism during the reclosing time, must be configured according to:

- the type of the physical circuit breaker (hydraulic or spring, SF6...)
- the network frequency (minimum 2 cycles acc. IEC62271-100)
- a presence of a Point-on-Wave-Switching (POWS) device on the electrical bay
- the reaction time of the BCU (less than **3ms** with a C264 equipped with a CPU4 board)

For optimal performances of the Synchrocheck function, the constant value **Ta** must be greater or equal to **50ms**.

11.2.8.17 LIMITS

- The Synchrocheck type 5 built-in function is used in conventional DCS architectures only;
- The Synchrocheck type 5 analog measurements (VT) are only processed by the TMU220 board;
- The SC type 5 function is not managed in case of DS Agile system redundancy;
- The following information is common to the synchrocheck and synchrocoupler functions:
  - Electrical values measured at the secondary side of VTs located on the busbar and on the line (voltages, frequencies and phases angles)
  - Analog acquisition devices (TMU220)
  - DSP hosted into the CPU board
  - Mathematical formulas used to calculate delta values, vector modules and arguments
- Only the following wiring modes are used by SC type 5:
  - star on both sides
  - delta on both sides

11.3 INTERLOCKING: LOGICAL EQUATIONS

In an electrical substation, the switching devices include primarily:

- Circuit-breakers
- Traditional disconnecting switches
- Disconnecting switches with abrupt loss
- Ground disconnecting switches

The operation of a switching device is directly related to its nature and its environment. It can be operated only with respect of specific conditions called **interlocking** conditions; they are checked within the control unit using **logical equations**.

Interlocking conditions allow blocking remote controls that are beyond the switching device standard conditions of operation. They can be applied to any module or any control.

The operation of the disconnecting switches is also checked against the topology. The topological interlocking equations are generated by independent software. This software takes in account the topology and some predefined rules.

Comparison of the interlocking schemes:

	Conventional interlock	Boolean equations	Topological interlock
Security-related interlock	Relay schemes	Boolean equations	Evaluation of potential isolating distance
Simple operation-related interlock	Additional circuits	Boolean equations	Path tracking
Zone	Selection of switchgear position indications		Complete connected area
Complex-operation related interlock	Restricted		Fully by “search of path”
Taking intermediate position into account	Restricted		Fully by “worst case” analysis
Applying set of rules	Project-specific		Generic conditions
Image of s/s topology	Ring wiring		Topological database
Testability	Restricted		Full

11.3.1 INPUTS

An Interlocking function can use the following inputs:

- Digital inputs from the system digital input boards, from other system control units (BCUs and SCUs), from protection relays and other IEDs via a communication network (single and double point, digital groups).
- Internal indications (e. g. system failures, equipment operation modes, ...).
- Limits derived from measured values by the systems analog input boards (CT, VT, transducers), other system control units, protection relays and other IEDs via a communication network.

11.3.2 OUTPUTS

The result of the interlocking equation is transmitted through a system binary output and saved locally in RAM.

Any task can get the result of the computation. For example, the function managing “control of sequence” uses this output to know whether the control can be executed; then, a simple transient binary input can be set if it has been configured. The same SPS is used for the commands “open” and “close” of an xPC.

11.3.3 CONTROL

There is no control. An equation is computed whenever one of its input changes of state or of validity.

11.3.4 BEHAVIOUR

11.3.4.1 PRINCIPLE

In a C26x, a logical interlocking equation is defined as a sum of products (AB+CDE+F for example).

11.3.4.1.1 Introduction

Interlocking function uses up to two interlocking equations per switching device on bay-level and on substation-level. During configuration process the definition of the switching devices can be:

- without associated interlocking equations,
- with only one interlocking equation, e. g. for opening, while closing is not checked or vice-versa,
- with two interlocking equations (for opening and closing). The interlocking equations can be different but can also be identical.

The equation is composed of Boolean information that mainly represents the position of other switching devices.

The interlocking for a switching device might include:

- Local equation, that requires information from its own digital inputs and IEDs connected to the C26x.
- Substation equation, that requires information from its digital inputs and inputs provided by the communications network from other C26x, from bay control units and from IED’s (protection relays, etc.). Substation interlocking can also include topological interlocking.

Both types are managed by the C26x which controls the switching device.

11.3.4.1.2 Local interlocking

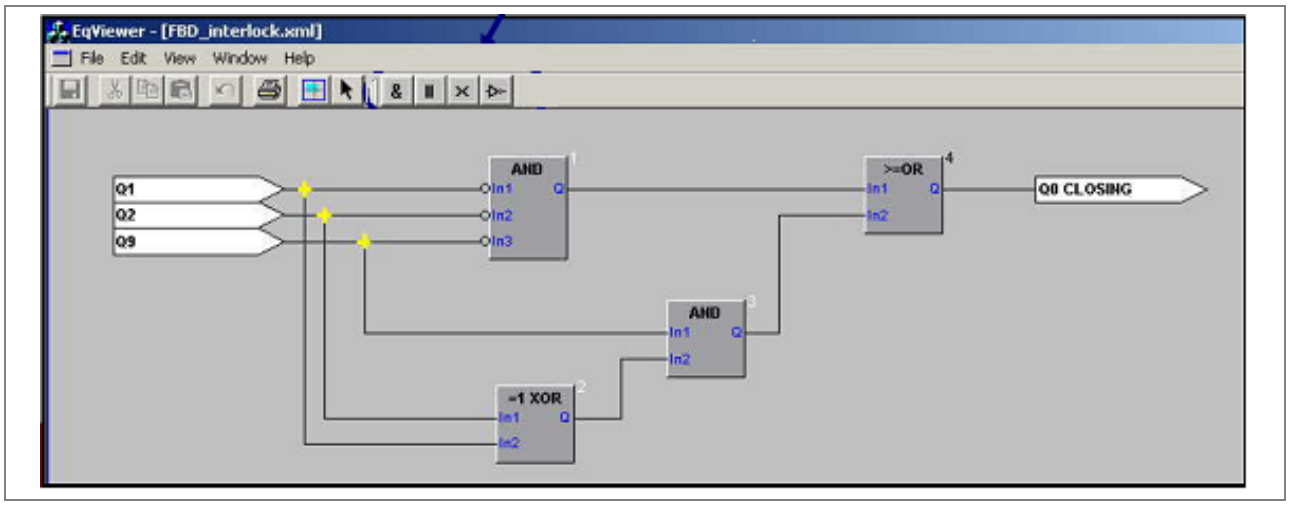
There can be up to one equation for each switching device and for each direction (open and close). If there is no equation for a switching device for a direction, the related variable equals true.

11.3.4.1.3 Substation interlocking

The substation interlocking analyses the position of all the switching devices in the substation and calculates the substation interlocking equation to authorise control of a switching device according to the mechanical

and electrical capabilities of the switching device. If there is no equation for a switching device for a direction, the related variable equals true.

Example



11.3.4.1.4 Validity of information

The interlocking equation uses not only the information value but also its validity (invalid, ...).

The evaluation of the result of the basic operators is as follows:

NOT	
True	False
False	True
Invalid	Invalid

OR	True	False	Invalid
True	True	True	True
False	True	False	Invalid
Invalid	True	Invalid	Invalid

XOR	True	False	Invalid
True	False	True	Invalid
False	True	False	Invalid
Invalid	Invalid	Invalid	Invalid

AND	True	False	Invalid
True	True	False	Invalid
False	False	False	False
Invalid	Invalid	False	Invalid

Key:

Input	Output

Note:
RS and timers are not allowed.

An Interlocking equation in the INVALID state is considered FALSE.

But the system binary input also generated can be valid (SET or RESET) or invalid.

11.3.4.1.5 Interlocking bypass

Bypass made by key switch

Interlocking can be overridden (interlocking bypass mode). Overriding of interlocking can be set from the LOCAL control point.

During configuration, optional overriding of interlocking from any other control point can be defined according to customer requirements. This includes the possibility of overriding of interlocking per switching device or per bay or per substation.

If an interlocking is overridden, the associated variable is true.

Bypass within the control

From ANY control point, the operator can bypass the interlocking check. Bypass is then an attribute of the control. If the bypass is set, the function managing the “control of sequence” does not use the service giving the current result of the interlocking equations.

11.3.4.2 SOFTWARE TASKS

A logical equation is a sum of products. Each product comprises logical data that can be complemented. Each electrical component has two logical equations at the most, and each logical equation is associated with one electrical component.

Example of Logical equation: X = A.$\underline{B}$ + $\underline{C}$.D.$\underline{E}$

In this example, the component X can be operated only if:

- (A is in the higher state) AND (B is in the lower state)

OR

- (C is in the lower state) AND (D is in the higher state) AND (E is in the lower state)

The terms of these equations can be issued from:

- Simple point status (BI)
- Double point status (BI)
- 1 among N BIs (SIG)
- Measurement (MEAS)

At configuration time, the operator must define the “interlocking profile” of each data included in an interlocking equation. It means that operator must select for each state or validity of a data a logical state (TRUE, FALSE or INVALID).

Interlocking computation

As said before, an interlocking equation

- is computed each time that one of its element changes of quality or state and
- is defined by a sum of product.

Upon reception of a new state or quality for a data

- Get logical state associated to the received state and validity of the data
- For each equation that includes the data
  - Compute the sum of product
  - Determine the result of the interlocking equation (TRUE or FALSE)
  - Send new state of the system binary input representing the result of the interlock. BI can be: SET, RESET or INVALID

Interlocking readout

On reception of an open or close request, if the logic equation associated with the switching device exists, the “control of sequence” function used the service offered by the interlocking function to get the result of the interlocking associated to the received request.

If result of the interlocking is TRUE, the check is considered as achieved, else request must be refused and a negative acknowledgement sent to the origin of the request.

Simulation and test of interlocking equations

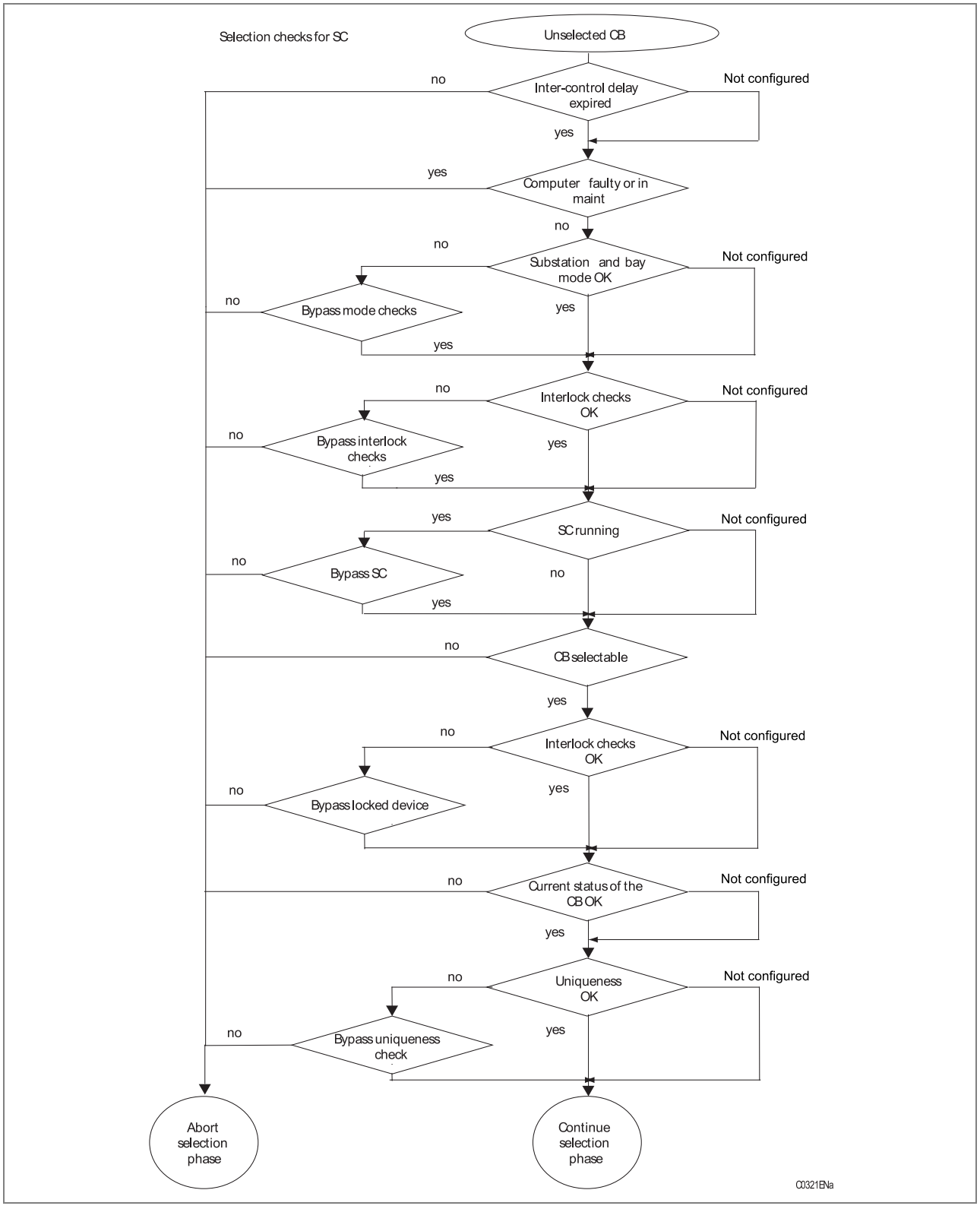
The interlocking system is checked during the factory acceptance test of the substation control system. Each interlocking equation may be checked by issuing a control to the corresponding switching device.

To check the interlocking on site, set the C26x to Test/blocked mode. In that operating mode, a valid control is sent to the output, but the contact is not closed. A positive acknowledgement message is generated.

11.3.5 INTERLOCKING AND SYNCHROCHECK

The interlocking conditions must be checked again after the Synchrocheck conditions are fulfilled.

In event the interlocking conditions are not fulfilled, a report message pops up.



11.4 SLOW AUTOMATION: PROGRAMMABLE LOGIC CONTROL (PLC)

During the substation configuration phase, the C26x allows you to configure the specific control sequences or automations: for example, the switching sequences, busbar transfer, load shedding, and GIS-pressure supervision.

You create the Programmable Logic Controls (PLC) or Configurable Automations and build them onto a logic development workbench. The real time kernel of the control unit operates them.

The software logic package includes the logic development workbench. The logic development workbench is a host-based software development environment related to the SCE. Use the software logic package and the logic development workbench to create the control logic programs in the DS Agile C26x.

The logic development workbench includes a set of tools that allow you to:

- Edit
- Generate code
- Simulate
- Debug
- Project management.

The software logic package supports standard programming languages of the IEC 1131-3:

- Sequential Function Chart, SFC (GRAFCET)
- For action and transition description, you can use this language with Function Block Diagram (FBD), Ladder Diagram (LD) or Instruction List (IL).
- Structured Text, ST

The logic development workbench generates code. The code is uploaded to the control unit target system that operates the code.

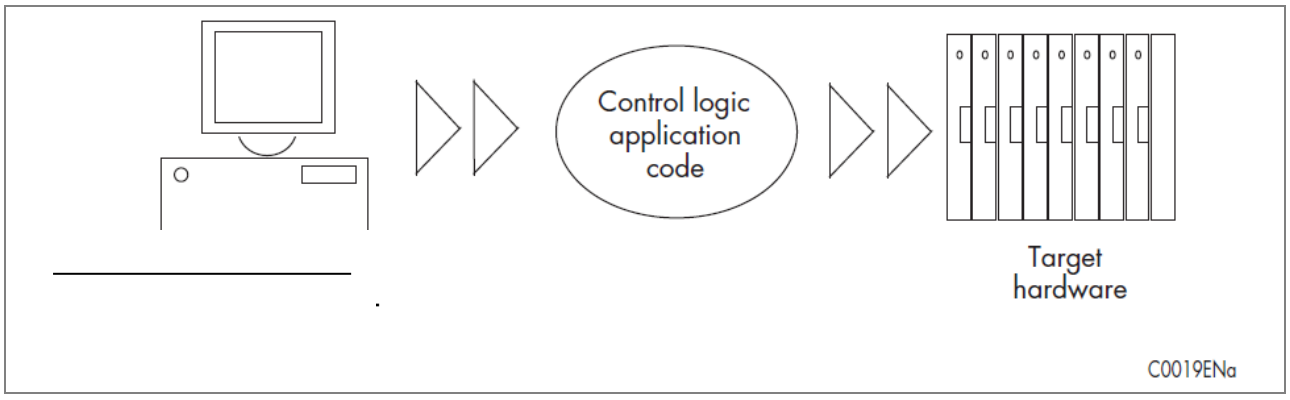


Figure 94: PLC workbench

For ISaGRAF, refer to the chapter *SCE/EN AP*.

11.4.1 INPUTS

All the datapoints of the C26x can be used as an input of a PLC.

11.4.1.1 DATA ACQUIRED BY C26X

- BI: non-filtered change of states are transmitted to PLC kernel
- MEAS (MV or DM)
- CT
- Tap position (TPI aka SPI)

11.4.1.2 DATA MANAGED BY C26X

- CO

Note:
A CO can be used as input of a PLC function, but only using 'C' function present by default with the kernel.

11.4.1.3 ACKNOWLEDGEMENT OF CONTROL

A PLC function can manage a control sequence:

- Send control
- Process acknowledgement to the sent control

11.4.2 OUTPUTS

A PLC function can:

- Generate a BI, for example. PLC is considered as source of acquisition of the data point
- Generate an MEAS
- Generate a CT
- Generate an SPI
- Generate a SIG
- Modify quality of a Binary Input defined in the control unit: force, suppress or substitution request
- Modify quality of an MEAS defined in the control unit: force, suppress or substitution request
- Modify quality of a SIG defined in the control unit: force, suppress or substitution request
- Send binary order to control unit boards or IED or to another control unit
- Send digital and analogue setpoints to control unit boards or IED or to another control unit.

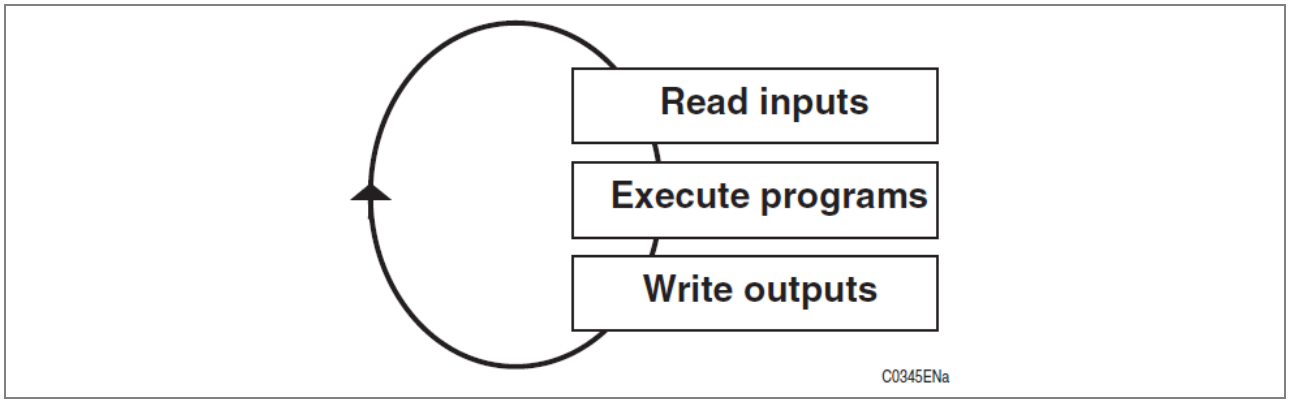
11.4.3 CONTROL

Automations can be triggered:

- By operator request,
- By events (digital or analogue input state changes),
- Cyclically (each day, each week or each month),
- At a specific date and time (e. g.: 20. 12. at 10:00).

11.4.4 BEHAVIOUR

The control unit has a software execution engine that interprets the automation application code as shown in the cycle that follows:



The cycle duration depends on the number of I/O to be scanned and the complexity of the operations to be performed. Set the cycle during the configuration process.

11.4.4.1 INTERFACING WITH AN HMI OR AN RCP/SCADA

A master station on a remote site can send and receive data to and from the automation applications of C26x.

In DB, the data sent by a master station to an automation application include DO and BI entities. Conversely, the data received by a master station from automation applications include DI, Measurements, Metering (non-tariff), and Tap Changer Position entities. These data have a unique transmission address for C26x.

11.4.5 LIMITS AND SPECIFICATIONS

- The execution of the automation sequences can be cyclic and/or event driven.
- Maximum number of cyclic PLC-programs is 32.
- The two different time cycles of a PLC-program can be set from 10 ms up to several seconds. For some specific equations a cycle less or equal to 10ms and a cycle less or equal to 100ms for the other logic equations. The time cycle for the automatic functions is less than 100ms.
- Each PLC-program operates on one control unit: this means a PLC-program cannot be distributed within the system. However, it is possible to use data obtained by other control units.
- Routing of the automatism applications to the memory must be in agreement with the memory and hardware design.
- To debug the applications, you can connect a PC to the front face. The hardware design separates the debug function and the application download function.

11.5 FAST AUTOMATION: PROGRAMMABLE SCHEME LOGIC (PSL)

11.5.1 GENERAL

As automations created through ISaGRAF are dependent on the ISaGRAF cycle whose value is about 50ms at least, it may be necessary to implement configurable automations that can be achieved in less than 50ms.

PSL is the solution for implementation of automatism to perform as quickly as possible.

Designed solution is mainly based on mechanism used for the computation of logical interlocking (see logical interlocking for details). Indeed, logical gates AND, OR, NOT, NAND, NOR or a combination of these gates can be processed as a logical equation. Some other functions (drop-off & pickup timer, bistables) are added to these logic gates.

These automations are event-driven: they are calculated each time an input changes: that is, there is no cycle time.

Only BI, CO and measurements described are usable as inputs. Transient SPS are transformed in permanent SPS. A reset state is created 1ms after the set state.

PSL are logical equations that use the following functions:

- AND, OR, XOR, NOT, NAND, NOR operators
- "bistable" functions
- pickup and drop-off timers (from 50 ms to 1 hour, by step of 10 ms)
- BI setting – the system BI is:
  - SET if the PSL is TRUE
  - RESET if the PSL is FALSE
  - INVALID if the PSL is INVALID
- Digital Output setting – the DO is:
  - closed if the PSL is TRUE
  - opened if the PSL is FALSE or INVALID (only in the event of a permanent DO)
  - INVALID if the PSL is INVALID

The equations management rules described for interlocking equations apply on PSL.

Digital outputs used as outputs are mandatory local hardwired DO directly managed by the control unit.

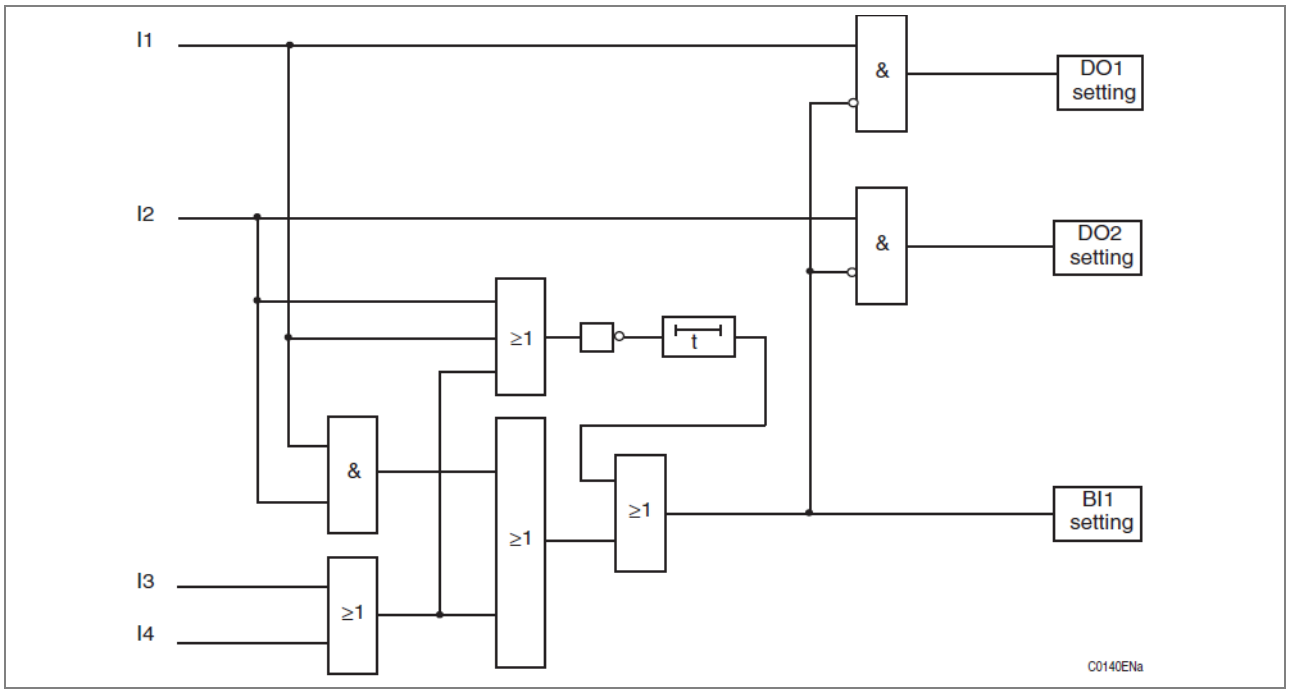
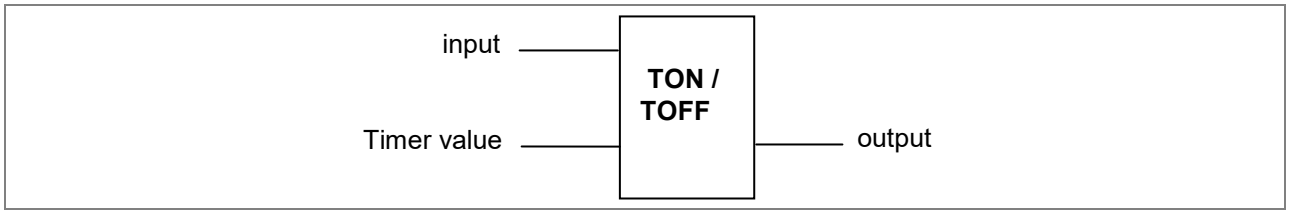


Figure 95: Example of PSL

11.5.2 TIMERS

For TON/TOFF timers, the timer value input can be associated:

- to a direct value
- to a timer setting input (FBD Timer)



In C26x, a timer setting is taken into account at the next evaluation of the TON/TOFF operator (i.e. when the input changes).

TON:

Event / State	Input = 0	Input = 1	Input = INV	T expiration
Not initialized 0	Output = 0 Goto state 1	Output = 0 Activate T Goto state 4	Output = INV Goto state 3	X
Output = 0 1	X	Activate T Goto state 4	Activate T Goto state 5	X
Output = 1 2	Output = 0 Goto state 1	X	Output = INV Goto state 3	X
Output = INV 3	Output = 0 Goto state 1	Output = 0 Activate T Goto state 4	X	X

Event / State	Input = 0	Input = 1	Input = INV	T expiration
Input = 1, Output = 0 and timer activated 4	Stop T Goto state 1	X	Goto state 5	Output = 1 Goto state 2
Input = INV, Output = 0 and timer activated 5	Stop T Goto state 1	Activate T Goto state 4	X	Output = INV Goto state 3

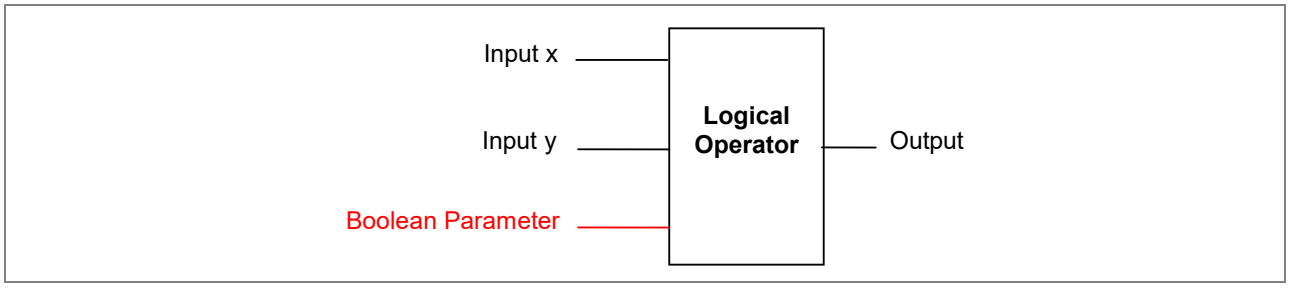
TOFF:

Event / State	Input = 0	Input = 1	Input = INV	T expiration
Not initialized 0	Output = 0 Goto state 1	Output = 1 Goto state 2	Output = INV Goto state 3	X
Output = 0 1	X	Output = 1 Goto state 2	Output = INV Goto state 3	X
Output = 1 2	Activate T Goto state 4	X	Activate T Goto state 5	X
Output = INV 3	Output = 0 Goto state 1	Output = 1 Goto state 2	X	X
Input = 0, Output = 1 and timer activated 4	X	Stop T Goto state 2	Goto state 5	Output = 0 Goto state 1
Input = INV, Output = 1 and timer activated 5	Goto state 4	Stop T Goto state 2	X	Output = INV Goto state 3

X is a forbidden action: it means the control unit goes in Halt mode.

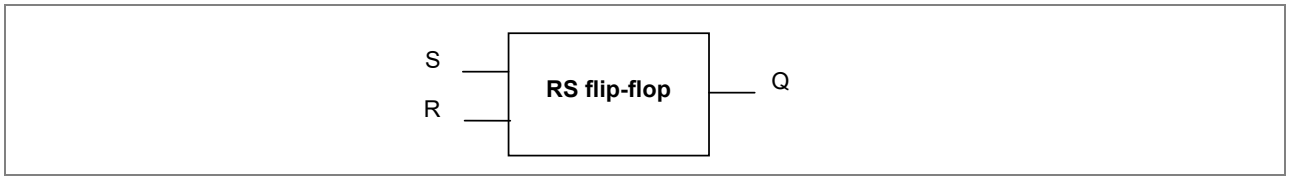
11.5.3 BOOLEAN

For one Boolean operator (i.e. AND, OR, XOR, NOT operators only), one (and only one) input can be defined as a parameter.



In C26x, the Boolean setting is taken into account immediately (i.e. managed as the modification of an operator input).

11.5.4 RS FLIP-FLOP



The Q state:

- equals to 1 when the S input is set
- equals to 0 when the R input is set
- is unchanged when both inputs are at 0
- is forced to reset when both inputs are at 1

Event / State	S = 0	S = 1	S = INV	R = 0	R = 1	R = INV	End of init
Not initialized 0	VAR= Q-1 Goto state 1	VAR=1 Goto state 1	VAR= Q-1 Goto state 1	VAR= Q-1 Goto state 2	VAR=0 Goto state 2	VAR= Q-1 Goto state 2	X
Not initialized, awaiting R init 1	X	X	X	Goto state 3	VAR=0 Goto state 3	Goto state 3	X
Not initialized, awaiting S init 2	Goto state 3	If R=1, then VAR=0, else VAR=1 Goto State 3	Goto state 3	X	X	X	X
Not initialized, awaiting end of init 3	X	X	X	X	X	X	Q=VAR If Q=0 goto state 4 else goto state 5
Q=0 4	No Action	If (R=0 or R=INV) then Q=1 Goto state 5, else no action	No Action	If S=1Q=1 Goto State 5 Else No Action	No Action	No Action	X
Q=1 5	No Action	If R=1 then Q=0 Goto state 4, else no action	No Action	No Action	Q=0 Goto state 4	No Action	X

X is a forbidden action: it means the control unit would go in Halt mode.

Q_{-1} is the output value before the reinitialization (stored in the C26x); at first boot (after change of data base) Q_{-1} =0.

N.B.: A change of software without a change of database is not considered as a first boot Q_{-1} is the memorised one.

Let I1, I2 be the inputs of RS latch.

These inputs can be acquired:

- directly by C26x's BIU
- through an IED

In the event of a loss of source of information, C26x can temporarily lose I1 or I2. Examples: reboot of C26x, disconnection of the IED sever of I1, I2, …

I1	I2	S	R	Q	
1	0	1	0	1	Initial state
1	1	-	-	1	source lost and I2 changed
1	1	1	1	0	source restored

I1	I2	S	R	Q	
1	0	1	0	1	Initial state
0	1	-	-	1	source lost, and I1 and I2 changed
0	1	0	1	0	source restored

I1	I2	S	R	Q	
1	1	1	1	0	Initial state
1	0	-	-	0	source lost and I2 changed
1	0	1	0	1	source restored

12 RECORDS & LOCAL ARCHIVING

Several kinds of records are stored in the C26x.

12.1 PERMANENT RECORDS STORAGE

All parameters or settings that can be modified via the front panel LHMI are stored in flash memory.

Lists of system information are also stored in the flash memory.

12.1.1 EVENTS

All data change or events declared in the C26x configuration database “To be logged” are stored in a circular queue.

The event records are available for viewing either via the front panel LHMI, via a slave protocol at SCADA level or on CMT/SMT equipment. They can also be printed.

Events, depending on the C26x configuration, can typically contain the C26x description, the date of the event and the time of the event with an accuracy of 1 ms, plus specific information regarding the causes of the events.

The C26x under the following circumstances can record events:

- Quality-valid changes of state of Binary Inputs (SP, DP, Groups)
- Changes of state of Measurements
- Changes of state and value of Tap Position Indications
- Devices Control actions and acknowledgements
- Alarm acknowledgement

The size of the queue is:

- 200 data for front panel
- 2000 data for CMT
- settable for each slave protocol for SCADA.

12.2 WAVEFORM RECORDING

A waveform recording deals with the storage of measurement and logical information in order to visualise the electrical network behaviour when electrical events appear, such as the start of the generator.

These types of events are called “trigger of waveform recording”.

In order to see the influence of a trigger, data are recorded before (pre trigger time) and after (post trigger time) the raise of the trigger.

Two types of waveform recording can be performed in the controller:

- **Fast Waveform recording** that gives access to samples. This record is useful for transient electrical events.
- Slow scan triggered recording (SST) referred to as **Slow Waveform recording** that gives access to RMS values. This record is useful to define load profile or power regulation.

12.2.1 FAST WAVEFORM

The “Fast Waveform" feature records samples into a **COMTRADE** format (Common Format for Transient Data Exchange).

Capacities

- COMTRADE records compliant with IEC 60255-24:2001 / IEEE C37.111:1991
- Digital channels : up to 128 digital inputs
- Analogue channels : up to 10
- 480 cycles maximum on 1, 2, 3, 4 or 5 files
- Pre-trigger cycles: from 1 to 477 (120 per default)
- Post-trigger cycles: from 3 to 479 (360 per default)
- Triggers: on digital channel transition, on analogue channels threshold violation (rising or falling edge)
- Sampling rate: 80 SA/cycle
- File management on DS Agile **CMT** tool
- File transmission by DS Agile **SMT** tool

Number of analogue channels

For the TMU2xx Boards, the inputs for the fast waveform records follow:

	Inputs			
TMU BOARD	CT: as many as	VT: as many as	Digital I&Os	Analog I&Os
TMU210	4	4	YES	YES
TMU220	4	5	NO	YES

With the IEC61850-9.2LE sample values, the waveform recorder provides up to 10 analogue measurements:

- 5 CT samples
- 5 VT samples

Number of digital channels

The inputs for the fast waveform records are the values of the selected digital inputs.

You can capture up to **128 digital channels**. The choice of selected inputs/outputs is defined in configuration (SPC and DPC could not be recorded).

Number of samples per cycle

The fault recorder integrated into the CX66 records analogue values with :

- **80** samples per cycle @50Hz (20ms)
- **80** samples per cycle @60Hz (16.66ms)

Number of files recorded in the C26x

The waveform(s) are stored into the non-volatile memory (FLASH) of the C264 CPU on **COMTRADE** format:

- an *.CFG file (configuration file)
- an *.DAT file (containing the analogue and digital samples in ASCII format)

For one bay, a maximum of 480 cycles (9.6 seconds at 50 Hz) of measurements samples, with 80 samples per cycle, can be stored, divided in 1, 2, 3, 4, with a maximum of 5 files.

A timer channel is also required to provide accurate timing information for each sample. The delay between each sample is assumed constant over a single cycle.

Number of Files	Number of cycles
5	96
4	120
3	160
2	240
1	480

Note: When 2 bays with 2 TMU or 2 SV are managed, the number of cycles remains the same for a bay.

The waveform(s) are stored into the non-volatile memory (FLASH) of the C264 CPU on **COMTRADE** format:

- 5Ko for the *.CFG file (configuration)
- 12.78 Mo for the *.DAT file (data)

If a new record occurs, the C26x will erase the last file before saving the new one.

In case of reboot, the fast waveform record in progress is stopped, and records are lost. The files already recorded in C26x local storage (FLASH) are preserved.

In case of DB switch: no impact on COMTRADE files already recorded in the C26x local storage (FLASH).

Trigger events

The waveform recorder can be triggered by the following user-settable events:

- Changes in state of binary inputs (SP, DP, or Groups). The triggering is available only from a state/value with VALID quality (ex: SET/RESET; OPEN/CLOSE) to a state/value with VALID quality Changes in state of digital outputs (in case of SBO, the execution order is the trigger)
- Operator request (controls) such as SPC, DPC
- Measurement threshold violations. The trigger happens on :
- Operator request (controls)

A **Close Order** (CO) may be a trigger for a Waveform if and only if the acknowledgment is positive.

The **Close Order** is recorded when the acknowledgment is received (positive or negative).

Recorded digital data can be SPS and DPS.

Note: only 2 values are possible for digital channels in COMTRADE format: 0 or 1 (open or close). Therefore, even for DPS, only "open" and "close" states are recorded. If the 4 values of a DPS (open, close, motion00, jammed) must be recorded, it is necessary to add an FBD at configuration level (SCE), to animate 2 SPS, according to the DPS state. These 2 SPS are added into the waveform record.

The total sum of triggers defined as per "Fast waveform" is:

- Changes in state of digital inputs (SPS): up to **32**
- Operator request or changes in state of digital outputs (SPC): up to **32**
- Analogue RMS measurement threshold violations (MV): up to **18**

note : DPS and DPC must be considered as 2 SPS and 2 SPC in the summation.

Re-triggering capability

Only one re-triggering is permitted: it means that a new trigger can only be accepted after the end of recording of the current waveform. The re-triggering is possible only if the number of files configured is greater than 1 (possible with 2, 3, 4 or 5 files).

Trigger limits

- In case of the SPC (or DPC) activation mode attribute is configured as "transient":
  - if the triggering order is "Set": the SPC/DPC SET state can trig a new waveform record
  - if the triggering order is "Reset": the SPC/DPC SET state is not taken into account
  - if the triggering order is "Set and Reset": only the SPC/DPC SET state can trig a new waveform record
- in case of the SPC (or DPC) activation mode attribute is configured as "permanent":
  - if the triggering order is "Set": the SPC/DPC SET state can trig a new waveform record
  - if the triggering order is "Reset": the SPC/DPC RESET state can trig a new waveform record
  - if the triggering order is "Set and Reset": the SPC/DPC SET and RESET states can trig new waveform records

Type of measurement records

Only values provided by the following CX66 acquisition modules can be recorded in fast waveforms records:

- TMU210 board (VI #, CI #)
- TMU220 board (VI #, CI #)
- IEC61850-9.2LE Sample Values (SV)

The RMS measurement values (MV) can NOT be recorded by Fast waveform recorder.

Time stamping

Data is time stamped using U.T.C. time.

When creating the waveform file, the trigger and the first sample date are converted into Local time.

All other samples are associated with a counter of microsecond calculated relatively to the date of the first one.

Quality of digital channel datapoint

For digital signals, only changes of state with "quality valid" are taken into account.

COMTRADE files management

The list of files in the C26x can be displayed, downloaded or removed using **CMT** ("Disturbance" menu).

12.2.2 SLOW WAVEFORM

The inputs for the slow waveform records are:

- Analogue values coming from CT VT calculation (RMS values)
- Analogue values coming from AIU boards
- Digital inputs
- Digital outputs

The function manages as many as 24 analogue and 48 digital values.

Data from TMU220 can be chosen among:

- RMS values of phase voltages (phase-to-neutral or phase-to-phase)
- RMS values of busbar voltage
- RMS values of phase current
- RMS values of residual voltage and current
- Fundamental sequence components
- Active, Reactive, Apparent Powers (components and total)
- Frequency and Harmonics level

Data from TMU210 can be chosen among:

- Star wiring: RMS values of phase-to-neutral voltages or/and instantaneous phase-to-phase voltage
- Delta wiring: RMS values of phase-to-phase voltage
- RMS values of busbar voltage (Vbb or Vr whether V4 or VN is connected on Busbar)
- RMS values of phase current
- RMS values of residual voltage and current (Vr, Ir)
- Zero sequence voltage (V0)
- Active, Reactive, Apparent Powers (total) and Power factor (total)
- Frequency of line (or busbar if V4 is connected to the busbar)
- Standard synchrocheck data (ΔF, ΔV, $\Delta \Phi$)

The C26x stores at maximum 5000 integrated values as follows:

Number of Files	Number of integrated values
1	5000
2	2500
5	1000
10	500
20	250
50	100

The integrated value has a duration of up to one hour. It is defined in configuration.

For analogue samples, the stored value is the average value of the signal over the integration time.

For digital samples, the stored value depends on the duration of the digital signal: if the signal duration is longer than the arbitration period, the stored value is 1, if it is shorter, the stored value is 0.

The slow waveform recorder can be triggered by the following events, each of which is settable:

- Changes in state of binary inputs (SP, DP or Groups). The triggering is available only from a state/value with VALID quality (ex: SET/RESET; OPEN/CLOSE) to a state/value with VALID quality
- Changes in state of digital outputs (in case of SBO, the execution order is the trigger)
- Measurement threshold violations
- Operator request
- Periodically: e.g., every day at 00h00

Conditions

The conditions for slow waveform recording include the following:

1 Digital inputs are not recorded if the integration time is longer than 100 ms (i.e. 5 cycles at 50 Hz, 6 cycles at 60 Hz)

2 A digital input is recorded as “1” if it remains at “1” during x% of the integration time (x between 10 and 100%, with a 1% step)

3 The permitted cycle numbers are as follows:

- 1 to 180 000 at 50 Hz
- 1 to 216 000 at 60 Hz

4 The measurements issued from analogue inputs boards are processed as follows:

- If the integration time is less or equal to 1 second, the recorded value is the current measurement value
- Otherwise, the recorded value is equal to:

$$Record = \sum_{i=1}^{N} \frac{TMi}{N}$$

N: number of seconds in the integration time

TMi: measurement value at the “i” second of the integration time



If the integration time is longer than 1 second, it can only be set as a multiple of 1 second, i.e.:
- At 50 Hz, it should be set to 100 (2s), 150 (3s), … 179950 (3599s) and 180000 (3600s).
- At 60 Hz, it should be set to 120 (2s), 180 (3s), … 215940 (3599s) and 216000 (3600s).

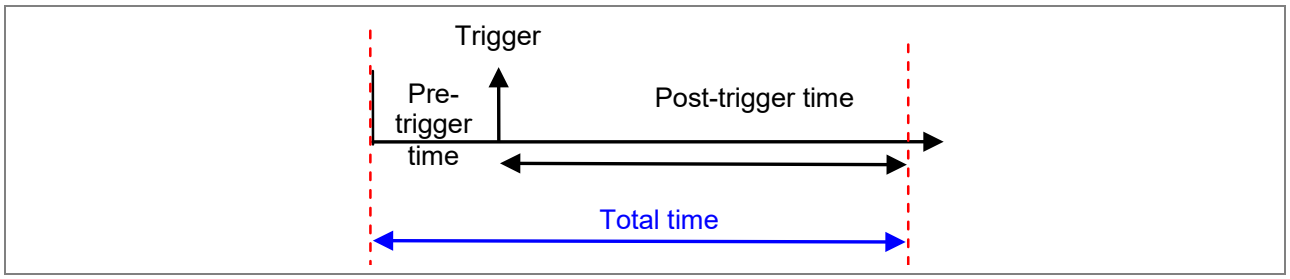
12.2.3 RECORDING MECHANISM

The CPU sends a command, referred to as a trigger, to start a disturbance recording.

The CPU4 stores in a buffer 32 samples by period of the 8 analogue channels according to the configuration:

- Pre-trigger time
- total time
- integration time

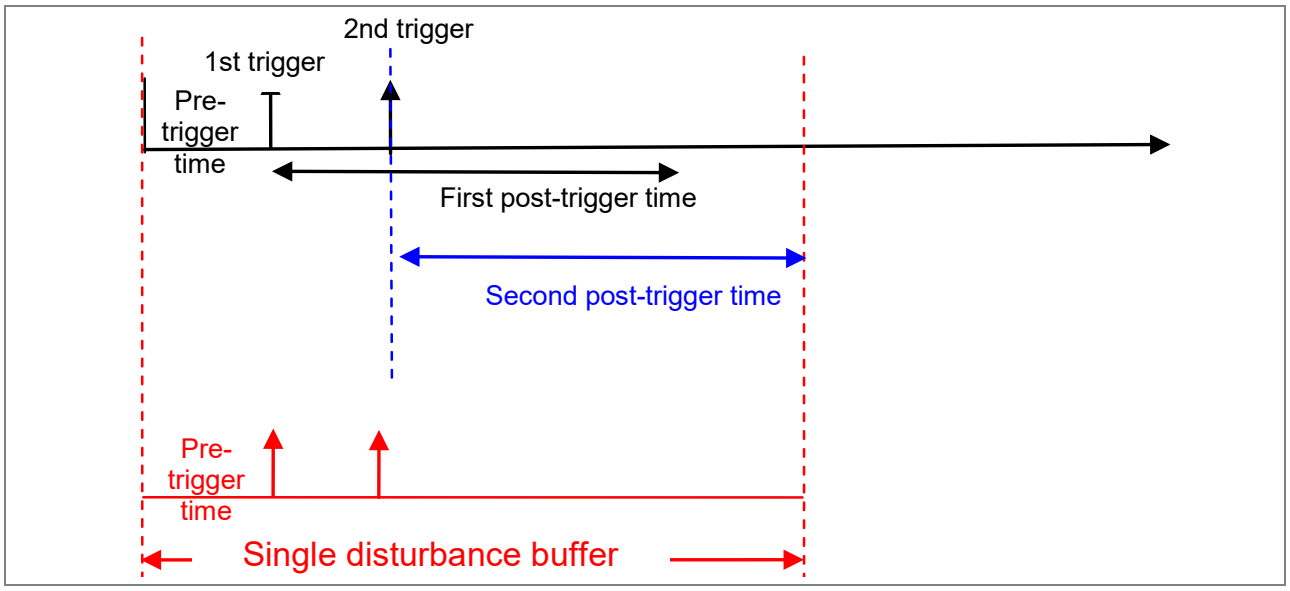
The CPU converts this buffer into a waveform, adding binary inputs/outputs defined in configuration.



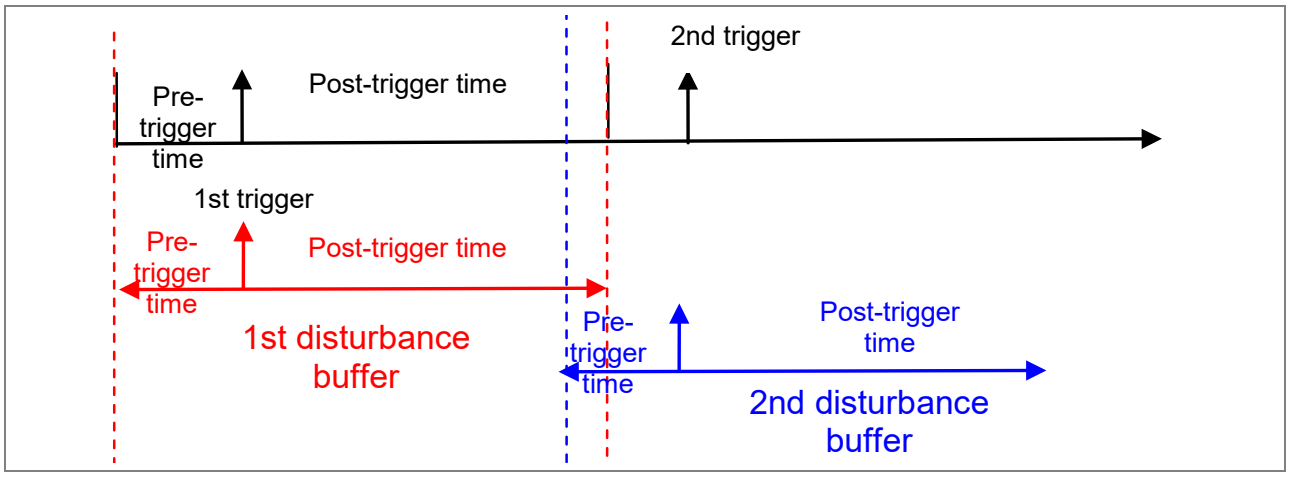
The maximum length of a disturbance record buffer is **2 * total time.**

One record contains at least one trigger and at most 2 triggers.

If a second trigger appears during the post time of the first trigger, only one buffer is generated and split into two files. Therefore the DS Agile C26x generates two files.



If a 2nd trigger appears after the post time of the first trigger, a second buffer is generated.



If a 3rd trigger appears, it is ignored if the previous buffer is not yet downloaded by the CPU.

12.3 NON-PERMANENT DATA STORAGE

12.3.1 ALARMS

12.3.1.1 DEFINITIONS

12.3.1.1.1 Definition of an alarm

An alarm is a visual (and optionally audible) annunciation of the appearance and/or disappearance, within the controlled electrical process or within the system itself, of an event, defined during the configuration phase as ”to be alarmed”.

These definitions, of what is to be alarmed and what it is not, are completely user relevant.

However, the concept of alarms into DS Agile has been introduced to inform the operators of “abnormal” or “special” events or other miscellaneous events that you must absolutely not overlook.

12.3.1.1.2 Types of alarmed data

These events can generate an alarm:

- Each Binary Input (SP, DP, MP, SI, IED input, Groups) state related to “the reason for change” of these events
- Each Measurement state related to “the reason for change” of these events
- Each TPI state or value related to “the reason for change” of these events
- Each metering state related to “the reason for change” of these events

For example, the OPEN state of a circuit-breaker can be un-alarmed if the change is due to a control, and alarmed if the change is due to another reason.

An alarm can be related to a control acknowledgement. In this event, the alarm is considered as “spurious”.

12.3.1.1.3 Alarm states definition

An alarm is generated by an event: for example, a particular datapoint in a state defined during the configuration phase as “to be alarmed”.

While this event is still present: for example, the previous particular datapoint is still in the same state, the alarm is “active”.

When this event disappears: for example, the previous particular datapoint is now in another not alarmed state; the previous alarm is “inactive”.

An existing alarm (active or inactive), can be acknowledged by an operator from the FP.

An alarm can have the following states:

- Inactive: no transition, no event
- Active-acknowledged: the cause is still present but the active state has been taken into account by the operator
- Active-unacknowledged: the cause is still present and the active state has not been taken into account by the operator
- Inactive-unacknowledged: the cause has disappeared but the inactive state has not been taken into account by the operator (only available for events alarmed on appearance and disappearance)
- Inactive-acknowledged: the cause has disappeared and the inactive state has been taken into account by the operator
- Inactive-active-unacknowledged: the cause has disappeared but the active state (previous state) has not been taken into account by the operator

12.3.1.1.4 Parameters associated to an alarm

The following user-selectable parameters can be associated with each alarm definition. The values are set during the configuration phase for each alarm:

- Immediate or differed:
  - an “immediate” alarm is displayed as soon it has been detected.
  - a “differed” alarm is displayed only after a user-selectable time delay following its detection (the event associated with the alarm must remain present during the delay; if not, the alarm will be not displayed); this delay is in the range of 1 to 120 seconds and can be set to particular value for each “differed” alarm.
- Gravity level: this level is defined for each alarm allowing a hierarchical classification to deal with the urgency of the events; the gravity level value can be: 0, 1, 2, 3, 4 or 5, 5 being the most grave and 0 meaning that there is no gravity level.
- Alarm generated:
  - only when the associated event appears

OR

  - when the associated event appears AND when it disappears

    In this event the “differed” parameter is taken into account only when event appears; when event disappears the new state of the alarm is displayed immediately.
- Alarm clearing mode:
  - manual: the alarm is cleared only on an operator request; this clearing command is only permitted on inactive-acknowledged alarms.
  - automatic: an alarm is automatically cleared when it reaches the appropriate state.
  - gravity basis
- Audible or not when detected.

12.3.1.2 ALARM PROCESSING

Only one alarm (the last one) associated with a state change of a data is displayed. The previous one (concerning the data) is replaced by the current one.

According to the previous example, only one from the three alarmed states can be displayed for the switching device: for example, "JAMMED" or "TOGGLING" or "OPEN" state (the last one that has appeared).

By configuration, one of the following behaviours is chosen:

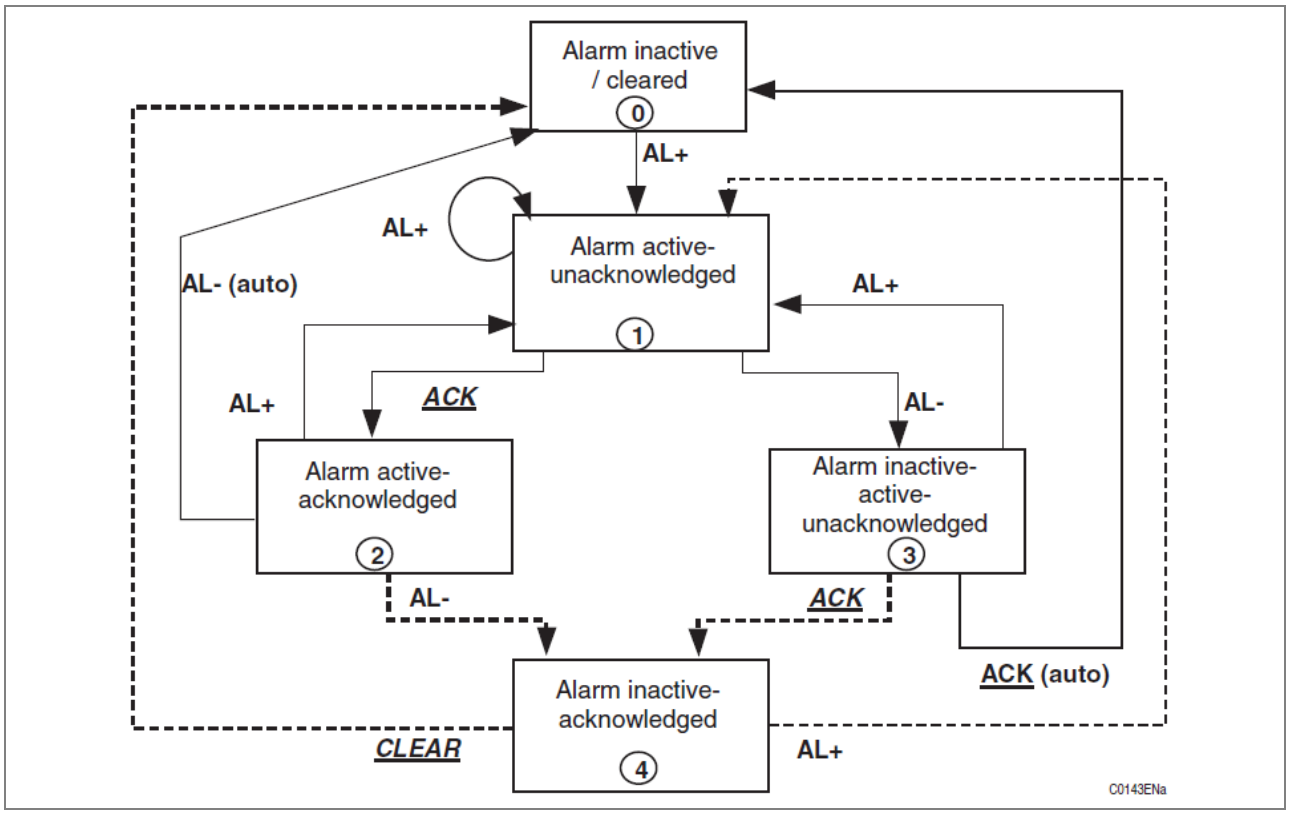


Figure 98: Event alarmed on appearance only

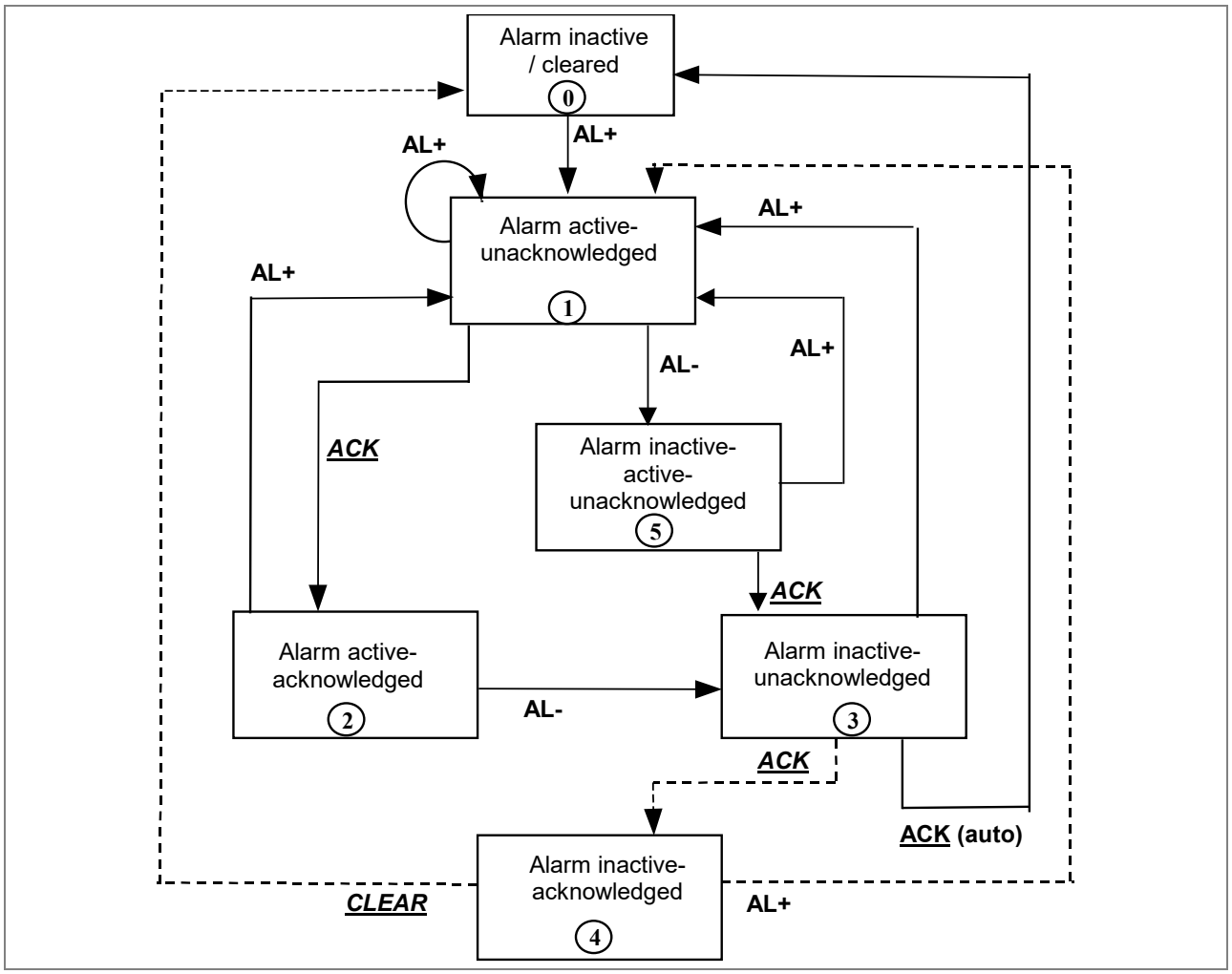


Figure 99: Event alarmed on appearance and disappearance

Transition events:

- AL+: alarmed event appearance
- AL–: alarmed event disappearance
- ACK: operator acknowledgement of the alarm
- CLEAR: operator clearing of the alarm

Note:
In that event "alarmed event disappears (AL-)" means that the associated data is now in another state that is not alarmed. The time stamp of the alarm is modified.

Transition conditions:

- (auto) means Automatic clearing

Transition description:

The transition from alarm state "0" to alarm state "1" is crossed when the alarmed event appears (AL+).

The alarm state transitions "1 → 1" and "2 → 1" are crossed when the state of the data associated with the alarm goes from a state that is flagged to be alarmed with any gravity level to another state that is also flagged to be alarmed with any gravity level (AL+). In this event the active alarm stays active but the time tagging of the alarm is changed. The new alarm time stamp corresponds to the last associated data state change. The alarm becomes unacknowledged if not already unacknowledged.

The alarm state transitions "1 → 2", "3 → 4" and “5 → 3” are crossed on operator acknowledge action. The time stamp of the alarm is unchanged.

The alarm state transitions "1 → 3" and “1 → 5” are crossed when the alarmed event disappears (AL-). The time stamp of the alarm is modified.

The alarm state transition "2 → 4" is crossed when the event disappears (AL-) the alarm being configured to be activated only "on appearance of the event". The time stamp of the alarm is modified.

The alarm state transition "2 → 3" is crossed when the event disappears (AL-) the alarm being configured to be activated "on appearance and disappearance of the event". The time stamp of the alarm is modified and the alarm will have to be acknowledged again.

The alarm state transitions "3 → 1", "4 → 1" and “5 → 1” are crossed when the previous alarmed event appears again or when another state that is also flagged to be alarmed with any gravity level appears (AL+). The alarm becomes active-unacknowledged. The time stamp of the alarm is modified.

The alarm state transition "2 → 0" is crossed when the event disappears (AL-) the alarm being configured to be activated only "on appearance of the event" and "to be cleared automatically". The alarm is removed from the alarm list.

The alarm state transition "3 → 0" is crossed on operator acknowledgement only if the alarm associated with the event is configured as "to be cleared automatically". The alarm is removed from the alarm list.

The alarm state transition "4 → 0" is crossed on operator clearing action. The alarm is removed from the alarm list.

12.3.1.2.1 Acknowledgement

Acknowledgement of an alarm can be done by two ways:

- **On operator request:** an operator can acknowledge an existing alarm from the front panel to signify that it has been taken into account.
- **Globally:** at substation level it is possible to use an SPS (named **Global alarm ack**) especially dedicated to a global acknowledgement of alarms: When this SPS is set to the SET state all alarms present in the controller are acknowledged. As long as this SPS remains in the SET state, any new alarm is inserted in the alarm list with the ACKLOWLEDGED status.

  In addition to the Global Alarm Acknowledgement SPS, a Local Alarm Acknowledgement SPS can be defined on a per C26x basis: that is, one for each C26x.
  This SPS can be wired or managed by an automation. When this SPS is configured in a C26x, the “Global Alarm Acknowledgement” SPS is no more taken into account by this C26x.
  When this SPS is SET, all C26x alarms are immediately acknowledged.
  This SPS cannot be transmitted on the Station Bus network: that is, it remains local to the C26x, so it cannot be associated to a remote – aView or SCADA - control.

12.3.1.2.2 Clearing

Whatever the clearing mode is, the clearing of an alarm is immediately taken into account: removal from the alarm list.

Automatic clearing

An alarm can be configured as “to be cleared automatically”. It means that when this alarm reaches the appropriate state, it is cleared automatically without any operator action. The events of “automatic clearing” are:

- the alarm is in the **active-acknowledged** state and the alarm disappears (for event alarmed on appearance only)
- the alarm is in the **inactive-active-unacknowledged** state and the operator acknowledges it (for event alarmed on appearance only)
- the alarm is in the inactive-unacknowledged state and the operator acknowledges it (for event alarmed on appearance and disappearance)

This feature can be configured on a per alarm basis.

Operator request clearing

An alarm that is not configured as “to be cleared automatically” has to be cleared by an explicit operator action (this action being only possible when it is in the “inactive-acknowledged” state). Otherwise it remains present in the alarm list.

As for an acknowledgement by an operator, clearing of alarms by an operator can be configured so as to be printed or not printed.

A global clearing procedure, that allows you to clear all “inactive-acknowledged” alarms in a single operation, will be provided.

Audible alarms

An audible alarm can be associated with the “unacknowledged” state of an alarm. This facility is configurable on a per alarm basis.

If an alarm is configured “audible” then the sound appears when the alarm is displayed.

The audible alarm is stopped when all audible alarms are acknowledged.

An audible alarm can be associated with the “unacknowledged” state of an alarm. This facility is configurable on a per alarm basis.

If an alarm is configured as “audible” then the sound appears when the alarm is displayed.

The audible alarm is stopped when all audible alarms are acknowledged.

HARDWARE

C26X/EN HW/E72c

Contents

1	**CHAPTER OVERVIEW**	**3**
2	**COMPONENTS**	**4**
3	**MECHANICAL IMPLEMENTATION**	**7**
3.1	**Compact 40TE case**	**7**
3.1.1	Overview	7
3.1.2	Front Panels	9
3.1.3	Internal Buses	11
3.1.4	Bonding	12
3.1.5	Rear Panel	13
3.2	**Standard 80TE case**	**14**
3.2.1	Overview	14
3.2.2	Front Panels	16
3.2.3	Internal Buses	17
3.2.4	Rear Panels	19
3.2.5	Without CT/VT board	20
4	**CODING OF BOARD ADDRESS**	**21**
5	**BOARD LOCATIONS**	**22**
6	**BOARD DESCRIPTION**	**25**
6.1	**Universal, Single or dual-Input auxiliary power supply and legacy ports module – BIU261S/BIU261D**	**25**
6.1.1	Configurable communications Port 1 - RS232/485	26
6.1.2	Configurable communications Port 2 - RS232/422/485	27
6.2	**Central Processing Unit and communications board – CPU4**	**28**
6.2.1	Digital Process Signals	32
6.2.2	Sampled Values	32
6.3	**Circuit breaker Control Unit - CCU200**	**33**
6.4	**Circuit breaker Control Unit - CCU211**	**34**
6.5	**Digital Inputs Unit – DIU200**	**36**
6.6	**Digital Inputs Unit – DIU211**	**37**
6.7	**Digital Inputs Unit – DIU221**	**39**
6.8	**Digital Outputs Unit – DOU201**	**41**
6.9	**High Break Unit – HBU200**	**42**
6.10	**Analogue Input Unit – AIU201**	**43**
6.11	**Analogue Input Unit – AIU211**	**44**
6.12	**Transducerless Measurements Unit – TMU220**	**45**
6.13	**Transducerless Measurements Unit – TMU210**	**46**
6.14	**Analogue Output Unit – AOU200**	**47**
6.15	**PRP Ethernet Switch SRP282/284**	**47**
6.16	**HSR Ethernet Switch SRP292/294**	**51**

1 CHAPTER OVERVIEW

This chapter provides information about the DS Agile C26x's hardware design.

2 COMPONENTS

The DS Agile C26x is based on a modular and scalable architecture to support dedicated hardware modules adapted to the plant data interfaces.

Each DS Agile C26x rack is equipped with the following modules:

- CPU4: **C**entral **P**rocessing **U**nit and communications board
- **Front panel**:
  - GHU301 (for 80TE case) or GHU300 (for 40TE case): **G**raphical **H**uman machine interface **U**nit: Front Panel including 17 LEDs (13 are user-configurable) + 7 pushbuttons (L/R, Open, Close, etc) + LCD (resolution of 128 x 128 pixels /16 lines of 21 characters each) and a keypad at the front plate for local HMI management

    or
  - GHU311 (for 80TE case) or GHU310 (for 40TE case): Front Panel including 17 LEDs (12 are user-configurable) + 1 pushbutton (L/R)

    Or
  - GHU221 (for 80TE case) or GHU220 (for 40TE case): Front Panel used to connect a detachable HMI (GHU30x or GHU31x)
- **Power supply**:
  - BIU261: **B**asic **I**nterface **U**nit with universal input power supply: this board can hold a daughter board carrying a redundant power supply input, thus offering a dual-input power supply module. It also includes a watchdog relay, 2 digital outputs/2 digital inputs for C26x redundancy and 2 isolated RS485/RS232 interfaces.
- **Internal bus**:
  - FBP28x: **F**ront **B**ack**P**lane: bus for 80TE case
  - ZP0066001 Front BackPlane: bus for 80TE case with 2 TMU220 boards
  - ZP0066001 Front BackPlane: bus for 80TE case with 1 TMU220 board and 1 TMU210 board

    or
  - FBP24x: **F**ront **B**ack**P**lane: bus for 40TE case

Depending on the needs, additional modules may be added (optional):

- CCU200: **C**ircuit breaker **C**ontrol **U**nit, each with 8 digital inputs and 4 digital outputs
- CCU211: **C**ircuit breaker **C**ontrol **U**nit, each with 8 digital inputs and 4 digital outputs (versions are jumper-selected)
- DIU200: **D**igital **I**nputs **U**nit, each with 16 digital inputs
- DIU211: **D**igital **I**nputs **U**nit, each with 16 digital inputs for voltages from 24 to 220V_{DC} (versions are jumper-selected)
- DIU221: **D**igital **I**nputs **U**nit, each with 16 digital inputs for voltages from 154 to 170V_{DC} or 250 V_{DC} +/-20% (versions are jumper-selected)
- DOU201: **D**igital **O**utputs **U**nit, each with 10 digital outputs
- HBU200: **H**igh **B**reak **U**nit, each with 10 heavy duty digital outputs
- AIU201: **A**nalogue **I**nput **U**nit, each with 4 analogue inputs (direct current or voltage loops)
- AIU211: **A**nalogue **I**nput **U**nit, each with 8 analogue inputs (direct current loops)
- TMU220: **T**ransducerless **M**easurements **U**nit board for direct CT/VT measurement
- TMU210: **T**ransducerless **M**easurements **U**nit board for direct CT/VT measurement and protection functions
- AOU200: **A**nalogue **O**utput **U**nit, each with 4 current analogue outputs
- SRP28x: Ethernet switch board for PRP (Parallel Redundancy) protocol, with 3 electrical links and 2 optical links
- SRP29x: Ethernet switch board for HSR (High availability Seamless Redundancy) protocol, with 3 electrical links and 2 optical links
- High Speed Bus: Internal bus present if an SRP28x switch board is used. It provides high speed communications between the CPU4 to the SRP28x.



Caution:
50% of digital inputs and 50% of digital outputs may be energized simultaneously at the maximum ambient temperature (-25°C; +55°C)

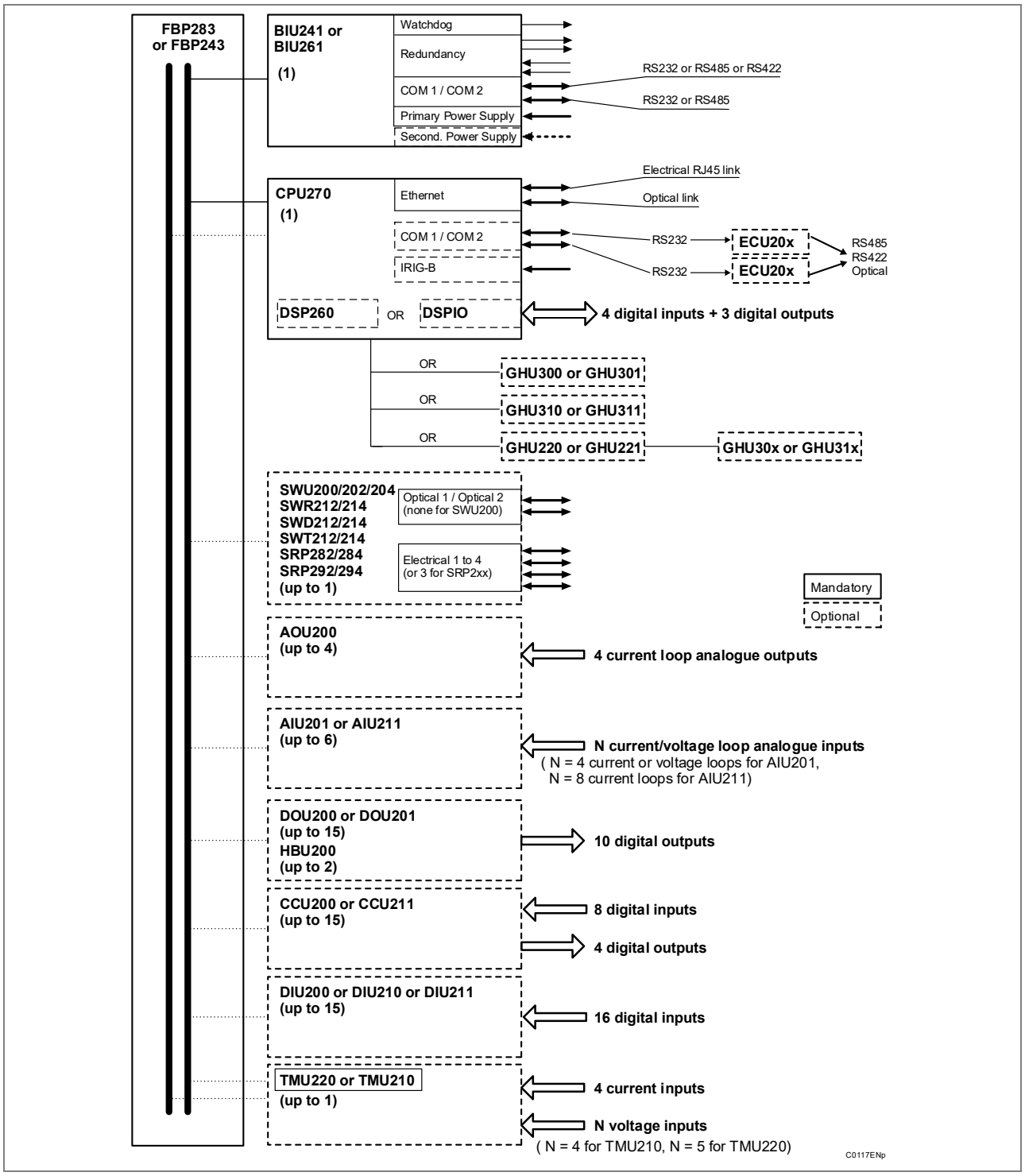


Figure 1: Standard hardware overview

Note:
The High Speed Bus is available only with SRP28x cards.

3 MECHANICAL IMPLEMENTATION

The DS Agile C26x range of products are implemented in one of two case sizes.

Case dimensions for industrial products usually follow modular measurement units based on rack sizes. These are: U for height and TE for width, where:

- 1U = 1.75 inches = 44.45 mm
- 1TE = 0.2 inches = 5.08 mm

All DS Agile C26x products are nominally 4U high. This equates to 177.8 mm or 7 inches.

The case width depends on the product type and its hardware options.

Two case widths are available:

- Compact case, 40TE-wide
- Standard case, 80TE-wide

3.1 COMPACT 40TE CASE

3.1.1 OVERVIEW

The dimensions of this rack are indicated in the figure below (in mm):

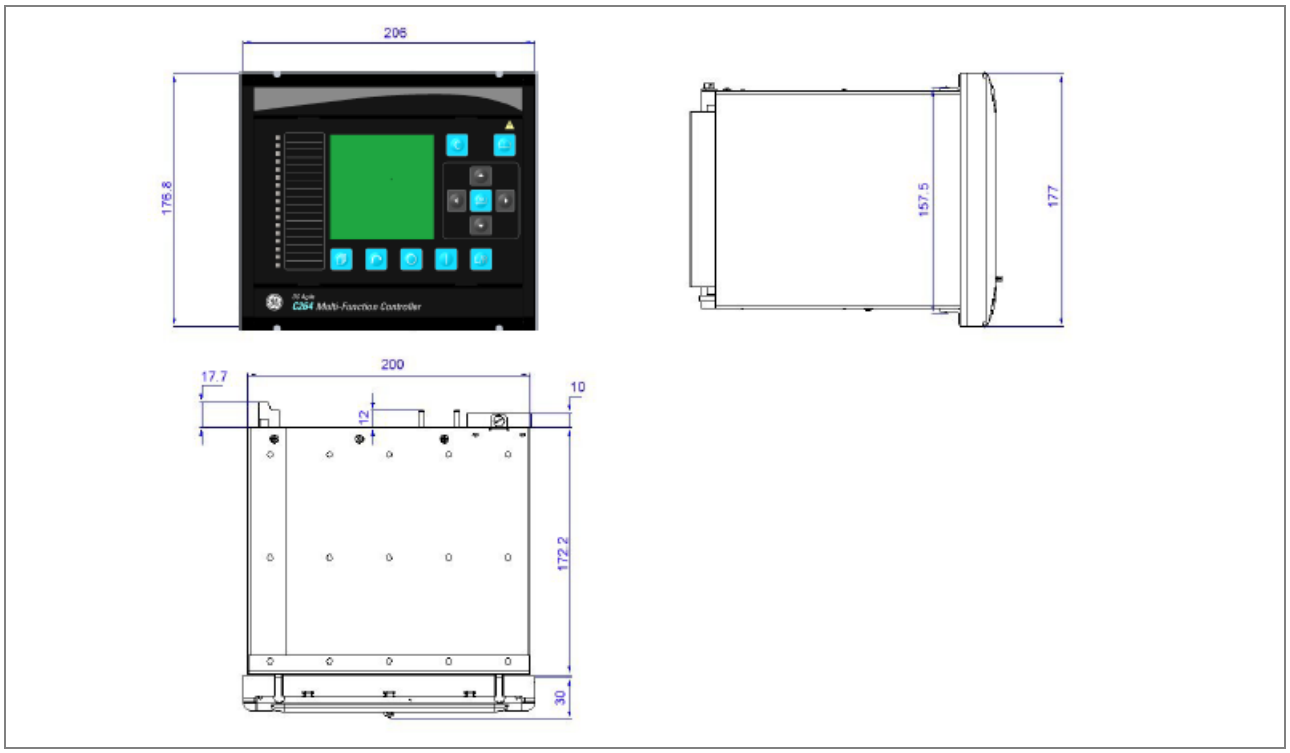


Figure 2: Compact 40TE case – Rack size

Case properties

- Degree of protection:
  - Case IP2x as standard
  - Front panel: IP52 for front panels with LEDs/LCD, IP10 for blind front panel (GHU220)
  - Rear panel: IP20 without TMU2xx board, IP10 with TMU2xx board Rear panel: IP2x without TMU2xx board, IP1x with TMU2xx board
- Metallic case
- Mounting holes position for compact 40TE case:

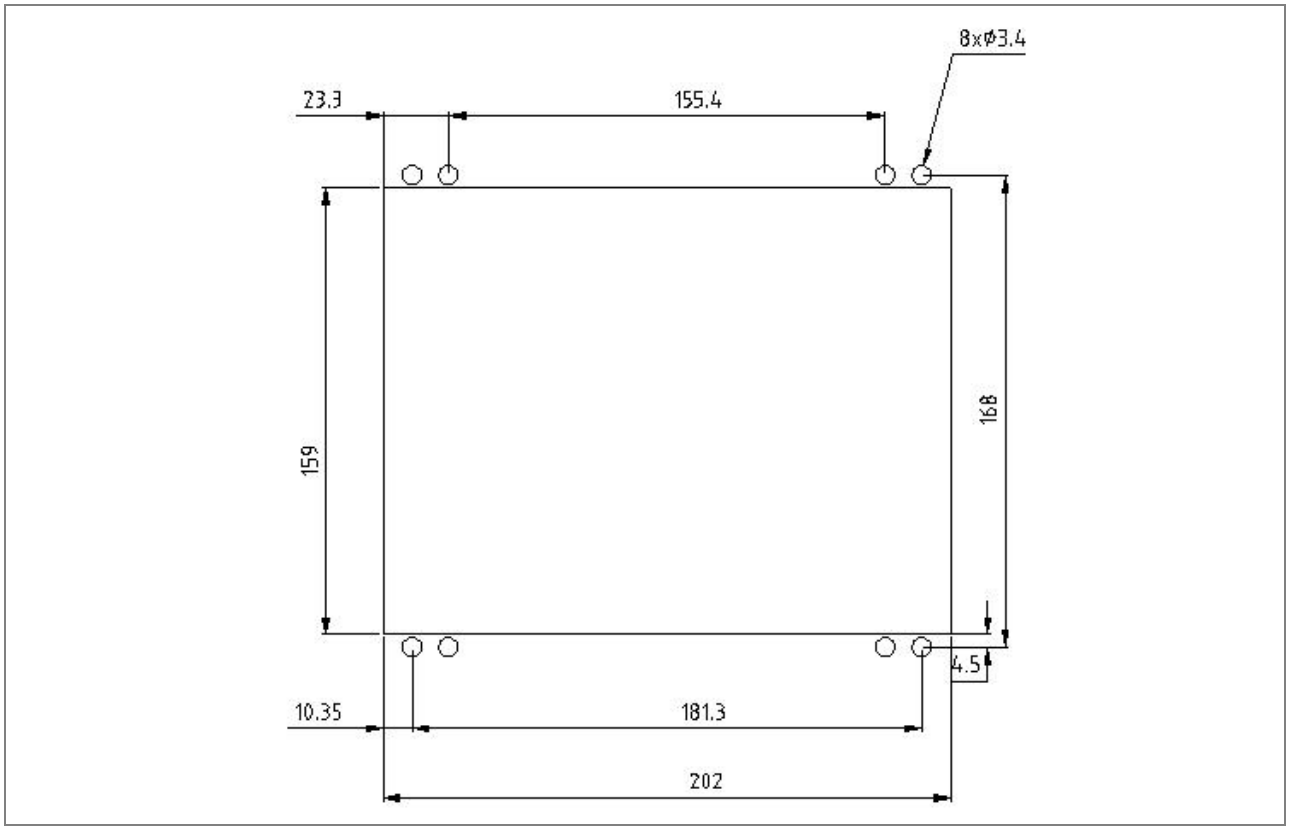


Figure 3: Mounting holes position for compact 40TE case

3.1.2 FRONT PANELS

3.1.2.1 GHU300

The GHU300 is the front panel with local control panel (LCD) and LEDs used for the 40TE case:

- 17 LEDs (13 are user-configurable)
- 7 pushbuttons (L/R, Open, Close, etc)
- a keypad at the front plate for local HMI management with 5 pushbuttons
- an LCD (resolution of 128 x 128 pixels /16 lines of 21 characters each)

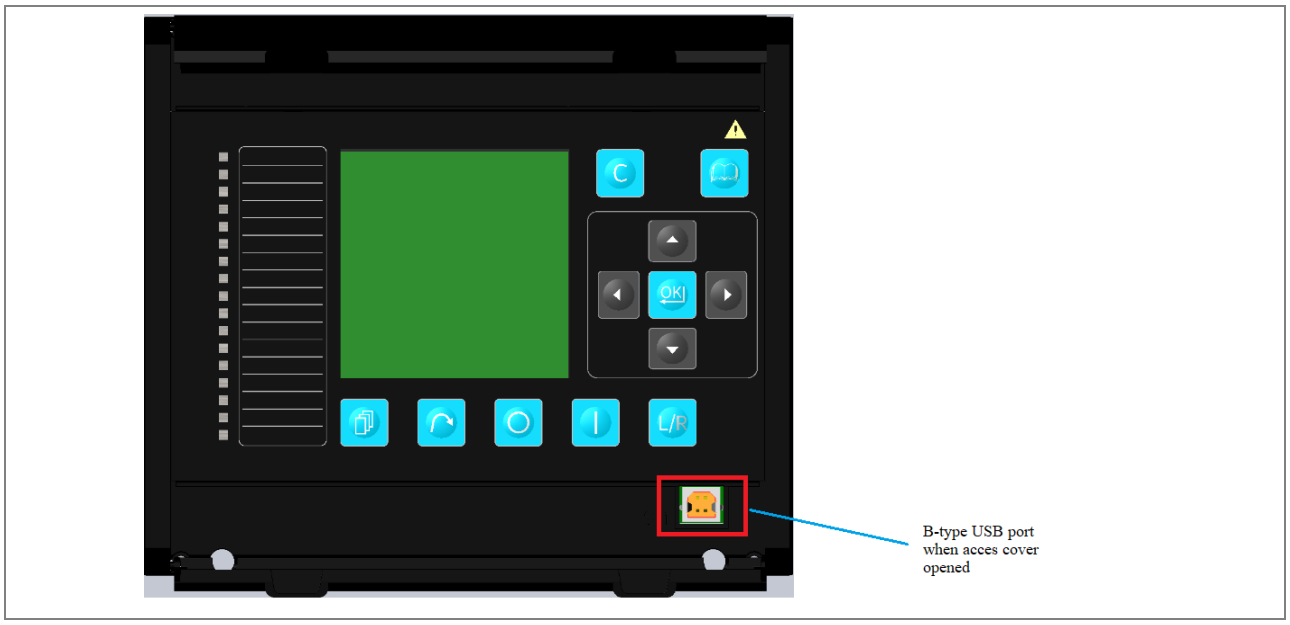


Figure 4: Compact 40TE case – GHU300 Front panel

3.1.2.2 GHU310

The GHU310 is the front panel with LEDs used for the 40TE case:

- 17 LEDs (12 are user-configurable)
- 1 pushbutton (L/R)

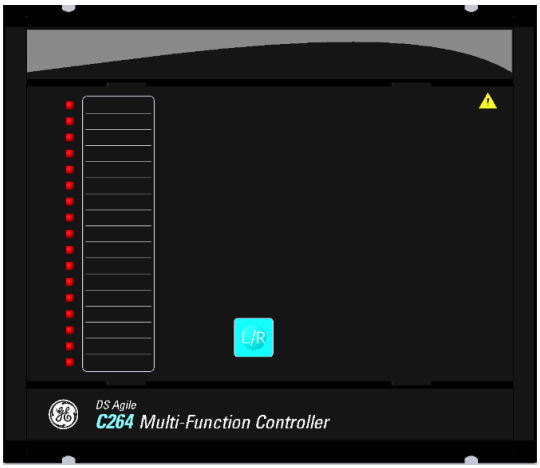


Figure 5: Compact 40TE case – GHU310 Front panel

3.1.2.3 GHU220

The GHU220 is the front panel used for the compact 40TE case. This includes only an RJ11 coupler in order to connect a remote GHU30x or GHU31x.

Note:
The GHU220 must be used only with a remote GHU30x or GHU31x. The FP is detachable through a 3 meters cables from the DS Agile C26x base case using a specific front panel (GHU220)



Figure 6: Compact 40TE case – GHU220 Front panel

3.1.3 INTERNAL BUSES

In conventional use, i.e. without extra switch board, there is only one internal bus in the case, used for communications between boards and to power them.

The FBP24x board is the standard front bus of the compact 40TE case equipped with the CPU4:

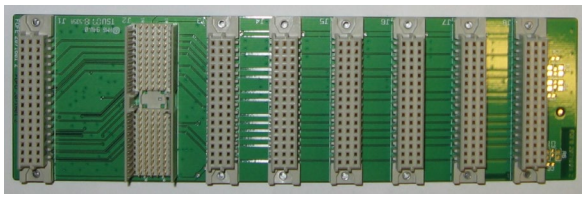


Figure 7: Compact 40TE case standard bus

If an additional switch board is present (SRP28x), it communicates with the CPU4 board via a second bus, called “High Speed Bus”.

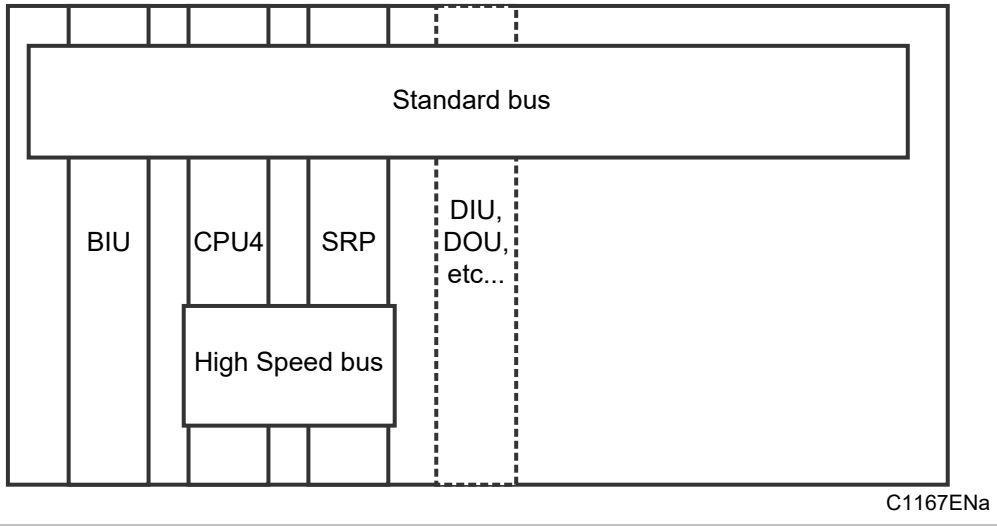
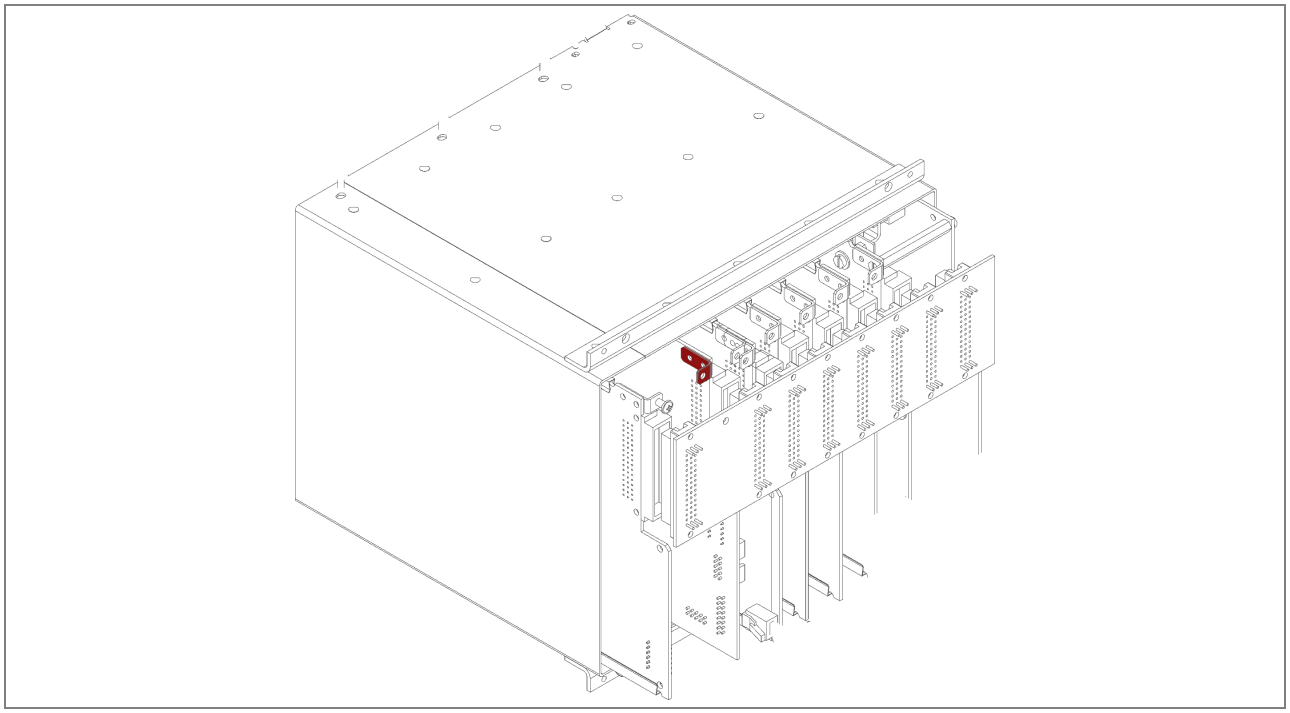


Figure 8: Internal buses

3.1.4 BONDING

In addition to its upper and lower sides, each board is grounded through a bracket (coloured red in the figure below). A conductive screw is used to link that bracket to the case via a fixed lug:



3.1.5 REAR PANEL

3.1.5.1 WITH TMU2XX BOARD

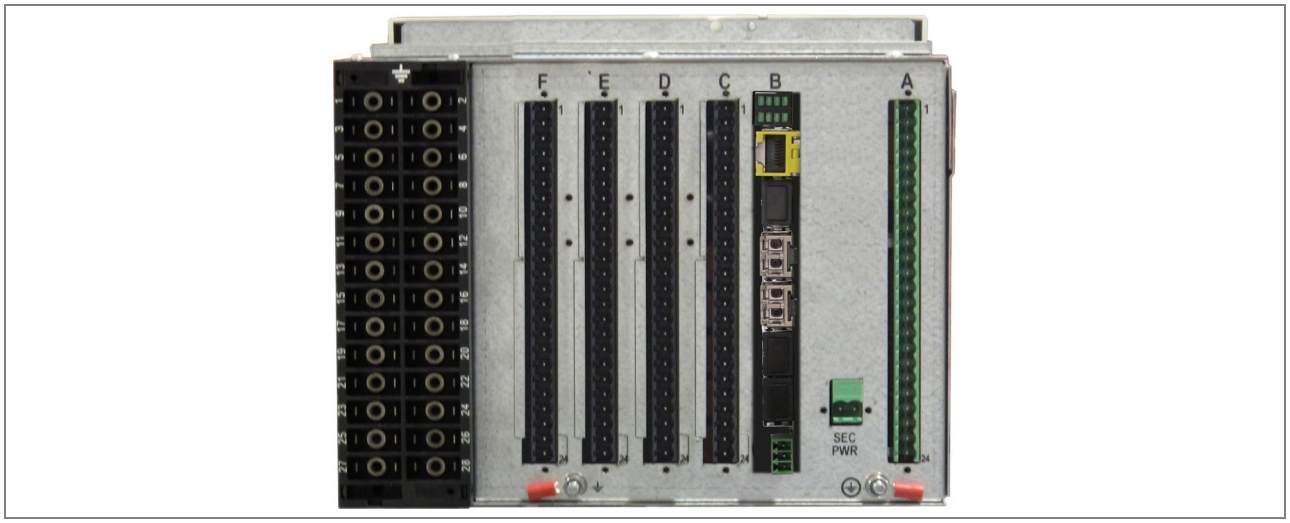


Figure 9: Compact 40TE case – Rear panel with CT/VT connector (on TMU2xx)

3.1.5.2 WITHOUT TMU2XX BOARD

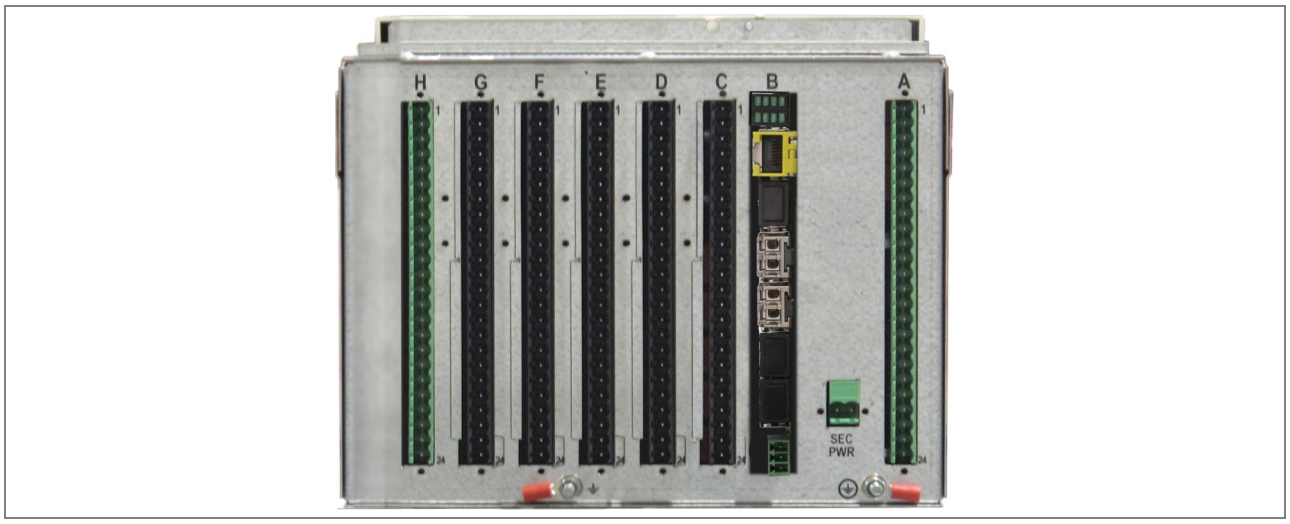


Figure 10: Compact 40TE case – Rear panel without CT/VT connector

3.2 STANDARD 80TE CASE

3.2.1 OVERVIEW

The dimensions of this rack are indicated in the figure below (in mm):

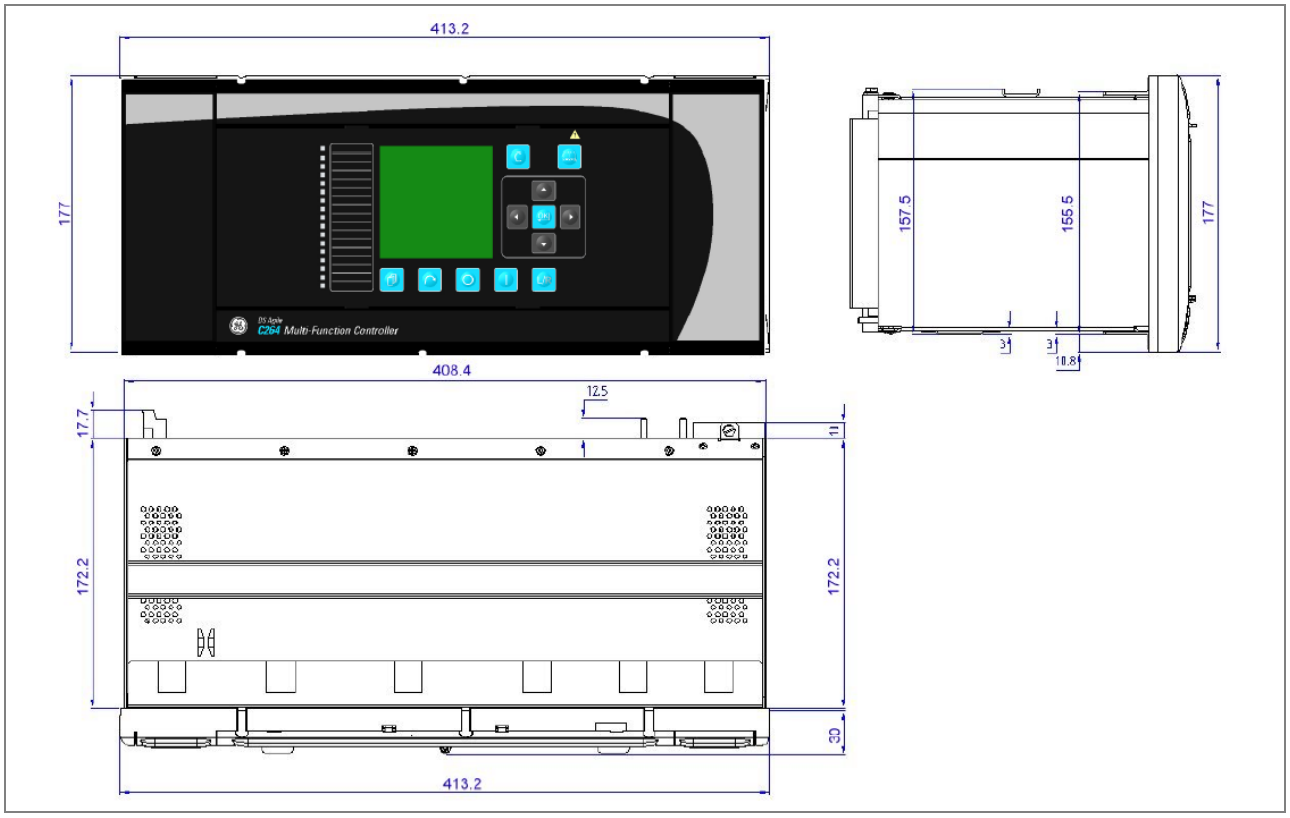


Figure 11: Front panel overview

Case properties

- Degree of protection:
  - Case IP20 as standard
  - Front panel with LEDs/LCD: IP52 for front face only, and IP10 for blind front panel (GHU221)
  - Rear panel: IP20 without TMU2xx board, IP10 with TMU2xx board
- Metallic case
- Mounting holes position for the standard 80TE case:

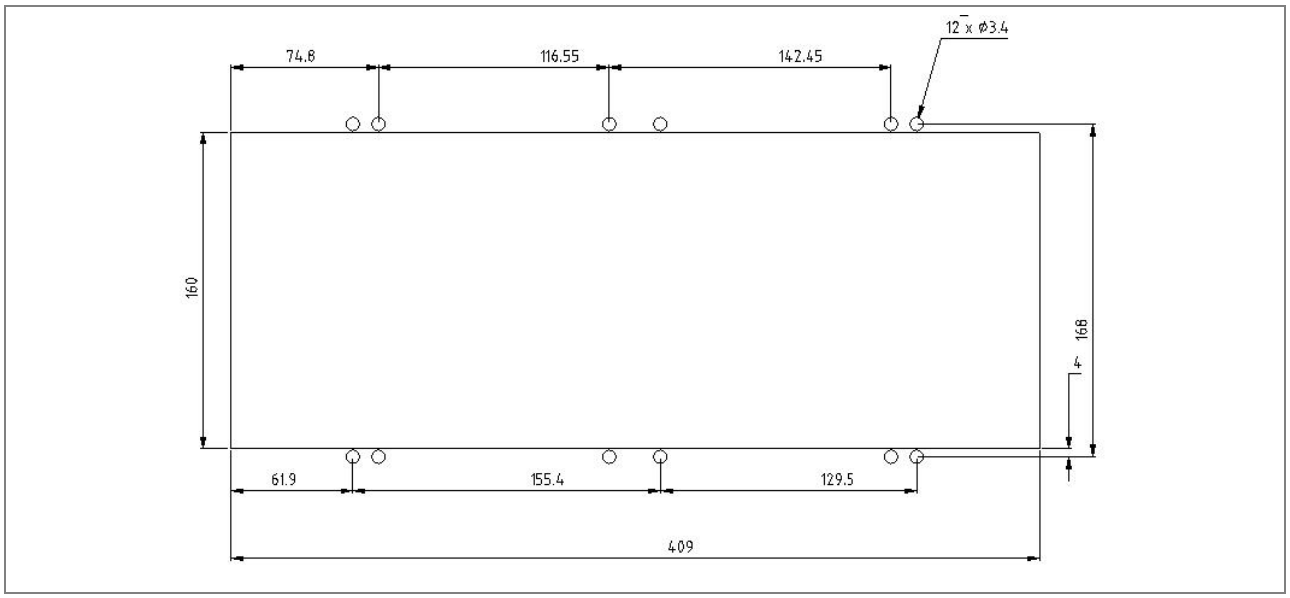


Figure 12: Standard 80TE case - Mounting holes position

3.2.2 FRONT PANELS

3.2.2.1 GHU301

The GHU301 is the front panel with LCD and LEDs used for the standard 80TE case:

- 17 LEDs (13 are user-configurable)
- 7 pushbuttons (L/R, Open, Close, etc)
- a keypad at the front plate for local HMI management with 5 pushbuttons
- an LCD (resolution of 128 x 128 pixels /16 lines of 21 characters each)



Figure 13: GHU301 Front Panel

3.2.2.2 GHU311

The GHU311 is the front panel with LEDs used for the standard 80TE case:

- 17 LEDs (12 are user-configurable)
- 1 pushbutton (L/R)

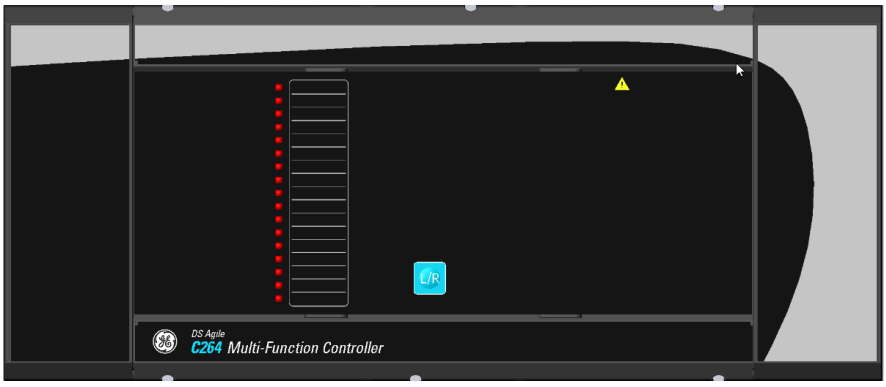


Figure 14: GHU311 Front Panel

3.2.2.3 GHU221

The GHU221 is the front panel used for the standard 80TE case. This includes only an RJ11 coupler in order to connect a remote GHU30x or GHU31x.

Note:
The GHU221 must be used only with a remote GHU30x or GHU31x. The FP is detachable through a 3 meters cables from the DS Agile C26x base case using a specific front panel (GHU221)

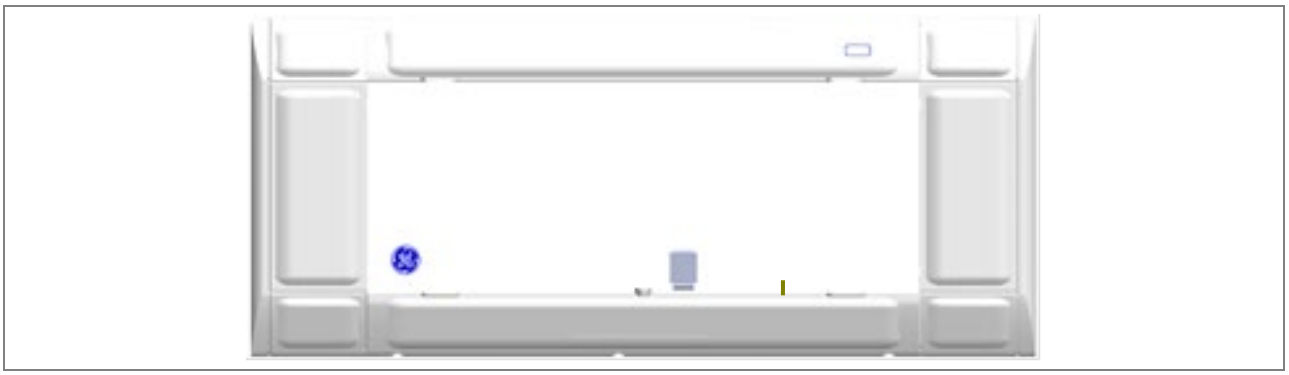


Figure 15: GHU221 Front Panel

3.2.3 INTERNAL BUSES

3.2.3.1 STANDARD BUS

In conventional use, i.e. without Process Bus, there is only one internal bus in the case, used for communications between boards and to power them.

The FBP28x board is the front bus of the standard 80TE case equipped with the CPU4.

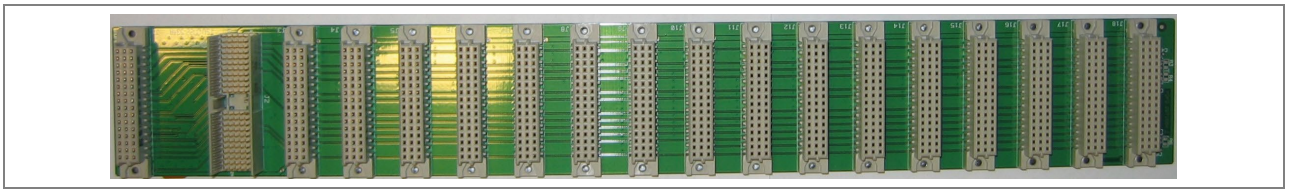


Figure 16: FBP28x Board

If an additional switch board is present (SRP28x), it communicates with the CPU4 board via a second bus, called “High Speed Bus”.

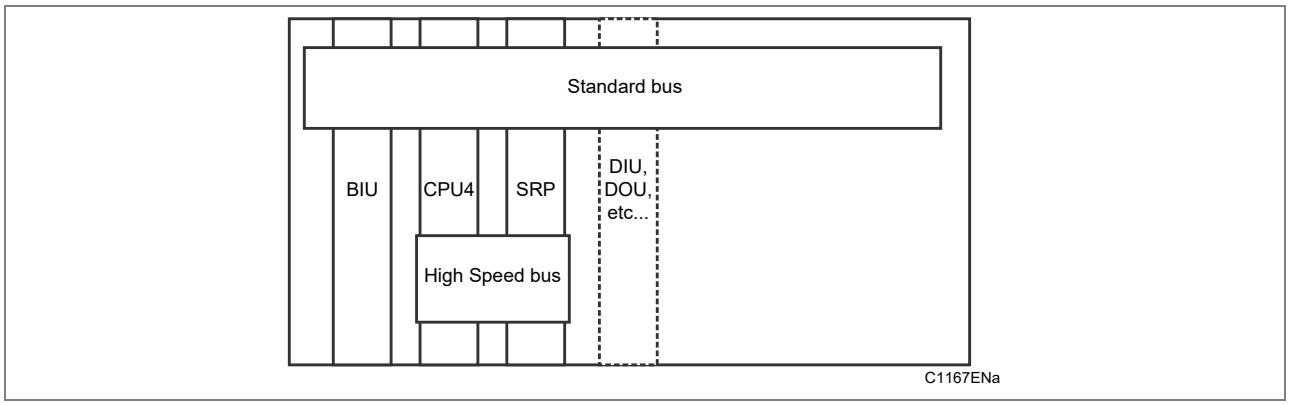


Figure 17: Internal buses

3.2.3.2 SPECIFIC BUS

To manage communications between boards in the case and to power them, a specific internal bus is used when the DS Agile C26x is equipped with two TMU2xx boards.

The ZP0066001 board is the front bus of the standard 80TE case equipped with the CPU4 and two TMU2xx boards.

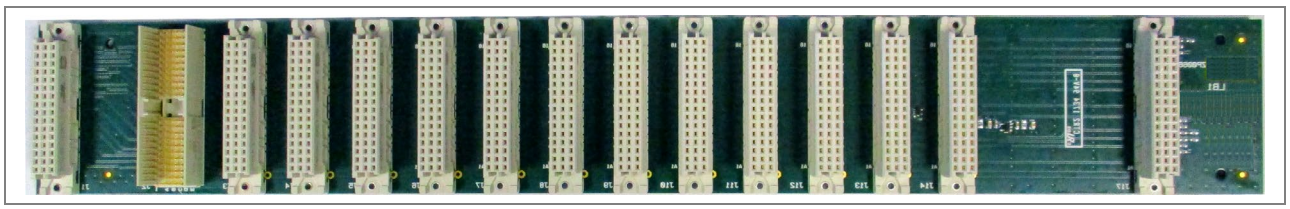


Figure 18: ZP0066001 Board

3.2.4 REAR PANELS

3.2.4.1 WITH ONE CT/VT BOARD (STANDARD RACK)

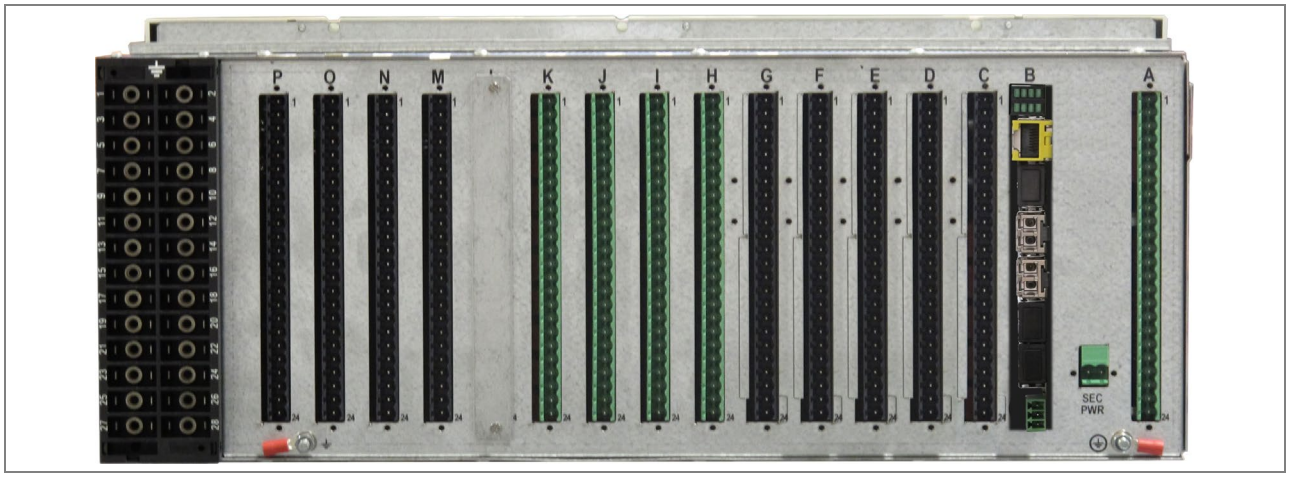


Figure 19: 80TE case – Rear panel with a CT/VT connector

3.2.4.2 WITH 2 CT/VT BOARDS (SPECIFIC RACK)

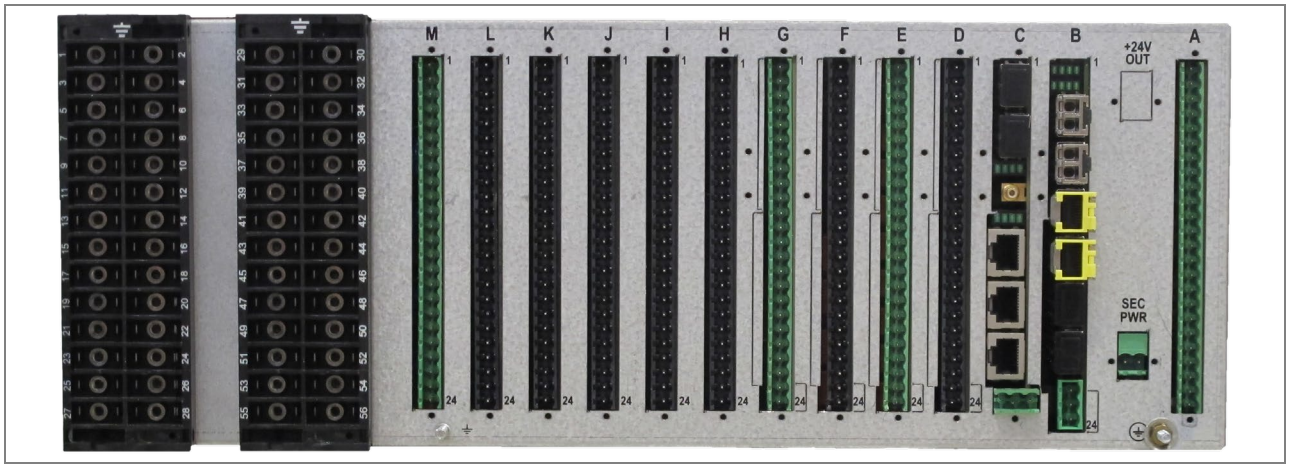


Figure 20: 80TE case – Rear panel with two CT/VT connectors

3.2.5 WITHOUT CT/VT BOARD

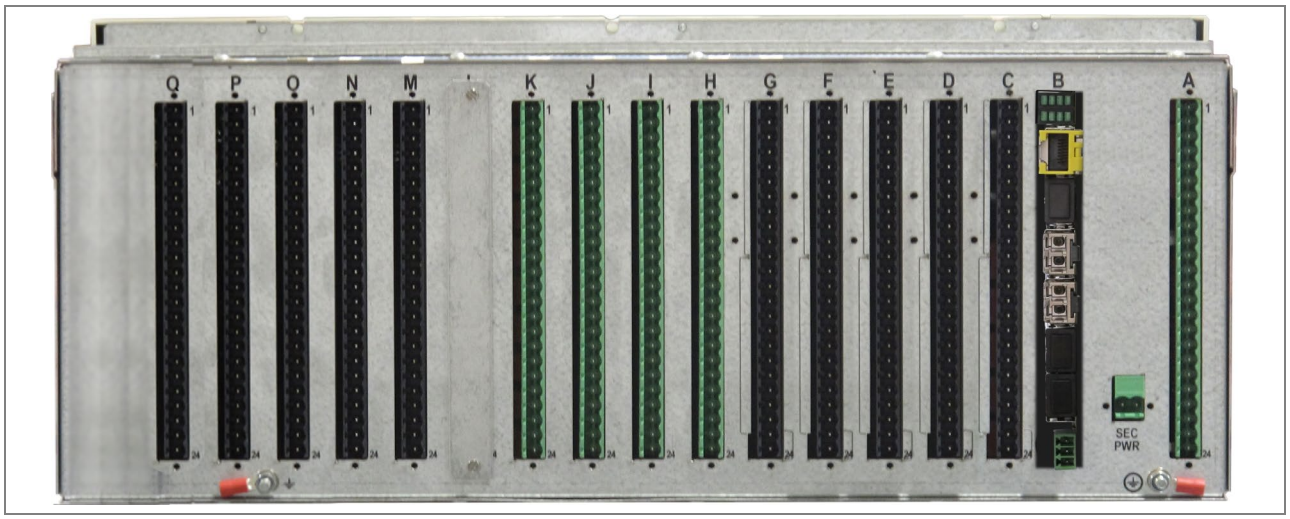
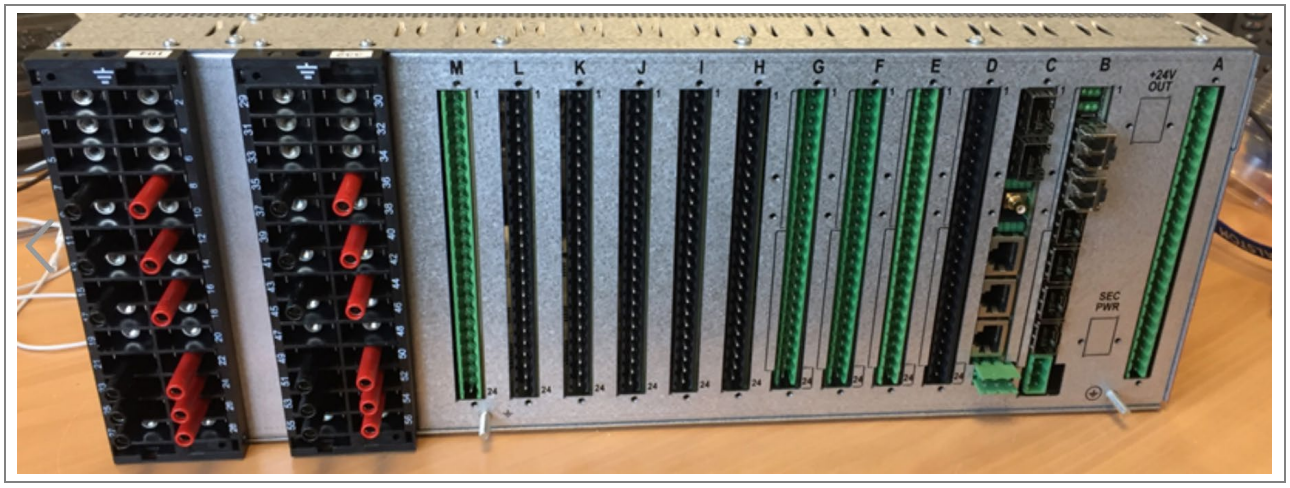


Figure 21: 80TE case – Rear panel without CT/VT connector

4 CODING OF BOARD ADDRESS

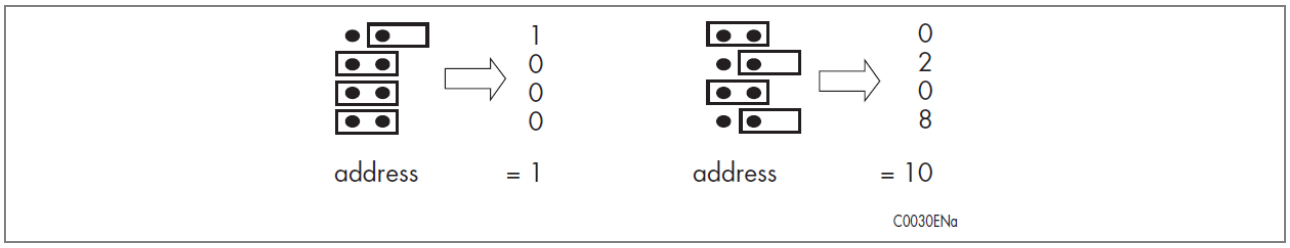
The same rule is applicable to all I/O boards (DIU211, DIU200, DIU221 AIU201, AIU211, DOU201, HBU200, CCU200 and CCU211) controlled by the CPU board:



Binary coding from 0 to 15 based on 4 jumpers top down:

- Jumper
  - missing => 1
  - present => 0

Example



Note:
Two boards of the same type must not have the same address.

Most I/O boards have to have their address set by positioning jumpers, but a few may optionally have their address set based on slot positions in the configuration database, i.e.:

- DIU211
- DOU201
- CCU211
- HBU200

Whichever the selected address configuration mode, the boards are to be placed in the order described in the next section.

5 BOARD LOCATIONS

TMU210/TMU220

Whenever a single CT/VT TMU2xx board is present (either TMU210 or TMU220) , it is always located at the far left of the rack, from the rear (at the far right from the front):

- 40TE rack: Slots G (one TMU2xx board)
- 80TE rack: Slots Q (one TMU2xx board)

Whenever two CT/VT TMU220 boards are used, the boards are located at the far left of the rack, from the rear (at the far right from the front), in their specific rack:

- 80TE rack: Slot Q-N (two TMU220 boards)

Whenever one CT/VT TMU220 board and one CT/CV TMU210 board are used, the boards are located at the far left of the rack, from the rear (at the far right from the front), in their specific rack:

- 80TE rack: Slot N (one TMU220 board) and Slot Q (one TMU210 board).

BIU261S/BIU261D

The power supply BIU2xx board or module is always present and located at the far right of the rack, from the rear (at the far left, from the front):

- 40TE & 80TE: Slot A

CPU4

The CPU4 main processor board or module is always present and located next to the BIU2xx board.

- 40TE & 80TE: Slot B

Switch boards

A PRP/HSR switch function is already integrated in the CPU4 board. A maximum of 1 extra switch board can be added if necessary. If an extra switch board is present, it is always located next to the CPU4 board

- 40TE & 80TE: Slot C

I/O boards

The location of I/O boards varies depending on which boards are present and how many of each.
The maximum number of I/O boards depends on the rack size (40TE: 8 slots, or 80TE: 17 slots) and on whether other boards such as TMU2xx and/or switch board(s) are present.

Note:
In the 40TE and 80TE rack, the TMU2xx board takes up 2 slots.

- From first available slot on the left, towards the right, from the rear (on the right, towards the left, from the front):

1	HBU200	Addresses increasing from 0	Max.: 2 boards (1)
2	DIU200 or DIU211 or DIU221 (do not mix)	Addresses increasing from 0	Max.: Nr of available slots
3	CCU200 or CCU211 (do not mix)	Addresses increasing from 0	Max.: Nr of available slots

- From first available slot on the right, towards the left, from the rear (towards the right, from the front):

1	AIU201	Addresses increasing from 0	Max.: 6 boards (1)

2	AIU211	Addresses increasing from 0	Max.: 6 boards (1)
3	DOU201	Addresses increasing from 0	Max.: Nr of available slots
4	AOU200	Addresses increasing from 0	Max.: 4 boards (1)

(1) if enough free slots are available in the rack.

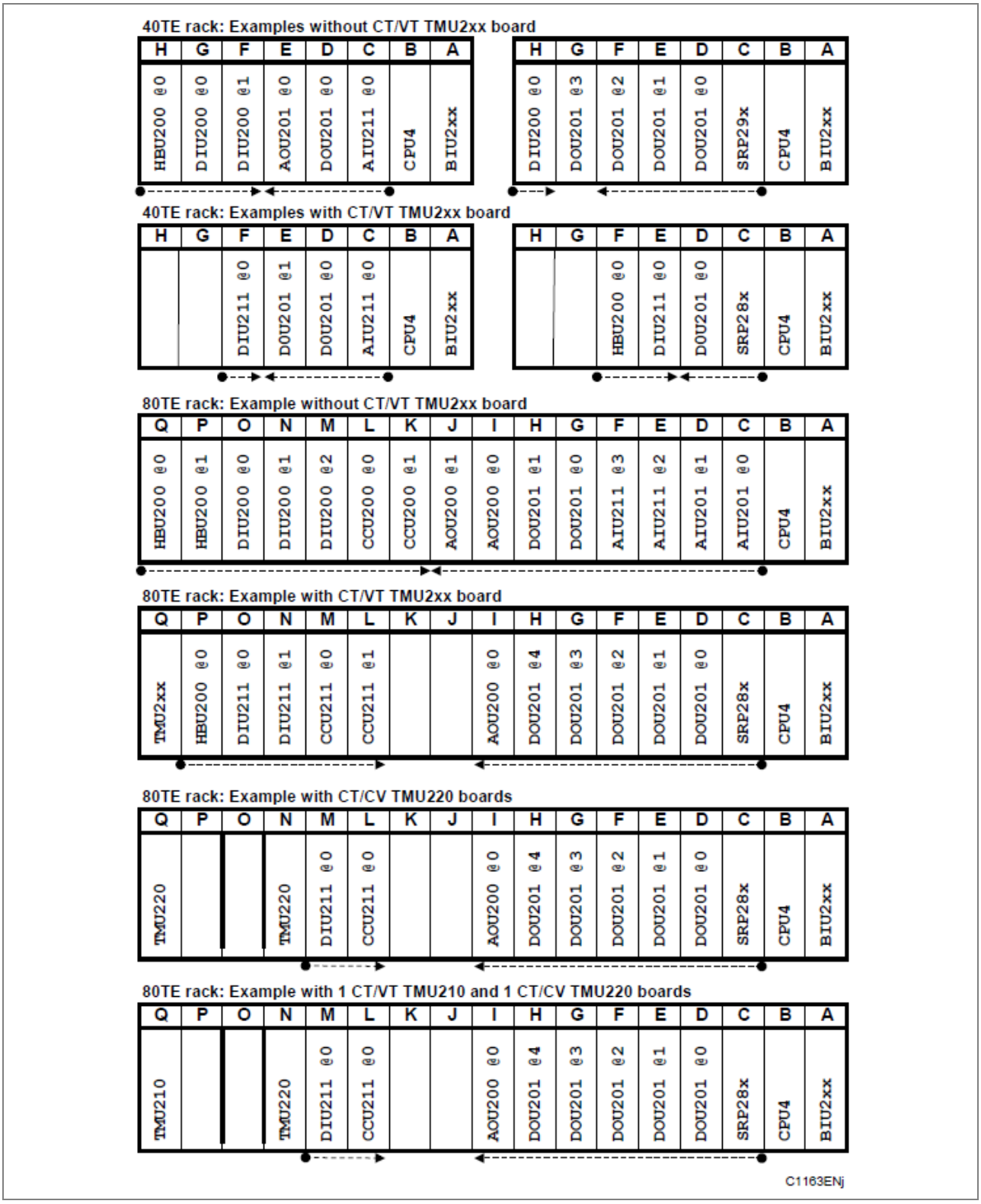


Figure 22: Examples of correct board locations in the racks

6 BOARD DESCRIPTION

6.1 UNIVERSAL, SINGLE OR DUAL-INPUT AUXILIARY POWER SUPPLY AND LEGACY PORTS MODULE – BIU261S/BIU261D

Depending on whether a secondary power supply is present, the BIU261 module comprises two boards:

- BIU261S - main board + fuse board
- BIU261D - main board + daughter board offering a secondary power supply input.

The main board houses:

- the primary universal auxiliary power supply converter
- the watchdog relay (closed if the product is healthy)
- 2 outputs (Normally Open contacts) and 2 inputs for redundancy (BCU only)
- 2 isolated interfaces (Port 1: RS232 or RS485, Port 2: RS232, RS422 or RS485)

The power supply board is protected against polarity reversal.

The daughter board carries the secondary auxiliary power supply converter.

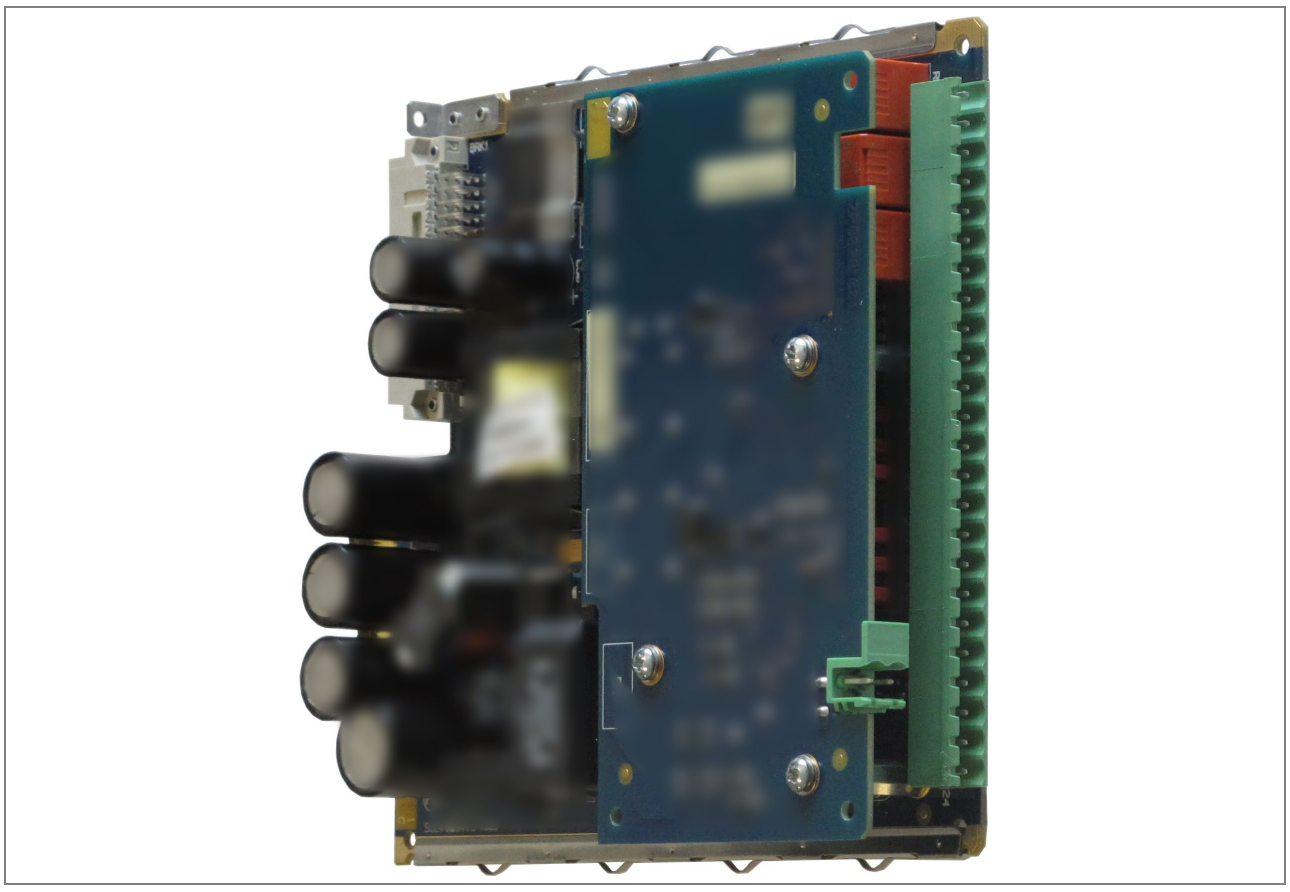


Figure 23: BIU261D module with dual-input power supply

The BIU261 mother board provides two isolated serial links.

This figure below locates the serial links' configuration jumpers.

Note:
These jumpers are not accessible if the daughter board is fitted.

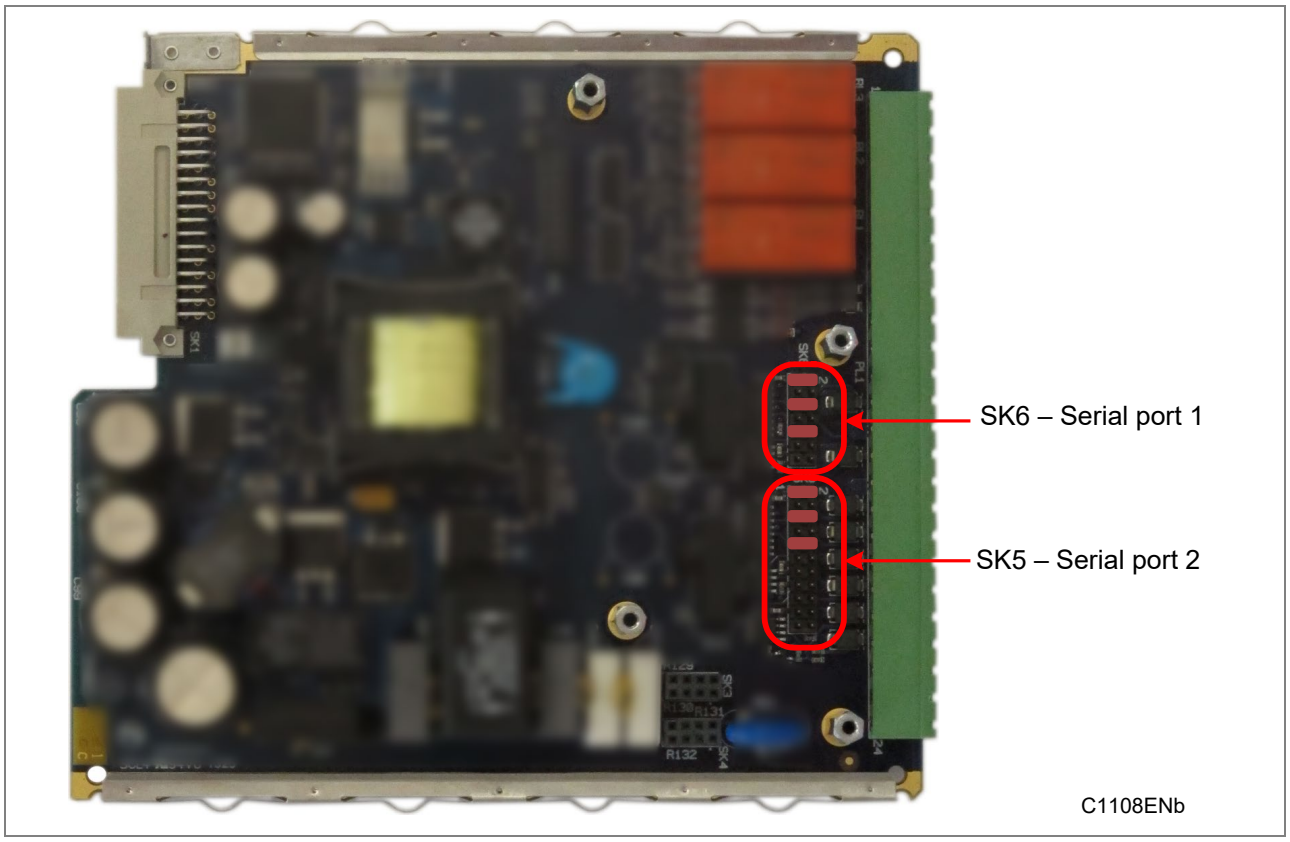


Figure 24: BIU261 without daughter board – Serial port jumpers visible

6.1.1 CONFIGURABLE COMMUNICATIONS PORT 1 - RS232/485

The communication link characteristics are:

- Full duplex serial protocol
- Transmission rate: 50 bps to 38400 bps (configurable in DS Agile SCE or settable on the front panel HMI)

Configuration

The hardware jumper arrangement is as follows (jumper block SK6):

- For RS232, set the jumpers 1-2, 5-6 and 9-10
- For RS485, set the jumpers 3-4, 7-8 and 11-12. It is possible to end the line with a 124 Ω resistor by setting 13-14. (See Connection chapter C26x/EN CO for information on when the resistor is required).

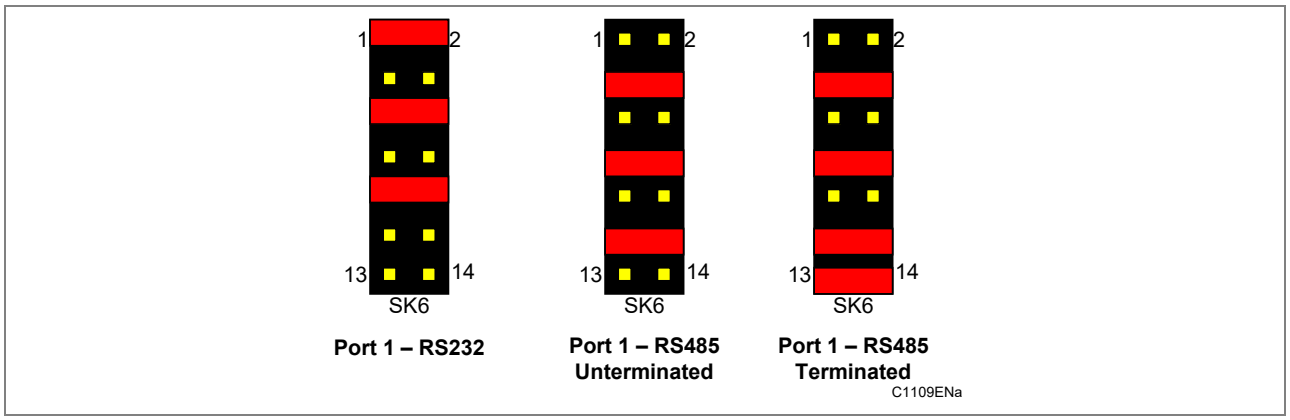


Figure 25: BIU261 – Port 1 jumper settings

6.1.2 CONFIGURABLE COMMUNICATIONS PORT 2 - RS232/422/485

The communication link characteristics are:

- full duplex serial protocol
- transmission rate: 50 bps to 38400 bps (configurable in DS Agile SCE or settable on the front panel HMI)

Configuration:

The hardware jumper arrangement is as follows (jumper block SK5):

- For RS232, set the jumpers 1-2, 5-6 and 9-10
- For RS485, set the jumpers 3-4, 7-8 and 11-12. It is possible to terminate the line with a 124 Ω resistor by setting 13-14. (See *Connection* chapter, *C26x/EN CO,* to know when the resistor is required).
- For RS422, set the jumpers 3-4, 7-8, 11-12, 15-16, 17-18 and 19-20. It is possible to terminate the line with a 124 Ω resistor by setting 13-14. (See *Connection* chapter, *C26x/EN CO,* to know when the resistor is required).

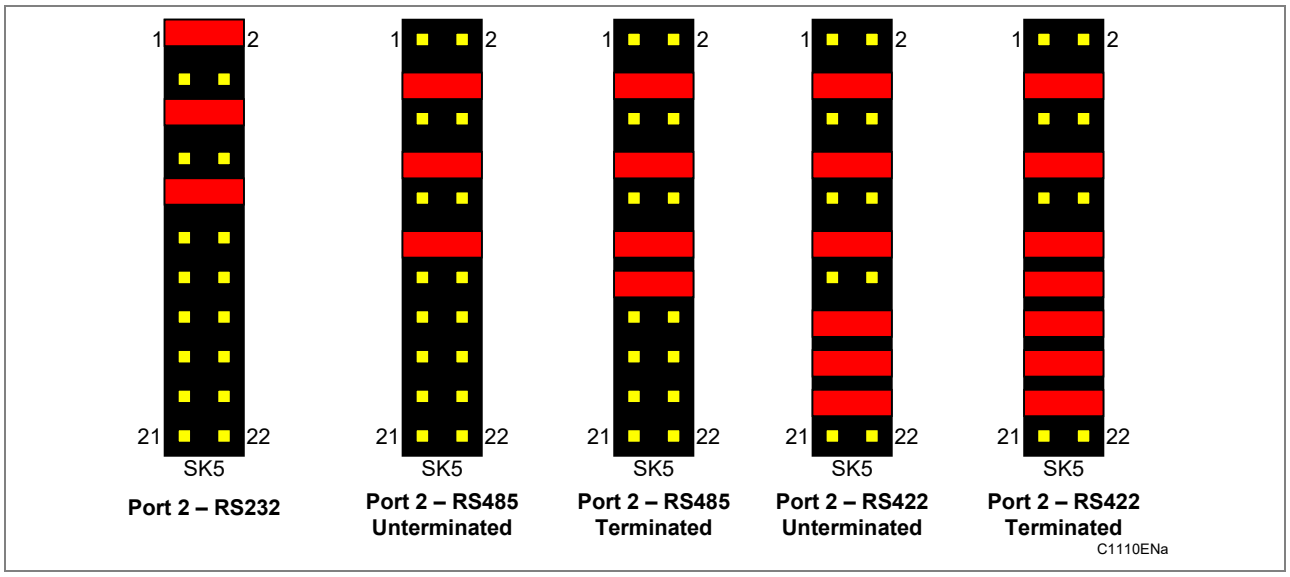


Figure 26: BIU261 – Port 2 jumper settings

6.2 CENTRAL PROCESSING UNIT AND COMMUNICATIONS BOARD – CPU4

The CPU4 handles all the calculations for the unit. It is also the main communications board: It can manage standard and redundant (PRP / HSR) links and acquire digital process signals and sampled values received from the process bus.

It features on the rear, from top to bottom:

- 6 status LEDs
- 6 SFP cages
- A 3-pin connector (Fault signal)

External communications

Depending on the configuration, the 6 SFP cages at the rear of the C26x case can contain:

- RJ45 plug for 10/100/1000BASE-Tx Ethernet port: The ports are half/full duplex and auto-sense the transmission speed. They auto-negotiate with the connected device to determine the optimal transmission speed: 10 Mbps, 100 Mbps or 1000 Mbps depending on the connected devices' capability.
- LC optical plugs for:
  - 100BASE-Fx port: 100 Mbps, multimode
  - 100BASE-Fx port: 100 Mbps, single mode over 15 km
  - 100BASE-Fx port: 100 Mbps, single mode over 2 km
  - 1000BASE-Sx port: 1000 Mbps, multimode over 550 m
  - 1000BASE-Lx port: 1000 Mbps, single mode over 10 km

The rear port configuration must match the "use case" in the board's memory (see *Installation* chapter, *C26x/EN IN)*.

At the front of the board, accessible only when the case is open, there is an RJ45 port, typically only used for maintenance purposes.

Internal communications

The CPU4 board is interfaced with:

- all the I/O boards and the BIU261 board through the standard bus,
- the front panel HMI using the RJ11 connector at the front,
- optionally, an SRP28x Ethernet switch board, through the high-speed bus.

Computing characteristics

The CPU4 board has 2 processors:

- the central "FPGA" processor, which manages most operations,
- the "DSP" sub-processor, which computes received analogue signals and/or sampled values.

Memory:

- **SDRAM DDR3 memory**:
  - 512 MB with a 40-bit data bus for the FPGA processor
  - 1 GB with a 40-bit data bus for the FPGA processor
- **Flash memory 1**:
  - 128 MB for boot and firmware storage
- **Flash memory 2**
  - 128 MB for file system drive including user configuration
- **SRAM static memory**
  - 256 kB
- **I²C EEPROM**
  - 256 kB
- **SDRAM DDR2 memory**
  - 64 MB DDR2 SDRAM with a 16-bit data bus for the DSP process

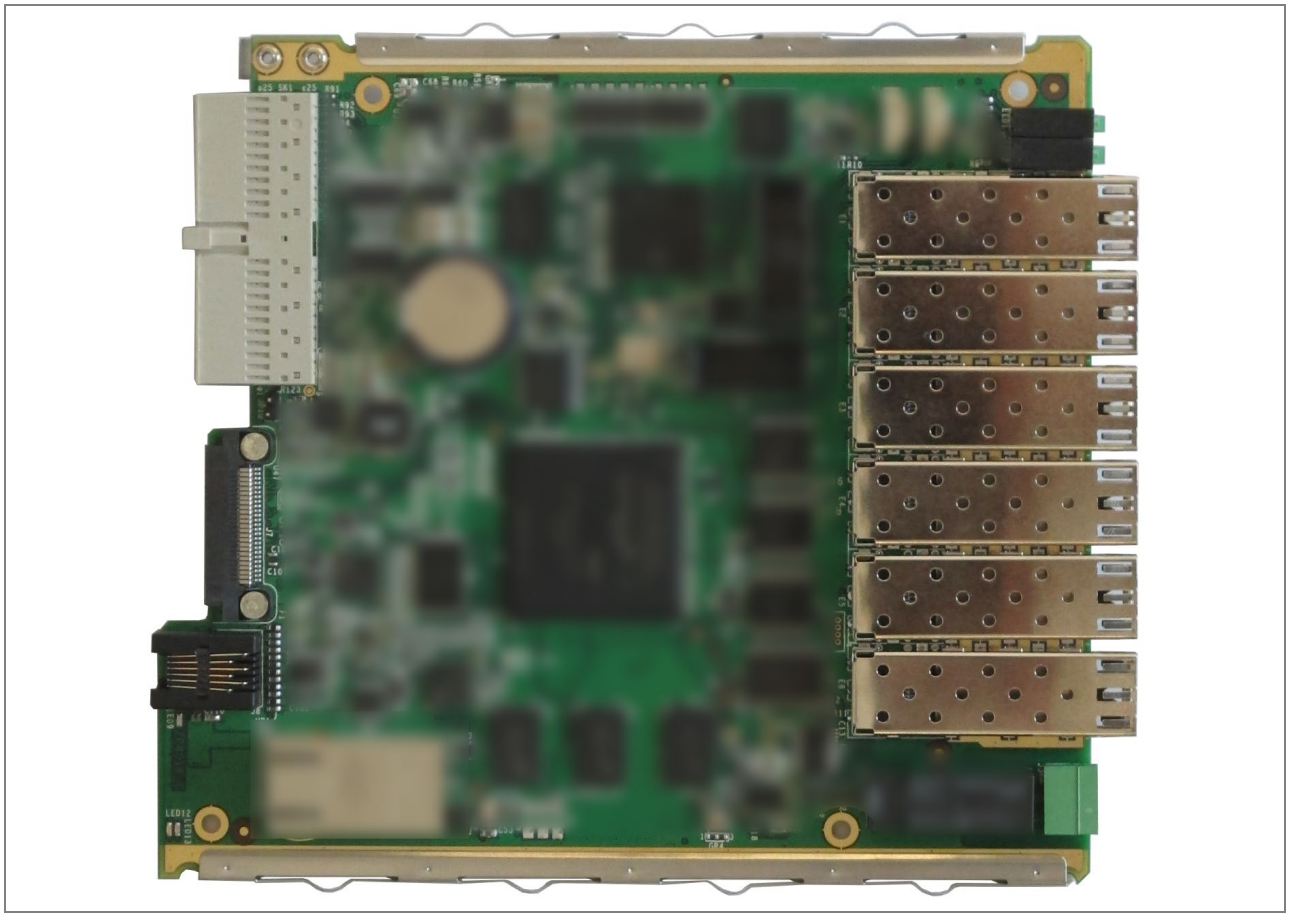


Figure 27: CPU4 board

Counter values are stored in static memory (secured with a capacitor, > 48h autonomy). The counters are kept for more than 48h when the C26x power supply is disconnected. The same goes for all datapoints states saved upon reboot.

LEDs

Eight LEDs are provided as shown in the diagram below, with their meaning indicated in the table that follows it.

They are situated at the rear of the board.

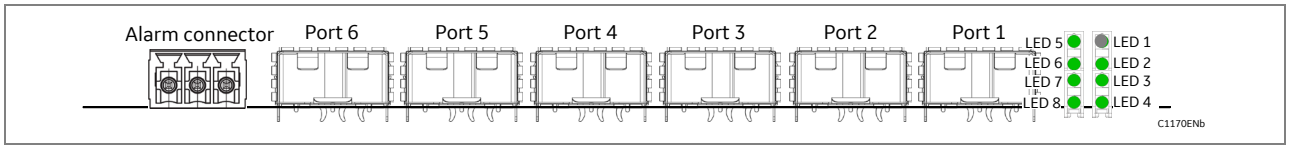


Figure 28: CPU4 LED positions

LED number	Assignment	Meaning
1	Not used	OFF = Configuration done
2	FPGA real time clock activity	ON = Normal OFF = Factory mode, or failsafe/alarm operation
3	Port 1 status	Off = No link On = Healthy link Blinking = activity
4	Port 2 status	Off = No link On = Healthy link Blinking = activity
5	Port 3 status	Off = No link On = Healthy link Blinking = activity
6	Port 4 status	Off = No link On = Healthy link Blinking = activity
7	Port 5 status	Off = No link On = Healthy link Blinking = activity
8	Port 6 status	Off = No link On = Healthy link Blinking = activity

Switch management

The switch is SNMP managed (it integrates an SNMP server) and can be remotely accessed using an SNMP “client”. The IP addresses are set via an SSH connection on any port.

Ethernet cable type

Use data quality twisted pair shielded cable rated category 5e or 6 with standard RJ45 connectors.

The maximum cable length for 10/100/1000BaseTX is 100 meters. Straight-through cable.

Ethernet Optical Fibre

The cables are connected to the corresponding elements.

The optical fibre connectors are **LC**-type small form-factor pluggable (SFP) transceivers that can use both single and multi-mode fibre.

Fibre Optic budget calculations

Optical power is expressed in Watts. However, the common unit of power measurement is the dBm, defined by the following equation: Power (dBm) = 10 log Power (mW) / 1 mW.

The fibre optic budget is the difference between the power emitted into the fibre and the sensitivity (minimum amount of power required) of the receiver connected through the fibre optic cable.

Link Power Budget = Transmitter Power (dBm) - Receiver Sensitivity (dBm). The distance over which the signals can be transmitted and successfully received is affected by the optical loss as shown in the figure below.

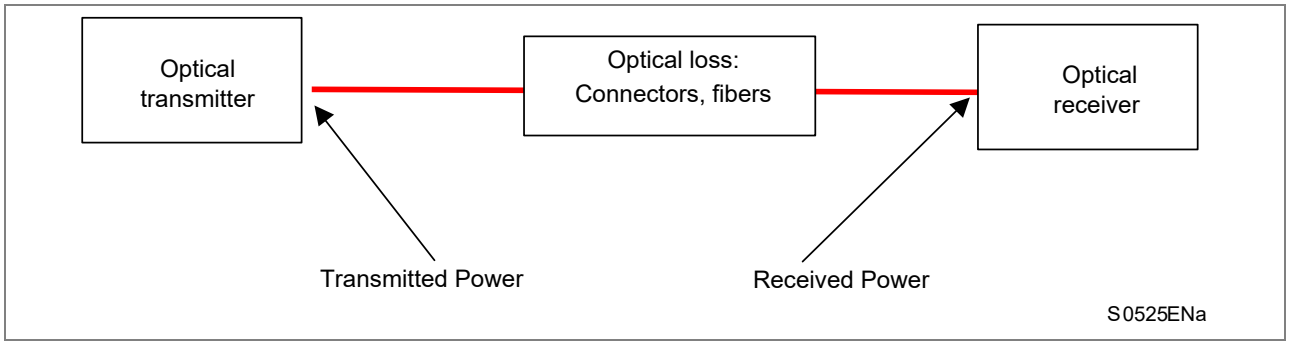


Figure 29: Fibre budget

For this product the optical budget is given in the table below.

Fibre type	Multimode	Single mode
	62.5/125 micron	**9/125 micron**
Power coupled into fibre	-19 dBm	-15 dBm
Sensitivity	-31 dBm	-34 dBm

In calculating the maximum distance, the following figures can be used as a guide, but you should check with your supplier for precise figures.

Fibre type	Multimode			Single mode
	50*µm	**62.5 µm**	**125 µm**	**62.5/125 µm**
Link budget	**12 dB**			**19 dB**
Typical connector loss (1 per receiver, 1 per transmitter)	0.8 dB			0.8 dB
Safety Margin	4 dB			4 dB
Allowed link attenuation	**6.4 dB**			**13.4 dB**
Typical cable attenuation	1 dB/km			0.4 dB/km
Maximum range				**100Base-FX IR-1: 15 km 100Base-FX SR: 2 km**
100 Mbits/s - 100Base-FX	N/A	: 2 km		
100 Mbits/s - 100Base-LX	550 m			
1000 Mbits/s	1000Base-SX: 500 m	1000Base-SX: 275 m	N/A	
Insertion of a patch panel (per panel)	2 dB			1 db

6.2.1 DIGITAL PROCESS SIGNALS

The CPU4 board can send and receive, over an Ethernet network, digital signals to and from switchgear control units, such as Grid Solutions' DS Agile C264 SCU, located near the circuit breaker. The signals are transmitted in both directions using IEC 61850-8-1 GOOSE frames.

6.2.2 SAMPLED VALUES

The CPU4 board can receive, over an Ethernet network, sampled analogue values from merging units, such as Grid Solutions' Reason MU320, located near the CTs/VTs or NCITs. The signals are transmitted using the IEC 61850-9-2 LE protocol.

6.3 CIRCUIT BREAKER CONTROL UNIT - CCU200

The Circuit breaker Control Unit (CCU200) board provides 8 digital inputs and 4 double pole outputs using integrated relays.

The digital input (DI) capabilities of the CCU200 boards are:

- 8 optically isolated digital inputs
- 1 common contact for 2 inputs
- Protection against polarity reversal

The digital inputs can be configured in single or double remote signalling inputs on the same module.

The digital output (DO) capabilities of the CCU200 boards are:

- 4 double pole switching relays with normally open (NO) contacts
- 1 common + and 1 common - contacts per 2 relays

A self-monitoring device for the output control chain is provided (address check, state monitoring)

The +5V voltage is monitored to avoid issuing unwanted signals.

The digital outputs can be configured in double remote signalling only.

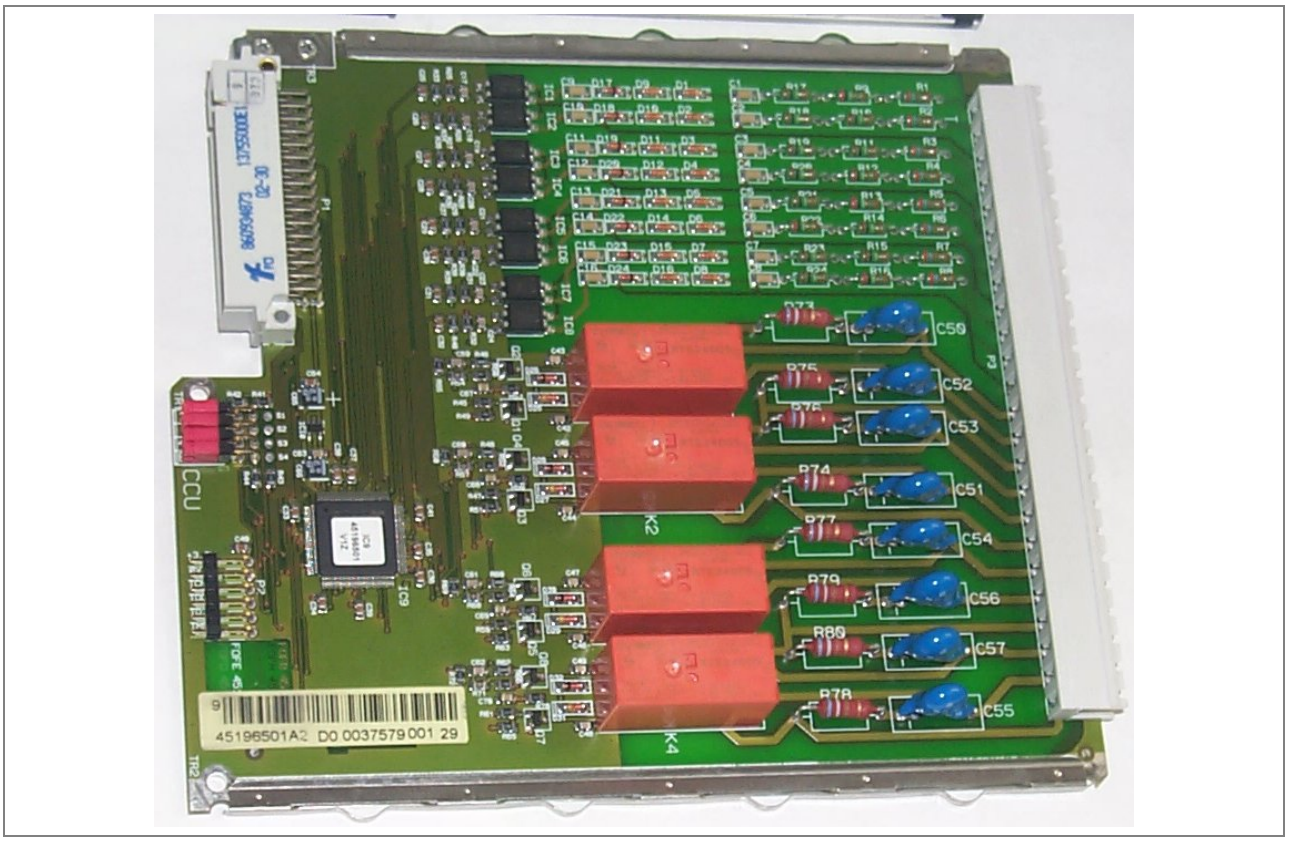


Figure 30: CCU200 board

6.4 CIRCUIT BREAKER CONTROL UNIT - CCU211

The CCU211 board provides 8 digital inputs and 4 digital outputs using integrated relays.

The Digital Input capabilities of the CCU211 board are:

- 8 optically isolated digital inputs
- 1 common contact for 2 inputs (positive or negative)
- The digital inputs can be used for single or double remote signalling, pulse or digital measurement input on the same module.
- The input responds to negative input voltages and they are not self-controlled
- All voltages between 24 V_{DC} and 220 V_{DC} selected using jumpers
- Pre-defined triggering thresholds selected using jumpers:

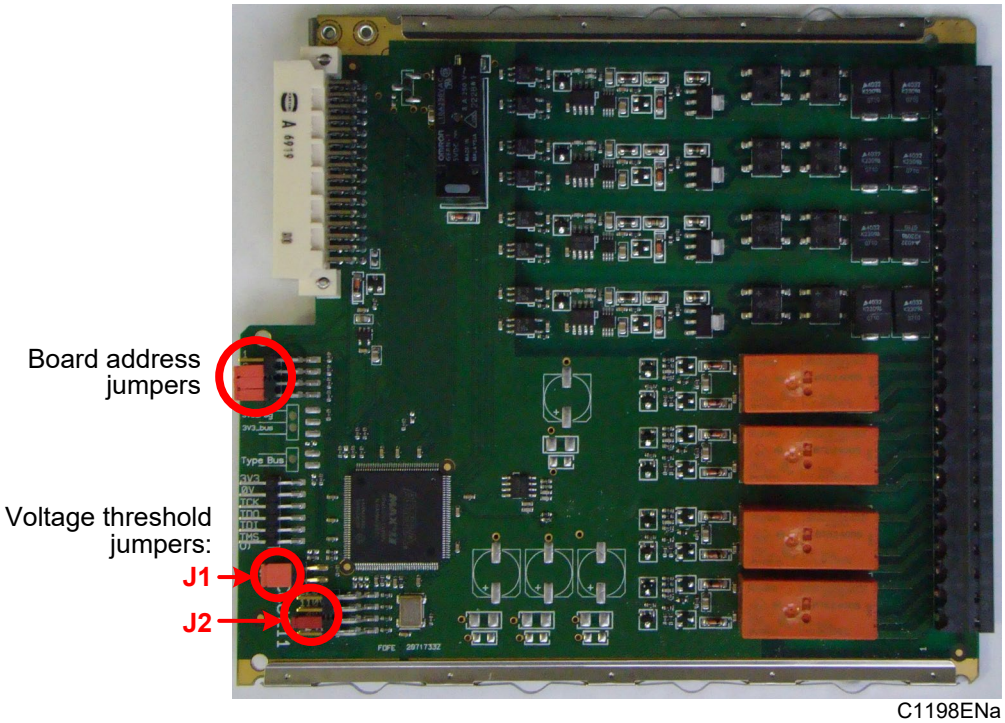
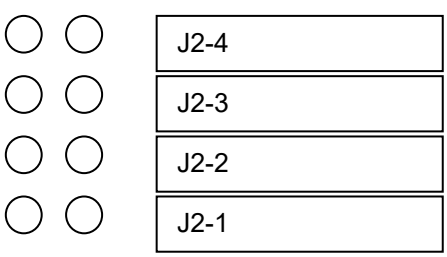


Figure 31: CCU211 board

J1 connector

Set the “jumper” on J1 for A07 and A08 VARIANTS ONLY

J2 connector



Set only one jumper on J2 connector:

Board variant	Jumper on J1	Jumper on J2
A01	No	J2-1
A02	No	J2-2
A03	No	J2-3
A04	No	J2-4
A07	Yes	J2-3
A08	Yes	J2-4

- From 24 V_{DC} to 220 V_{DC}: a peak current (>27 mA) circulates during a short time (approximately 2 ms) to clean external relays' contacts:

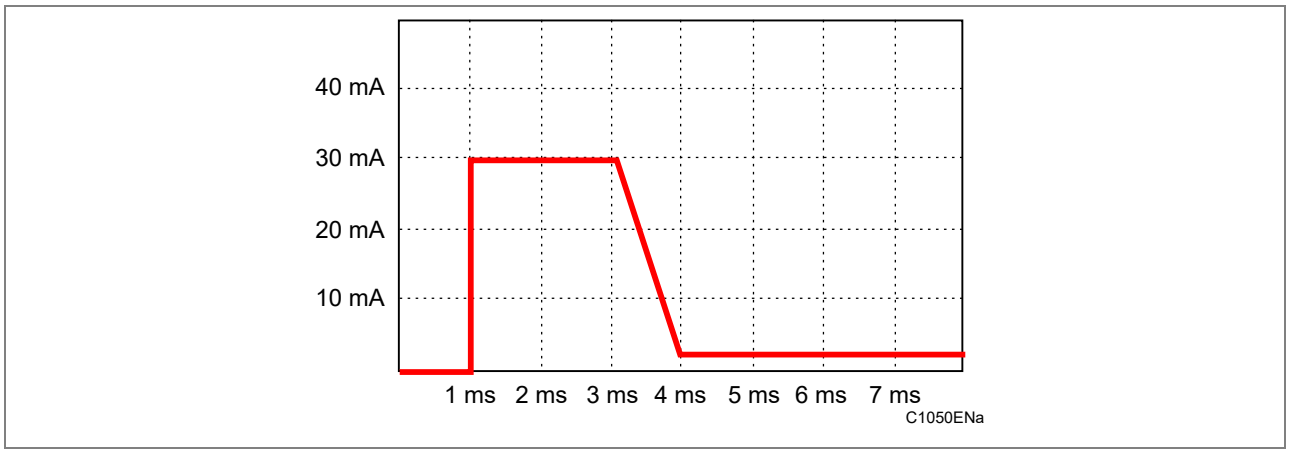


Figure 32: Peak current response curve

The Digital Output capabilities of the CCU211 board are:

- 4 double pole switching relays with normally open (NO) contacts
- 1 common + and 1 common - contacts per 2 relays
- Nominal operating voltage range of 24 V_{DC} to 250 V_{DC} / 230 V_{AC}

A self-monitoring device for the output control chain is provided (address check, state monitoring).

The +5 V voltage is monitored to avoid issuing unwanted signals.

The digital outputs can be configured in double remote signalling only.

Board address setting

The address of the board can be defined by the location of the CCU211 in the C26x rack (or by jumper if the board is used as spare of a previous board). This location is defined using the SCE (refer to C26x/EN AP).

6.5 DIGITAL INPUTS UNIT – DIU200

Depending on the applied voltage, 4 versions of the DIU200 are available.

The capabilities of the DIU200 boards are:

- 16 optically isolated digital inputs
- 1 negative common contact for 2 inputs
- Protection against polarity reversal
- The digital inputs can be used for single or double status, pulse or digital measurement input on the same module.

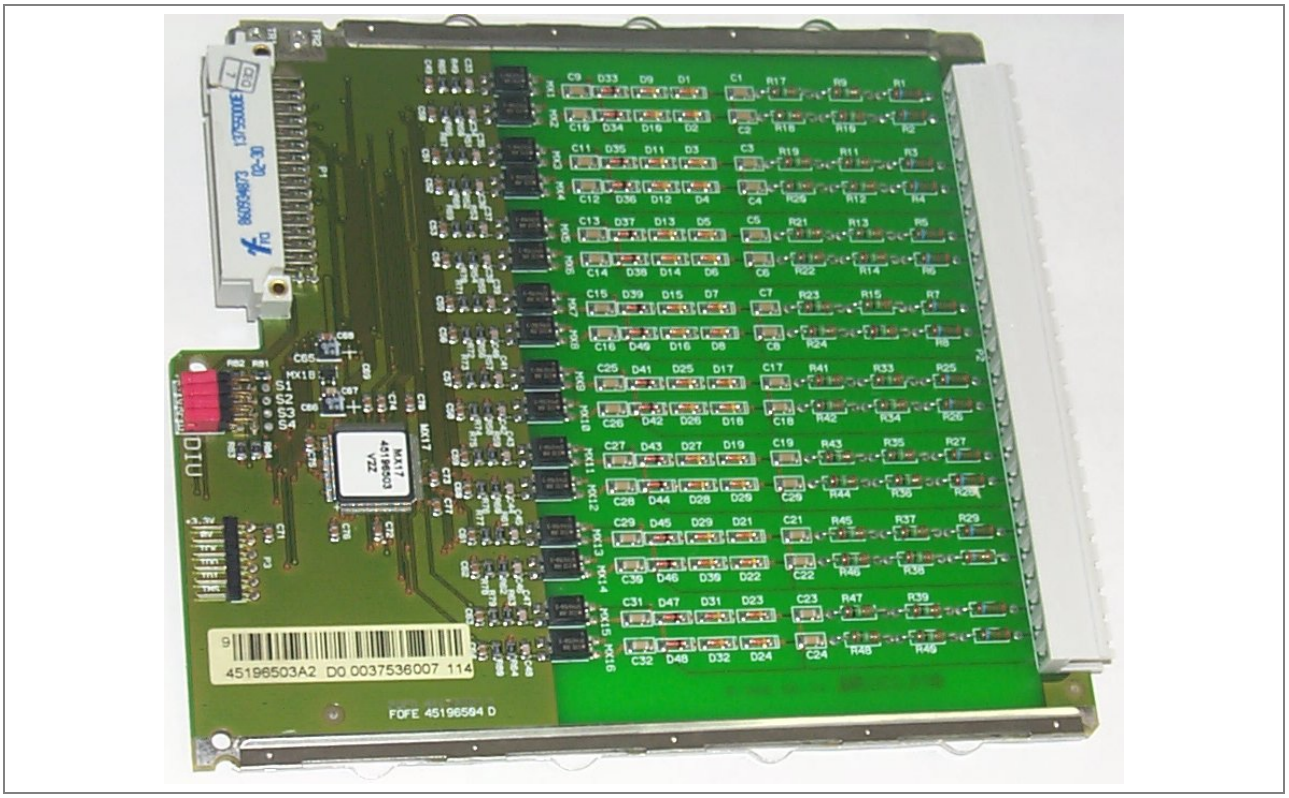


Figure 33: DIU200 board

6.6 DIGITAL INPUTS UNIT – DIU211

The capabilities of the DIU211 boards are:

- 16 optically isolated digital inputs
- 1 common contact for 2 inputs (positive or negative)
- The digital inputs can be used for single or double status, pulse or digital measurement input on the same unit.
- All voltages between 24 V_{DC} and 220 V_{DC}
- Pre-defined triggering thresholds selected using jumpers:

Variants

Variant	Input voltage
A01	24 V_{DC}
A02	48 V_{DC} – 60 V_{DC}
A03	110 V_{DC} – 125 V_{DC}
A04	220 V_{DC}
A07	110 V_{DC} – 125 V_{DC} with 80% threshold
A08	220 V_{DC} with 80% threshold

The board variants are determined by the position of 2 jumpers:

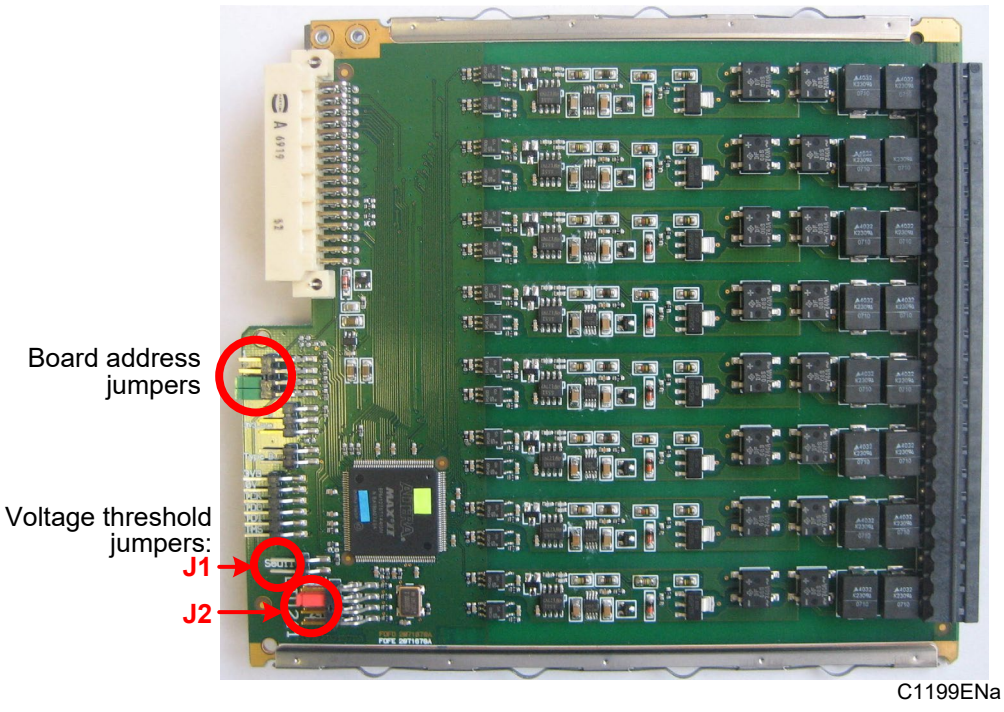
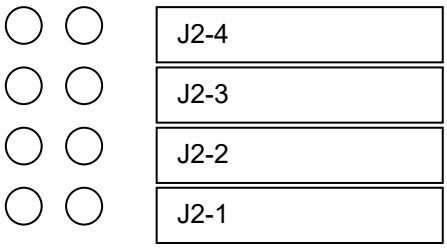


Figure 34: Voltage variant jumpers on the DIU211 board

J1 connector

Set the “jumper” on J1 for A07 and A08 VARIANTS ONLY

J2 connector



Set only one jumper on J2 connector:

Board variant	Jumper on J1	Jumper on J2
A01	No	J2-1
A02	No	J2-2
A03	No	J2-3
A04	No	J2-4
A07	Yes	J2-3
A08	Yes	J2-4

- From 24 V_{DC} to 220 V_{DC}: a peak current (>27 mA) circulates during a short time (approximately 2 ms) to clean external relays' contacts:

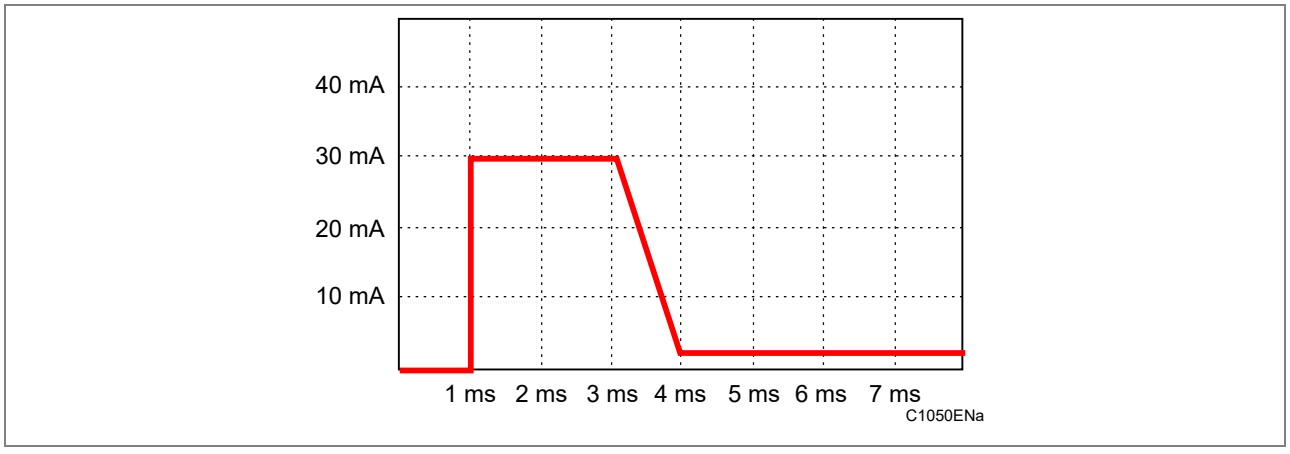


Figure 35: Peak current response curve

Settings: When used with a CPU4 board, the address of the board can be defined by the location of the DIU211 in the C26x rack (or by jumper if the board is used as spare of a previous board). This location is defined using the SCE (refer to C26x/EN AP).

6.7 DIGITAL INPUTS UNIT – DIU221

The capabilities of the DIU221 boards are:

- 16 galvanically-isolated (40 kΩ) digital inputs
- 1 common contact for 2 inputs (positive or negative)
- The digital inputs can be used for single or double status, pulse or digital measurement input on the same unit.
- Pre-defined triggering thresholds selected using jumpers:

Variants

Variant	Input voltage
A09	170 V_{DC}
A10	250V_{DC}

The board rated input voltage variant is determined by jumpers on the PL3 connector:

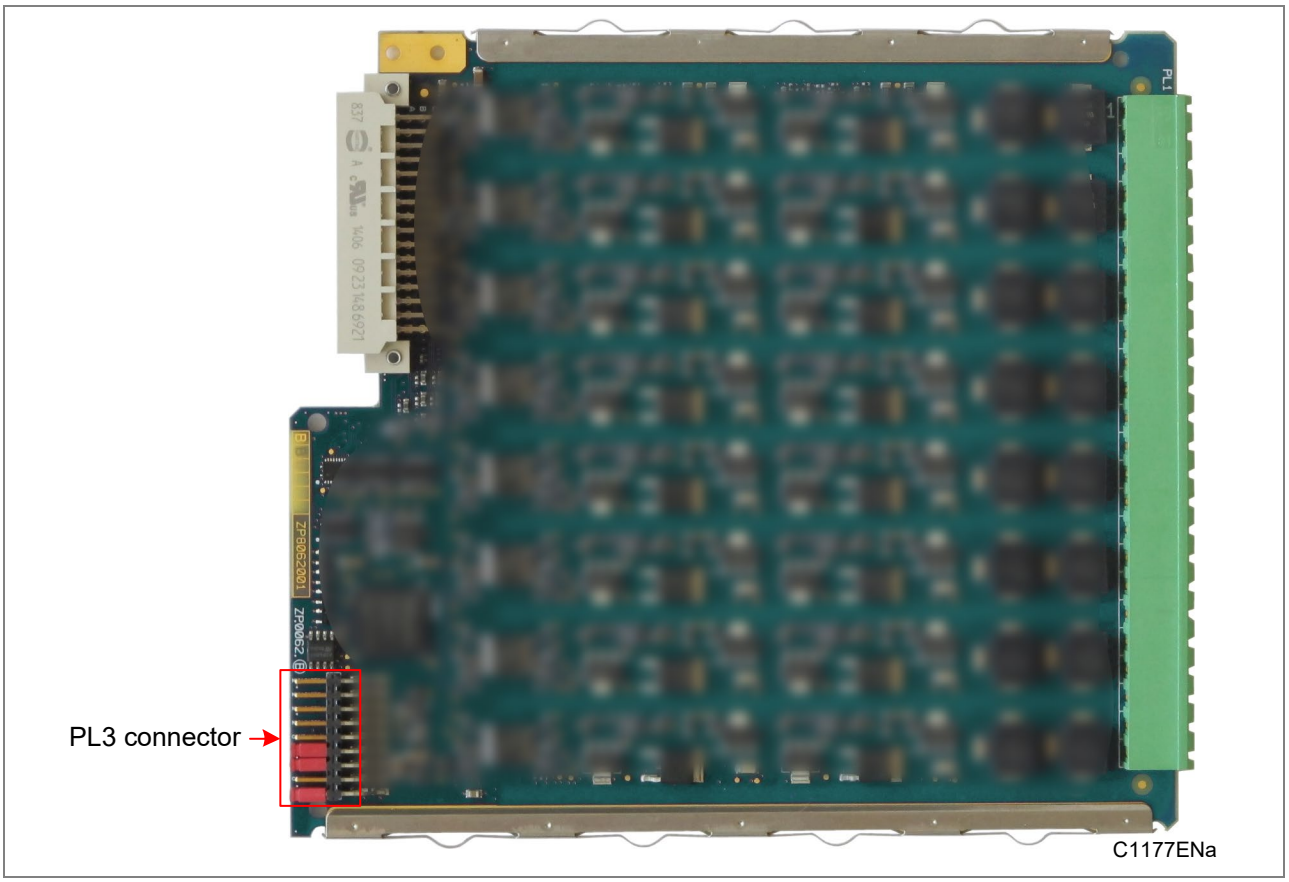


Figure 36: PL3 connector location on the DIU221 board (A09 variant)

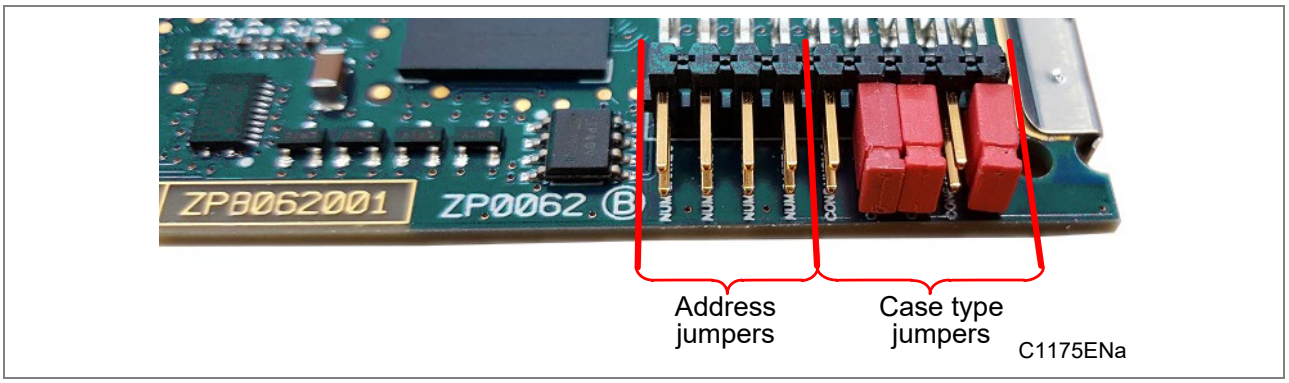
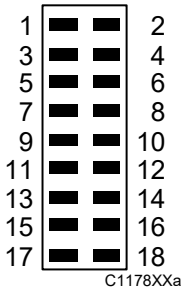


Figure 37: Voltage variant jumpers on the DIU221 board, A09 variant



At this time only the A09 and A10 variants are available. For these variants, jumpers must be fitted on pins:

A09	A10
11-12	9-10
13-14	13-14
17-18	17-18

6.8 DIGITAL OUTPUTS UNIT – DOU201

The Digital Outputs Unit (DOU201) board provides 10 isolated digital outputs using integrated relays.

The DOU201 board capabilities are:

- 8 single pole relays with one normally open (NO) contact
- 2 double pole relays with 1 common for 2 output contacts (NO/NC changeover)
- Nominal operating voltage range of 24 V_{DC} to 250 V_{DC} / 230 V_{AC}

The DOU201 has 8 single pole contacts that are normally open and 2 double pole contacts in which one pole contact is normally open and one pole contact is normally close.

The address of the board can be defined by the location of the DOU201 in the C26x rack (or by jumper if the board is used as spare of a previous board). This location is defined using the SCE (refer to C26x/EN AP).

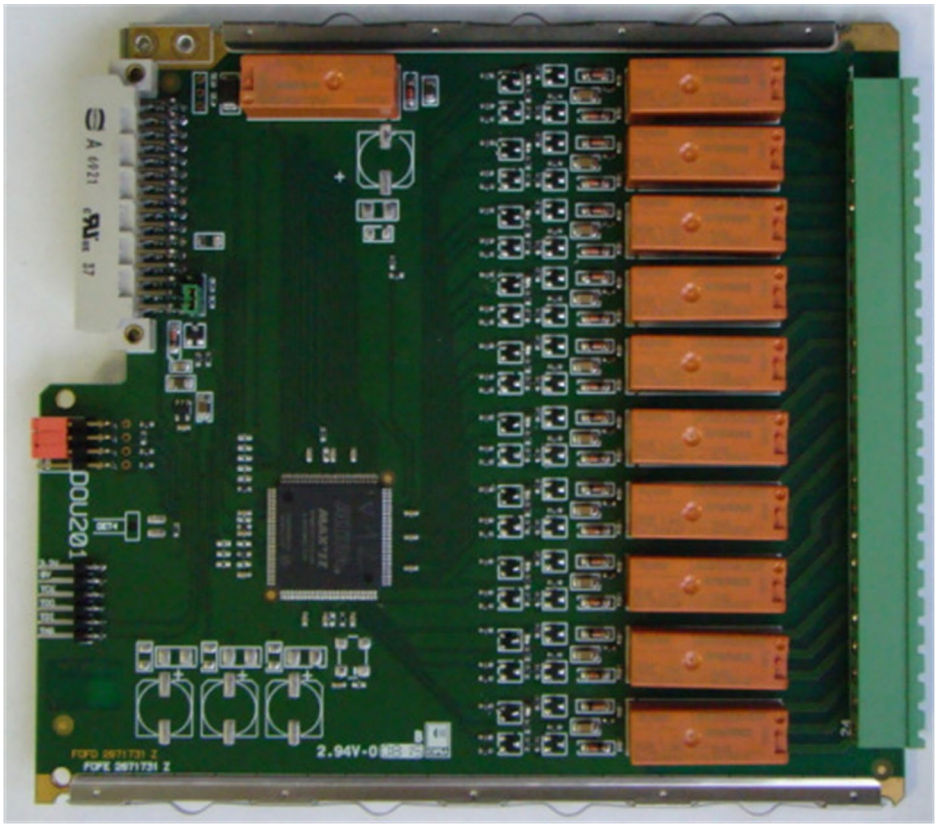


Figure 38: DOU201 board

6.9 HIGH BREAK UNIT – HBU200

The High Break Unit (HBU200) board provides 10 normally open single pole output channels. These can be configured to operate in pairs to give dual pole operation or parallel operation for enhanced current carrying capability.

The HBU200 board capabilities are:

- 10 single pole relays with one normally open (NO) contact
- Nominal operating voltage range of 24 V_{DC} to 250 V_{DC} / 250 V_{AC} +20%

The HBU200 has 10 single pole contacts that are normally open.

The address of the board can be defined by the location of the HBU200 in the C26x rack (or by jumper if the board is used as spare of a previous board). This location is defined using the SCE (refer to C26x/EN AP).

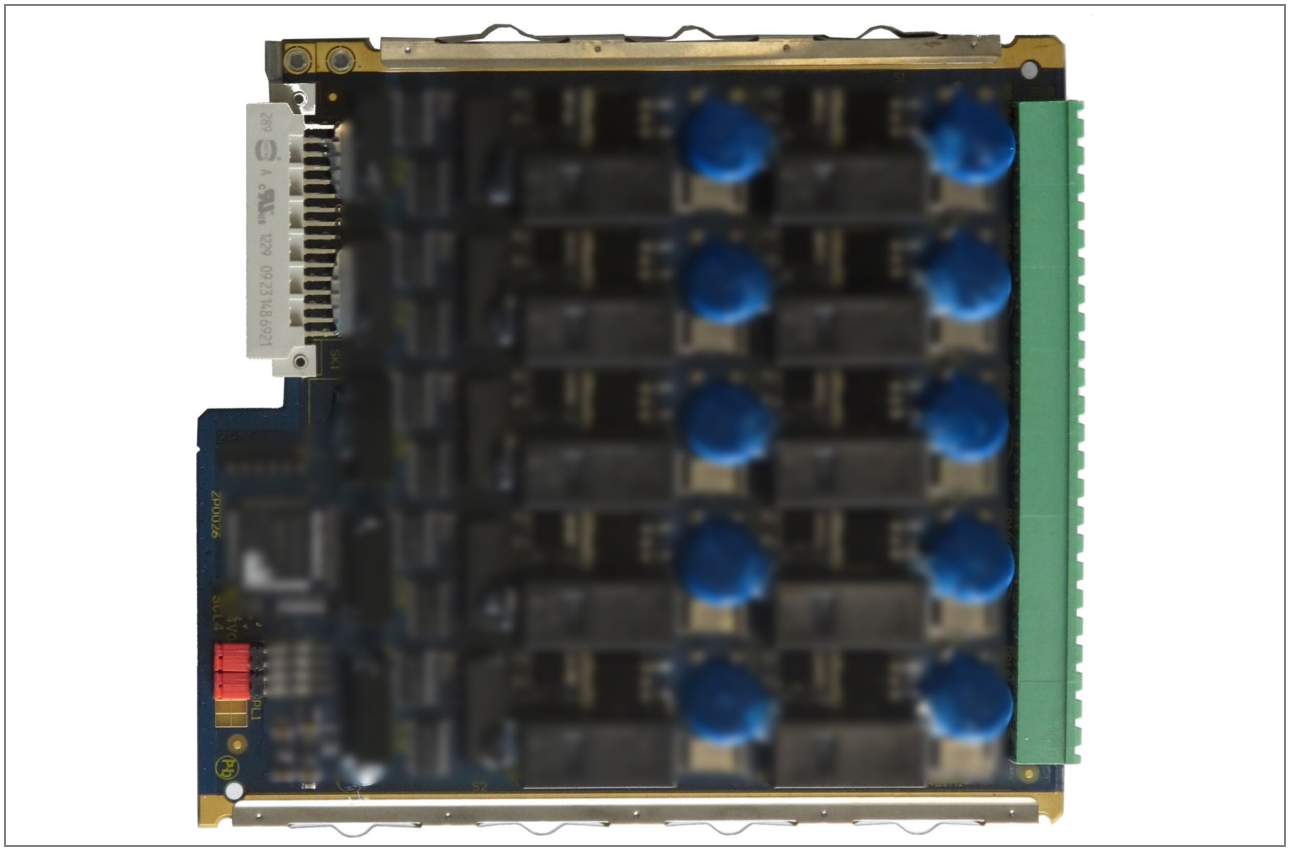


Figure 39: HBU200 board

6.10 ANALOGUE INPUT UNIT – AIU201

The Analogue input module (AIU201) has 4 independent Analogue Inputs. Each AI can be software-configured in a voltage or current range.

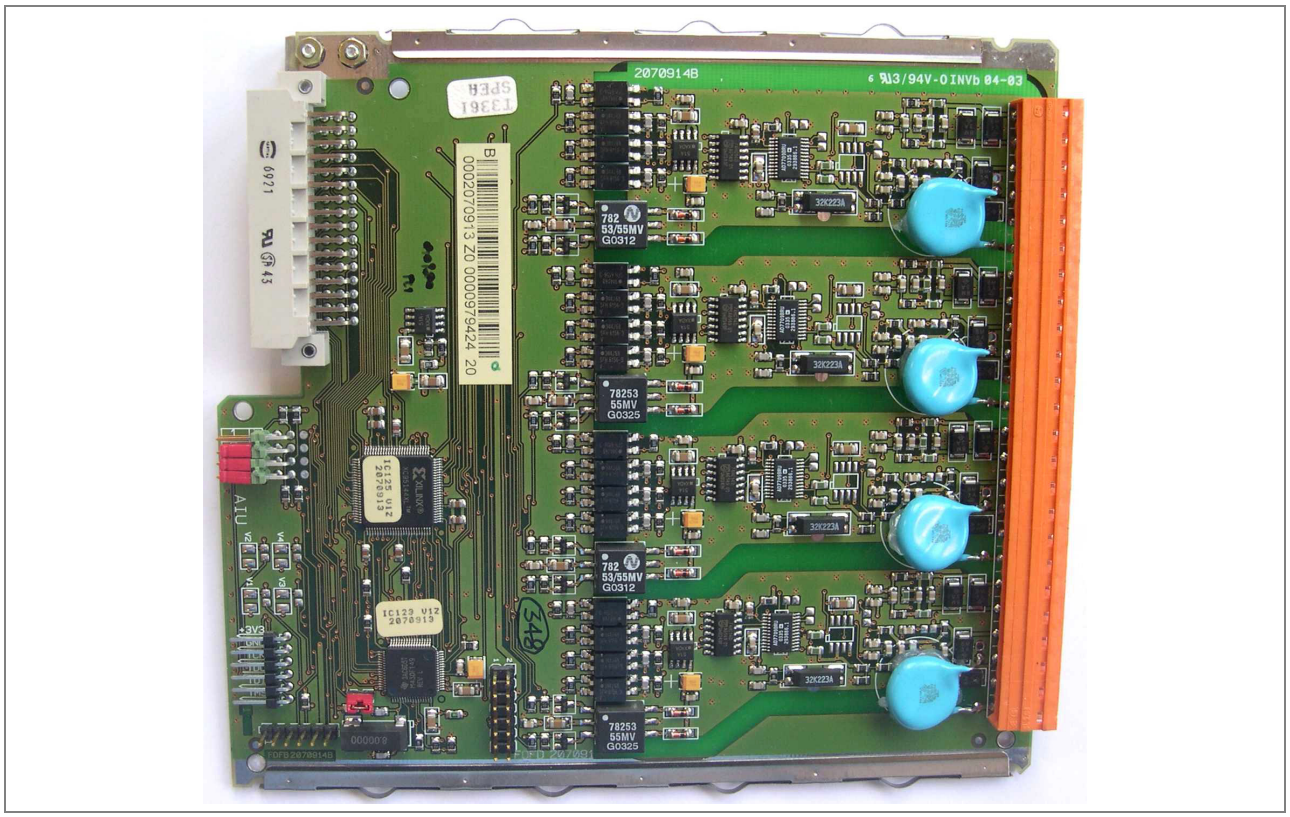


Figure 40: AIU201 board

6.11 ANALOGUE INPUT UNIT – AIU211

The Analogue input module (AIU211) has 8 isolated Analogue Inputs.

Analogue inputs (AI) are current DC signals delivered by transducers. Each AI can be software-configured in a current input range (among four ranges).

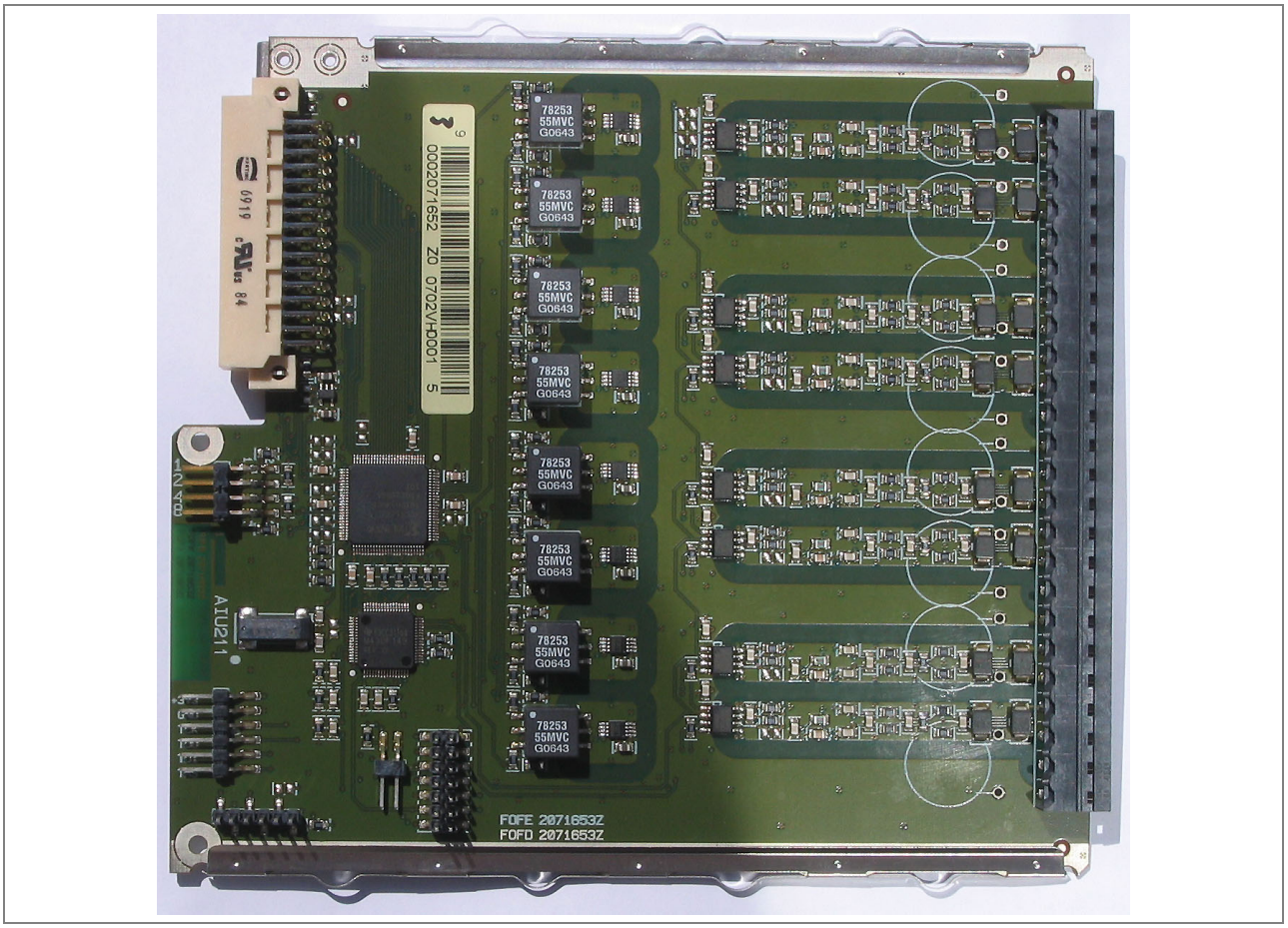


Figure 41: AIU211 board

6.12 TRANSDUCERLESS MEASUREMENTS UNIT – TMU220

The transducerless measurement capabilities are the following:

- 4 measurement Current Transformers (4 CT) inputs
  - Transformers have two ranges 1 A and 5 A
- 5 measurement Voltage Transformers (5 VT) inputs
  - AC voltage (Vn): 57.73 V_{RMS} to 500 V_{RMS}
- Frequency operating range: 50 or 60 Hz ± 10%

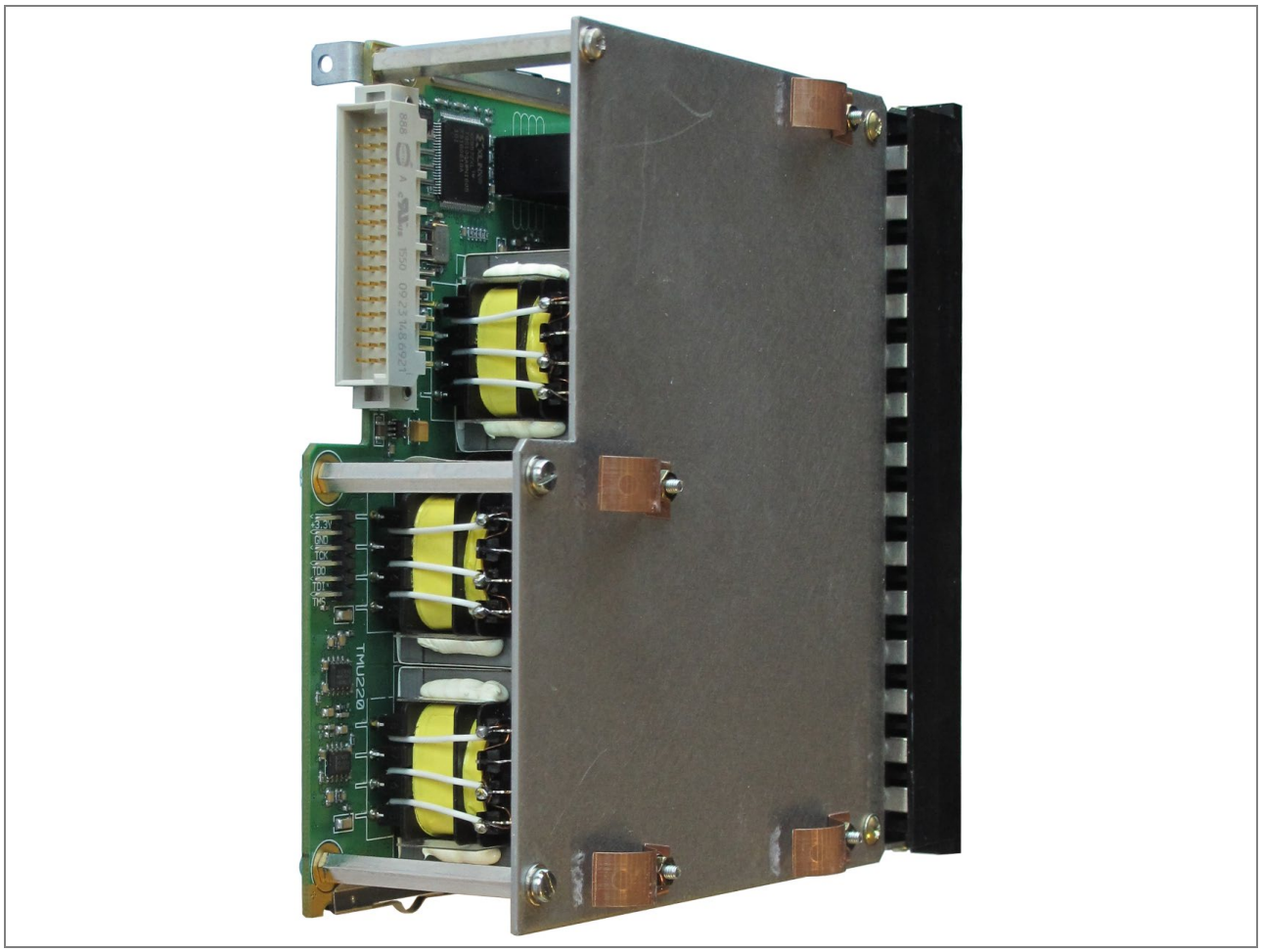


Figure 42: TMU220 board

The measured values are processed by the CPU4 board.

6.13 TRANSDUCERLESS MEASUREMENTS UNIT – TMU210

The TMU210 board is a Protection Current and Voltage acquisition board (CT/VT) module used in the DS Agile C26x device.

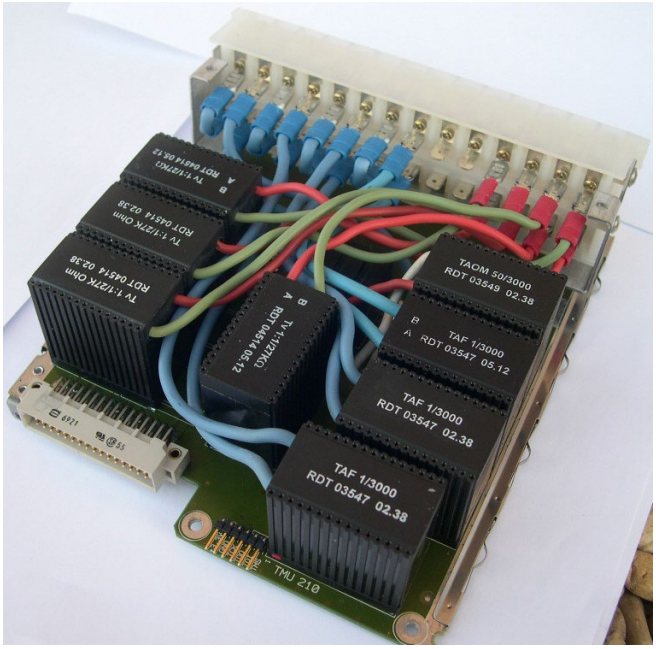


Figure 43: TMU210 board

The transducerless measurement capabilities are the following:

- 4 measurement Current Transformers (4 CT) inputs. Each transformer has two ranges 1 A and 5 A, selectable using a jumper
- 4 measurement Voltage Transformers (4 VT) inputs. Each transformer has two AC voltage ranges (Vn): 57.73 V_{RMS} to 130 V_{RMS} or 220V_{RMS} to 480 V_{RMS}
- Frequency operating range: 50 or 60 Hz ± 10%

3 use cases are available

- A01 (default variant):
  - 4 voltage channels (57.7V to 130V)
  - 4 current channels (1A or 5A)
- A02 (sensitive variant):
  - 4 voltage channels (57.7V to 130V).
  - 3 current channels (1A or 5A)
  - 1 current channel (1A sensible or 5A sensible)
- A03 (ultrasensible variant):
  - 4 voltage channels (57.7V to 130V).
  - 3 current channels (1A or 5A)
  - 1 current channel (1A very sensible or 5A very sensible)

6.14 ANALOGUE OUTPUT UNIT – AOU200

The AOU200 board provides 4 current analogue outputs. Each output is associated to a Read Inhibit relay. The outputs are powered using an external power supply. The external power supply has to provide a regulated voltage of +48V (+/- 5%).

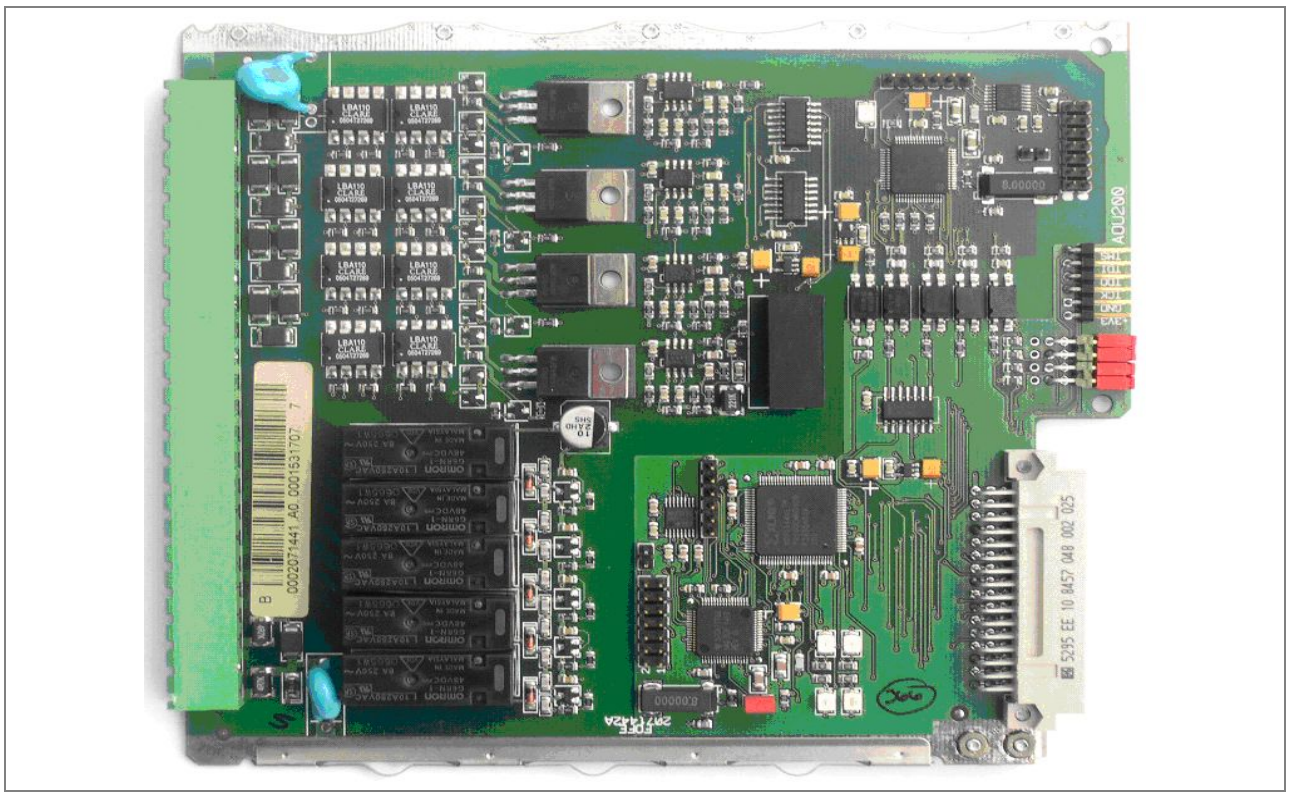


Figure 44: AOU200 board

6.15 PRP ETHERNET SWITCH SRP282/284

The SRP28x is a circuit board providing an Ethernet Switch embedded with the Parallel Redundancy Protocol (PRP according to IEC 62439-3) to provide redundancy of communications. The board can also provide support for the Precision Time Protocol (PTP) according to IEEE 1588 v2, to deliver precise local time synchronisation. The board is designed to be integrated into DS Agile products such as the H38x.

It is designed to work in an electrical plant environment where standards such as IEC 61000-4 & IEC 60255-5 apply.

The switch is configurable using a TELNET connection to a terminal emulation package on a personal computer or similar device.

This board includes 3 electrical links 10/100BaseTX and 2 optical links 100BaseFX for “bumpless” redundancy (PRP). It turns the C26x into a Double Attached Node running PRP.

It features on the rear, from top to bottom:

- Two sockets that receive removable transceivers providing either Single-mode or Multi-mode optical interface; each transceiver is locked with a clamp and protected with a rubber plug when not used
- Status LEDs on both sides of IRIG-B connector (golden connector)
- Three RJ45 sockets
- A 3-pin connector (Fault signal)
- An alarm connector (Fault signal)

Note:
The alarm connector is changed from srp28x-3.x.x.x.

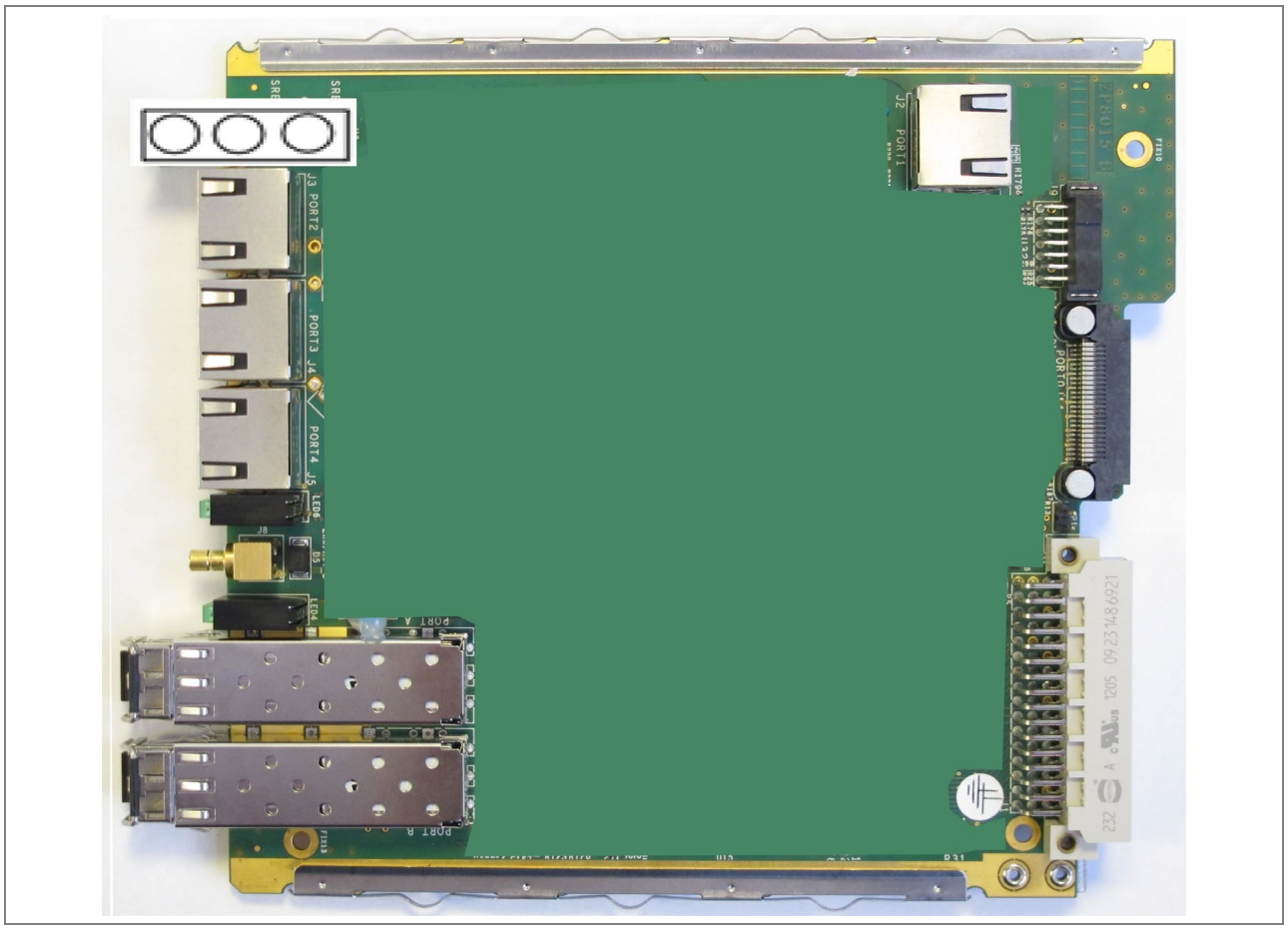


Figure 45: SRP28x board

LEDs

Eight LEDs are provided as shown in the diagram below, with their meaning indicated in the table that follows it.

They are situated at the rear of the board.

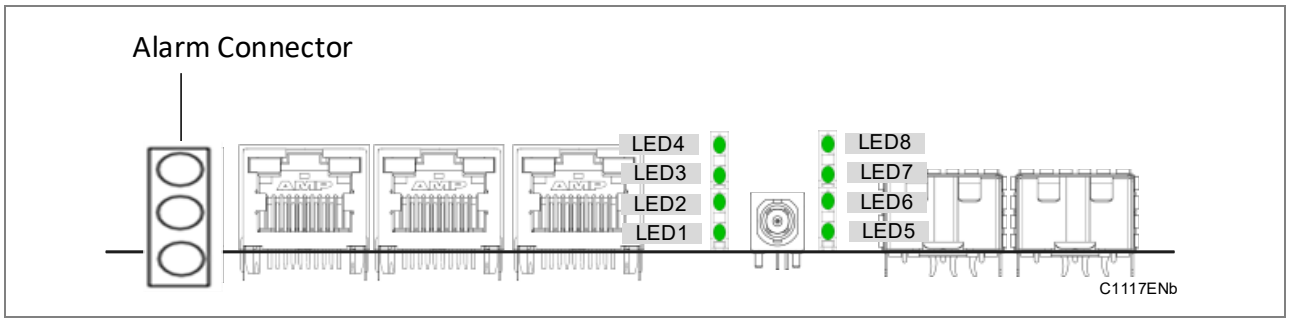


FIGURE 46: SRP28x LED positions

LED number	Assignment	Meaning
1	Port2 status	Off = no link
2	Port3 status	On = link good
3	Port4 status	Blinking = activity on the link
4	PPS	A pulse per second signal generated by the clock core on the board
5	PRP link B status	Off = no link
6	PRP link A status	On = link good Blinking = activity on the link
7	Software status	ON = normal OFF = factory mode, or failsafe/alarm operation
8	Initiation status	ON = configuration in progress OFF = configuration done

Switch management

The switch is SNMP managed (it integrates an SNMP server) and can be remotely accessed using an SNMP "client". The IP addresses are set via a telnet connection on any port. CMT can be used; refer to the chapter C26x/EN IN.

Ethernet cable type

Use data quality twisted pair shielded cable rated category 5 with standard RJ45 connectors.

The maximum cable length for 10/100BaseTX is 100 meters. Straight-through cable.

Variants

- SRP282 with two multi-mode optical connectors
- SRP284 with two single-mode optical connectors

Ethernet Optical Fibre

The cables are connected to the corresponding elements.

In both variants, the optical fibre connectors are **LC**-type small form-factor pluggable (SFP) transceivers that can use both single and multi mode fibre.

The table below lists the supports LC-Type SFP and references:

Item	Manufacturer Reference	Manufacturer	Description	Connector Type	Image
SRP282 PRP Switch Multimode	HFBR-57E5APZ	Avago	125Mbps Multimode 1310 nm wavelength	LC Duplex	
SRP284 PRP Switch Single mode	AFCT-5765ATLZ	Fit-foxconn / Avago	155Mbps Single-mode SR (up to 2 km) 1310 nm wavelength	LC Duplex	

Fibre Optic budget calculations

Optical power is expressed in Watts. However, the common unit of power measurement is the dBm, defined by the following equation: Power (dBm) = 10 log Power (mW) / 1 mW.

The fibre optic budget is the difference between the power emitted into the fibre and the sensitivity (minimum amount of power required) of the receiver connected through the fibre optic cable.

Link Power Budget = Transmitter Power (dBm) - Receiver Sensitivity (dBm). The distance over which the signals can be transmitted and successfully received is affected by the optical loss as shown in the figure below.

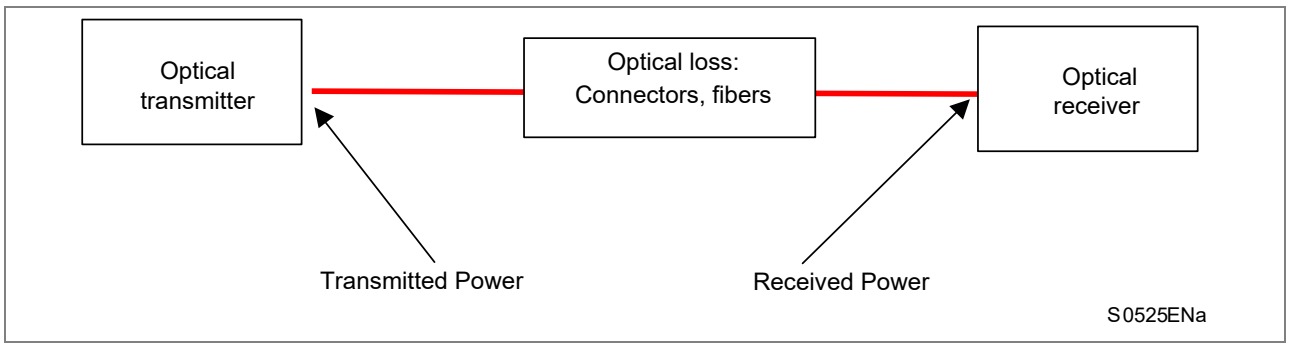


Figure 47: Fibre budget

For this product the optical budget is given in the table below.

Fibre type	Multimode	Single mode
	62.5/125 micron	**9/125 micron**
Power coupled into fibre	-19 dBm	-15 dBm
Sensitivity	-31 dBm	-34 dBm

In calculating the maximum distance, the following figures can be used as a guide, but you should check with your supplier for precise figures.

Fibre type	Multimode	Single mode
Link budget	**12 dB**	**19 dB**
Connector loss (1 per receiver, 1 per transmitter)	0.8 dB	0.8 dB
Safety Margin	4 dB	4 dB
Allowed link attenuation	**6.4 dB**	**13.4 dB**

Fibre type	Multimode	Single mode
Typical cable attenuation	1 dB/km	0.4 dB/km
Maximum range	**2 km**	**15 km**
Insertion of a patch panel (per panel)	2 dB	1 db

6.16 HSR ETHERNET SWITCH SRP292/294

This board includes 3 electrical links 10/100BaseTX and 2 optical links 100BaseFX for “seamless” redundancy (HSR). It turns the C26x into a Doubly Attached Node running HSR.

It features on the rear, from top to bottom:

- Two sockets that receive removable transceivers providing either Single-mode or Multi-mode optical interface; each transceiver is locked with a clamp and protected with a rubber plug when not used
- Connection status LEDs
- IRIG-B connector (not used)
- Three RJ45 sockets
- A 3-pin connector (Fault signal)
- An alarm connector (Fault signal)

Note:
The alarm connector is changed from srp28x-3.x.x.x.

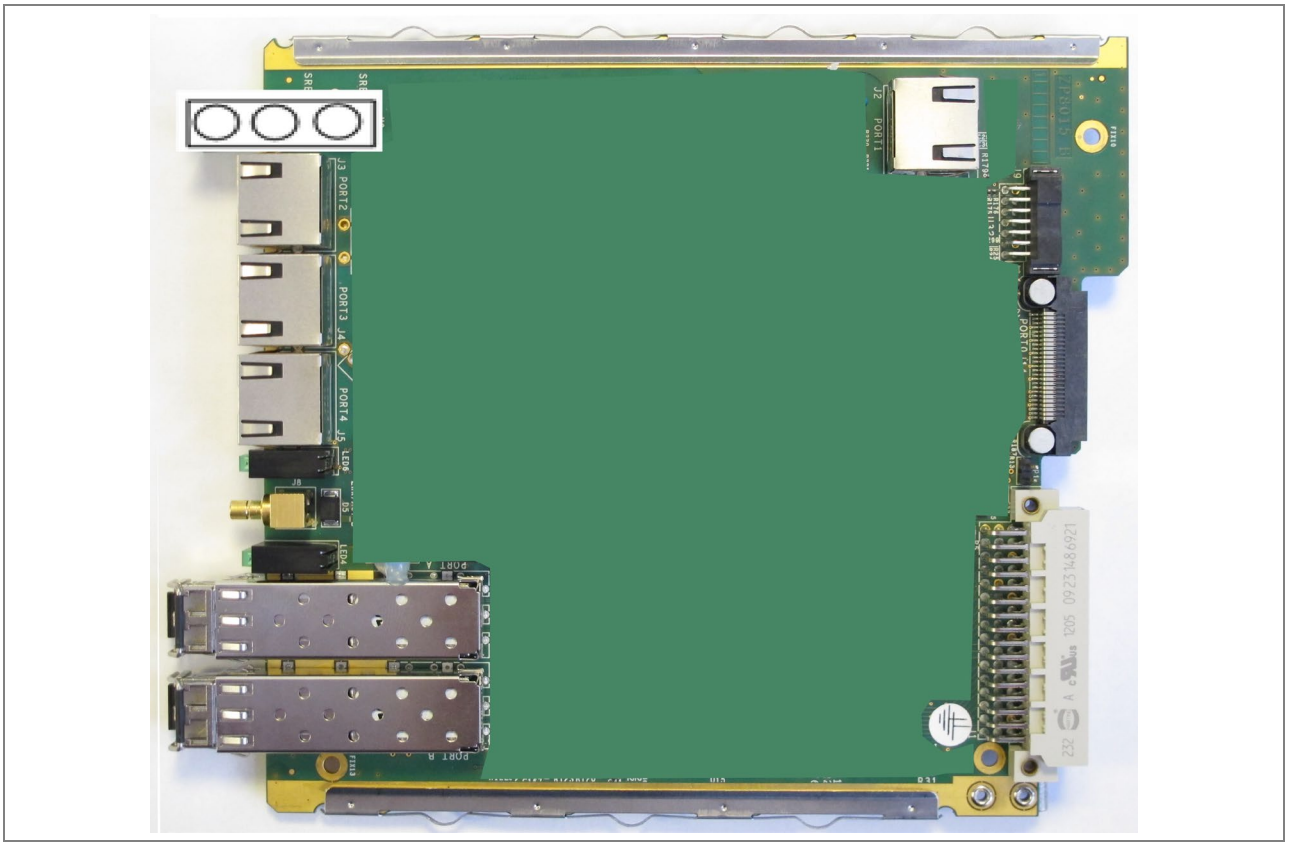


Figure 48: SRP29x board

LEDs

Eight LEDs are provided as shown in the diagram below, with their meaning indicated in the table that follows it.

They are situated at the rear of the board.

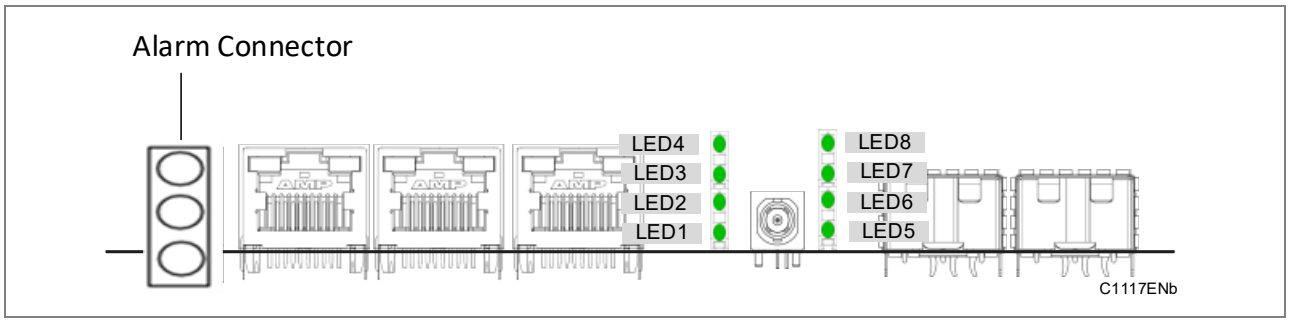


Figure 49: SRP29x LED positions

LED number	Assignment	Meaning
1	Port 4 status	Off = No link On = Healthy link Blinking = Activity
2	Port 3 status	
3	Port 2 status	
4	Not used	
5	HSR link B status	Off = No link On = Healthy link Blinking = activity
6	HSR link A status	
7	Software status	ON = Normal OFF = Factory mode, or failsafe/alarm operation
8	Initiation status	ON = Configuration in progress OFF = Configuration done

Switch management

The switch is SNMP managed (it integrates an SNMP server) and can be remotely accessed using an SNMP “client”. The IP addresses are set via an SSH connection on any port.

Ethernet cable type

Use data quality twisted pair shielded cable rated category 5 with standard RJ45 connectors.

The maximum cable length for 10/100BaseTX is 100 meters. Straight-through cable.

Variants

- SRP292 with two multi-mode optical connectors
- SRP294 with two single-mode optical connectors

Ethernet Optical Fibre

The cables are connected to the corresponding elements.

In both variants, the optical fibre connectors are **LC**-type small form-factor pluggable (SFP) transceivers that can use both single and multi mode fibre.

The table below lists the supports LC-Type SFP and references:

Item	Manufacturer Reference	Manufacturer	Description	Connector Type	Image
SRP292 HSR Switch Multimode	HFBR-57E5APZ	Avago	125Mbps Multimode 1310 nm wavelength	LC Duplex	
SRP294 HSR Switch Single mode	AFCT-5765ATLZ	Fit-foxconn / Avago	155Mbps Single-mode SR (up to 2 km) 1310 nm wavelength	LC Duplex	

Fibre Optic budget calculations

Optical power is expressed in Watts. However, the common unit of power measurement is the dBm, defined by the following equation: Power (dBm) = 10 log Power (mW) / 1 mW.

The fibre optic budget is the difference between the power emitted into the fibre and the sensitivity (minimum amount of power required) of the receiver connected through the fibre optic cable.

Link Power Budget = Transmitter Power (dBm) - Receiver Sensitivity (dBm). The distance over which the signals can be transmitted and successfully received is affected by the optical loss as shown in the figure below.

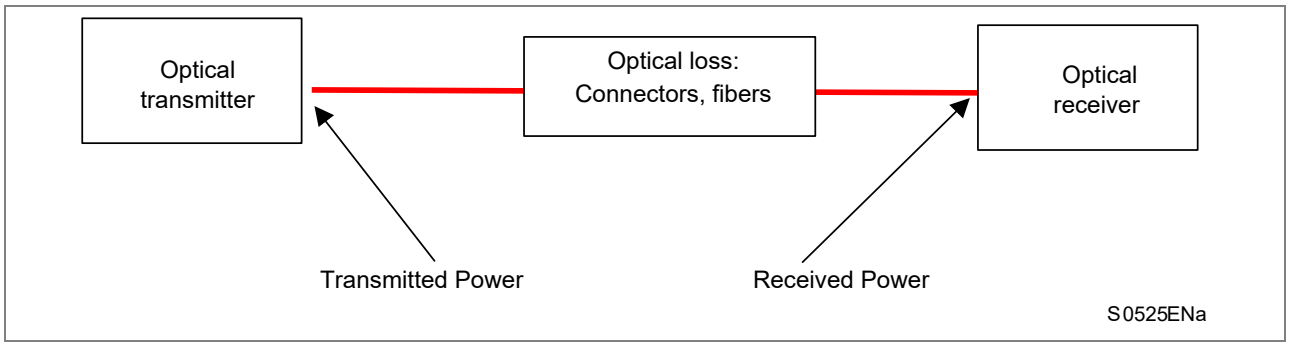


Figure 50: Fibre budget

For this product the optical budget is given in the table below.

Fibre type	Multimode	Single mode
	62.5/125 micron	**9/125 micron**
Power coupled into fibre	-19 dBm	-15 dBm
Sensitivity	-31 dBm	-34 dBm

In calculating the maximum distance, the following figures can be used as a guide, but you should check with your supplier for precise figures.

Fibre type	Multimode	Single mode
Link budget	**12 dB**	**19 dB**
Connector loss (1 per receiver, 1 per transmitter)	0.8 dB	0.8 dB
Safety Margin	4 dB	4 dB
Allowed link attenuation	**6.4 dB**	**13.4 dB**
Typical cable attenuation	1 dB/km	0.4 dB/km

Fibre type	Multimode	Single mode
Maximum range	**2 km**	**15 km**
Insertion of a patch panel (per panel)	2 dB	1 db

CONNECTION

C26X/EN CO/E72c

Contents

1	**SCOPE OF THE DOCUMENT**	**3**
2	**CONNECTOR BLOCKS**	**4**
2.1	**I/O Connectors**	**4**
2.2	**CT/VT Connector Block (located on the TMU2xx board)**	**5**
2.3	**Serial communications connections**	**6**
2.4	**Optical communications connections**	**7**
2.5	**Ethernet-based communications connections**	**7**
3	**CONNECTION OF THE PROTECTIVE CONDUCTOR (EARTH)**	**8**
3.1	**Earthing**	**8**
3.2	**Earthing Front panel**	**9**
3.3	**Cable fitting**	**10**
4	**CONNECTION DIAGRAMS FOR EACH I/O BOARD**	**12**
4.1	**Universal, Single or Dual Input Power Supply and legacy ports module – BIU261S/BIU261D**	**12**
4.1.1	Block diagrams	13
4.1.2	BIU261S/BIU261D mother board connector description	14
4.1.3	BIU261D daughter board connector description	15
4.1.4	BIU261 wiring for redundant C26x	15
4.2	**Central Processing and Communications Unit – CPU4**	**16**
4.2.1	Block diagram	17
4.2.2	Small Form-factor Pluggable module (SFP)	18
4.2.3	RJ45-Type Connections	19
4.2.4	Watchdog connector description	19
4.3	**Circuit breaker Control Unit – CCU200/CCU211**	**21**
4.3.1	Block diagram	21
4.3.2	Connector description	22
4.4	**Digital Inputs module – DIU200**	**23**
4.4.1	Block diagram	23
4.4.2	Connector description	24
4.5	**Digital Inputs module – DIU211**	**25**
4.5.1	Block diagram	25
4.5.2	Connector description	26
4.6	**Digital Inputs module – DIU221**	**27**
4.6.1	Block diagram	27
4.6.2	Connector description	28
4.7	**Digital Outputs module – DOU201**	**29**
4.7.1	Block diagram	29
4.7.2	Connector description	30
4.8	**High break-High speed Outputs module – HBU200**	**31**
4.8.1	Block diagram	31
4.8.2	Connector description	32
4.9	**Analogue Input module – AIU201**	**34**
4.9.1	Block diagram	34
4.9.2	Connector description	35

4.9.3	Connection of sensors to the AIU201 analogue input terminals	35
4.10	**Analogue Input module – AIU211**	**36**
4.10.1	Block diagram	36
4.10.2	Connector description	37
4.10.3	Connection of sensors to the AIU211 analogue input terminals	37
4.11	**Transducerless Measurements Unit module – TMU220**	**38**
4.11.1	Block diagram	38
4.11.2	Connector description	39
4.12	**Transducerless Measurements Unit module – TMU210**	**43**
4.12.1	Block diagram	43
4.12.2	Connector description	44
4.13	**Analogue Output module – AOU200**	**47**
4.13.1	Block diagram	47
4.13.2	Connector description	48
4.14	**PRP Ethernet Switch Unit – SRP282/SRP284**	**49**
4.14.1	Block diagram	50
4.14.2	Parallel Redundancy Protocol (PRP) Connection	51
4.14.3	Copper Ethernet Connections	51
4.14.4	Fault signal connector description	51
4.14.5	IRIG-B connector description	53
4.15	**HSR Ethernet Switch Unit – SRP292/SRP294**	**54**
4.15.1	Block diagram	55
4.15.2	High-availability Seamless Redundancy Protocol (HSR) Fibre-Optic Connection	56
4.15.3	RJ45 Ethernet Connections	57
4.15.4	Fault signal connector description	57
4.15.5	IRIG-B connector description	59
4.16	**Detachable Front panel**	**60**
4.17	**LOCAL Front panel**	**61**

1 SCOPE OF THE DOCUMENT

This document is a chapter of the DS Agile C26x documentation. It describes the connectors of the product I/O connectors and the connection diagrams of each I/O boards.

2 CONNECTOR BLOCKS

2.1 I/O CONNECTORS

Apart from the 2-way connector on the BIU261D's daughter board, all the I/O are connected using a standard type of 24-way connector block with a 5.08 mm pitch.

The 24-way I/O connector block characteristics are as follows:

- Continuous rating 10 A
- Connection method M3 screws
- Cable section 1.0 - 2.5 mm^2
- Connection pitch 5.08 mm
- Insulation between terminals and to the earth 300 V basic insulation
- Standards UL, CSA

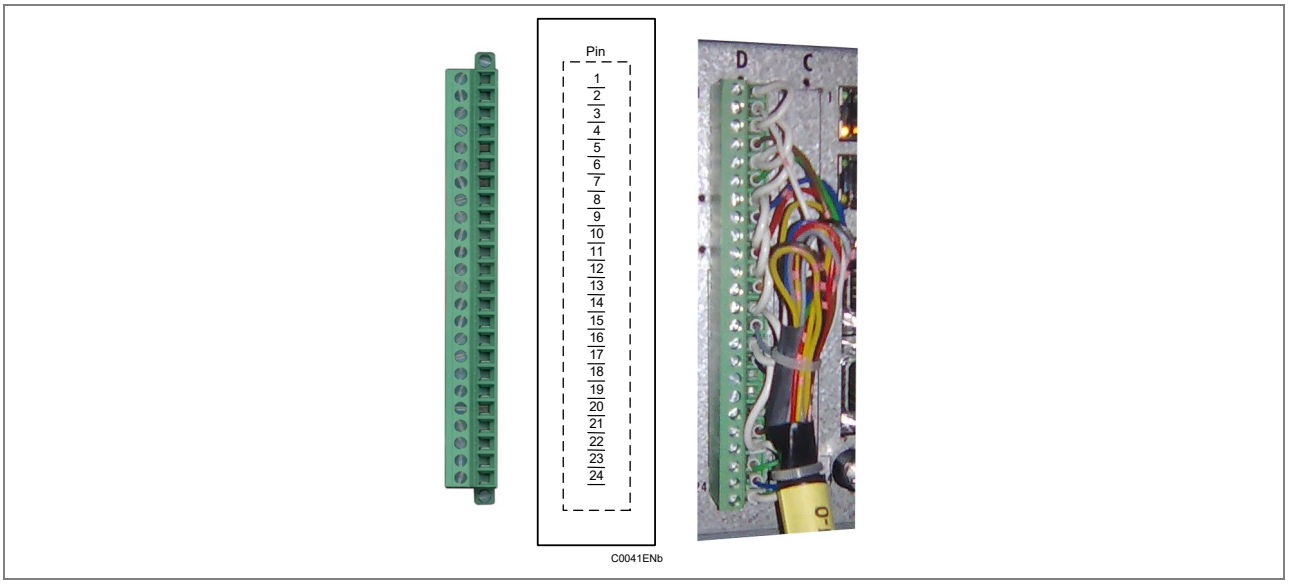


Figure 1: Typical 24-way female connector

Note:
The connector is fixed using 2 M3 screws located at each end of the connector.

The 2-way connector block characteristics are as follows:

- Continuous rating 10 A
- Connection method M2.5 screws
- Cable section 1.0 - 2.5 mm^2
- Connection pitch 5.08 mm
- Insulation between terminals and to the earth 300 V basic insulation
- Standards UL, CSA

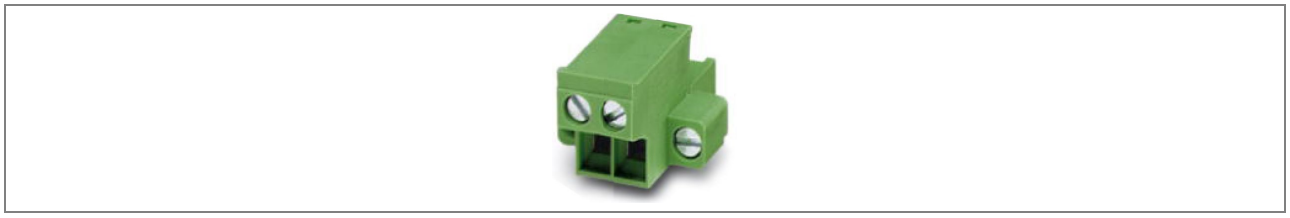


Figure 2: Typical 2-way female connector

2.2 CT/VT CONNECTOR BLOCK (LOCATED ON THE TMU2XX BOARD)

The C26x uses a standard black MiDOS 28-terminal block for transformer connection.

CT connection has 2 dual terminal groups, this allows dual rated transformer (1A/5A). Each group has shorting contact to allow disconnection of CTs without damage.

The CT/VT connector block characteristics are the following:

Parameter	Value
VT connection	
Continuous rating	10 A
3 second rating	30 A
30 ms rating	250 A
Connection method	Screw M4
Cable size	2 off 2.5 mm2
Isolation to other terminal and to earth	500 V basic insulation
CT connection	
Continuous rating	20 A
10 second rating	150 A
1 second rating	500 A
Connection method	Screw M4
Cable size	2 off 2.5 mm2 / 1 off 4 mm2
Isolation to other terminal and to earth	300 V basic insulation

Table 1: CT/VT Connector block

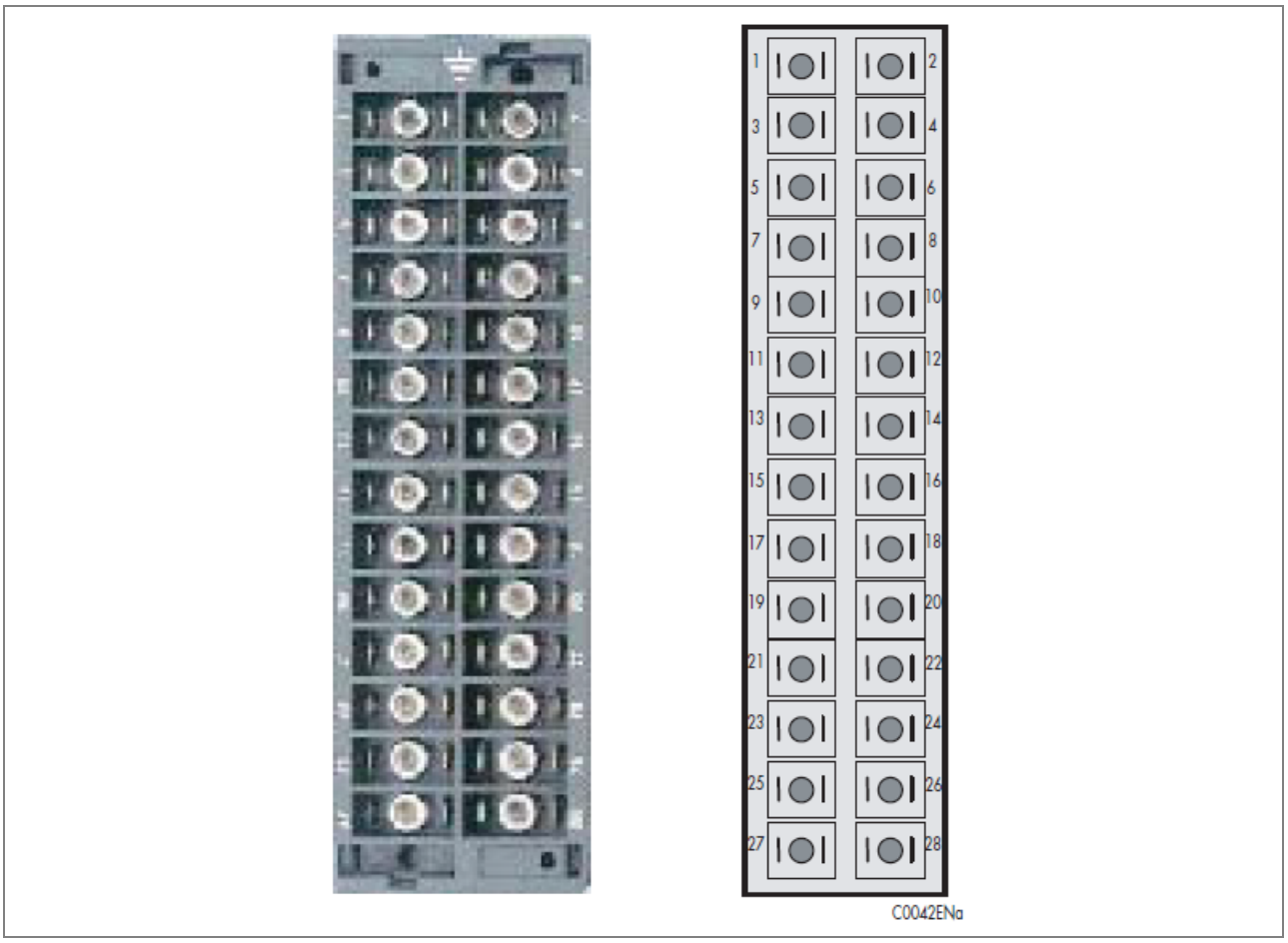


Figure 3: Standard MIDOS 28-way connector

Note:
The connector is fixed to the rack with 4 Phillips screws M4; 2 are located on the top part and 2 on the bottom part.

2.3 SERIAL COMMUNICATIONS CONNECTIONS

For a RS485 or RS422 serial communication interface a termination resistor has to be connected at each extremity of the bus.

If the IEDs or remote equipment (like Control Centre, etc) are located at a long distance (>10 m for RS232, >100 m for RS422 and >1000 m for RS485) from the communication equipment or if the cables run through a noisy area, then optical fibre communication should be used.

For both RS422 and RS485, the cable should be terminated at each end with a 120 ohm resistor or the resistance of the BIU board can be used.

2.4 OPTICAL COMMUNICATIONS CONNECTIONS

WARNING ABOUT LASER RAYS:



Where fibre optic communication devices are fitted, these should not be viewed directly. Optical power meters should be used to determine the operation or signal level of the device.

Non–observance of this rule could possibly result in personal injury.

Signals transmitted via optical fibres are unaffected by interference. The fibres guarantee electrical isolation between the connections.

If electrical to optical converters are used, they must have management of character idle state capability (for when the fibre optic cable interface is "Light off").

2.5 ETHERNET-BASED COMMUNICATIONS CONNECTIONS

The Ethernet-based communication available in the C26x works in full duplex mode, using either fibre optic media or 4 pair twisted cable.

Only the cable isolated category 5 (FTP: Foil Twisted Pair) or isolated (STP - Shielded Twisted Pairs) with RJ45 connectors must be used.

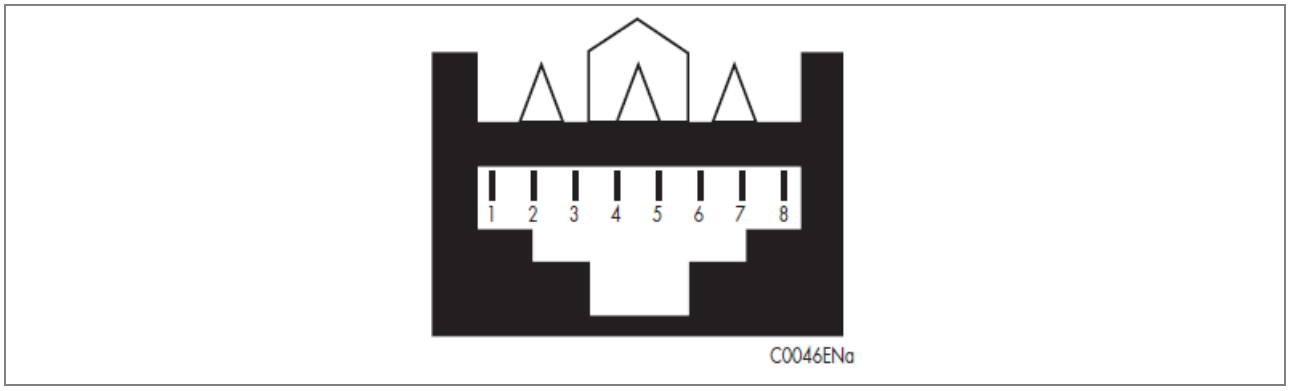


Figure 4: RJ45 connector

Only pins N°1, 2, 3 and 6 is used in RJ45 Ethernet 10/100BaseTX.

The standard is:

- 1 = white / orange
- 2 = orange
- 3 = white / green
- 4 = blue (non used)
- 5 = white / blue (non used)
- 6 = green
- 7 = white / brown (non used)
- 8 = brown (non used)

The RJ45 connector when seen face on, flat side on bottom, side tab on top, then pin 1 is on the left and pin 8 on the right.

3 CONNECTION OF THE PROTECTIVE CONDUCTOR (EARTH)

3.1 EARTHING

The DS Agile C26x must be connected to the earth using the protective conductor (earth) terminal located on the rear panel.

Connection of the Protective conductor (earth).

The DS Agile C26x racks must be earthed, for safety reasons, by connection of the protective conductor (earth) to the M4 threaded stud allocated as the protective conductor terminal (PCT), marked with the symbol shown.



Warning:
– To maintain the safety features of the equipment it is essential that the protective conductor (earth) is not disturbed when connecting or disconnecting functional earth conductors such as cable screens, to the PCT stud.
– The protective conductor must be connected first, in such a way that it is unlikely to be loosened or removed during installation, commissioning or maintenance. It is recommended that this is achieved by use of an additional locking nut.

The protective conductor (earth) must be as short as possible with low resistance and inductance. The best electrical conductivity must be maintained at all times, particularly the contact resistance of the plated steel stud surface. The resistance between the DS Agile C26x protective conductor (earth) terminal (PCT) and the protective earth conductor must be less than 10 mΩ at 12 Volt, 100 Hz.

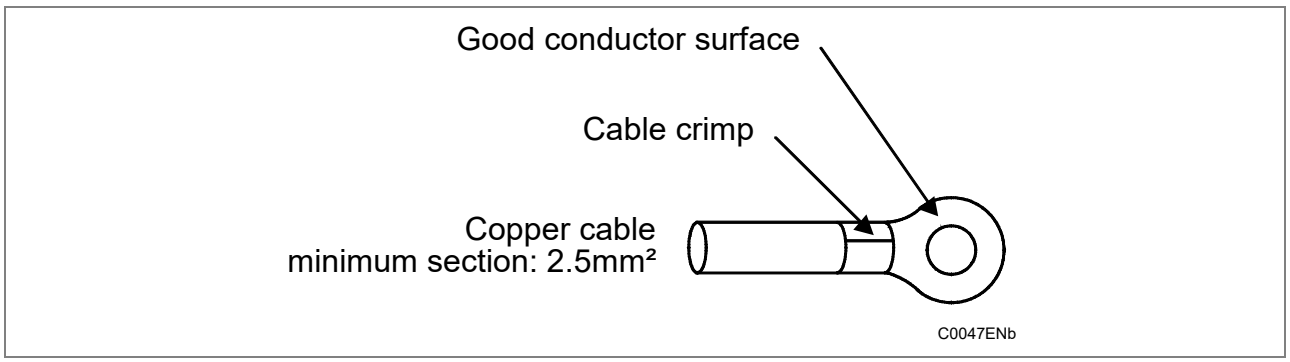


Figure 5: Earthing cable example

3.2 EARTHING FRONT PANEL

When remote GHU20x or GHU21x is installed, rear face of the front panel has to be grounded through the metal parts. The protective conductor to use has the same property than the one specified in above section *3.1 Earthing*:

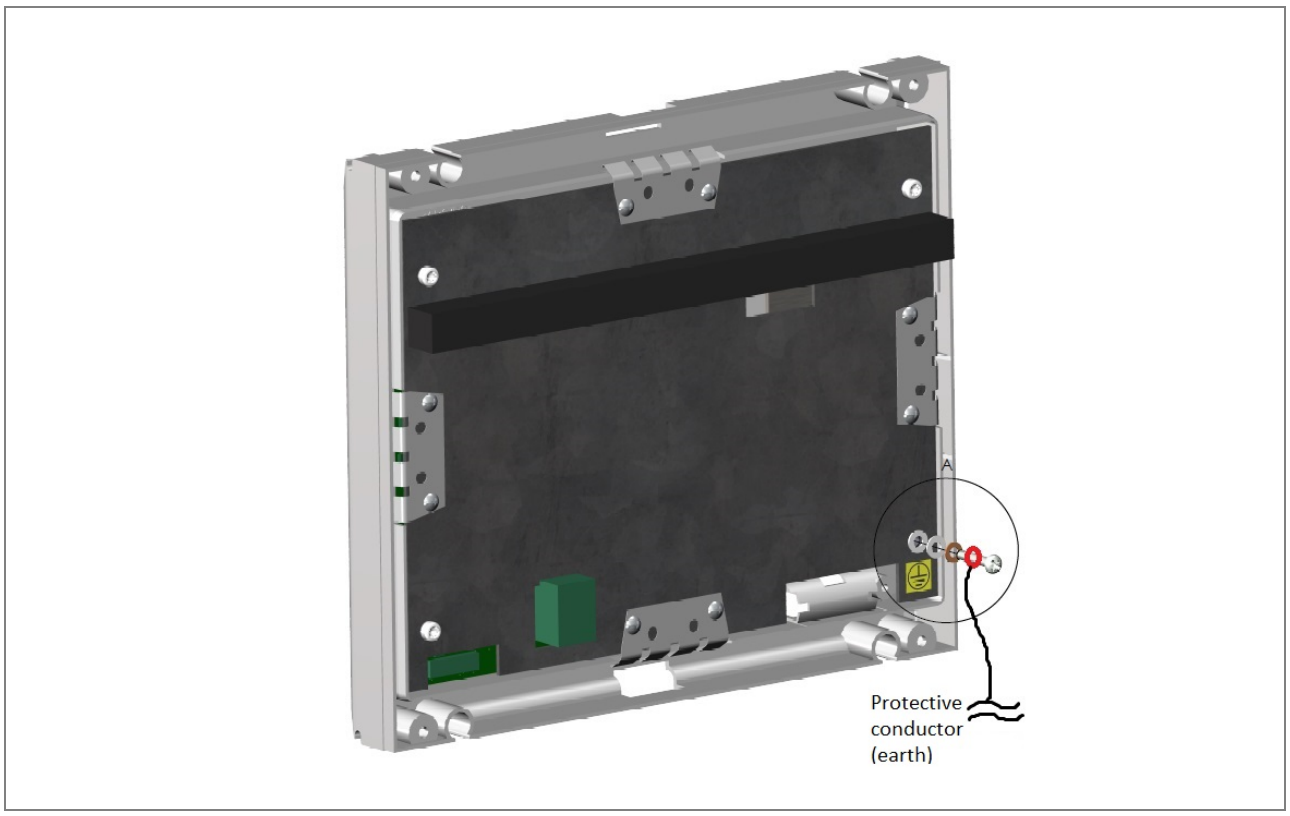


Figure 6: Earthing Front Panel

3.3 CABLE FITTING

It is recommended to use cables (0.8 mm^2) as following:

- Screened multi-strand cable has to be used for digital input-output signals. For cables within the cubicle the cable screen can be connected to the earth at both ends of the cable. If the cable is taken beyond the system cubicle the cable screen should be earthed at one end only to prevent current flowing in the screen due any differences in ground potential.
- Screened and twisted pair has to be used for analogue input-output signals. The screen is connected to the earth by the end of Bay Module side.
- One or two screened and twisted pairs have to be used for lower communication signals. The screen is connected to the earth by two cable ends.

It is recommended to group cables and fit them as near as possible to an earth plane or to an element of an earth wire-mesh.

First example: DS Agile C26x fitted without metallic cubicle.

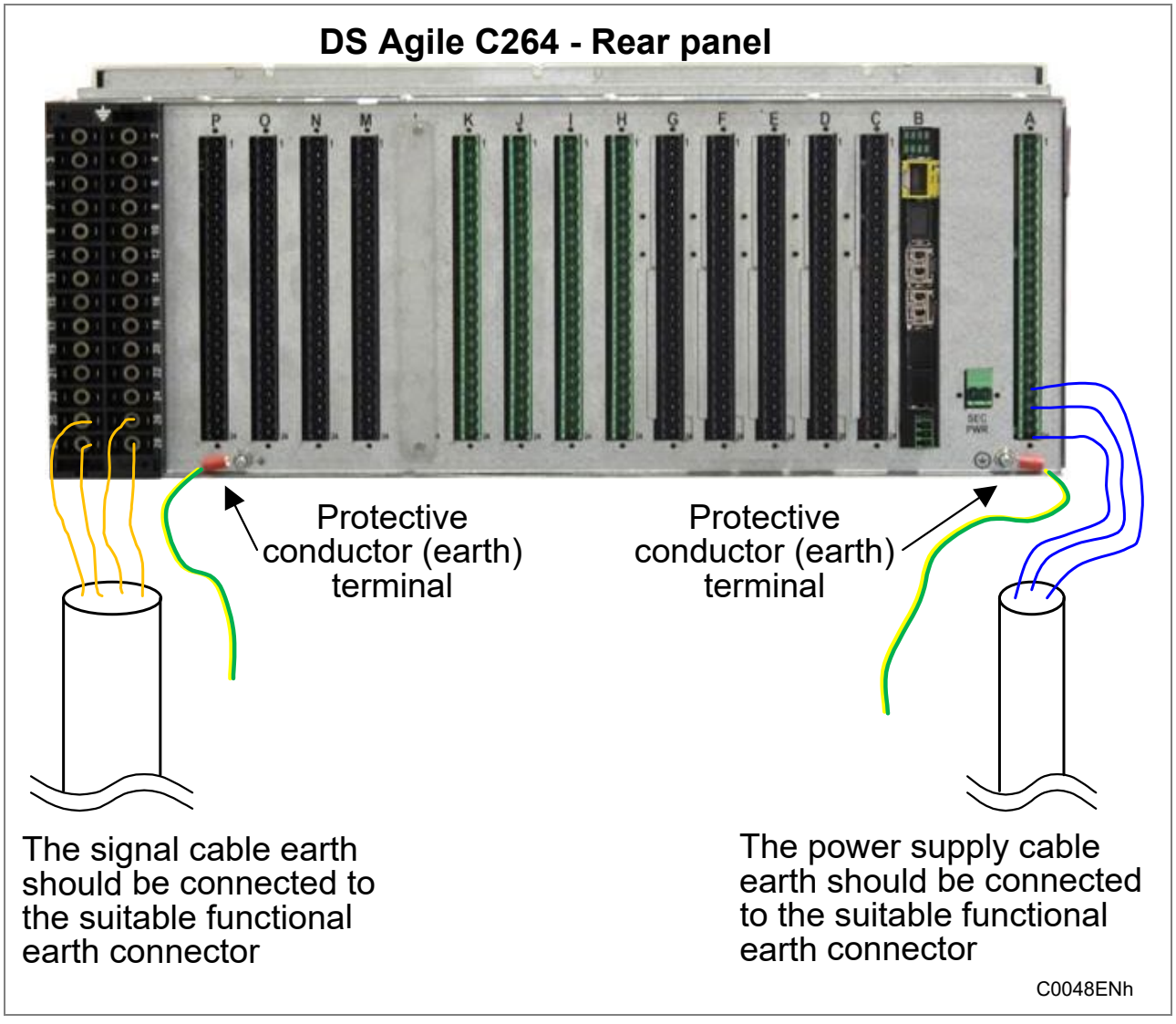


Figure 7: First example of earthing arrangement

Second example: DS Agile C26x fitted in a metallic cubicle with other devices.

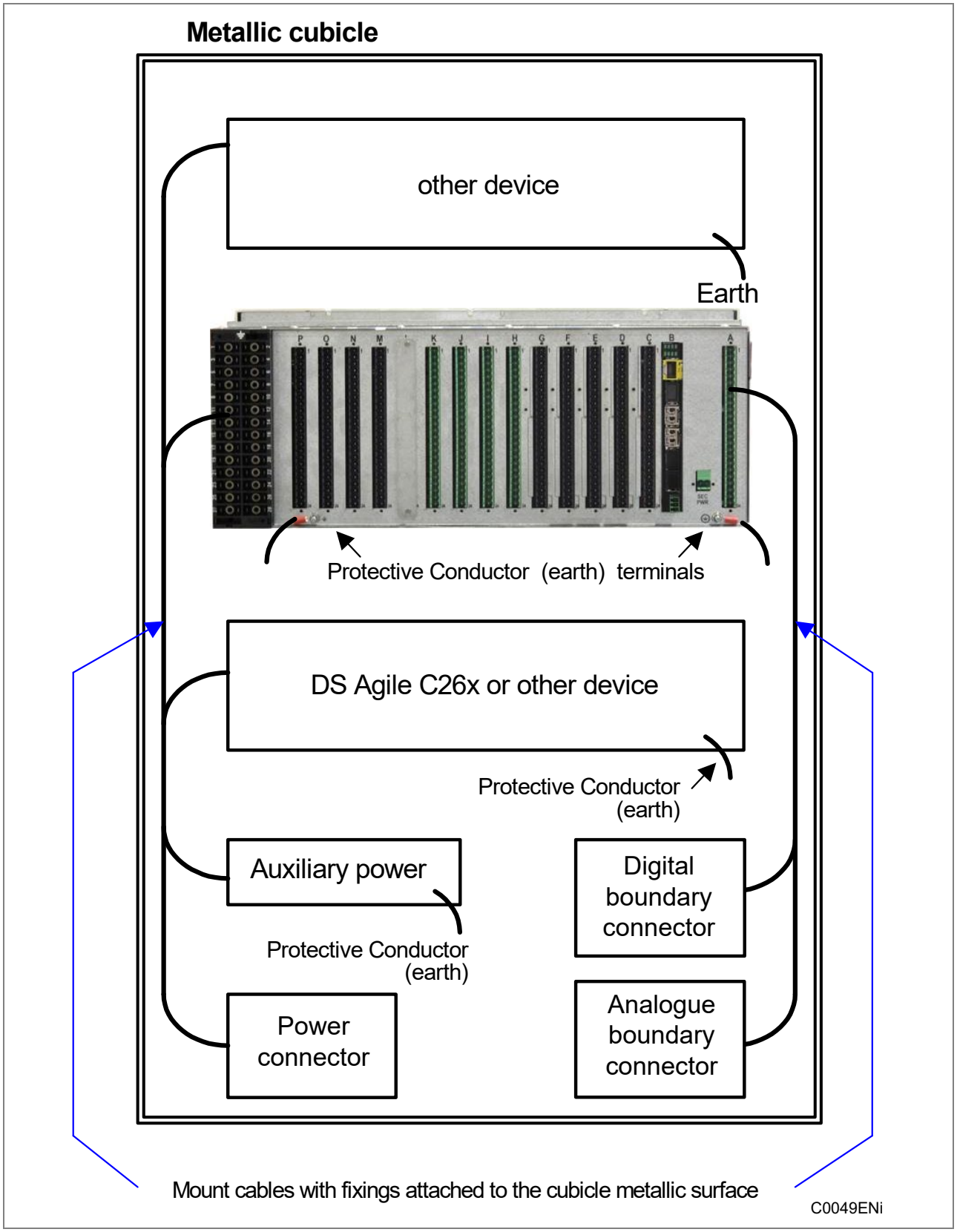


Figure 8: Second example of cable fitting

4 CONNECTION DIAGRAMS FOR EACH I/O BOARD

4.1 UNIVERSAL, SINGLE OR DUAL INPUT POWER SUPPLY AND LEGACY PORTS MODULE – BIU261S/BIU261D

This module can be composed of 2 boards, depending on whether a back-up power supply is present:

- BIU261S – Single source power supply

  The BIU261S board houses the primary power supply transformer, the watchdog relay, 2 inputs/ outputs for C26x redundancy and 2 legacy isolated serial ports (Ports N°1 / N°2).

- BIU261D – Dual source power supply (mother board + daughter board).

  The mother board of the BIU261D module houses the main auxiliary power supply transformer, the watchdog relay, 2 inputs/ outputs for C26x redundancy and 2 legacy isolated serial ports (Ports N°1 / N°2).

  The daughter board of the BIU261D module houses the secondary power supply transformer.

In both variants, the factory-set combinations for the two legacy isolated serial ports are:

Case	Port N°1	Port N°2
1	RS232	RS232
2	RS232	RS485
3	RS422	RS232
4	RS422	RS485
5	RS485	RS232
6	RS485	RS485

Table 2: Base legacy ports (ports N°1 / N°2) – Capabilities

4.1.1 BLOCK DIAGRAMS

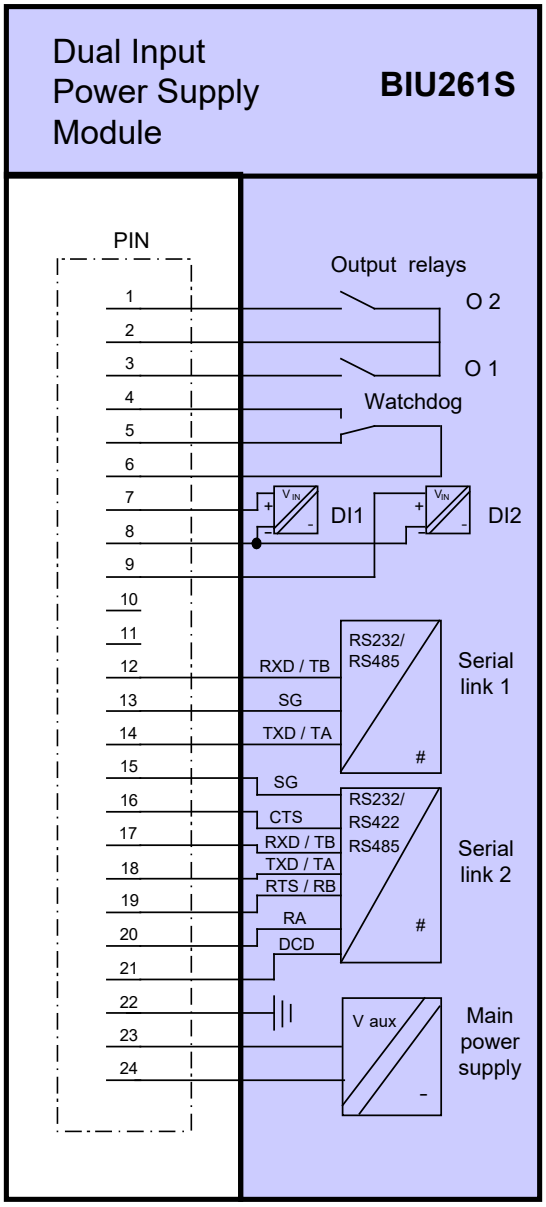


Figure 9: BIU261S board – Block diagram

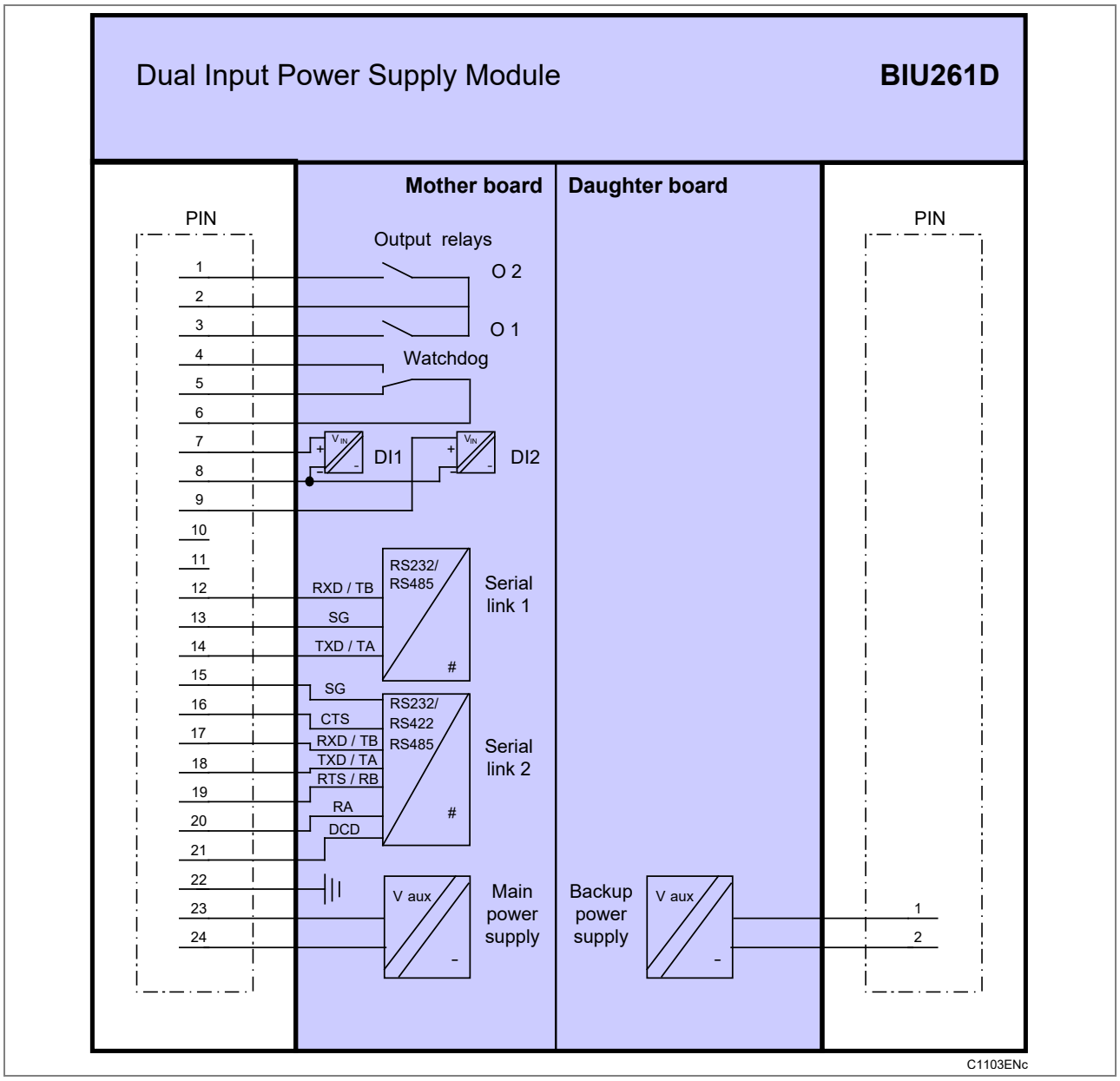


Figure 10: BIU261D module – Block diagram

4.1.2 BIU261S/BIU261D MOTHER BOARD CONNECTOR DESCRIPTION

Pin n°	Signal	
1	Redundancy relay 2	- NO contact
2	Redundancy relay	- common 1-2
3	Redundancy relay 1	- NO contact
4	Watchdog relay	- NO contact
5	Watchdog relay	- NC contact
6	Watchdog relay	- common
7	Redundancy input	- 1+
8	Redundancy input	- common 1 / 2
9	Redundancy input	- 2+
10		

Pin n°	Signal			
11				
12	RS232: RxD	RS485: B		- Port 1
13	GND			- Port 1
14	RS232: TxD	RS485: A		- Port 1
15	GND			- Port 2
16	RS232: CTS			- Port 2
17	RS232: RxD	RS485 B	RS422: TB	- Port 2
18	RS232: TxD	RS485 A	RS422: TA	- Port 2
19	RS232: RTS	RS422: RB		- Port 2
20		RS422: RA		- Port 2
21	RS232: DCD			- Port 2
22	Voltage input: Gnd			Gnd
23	Voltage input: AC/DC			(+)
24	Voltage input: AC/DC			(-)

4.1.3 BIU261D DAUGHTER BOARD CONNECTOR DESCRIPTION

Power supply input

Pin n°	Location	Signal
1	Left when view from the rear of the device	Voltage input: AC/DC (+)
2	Right when view from the rear of the device	Voltage input: AC/DC (-)

4.1.4 BIU261 WIRING FOR REDUNDANT C26X

In case of C26x redundancy, the following signals are to be wired on the the main board of the BIU261 module for the management of main/backup redundancy:

C26x_1 Signal	C26x_1 BIU Pin		C26x_2 BIU Pin	C26x_2 Signal
Redundancy output contact relay 2 (Open on C26x Failure)	1	------>	9	Redundancy input: 2+
Redundancy relay: common 1 & 2 (+)	2	(+)	2	Redundancy relays: common 1 & 2 (+)
Redundancy output contact relay 1 (Closed when “Active”, Open when “Standby”)	3	------>	7	Redundancy input: 1+
Redundancy input: 1+	7	<------	3	Redundancy output contact relay 1 (Closed when “Active”, Open when “Standby”)
Redundancy input - common 1 & 2 (-)	8	(-)	8	Redundancy input - common 1 & 2 (-)
Redundancy input: 2+	9	<------	1	Redundancy output contact relay 2 (Open on C26x Failure)

Note:
Both C26x must be fitted with the same type of BIU board/module, with the same power supply configuration.

4.2 CENTRAL PROCESSING AND COMMUNICATIONS UNIT – CPU4

This board offers one fixed 100 Mb electrical maintenance port (RJ45 connector) + 6 SFP cages which can hold any of the following, depending on the configuration:

- RJ45 plug for 10/100/1000BASE-Tx Ethernet port: The ports are half/full duplex and auto-sense the transmission speed. They auto-negotiate with the connected device to determine the optimal transmission speed: 10 Mbps, 100 Mbps or 1000 Mbps depending on the connected devices' capability.
- LC optical plugs for:
  - 100BASE-Fx port: 100 Mbps, multimode
  - 100BASE-Fx port: 100 Mbps, single mode over 15 km
  - 100BASE-Fx port: 100 Mbps, single mode over 2 km
  - 1000BASE-Sx port: 1000 Mbps, multimode over 550 m
  - 1000BASE-Lx port: 1000 Mbps, single mode over 10 km

4.2.1 BLOCK DIAGRAM

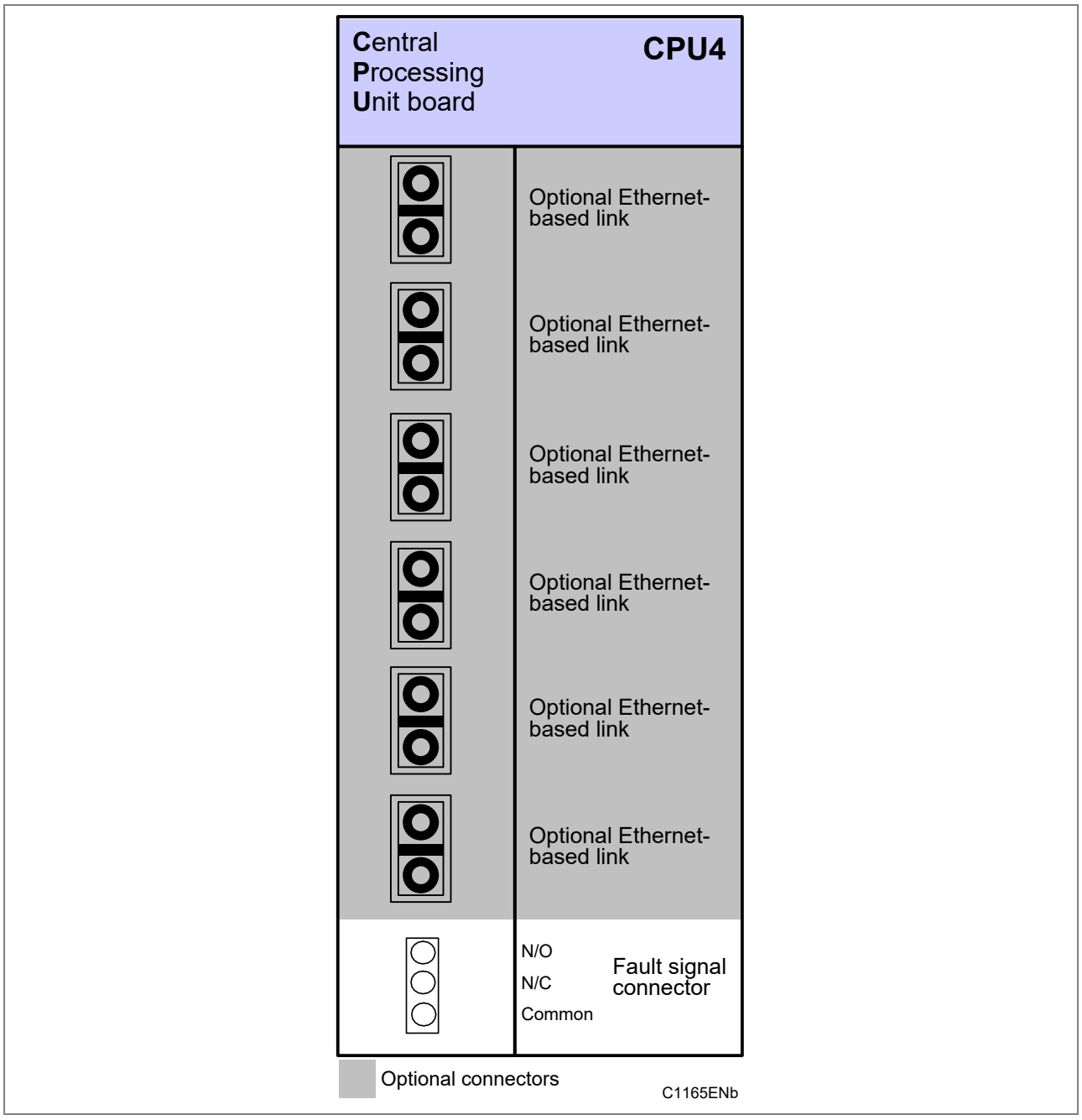


Figure 11: CPU4 board – Block diagram example

4.2.2 SMALL FORM-FACTOR PLUGGABLE MODULE (SFP)

Small Form-factor Pluggable module (SFP) can be used to connect to the network. The SFP module is a hot-swappable connector that provides high-speed performance.

DS Agile C26x supports two kinds of modules:

- Optical LC-type SFP
- RJ45-type SFP.

The table below lists the supported **LC-type** SFP and references:

Reference	Manufacturer	Description	Connector Type	Image
AFBR-5715ALZ	fit-foxconn	1Gbps Multimode 850nm wavelength	LC Duplex	
HFBR-57E0APZ	AVAGO	100Mbps Multimode 1300 nm wavelength	LC Duplex	
AFCT-5765ALZ	fit-foxconn	100Mbps Single-mode SR (up to 2 km) 1300 nm wavelength	LC Duplex	
AFCT-5715ALZ	fit-foxconn	1Gbps Single-mode (up to 10km) 1310 nm wavelength	LC Duplex	
AFCT-5765ATLZ	fit-foxconn / Avago	100Mbps Single-mode IR-1 (up to 15 km) 1300 nm wavelength	LC Duplex	

The table below lists the supported **RJ45-type** SFP and references:

Reference	Manufacturer	Description	Connector Type	Image
ABCU-5741ARZ	fit-foxconn	10/100/1000Mbps	RJ45	

Caution:
DS Agile C26x is delivered with SFP cap inserted in each SFP cage. The cap must be inserted in each SFP cage unused. It is a protection against dust.

4.2.3 RJ45-TYPE CONNECTIONS

The user-accessible copper Ethernet communication ports use 4 twisted pair cable.

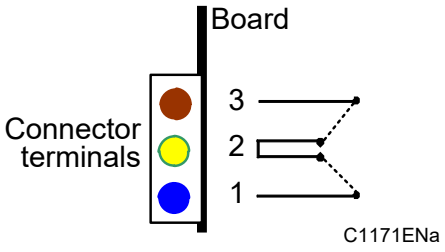
If connected devices are located a long distance away from the switch (>100 m), or if the cables run through a harsh electrical environment, then copper to fibre converters should be used in conjunction with optical fibres.

Ethernet cable type

Insulated cable category 6 or e (FTP: Foil Twisted Pair or STP: Shielded Twisted Pair) with RJ45 connectors are mandatory.

4.2.4 WATCHDOG CONNECTOR DESCRIPTION

The operational state of the board is indicated on contacts at the rear of the board according to the diagram and table below: The alarm contacts share a common terminal.



Terminal number	Assignment	Signal	Meaning
1	Operational state	NO	Open = Boot in progress/faulty Closed = Normal operation
2	Common		
3	Operational state	NC	Open = Normal operation Closed = Boot in progress/faulty

A closed contact indicates an alarm or a fault.

The characteristics of the alarm connector are presented below.

- Terminals: 1 normally closed (NC) contact
1 normally open (NO) contact
- Voltage: 30 V_{DC} / 33 V_{AC}
- Current: 5 A

Wiring recommendations

For safety reasons and for compliance with the European Commission Low Voltage Directive (2014/35/EU), the authorised voltage rating to be applied on the watchdog terminals is limited to 30 V_{DC} or 33 V_{AC} and must not exceed 5 A.

Due to the proximity of the port N°6 Ethernet connector, it is strongly recommended that the watchdog connections are visually checked before any handling of the Ethernet connectors.

Particular attention is to be paid not to damage the cable's isolation during the wiring phase.

The figure below shows the allocation of the CPU4 alarm contacts.

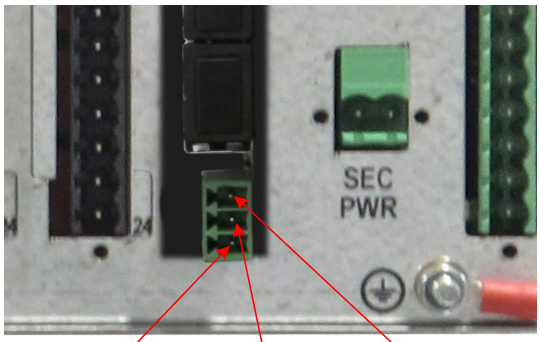


Figure 12: CPU4 Alarm Contact connections

4.3 CIRCUIT BREAKER CONTROL UNIT – CCU200/CCU211

The Circuit breaker Control boards provide 8 digital inputs (8 DI with one common for 2DI) and 4 double pole outputs (4 DO) using integrated relays.

4.3.1 BLOCK DIAGRAM

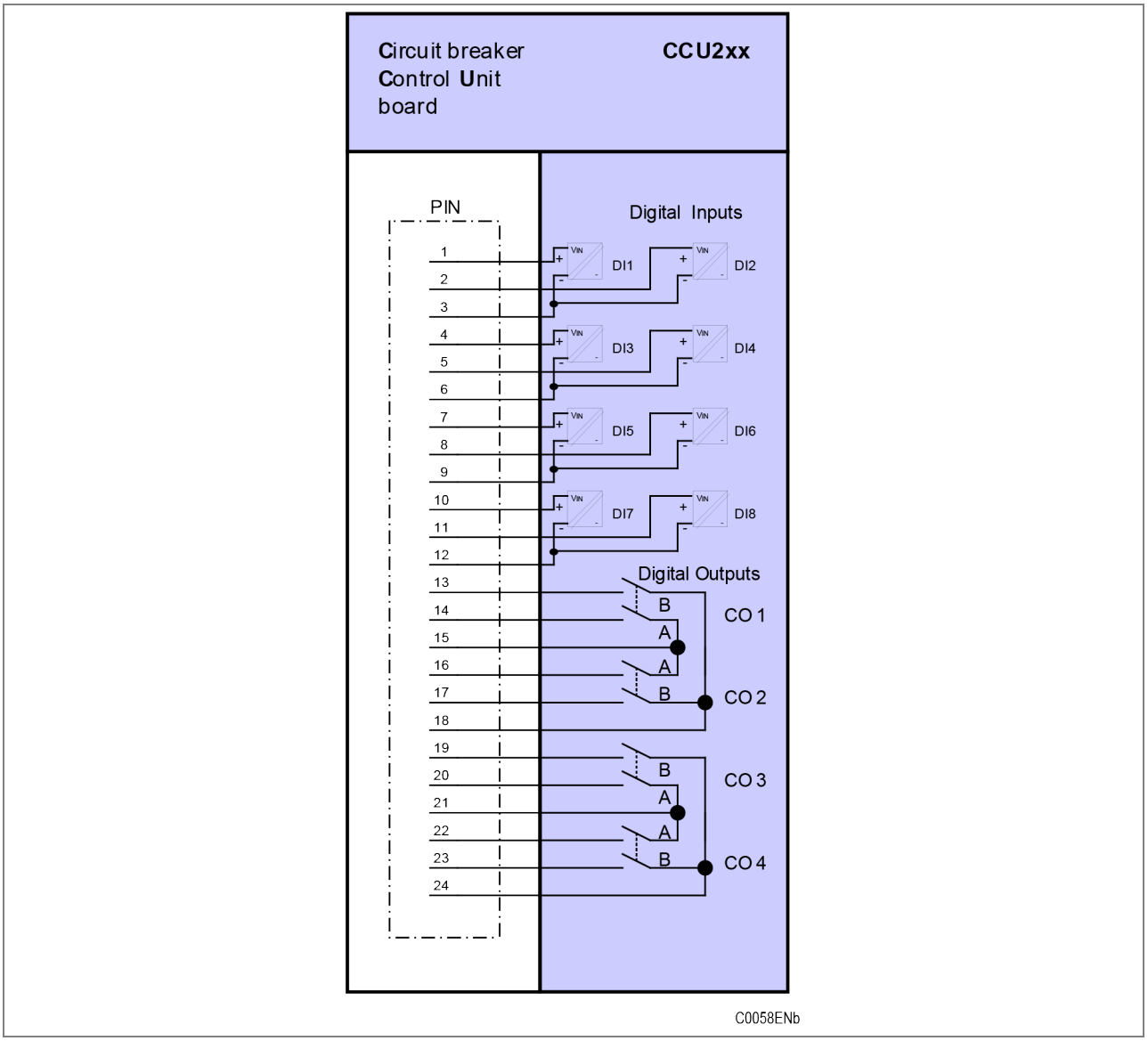


Figure 13: CCU2xx board – Block diagram

Note:
On the CCU211, the + and – of Digital Inputs can be inverted

Note:
Different types of CCU200 boards are available, depending on the input voltage range. Therefore, before connection, special attention should be paid to the version of the board:
- version A01 for 24V_{DC},
- version A02 for 48/60 V_{DC},
- version A03 for 110/125V_{DC}
- version A04 for 220 V_{DC}

4.3.2 CONNECTOR DESCRIPTION

The CCU2xx board is equipped with a 24-way 5.08 mm pitch connector.

Pin N°.	Signal
1	Digital Input 1+
2	Digital Input 2+
3	Common Digital Input 1 / 2
4	Digital Input 3+
5	Digital Input 4+
6	Common Digital Input 3 / 4
7	Digital Input 5+
8	Digital Input 6+
9	Common Digital Input 5 / 6
10	Digital Input 7+
11	Digital Input 8+
12	Common Digital Input 7 / 8
13	Digital Output 1 B
14	Digital Output 1 A
15	Common Digital Output 1 - 2 A
16	Digital Output 2 A
17	Digital Output 2 B
18	Common Digital Output 1 - 2 B
19	Digital Output 3 B
20	Digital Output 3 A
21	Common Digital Output 3 – 4 A
22	Digital Output 4 A
23	Digital Output 4 B
24	Common Digital Output 3 - 4 B

Table 3: CCU2xx board – Connector description

Note :
On the CCU211, "Common Digital inputs" can be connected with a positive or negative polarity.

4.4 DIGITAL INPUTS MODULE – DIU200

The Digital Input module (DIU200) provides 16 optically isolated Digital Inputs (with one common for two DI).

4.4.1 BLOCK DIAGRAM

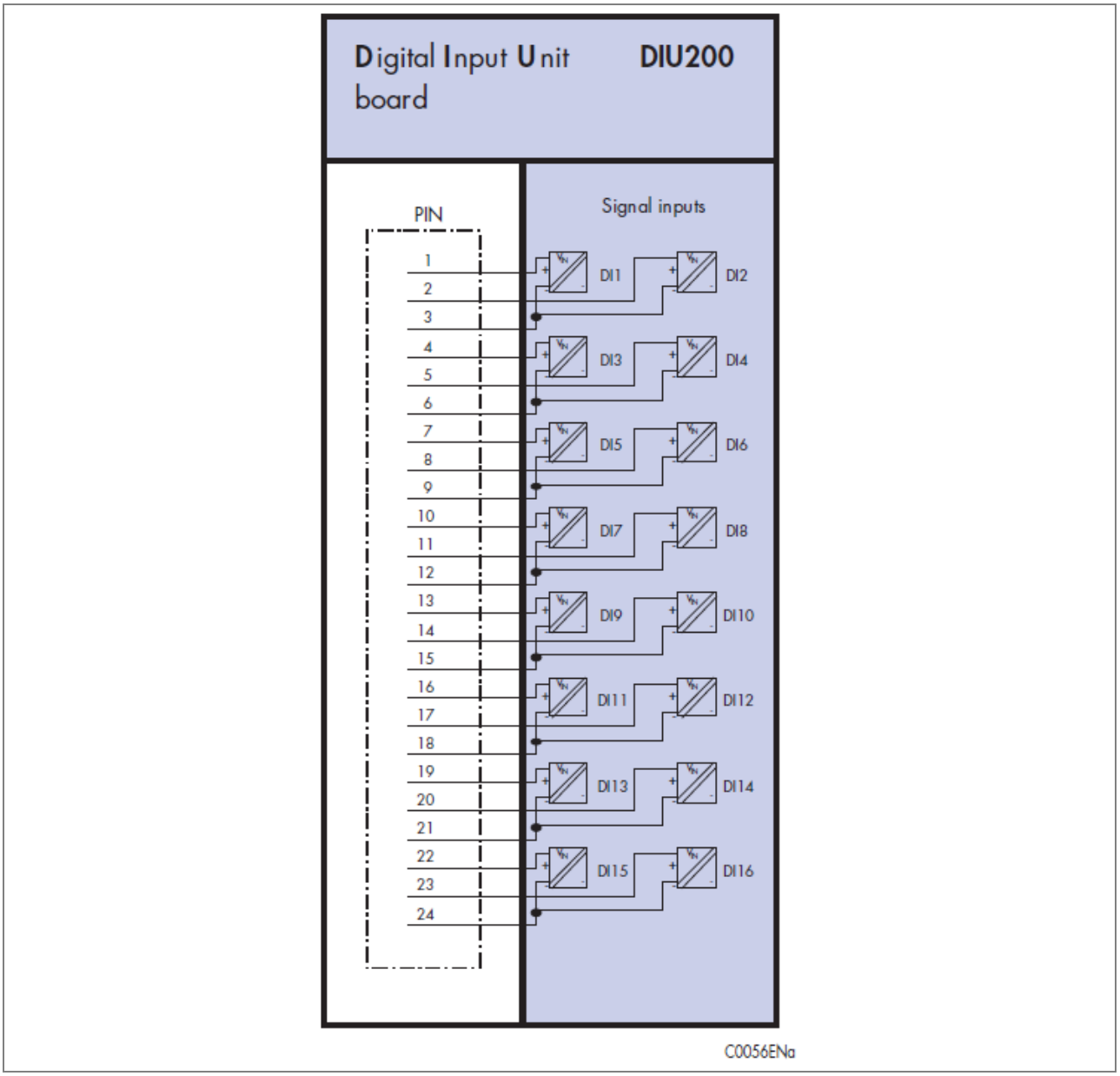


Figure 14: DIU200 board – Block diagram

Note:
Different types of DIU200 boards exist depending on the input voltage range
Before connection, a special attention is to be paid about the version of the board:
- version A01 for 24V_{DC},
- version A02 for 48/60 V_{DC},
- version A03 for 110/125V_{DC}
- version A04 for 220 V_{DC}

4.4.2 CONNECTOR DESCRIPTION

The DIU200 board is equipped with a 24-way 5.08 mm pitch connector.

Pin N°.	Signal
1	Digital Input 1+
2	Digital Input 2+
3	Negative Common Digital Input 1 / 2
4	Digital Input 3+
5	Digital Input 4+
6	Negative Common Digital Input 3 / 4
7	Digital Input 5+
8	Digital Input 6+
9	Negative Common Digital Input 5 / 6
10	Digital Input 7+
11	Digital Input 8+
12	Negative Common Digital Input 7 / 8
13	Digital Input 9+
14	Digital Input 10+
15	Negative Common Digital Input 9 / 10
16	Digital Input 11+
17	Digital Input 12+
18	Negative Common Digital Input 11 / 12
19	Digital Input 13+
20	Digital Input 14+
21	Negative Common Digital Input 13 / 14
22	Digital Input 15+
23	Digital Input 16+
24	Negative Common Digital Input 15 / 16

Table 4: DIU200 board – Connector description

4.5 DIGITAL INPUTS MODULE – DIU211

The Digital Input module (DIU211) provides 16 optically isolated digital inputs with one common for two DIs. This common links the positive inputs of the two opto-couplers.

Note:
The board supports polarity reversal.

4.5.1 BLOCK DIAGRAM

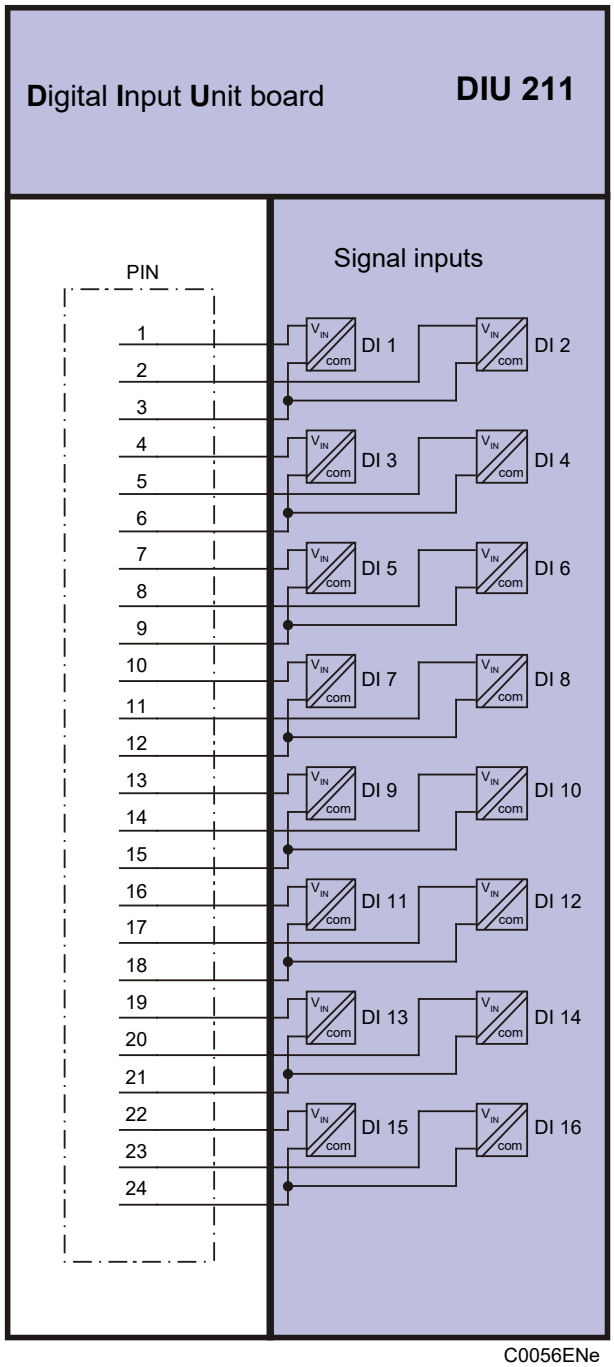


Figure 15: DIU211 board – Block diagram

Note:
Different variants of DIU211 boards are available according to the input voltage range.
Before connection, special attention is to be paid to the board variant:
- variant A01 for 24 V_{DC},
- variant A02 for 48/60 V_{DC},
- variant A03 for 110/125 V_{DC}
- variant A04 for 220 V_{DC}
- variant A07 for 110/125 V_{DC} with 80% threshold
- variant A08 for 220 V_{DC} with 80% threshold

4.5.2 CONNECTOR DESCRIPTION

The DIU211 board is equipped with a standard type of connector with a 24-way and 5.08 mm pitch.

Pin N°.	Signal
1	Digital Input 1-
2	Digital Input 2-
3	Positive Common Digital Input 1 / 2
4	Digital Input 3-
5	Digital Input 4-
6	Positive Common Digital Input 3 / 4
7	Digital Input 5-
8	Digital Input 6-
9	Positive Common Digital Input 5 / 6
10	Digital Input 7-
11	Digital Input 8-
12	Positive Common Digital Input 7 / 8
13	Digital Input 9-
14	Digital Input 10-
15	Positive Common Digital Input 9 / 10
16	Digital Input 11-
17	Digital Input 12-
18	Positive Common Digital Input 11 / 12
19	Digital Input 13-
20	Digital Input 14-
21	Positive Common Digital Input 13 / 14
22	Digital Input 15-
23	Digital Input 16-
24	Positive Common Digital Input 15 / 16

Note:
The triggering threshold depends on jumper positions; see the chapter C26x/EN HW.



Caution:
Protect the opto-inputs and their wiring with a maximum 16 A high rupture capacity (HRC) type NIT or TIA fuse.

4.6 DIGITAL INPUTS MODULE – DIU221

The Digital Input module (DIU221) provides 16 galvanically isolated digital inputs with one common connection for two inputs. This common connection links the positive inputs of the two channels.

Note:
In its A09 (170 V_{DC}) and A10 (250 V_{DC}) voltage variants, the board does not support polarity reversal. It does not operate if the voltage has the wrong polarity.

4.6.1 BLOCK DIAGRAM

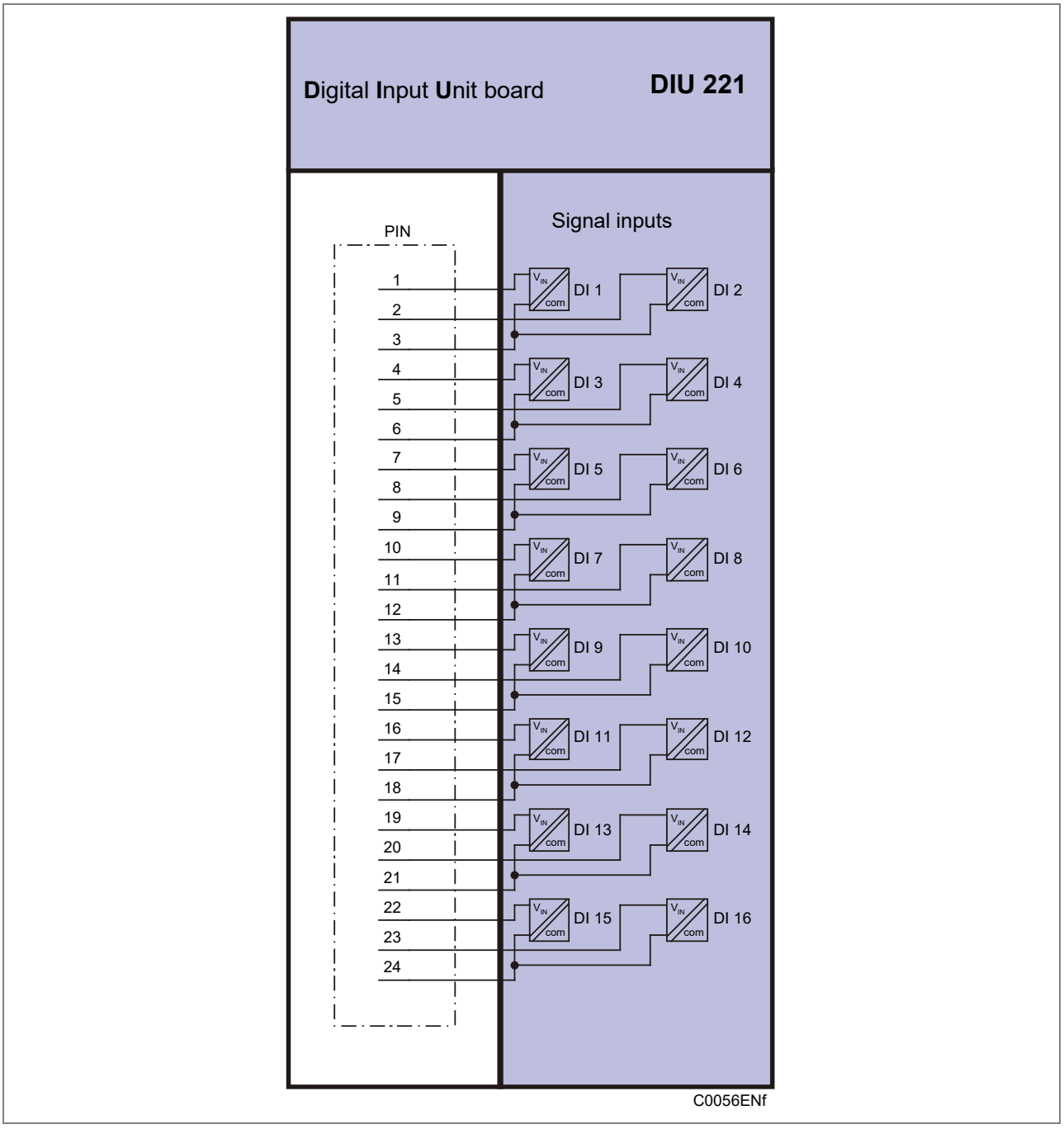


Figure 16: DIU221 board – Block diagram

4.6.2 CONNECTOR DESCRIPTION

The DIU221 board is equipped with a standard type of connector with a 24-pin and 5.08 mm pitch.

Pin N°.	Signal
1	Digital Input 1-
2	Digital Input 2-
3	Positive Common Digital Input 1 / 2
4	Digital Input 3-
5	Digital Input 4-
6	Positive Common Digital Input 3 / 4
7	Digital Input 5-
8	Digital Input 6-
9	Positive Common Digital Input 5 / 6
10	Digital Input 7-
11	Digital Input 8-
12	Positive Common Digital Input 7 / 8
13	Digital Input 9-
14	Digital Input 10-
15	Positive Common Digital Input 9 / 10
16	Digital Input 11-
17	Digital Input 12-
18	Positive Common Digital Input 11 / 12
19	Digital Input 13-
20	Digital Input 14-
21	Positive Common Digital Input 13 / 14
22	Digital Input 15-
23	Digital Input 16-
24	Positive Common Digital Input 15 / 16

4.7 DIGITAL OUTPUTS MODULE – DOU201

The Digital Outputs Unit board DOU201 provides 10 isolated outputs using relays.

4.7.1 BLOCK DIAGRAM

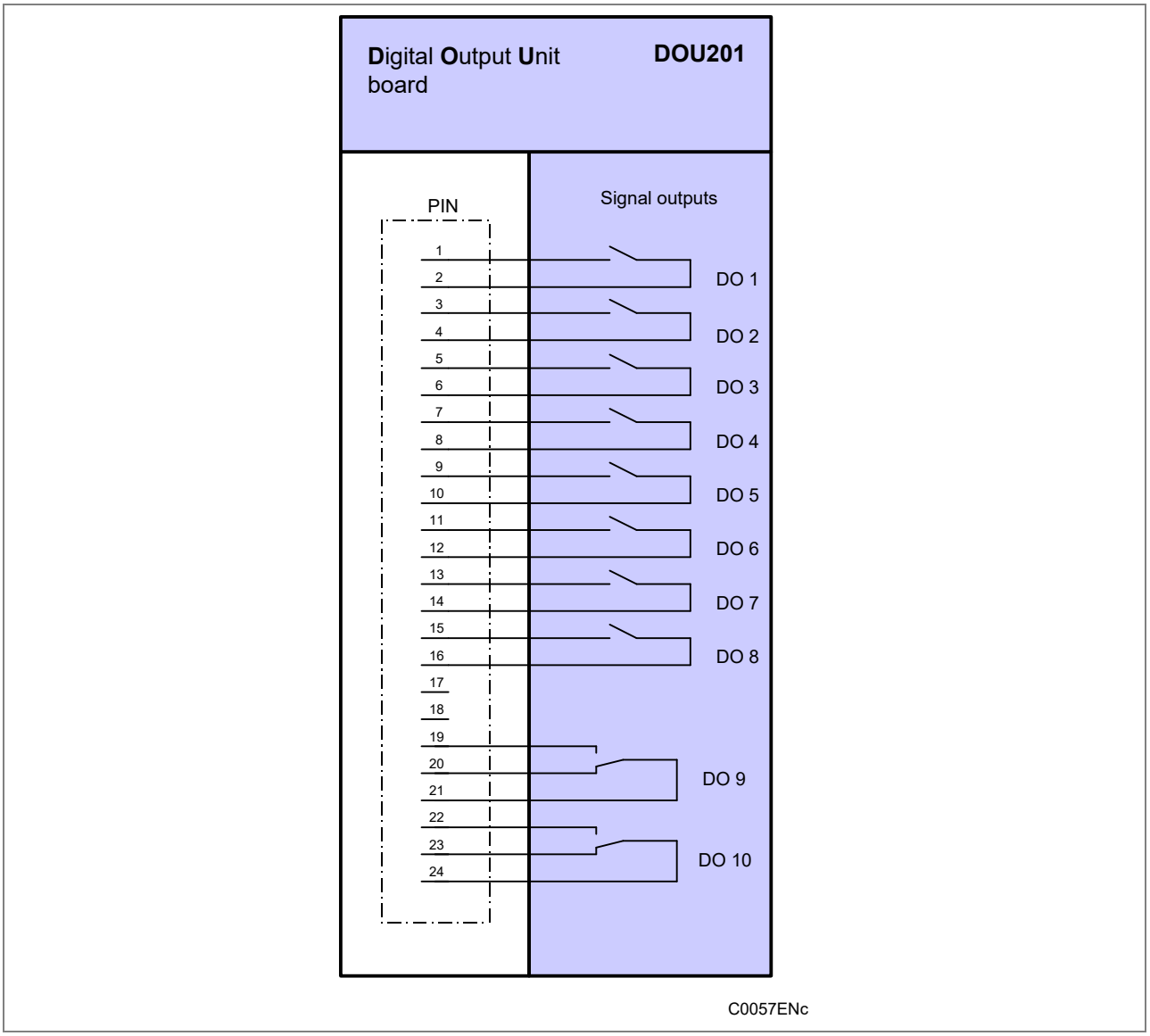


Figure 17: DOU200/DOU201 board – Block diagram

4.7.2 CONNECTOR DESCRIPTION

The DOU201 board is equipped with a 24pin 5.08 mm pitch connector.

Pin N°.	Signal
1	Digital output 1 +
2	Digital output 1 -
3	Digital output 2 +
4	Digital output 2 -
5	Digital output 3 +
6	Digital output 3 -
7	Digital output 4 +
8	Digital output 4 -
9	Digital output 5 +
10	Digital output 5 -
11	Digital output 6 +
12	Digital output 6 -
13	Digital output 7 +
14	Digital output 7 -
15	Digital output 8 +
16	Digital output 8 -
17	NC
18	NC
19	Digital output 9 – NO contact
20	Digital output 9 – NC contact
21	Common Digital output 9
22	Digital output 10 – NO contact
23	Digital output 10 – NC contact
24	Common Digital output 10

Table 5: DOU201 board – Connector description

4.8 HIGH BREAK-HIGH SPEED OUTPUTS MODULE – HBU200

The High Break Unit board (HBU200) comprises 10 normally open output contacts, which are suitable for high breaking loads.

4.8.1 BLOCK DIAGRAM

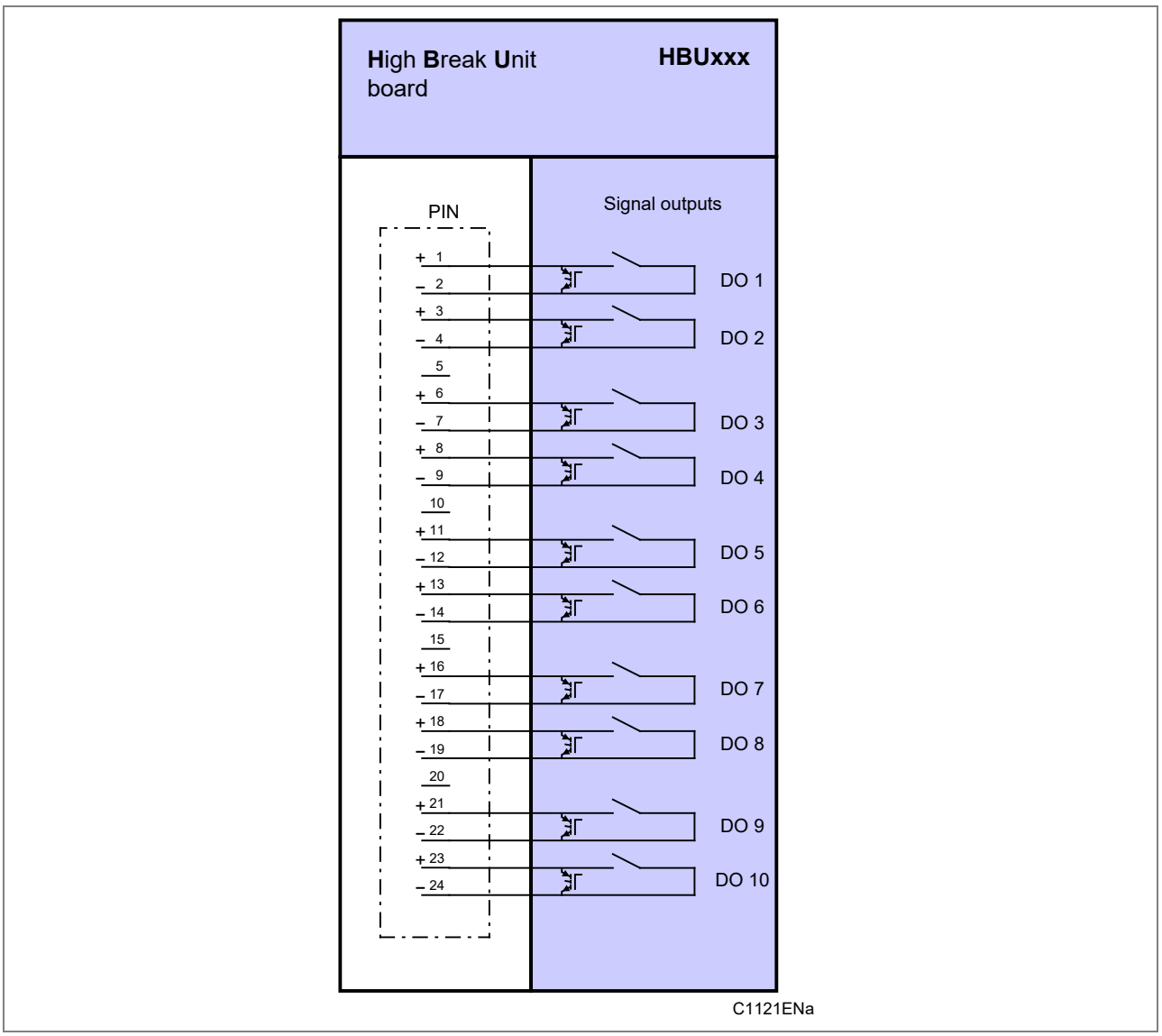


Figure 18: HBU200 board – Block diagram

4.8.2 CONNECTOR DESCRIPTION

The HBU200 board is equipped with a 24pin 5.08 mm pitch connector.

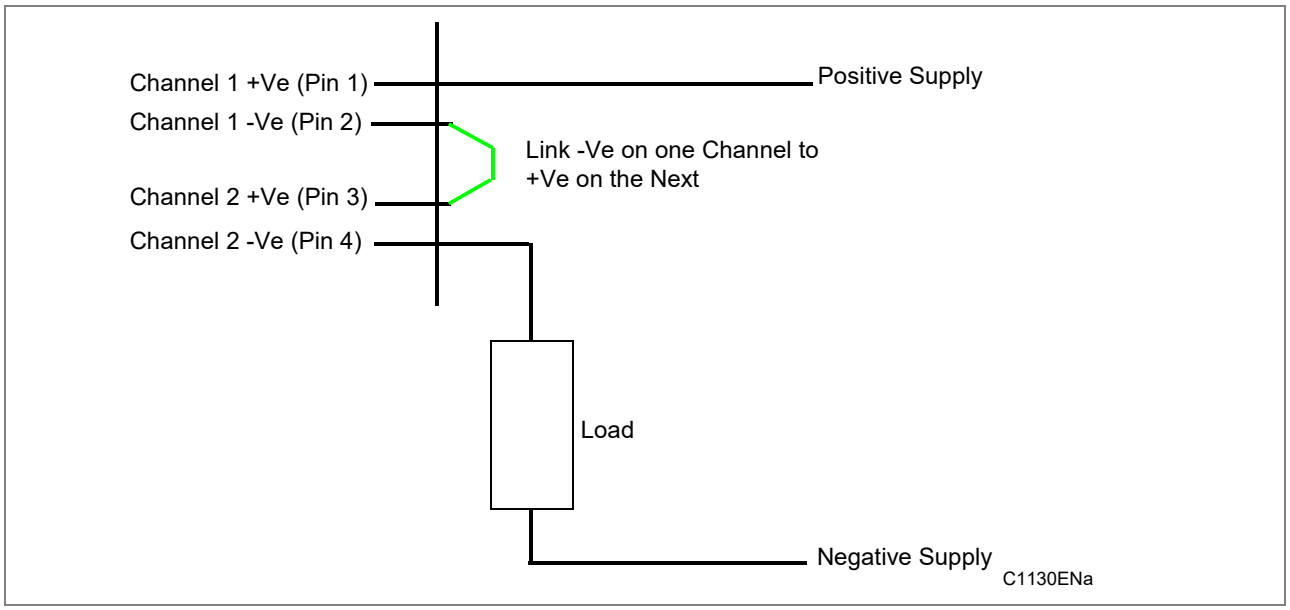
Pin N°.	Signal
1	Digital output 1 +Ve
2	Digital output 1 -Ve
3	Digital output 2 +Ve
4	Digital output 2 -Ve
5	NC
6	Digital output 3 +Ve
7	Digital output 3 -Ve
8	Digital output 4 +Ve
9	Digital output 4 -Ve
10	NC
11	Digital output 5 +Ve
12	Digital output 5 -Ve
13	Digital output 6 +Ve
14	Digital output 6 -Ve
15	NC
16	Digital output 7 +Ve
17	Digital output 7 -Ve
18	Digital output 8 +Ve
19	Digital output 8 -Ve
20	NC
21	Digital output 9 +Ve
22	Digital output 9 -Ve
23	Digital output 10 +Ve
24	Digital output 10 -Ve

Table 6: HBU200 board – Connector description

The pin-out groups the channels into pairs that give a logical grouping for dual cutting operation or for AC operation.

DC Dual-Cutting Operation

Dual Cutting is possible by connecting two channels in series as illustrated below. Note that in this illustration the selected channels are channel 1 & 2, but any pair of channels can be used.

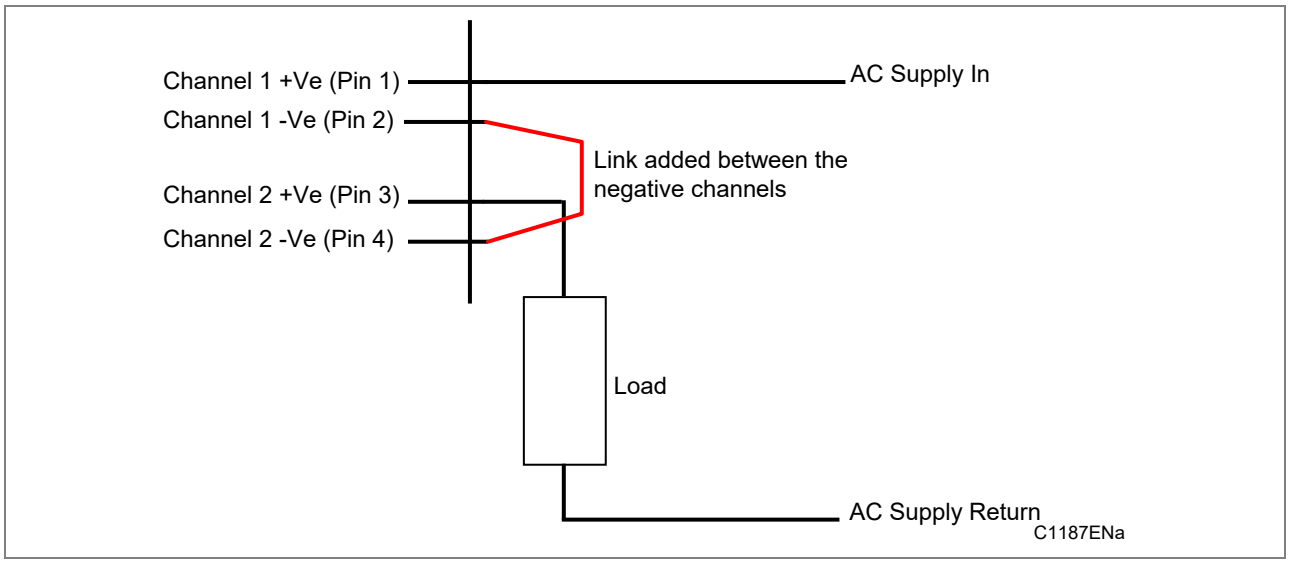


Reversed DC Operation

If the system is operating on DC and a channel is connected incorrectly (+Ve to –Ve -Ve to +Ve) the contact will behave as though it is permanently switched on (activated). It will not be possible to switch the output off.

AC Operation

To use the HBU200 to switch AC loads, two channels are required. These are connected in series with the negative of one channel connected to the negative of the other. The supply is connected to one positive input and the load to the other as illustrated below. This example uses channels 1 and 2 but any two channels can be used.



4.9 ANALOGUE INPUT MODULE – AIU201

The Analogue input module (AIU201) provides 4 independent analogue inputs.

4.9.1 BLOCK DIAGRAM

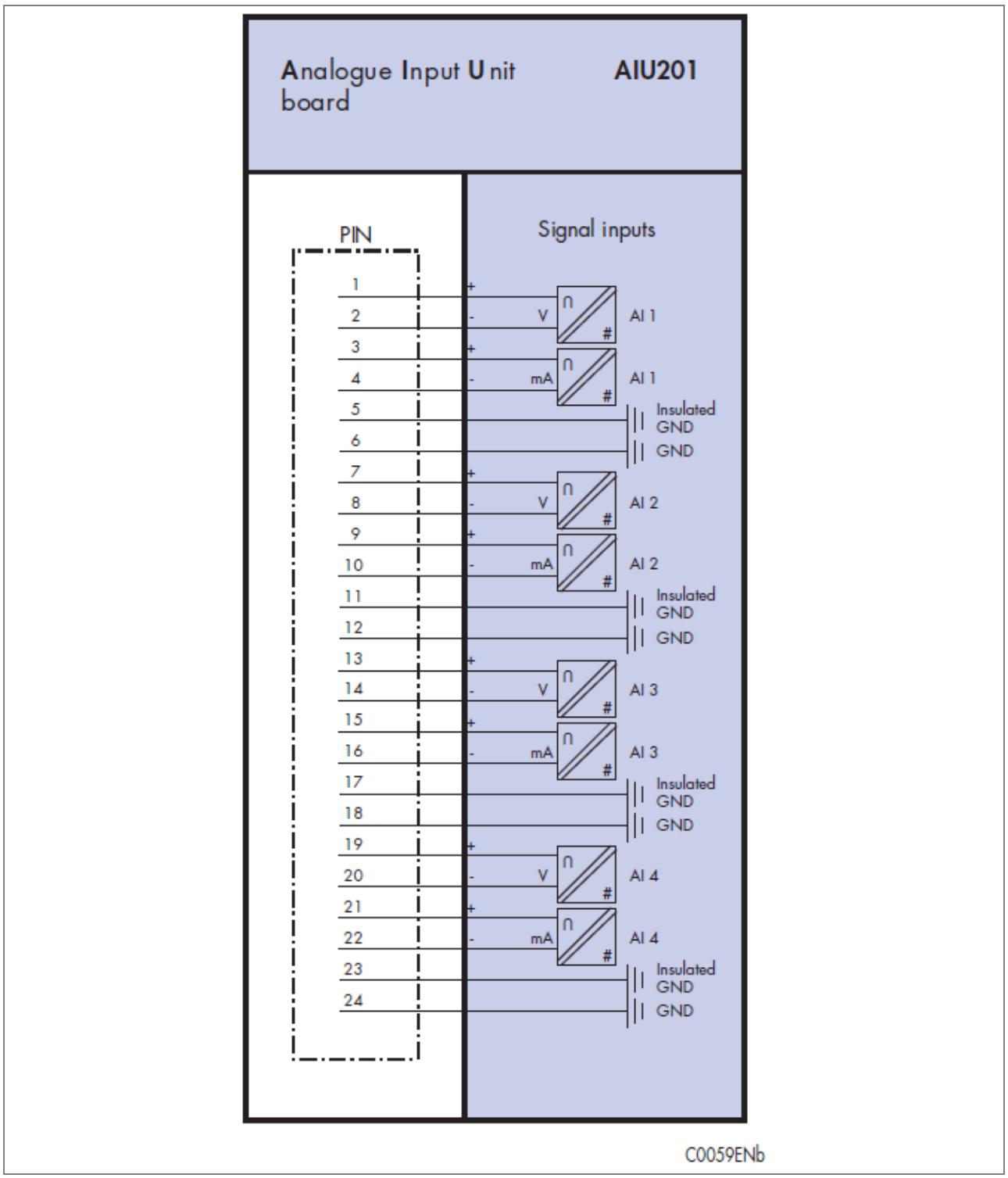


Figure 19: AIU201 board – Block diagram

4.9.2 CONNECTOR DESCRIPTION

The AIU201 board is equipped with a 24-way 5.08 mm pitch connector.

Pin N°.	Signal
1	Analogue Input 1+ (voltage)
2	Analogue Input 1- (voltage)
3	Analogue Input 1+ (current)
4	Analogue Input 1- (current)
5	Insulated Ground 1
6	Ground for cable shield
7	Analogue Input 2+ (voltage)
8	Analogue Input 2- (voltage)
9	Analogue Input 2+ (current)
10	Analogue Input 2- (current)
11	Insulated Ground 2
12	Ground for cable shield
13	Analogue Input 3+ (voltage)
14	Analogue Input 3- (voltage)
15	Analogue Input 3+ (current)
16	Analogue Input 3- (current)
17	Insulated Ground 3
18	Ground for cable shield
19	Analogue Input 4+ (voltage)
20	Analogue Input 4- (voltage)
21	Analogue Input 4+ (current)
22	Analogue Input 4- (current)
23	Insulated Ground 4
24	Ground for cable shield

Table 7: AIU201 board – Connector description

4.9.3 CONNECTION OF SENSORS TO THE AIU201 ANALOGUE INPUT TERMINALS

Cable shield earthing

Wiring from the sensors may be enclosed in shielded cables and those shields may necessitate earthing. To this effect, the BIU201 board offers 4 dedicated terminals to connect these cables to the case earth of the unit: pins 6, 12, 18 and 24. These terminals are internally linked to the case earth and are independent of the analogue inputs. Therefore, cable shields can be connected to any of those terminals, irrespective of which inputs the sensors are wired to.

If cable shield earthing is used, make sure to earth only one end of each shield, especially for long cables, as the ground loop created by the difference of potential between distant ends could generate noise that may render the measurements from the sensors inaccurate.

Analogue inputs

Wiring of the sensors to the analogue inputs must be done according to instructions given by the sensors' user manuals. In addition, because each analogue input channel has an impedance of 75 ohms, ensure that you only use sensors with outputs rated for 75 ohms.

4.10 ANALOGUE INPUT MODULE – AIU211

The Analogue input board AIU211 provides 8 isolated Analogue inputs.

4.10.1 BLOCK DIAGRAM

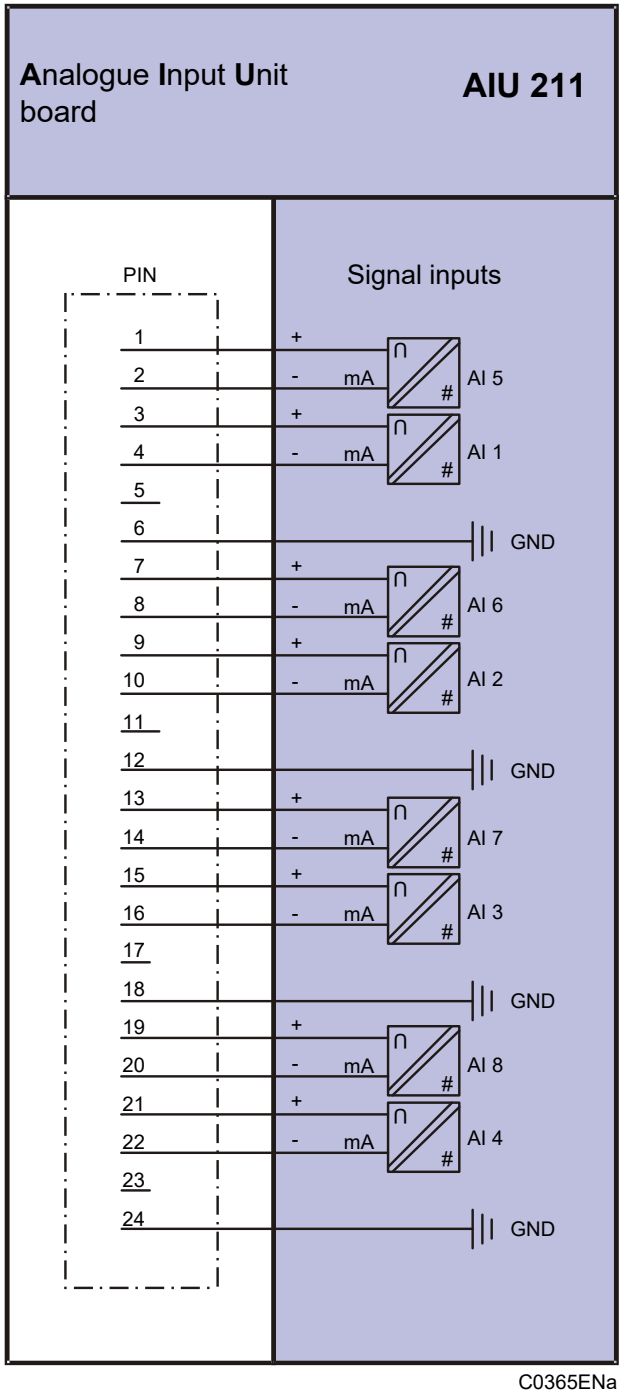


Figure 20: AIU211 board – Block diagram

4.10.2 CONNECTOR DESCRIPTION

The AIU211 board is equipped with a 24-way 5.08 mm pitch connector.

Pin N°.	Signal
1	Analogue Input 5+ (current)
2	Analogue Input 5- (current)
3	Analogue Input 1+(current)
4	Analogue Input 1-(current)
5	Not Connected
6	Ground for cable shield
7	Analogue Input 6+ (current)
8	Analogue Input 6- (current)
9	Analogue Input 2+ (current)
10	Analogue Input 2- (current)
11	Not Connected
12	Ground for cable shield
13	Analogue Input 7+ (current)
14	Analogue Input 7- (current)
15	Analogue Input 3+ (current)
16	Analogue Input 3- (current)
17	Not Connected
18	Ground for cable shield
19	Analogue Input 8+ (current)
20	Analogue Input 8- (current)
21	Analogue Input 4+ (current)
22	Analogue Input 4- (current)
23	Not Connected
24	Ground for cable shield

Table 8: AIU211 board – Connector description

4.10.3 CONNECTION OF SENSORS TO THE AIU211 ANALOGUE INPUT TERMINALS

Cable shield earthing

Wiring from the sensors may be enclosed in shielded cables and those shields may necessitate earthing. To this effect, the BIU211 board offers 4 dedicated terminals to connect these cables to the case earth of the unit: pins 6, 12, 18 and 24. These terminals are internally linked to the case earth and are independent of the analogue inputs. Therefore, cable shields can be connected to any of those terminals, irrespective of which inputs the sensors are wired to.

If cable shield earthing is used, make sure to earth only one end of each shield, especially for long cables, as the ground loop created by the difference of potential between distant ends could generate noise that may render the measurements from the sensors inaccurate.

Analogue inputs

Wiring of the sensors to the analogue inputs must be done according to instructions given by the sensors' user manuals. In addition, because each analogue input channel has an impedance of 75 ohms, ensure that you only use sensors with outputs rated for 75 ohms.

4.11 TRANSDUCERLESS MEASUREMENTS UNIT MODULE – TMU220

The Transducerless Measurements Unit module (TMU220) provides 5 transducerless voltage inputs (VT) and 4 transducerless current inputs (CT).

4.11.1 BLOCK DIAGRAM

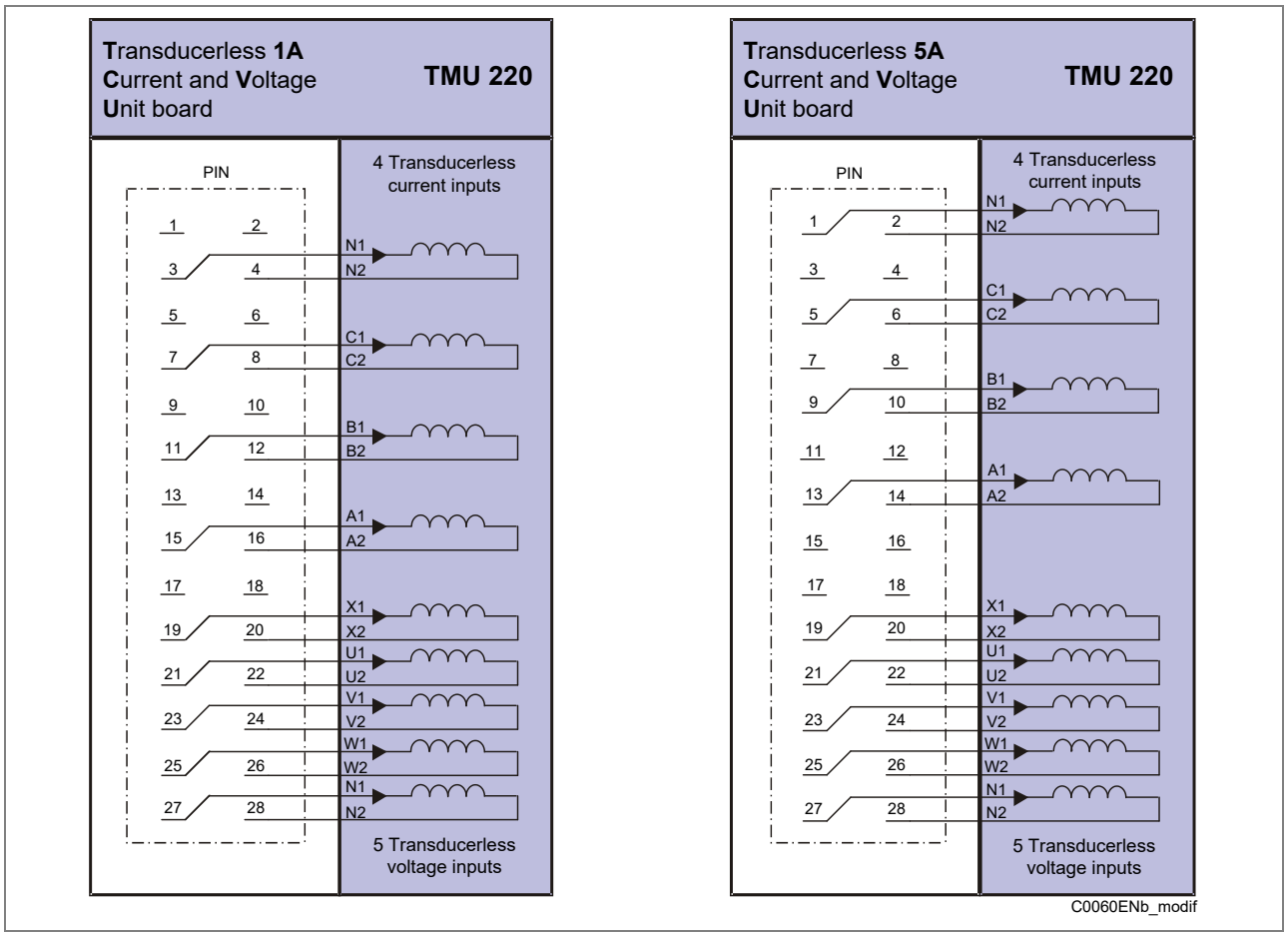


Figure 21: TMU220 board – Block diagram

4.11.2 CONNECTOR DESCRIPTION

The TMU220 board is fitted with a standard MIDOS 28 connector (see *Figure 2: Standard MIDOS 28 connector*).

Pin N°.	Signal	Electrical Signal	STAR topology "Measure type" label in DS Agile SCE Wiring panel	DELTA topology "Measure type" label in DS Agile SCE Wiring panel	Waveform channel
1	Current Input 5A - N1	IN 5A -	Ibusbar RMS 1 value of the current phase	Ibusbar RMS 1 value of the current phase	CI#4
2	Current Input 5A – N2	IN 5A +			
3	Current Input 1A – N1	IN 1A -			
4	Current Input 1A – N2	IN 1A +			
5	Current Input 5A – C1	IC 5A -	IC, RMS value of the current phase C	IC, RMS value of the current phase C	CI#3
6	Current Input 5A – C2	IC 5A +			
7	Current Input 1A – C1	IC 1A -			
8	Current Input 1A – C2	IC 1A +			
9	Current Input 5A – B1	IB 5A -	IB, RMS value of the current phase B	IB, RMS value of the current phase B	CI#2
10	Current Input 5A – B2	IB 5A +			
11	Current Input 1A – B1	IB 1A -			
12	Current Input 1A – B2	IB 1A +			
13	Current Input 5A – A1	IA 5A -	IA, RMS value of the current phase A	IA, RMS value of the current phase A	CI#1
14	Current Input 5A – A2	IA 5A +			
15	Current Input 1A – A1	IA 1A -			
16	Current Input 1A – A2	IA 1A +			
17	NC	NC	NA	NA	NA
18	NC	NC	NA	NA	NA
19	Voltage Input – X1	V busbar2 -	Vbusbar, RMS 2 value of the busbar voltage	Vbusbar, RMS 2 value of the busbar voltage	VI#5
20	Voltage Input – X2	V busbar2 +			
21	Voltage Input – U1	VAN - / VAB -	VAN, RMS value of the voltage phase A	VAB, RMS value of the voltage phase AB	VI#1
22	Voltage Input – U2	VAN + / VAB +			
23	Voltage Input – V1	VBN - / VBC -	VBN, RMS value of the voltage phase A	VBC, RMS value of the voltage phase BC	VI#2
24	Voltage Input – V2	VBN + / VBC +			
25	Voltage Input – W1	VCN - / VCA -	VCN, RMS value of the voltage phase C	VCA, RMS value of the voltage phase CA	VI#3
26	Voltage Input – W2	VCN+ / VCA+			
27	Voltage Input – N1	V busbar1 - / VN -	Vbusbar, RMS 1 value of the busbar voltage	Vbusbar, RMS 1 value of the busbar voltage	VI#4
28	Voltage Input – N2	V busbar1 + / VN +			

Table 9: TMU220 board – Connector description

Note:
Odd-numbered terminals should be connected to the neutral current or voltage. However, because the board acquires AC signals, inverting that connection (even-numbered terminals to neutral) is permitted, provided that the connections of ALL the terminals are inverted.

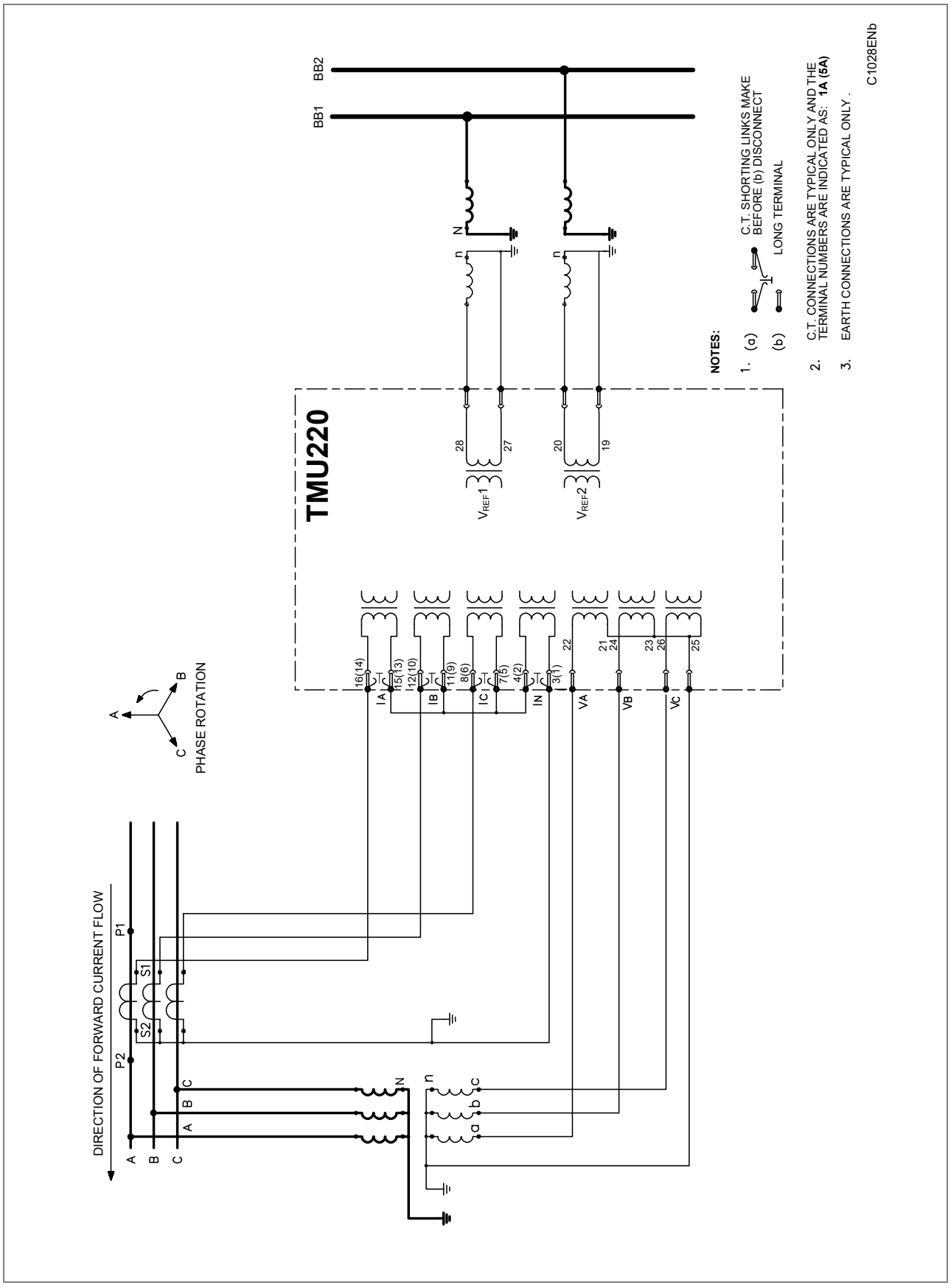


Figure 22: TMU220 board – External connection diagram with 2 x V_{REF}

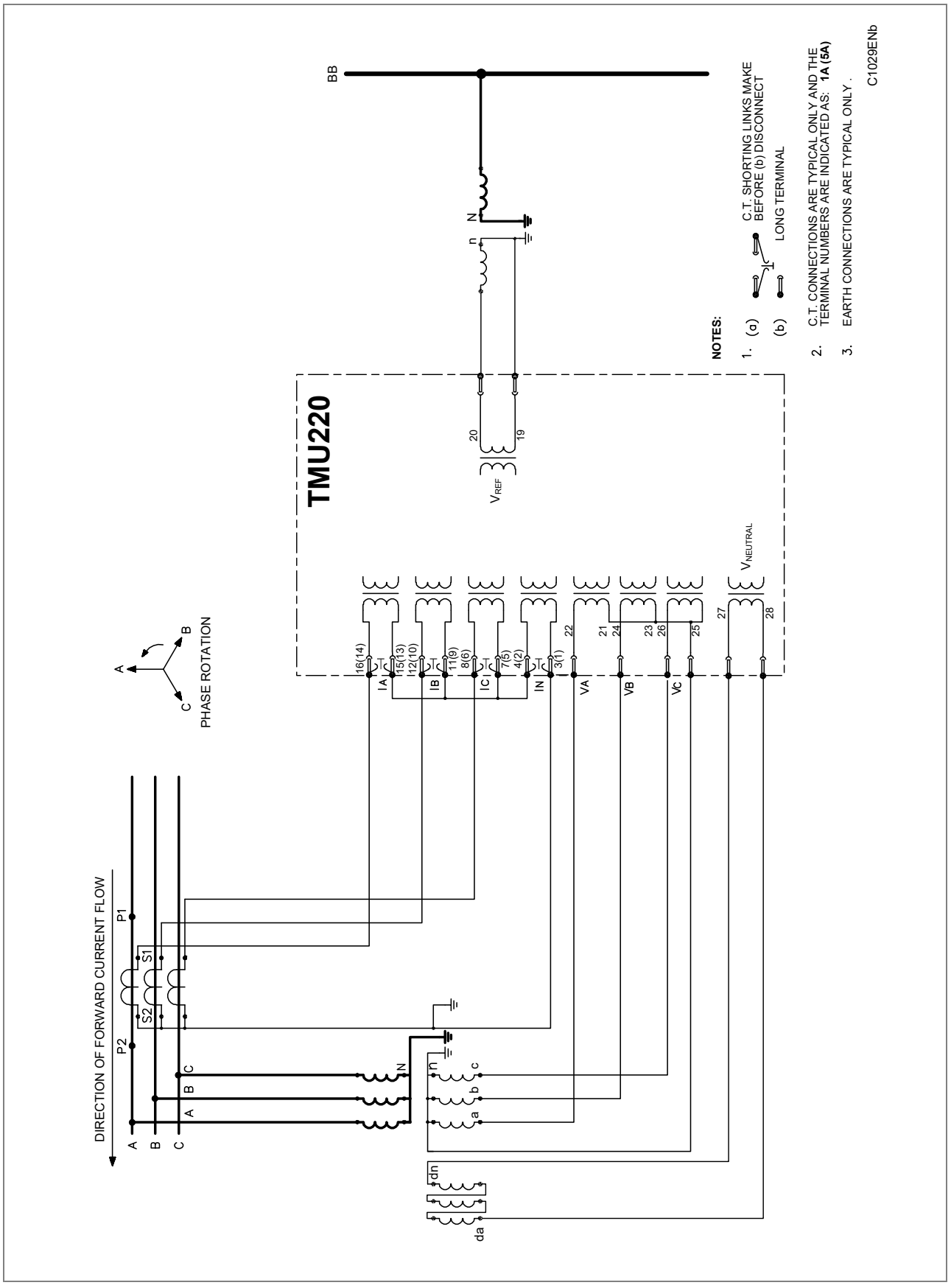


Figure 23: TMU220 board – External connection diagram with V_{REF} +V_N

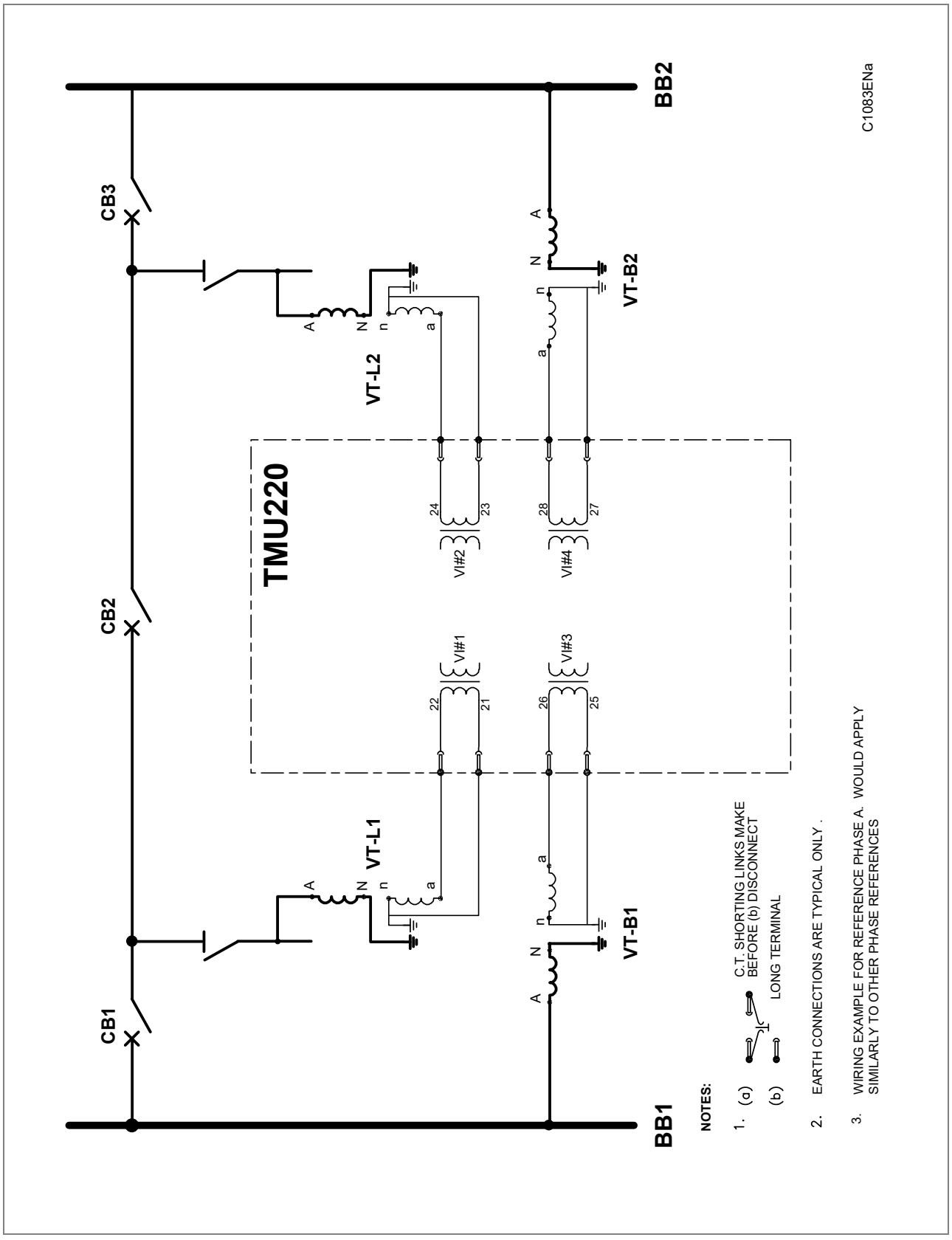


Figure 24: TMU220 board – External connection diagram for breaker-and-a-half topology

4.12 TRANSDUCERLESS MEASUREMENTS UNIT MODULE – TMU210

The Transducerless Measurements Unit module TMU210 provides 4 transducerless voltage inputs (VT) and 4 transducerless current inputs (CT).

4.12.1 BLOCK DIAGRAM

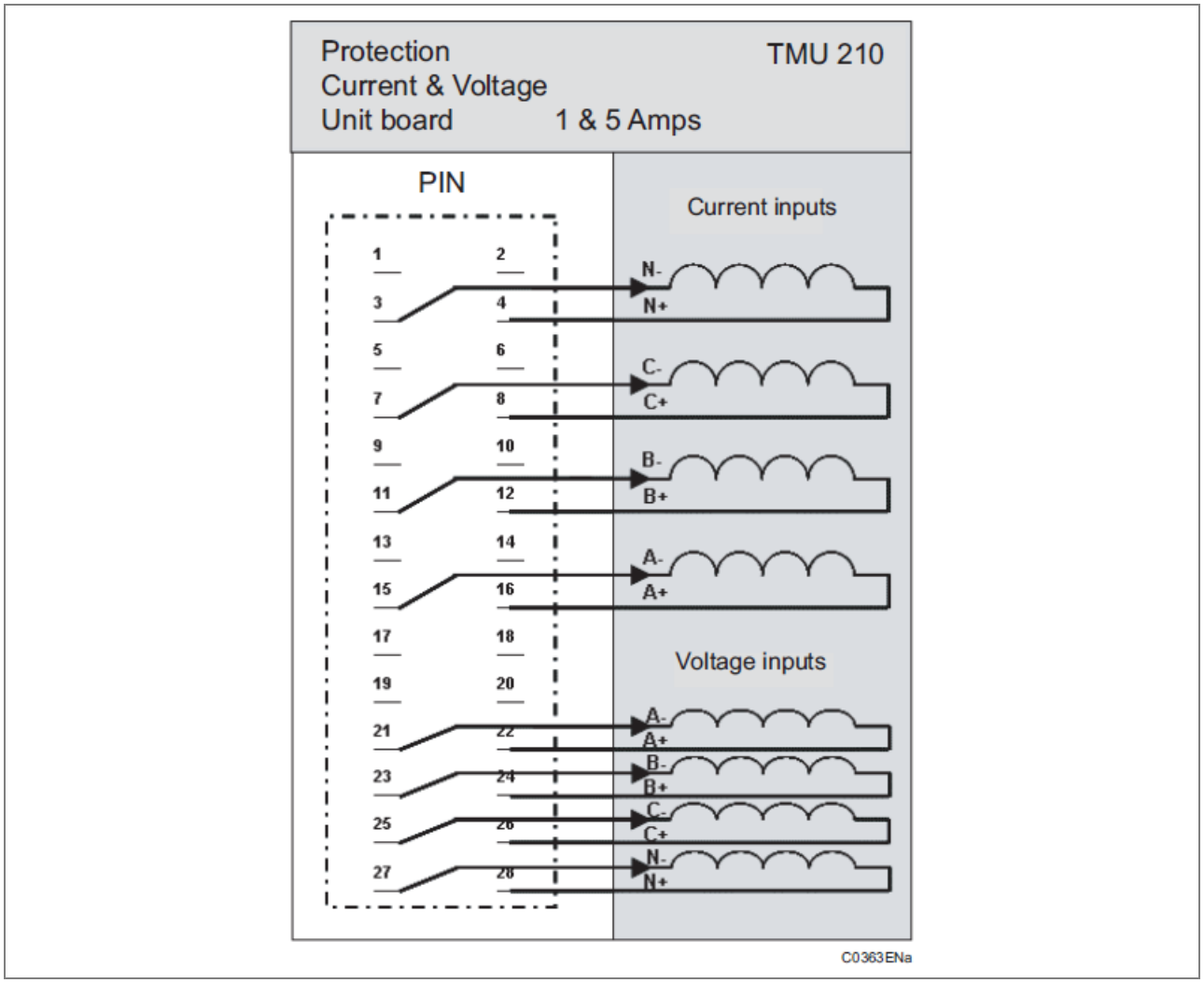


Figure 25: TMU210 board – Block diagram

4.12.2 CONNECTOR DESCRIPTION

The TMU210 board is equipped with a standard MiDOS 28 connector.

The current input (1 or 5A) is selected directly on the TMU210 board, by changing the jumper position (one jumper per CT channel as highlighted in the table below).

Pin N°.	Signal
1	Not connected
2	Not connected
3	Current Input 1 Amps or 5 Amps – N-
4	Current Input 1 Amps or 5 Amps – N+
5	Not connected
6	Not connected
7	Current Input 1 Amps or 5 Amps – C-
8	Current Input 1 Amps or 5 Amps – C+
9	Not connected
10	Not connected
11	Current Input 1 Amps or 5 Amps – B-
12	Current Input 1 Amps or 5 Amps – B+
13	Not connected
14	Not connected
15	Current Input 1 Amps or 5 Amps – A-
16	Current Input 1 Amps or 5 Amps – A+
17	Not connected
18	Not connected
19	Not connected
20	Not connected
21	Voltage Input – U1
22	Voltage Input – U2
23	Voltage Input – V1
24	Voltage Input – V2
25	Voltage Input – W1
26	Voltage Input – W2
27	Voltage Input – N1
28	Voltage Input – N2

Table 10: TMU210 board - Connector description

Note:
Odd-numbered terminals should be connected to the neutral current or voltage. However, because the board acquires AC signals, inverting that connection (even-numbered terminals to neutral) is permitted, provided that the connections of ALL the terminals are inverted.

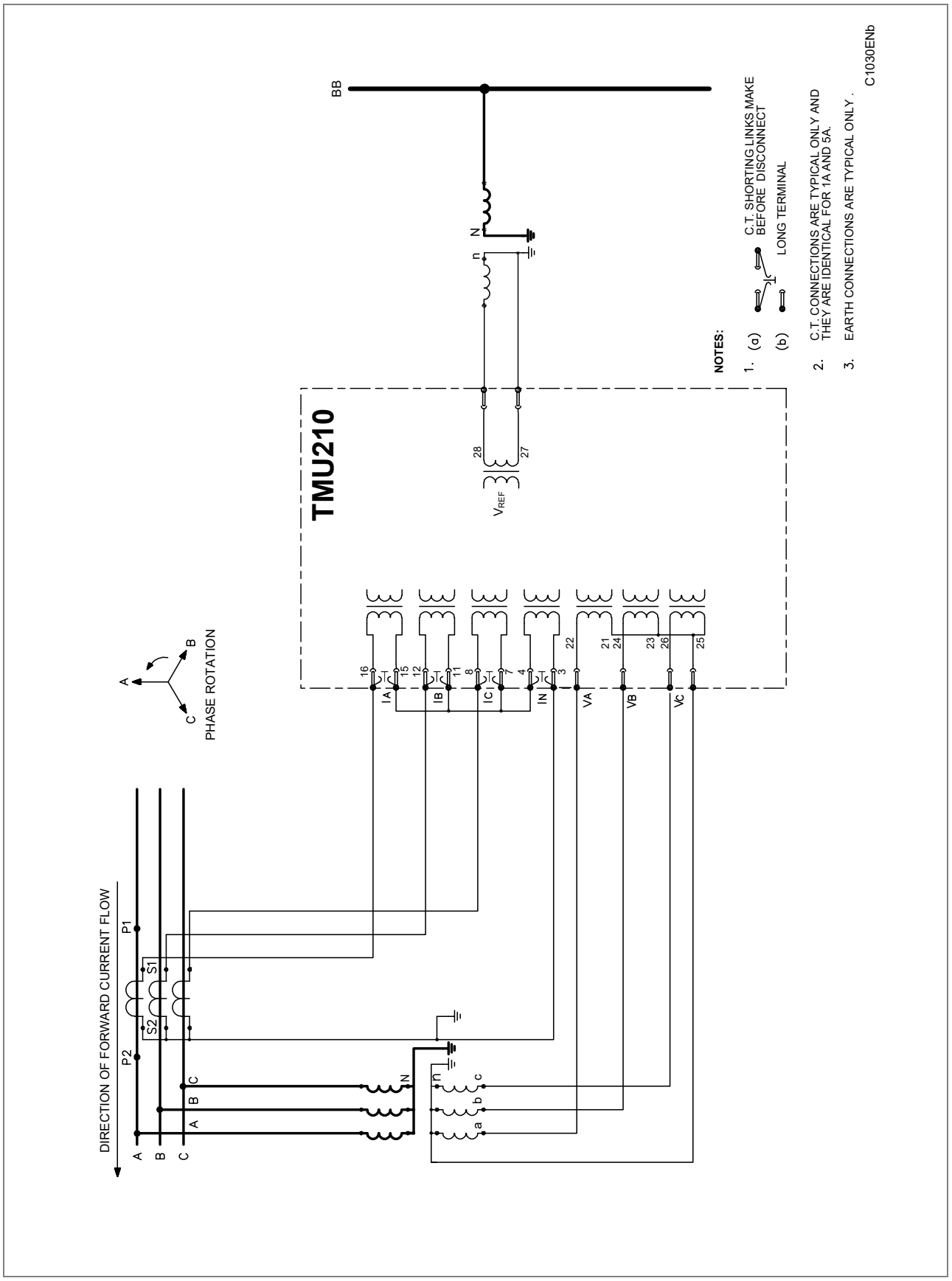


Figure 26: TMU210 board – External connection diagram with V_{REF}

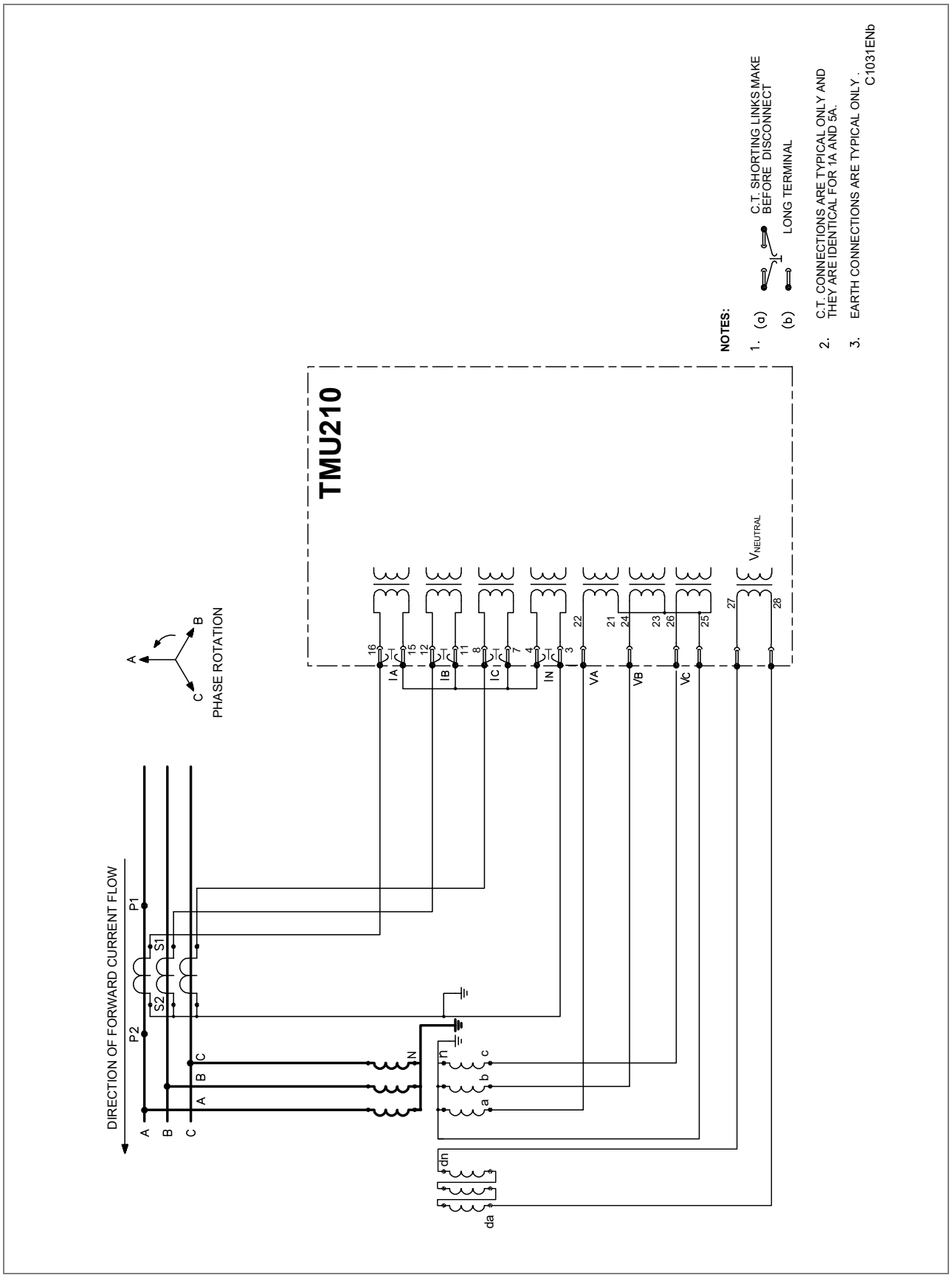


Figure 27: TMU210 board – External connection diagram with V_N

4.13 ANALOGUE OUTPUT MODULE – AOU200

The AOU200 board provides 4 current analogue outputs. Each output is associated to a Read Inhibit relay. The outputs are powered using an external power supply. The external power supply has to provide a regulated voltage of +48V (+/- 5%).

This power supply will supply a minimum of 7W per AOU200 board.

Ex: if four AOU200 boards are installed in the C26x, it must supply at least 28 W.

4.13.1 BLOCK DIAGRAM

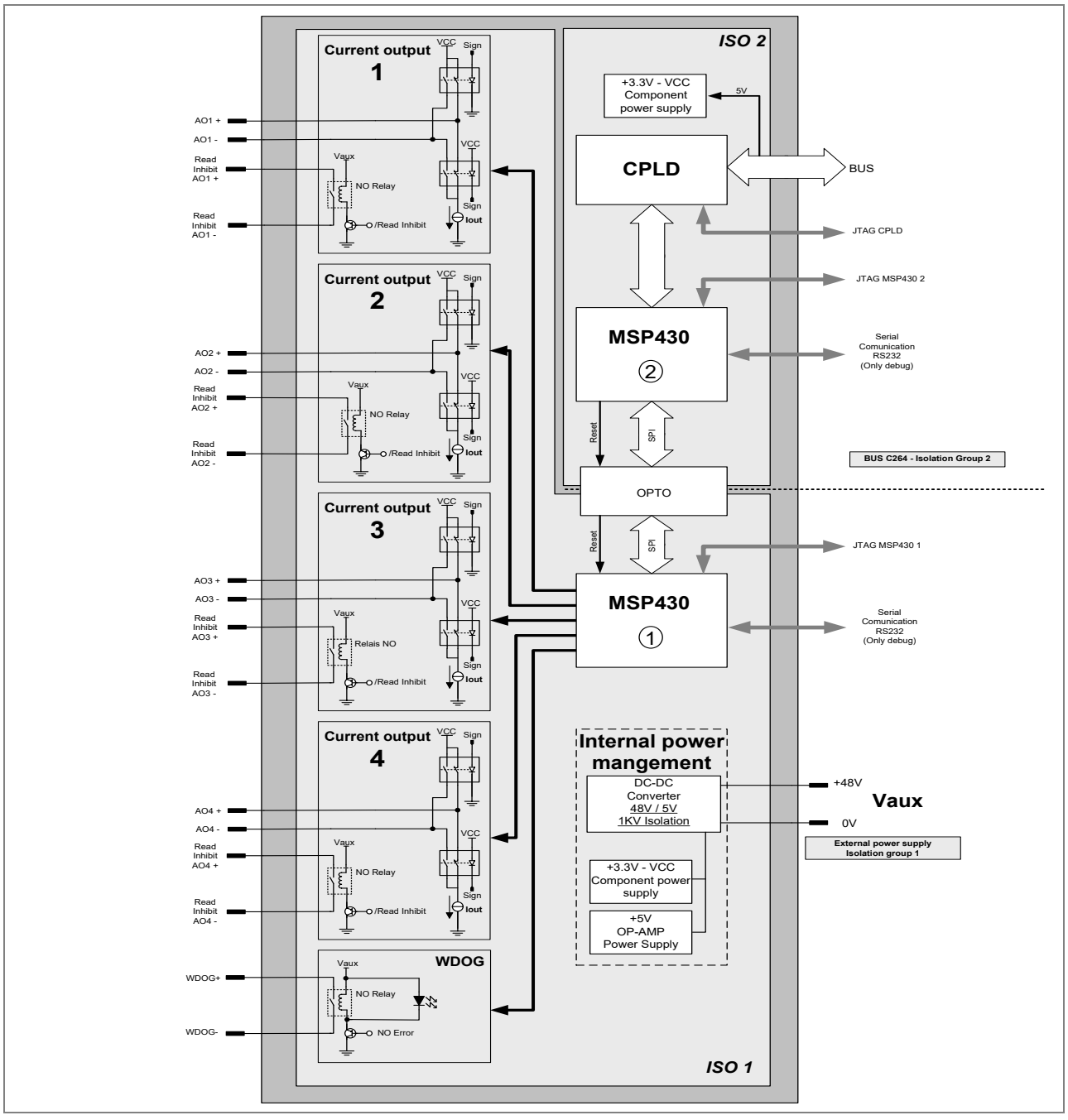


Figure 28: AOU200 board – Block diagram

4.13.2 CONNECTOR DESCRIPTION

N°	Description
1	External power supply +48V
2	NIL
3	External power supply (0V)
4	NIL
5	WDOG+
6	WDOG-
7	NIL
8	READ INHIBIT AO n° 1+
9	READ INHIBIT AO n° 1-
10	READ INHIBIT AO n° 2+
11	READ INHIBIT AO n° 2-
12	READ INHIBIT AO n° 3+
13	READ INHIBIT AO n° 3-
14	READ INHIBIT AO n° 4+
15	READ INHIBIT AO n° 4-
16	NIL
17	AO n° 1+
18	AO n° 1-
19	AO n° 2+
20	AO n° 2-
21	AO n° 3+
22	AO n° 3-
23	AO n° 4+
24	AO n° 4-

Table 11: AOU200 board – Connector description

4.14 PRP ETHERNET SWITCH UNIT – SRP282/SRP284

These boards are Ethernet switches with 3 electrical links and 2 optical links for a redundancy star. An internal High Speed Bus board between SRP28x and CPU4 has to be connected for SRP2xx use.

The picture below shows connections to an SRP28x board fitted in a DS Agile C26x unit.

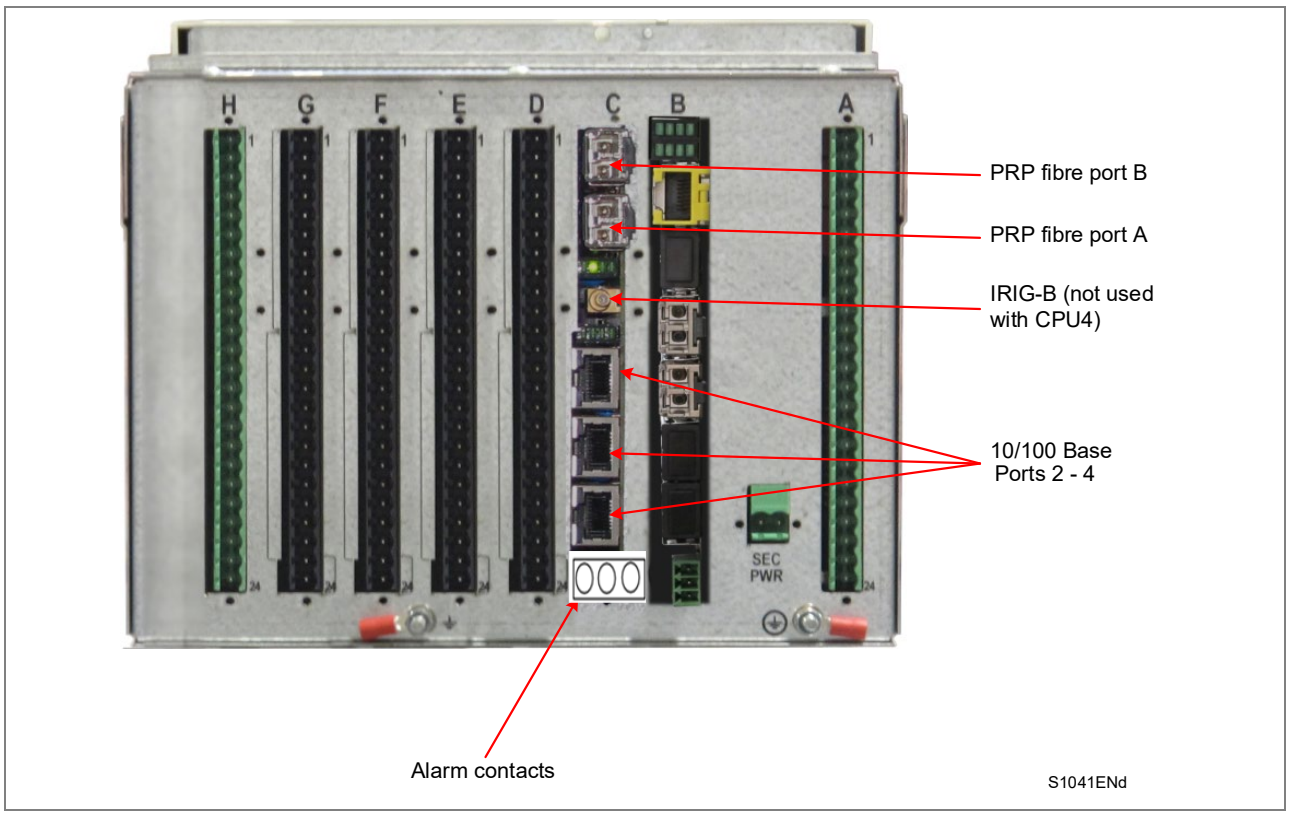


Figure 29: Example SRP28x User connections

4.14.1 BLOCK DIAGRAM

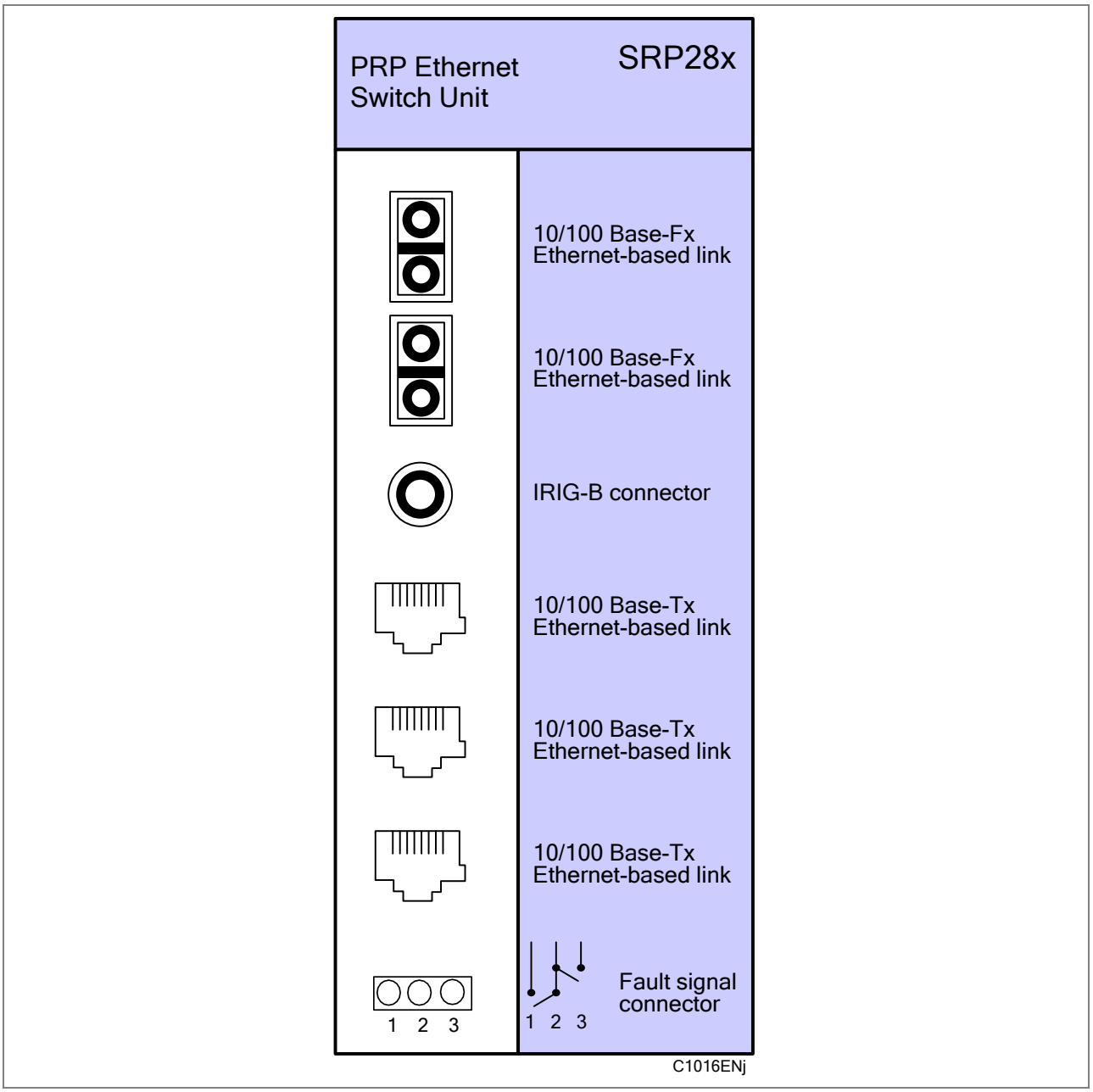


Figure 30: SRP28x Board – Block diagram

4.14.2 PARALLEL REDUNDANCY PROTOCOL (PRP) CONNECTION

The SRP28x PRP ports use type **LC** connectors as shown in the figure below.



Figure 31: Ethernet optical FIBRE – LC Connections

4.14.3 COPPER ETHERNET CONNECTIONS

The user-accessible copper Ethernet communication ports use 4 twisted pair cable.

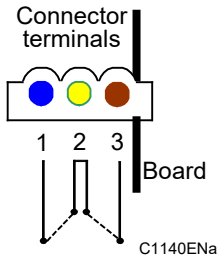
If connected devices are located a long distance away from the switch (>100 m), or if the cables run through a harsh electrical environment, then copper to fibre converters should be used in conjunction with optical fibres.

Ethernet cable type

Category 5 (FTP: Foil Twisted Pair) or insulated (STP – Shielded Twisted Pair) with RJ45 connectors should be used.

4.14.4 FAULT SIGNAL CONNECTOR DESCRIPTION

The status of the two PRP links is indicated on contacts at the rear of the board according to the diagram and table below: The alarm contacts share a common terminal.



Terminal number	Assignment	Meaning
1	PRP link B status	Open = Link healthy Close = Link failure (contact 1 and 2 are closed)
2	Common	
3	PRP link A status	Open = Link healthy Close = Link failure (contact 2 and 3 are closed)

A closed contact indicates an alarm or a fault.

The characteristics of the alarm contacts are presented below.

- Connections — 2 normally closed (NC) contacts - potential free
- Max. switching voltage — 70 V_{DC}/33 V_{AC}
- Max. switching current — 5 A
- Max. switching power — 150 W / 165 VA

Wiring recommendations

For safety reasons and for compliance with the European Commission Low Voltage Directive (2014/35/EU), the authorised voltage rating to be applied on the "Fault signal connector" is limited to 70 V_{DC} or 33 V_{AC} and does not exceed 5 A.

Due to the proximity of the port N°4 Ethernet connector, it is strongly recommended that the “Fault signal connector” connections are visually checked before any handling of the Ethernet connectors.

Particular attention is to be paid not to damage the cable’s isolation during the wiring phase.

The figure below shows the allocation of the SRP28x alarm contacts.

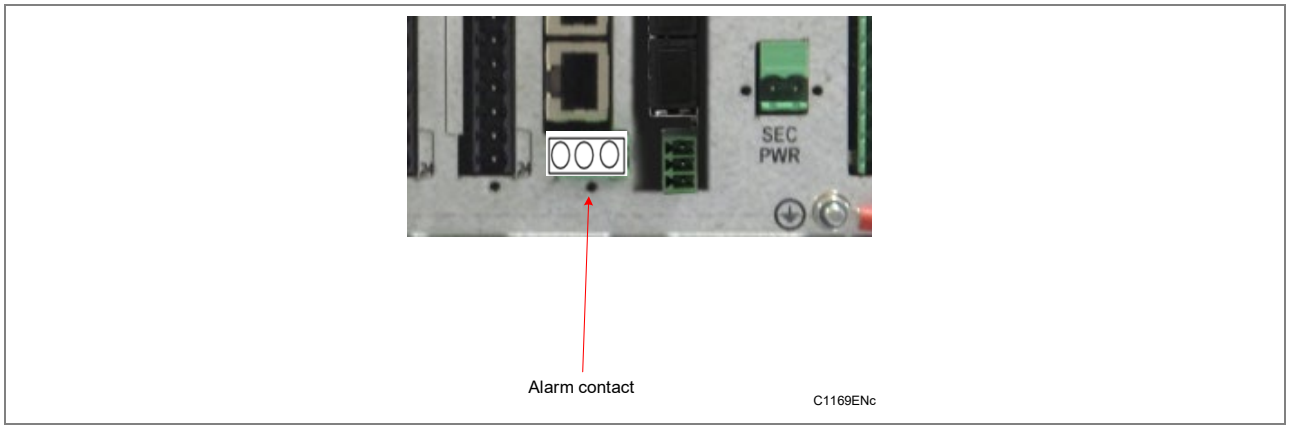


Figure 32: SRP28x PRP Alarm Contact connections

1 The characteristics of the alarm connectors are presented below:



Figure 33: Alarm Contact connections version 1

- Connections — 2 normally closed (NC) contacts - potential free
- Max. switching voltage: — 70 VDC/33 VAC
- Max. switching current — 5 A

Wiring recommendations

For safety reasons and for compliance with the European Commission Low Voltage Directive (2014/35/EU), the authorised voltage rating to be applied on the "Fault signal connector" is limited to 150 V_{DC} or 150 V_{AC} and does not exceed 5 A.

Due to the proximity of the port N°4 Ethernet connector, it is strongly recommended that the “Fault signal connector” connections are visually checked before any handling of the Ethernet connectors.

Particular attention is to be paid not to damage the cable’s isolation during the wiring phase.

1 The characteristics of the alarm connectors are presented below:



Figure 34: Alarm Contact connections version 2

- Connections — 2 normally closed (NC) contacts - potential free
- Max. switching voltage: — 150 V_{DC}/150 V_{AC}
- Max. switching current — 5 A

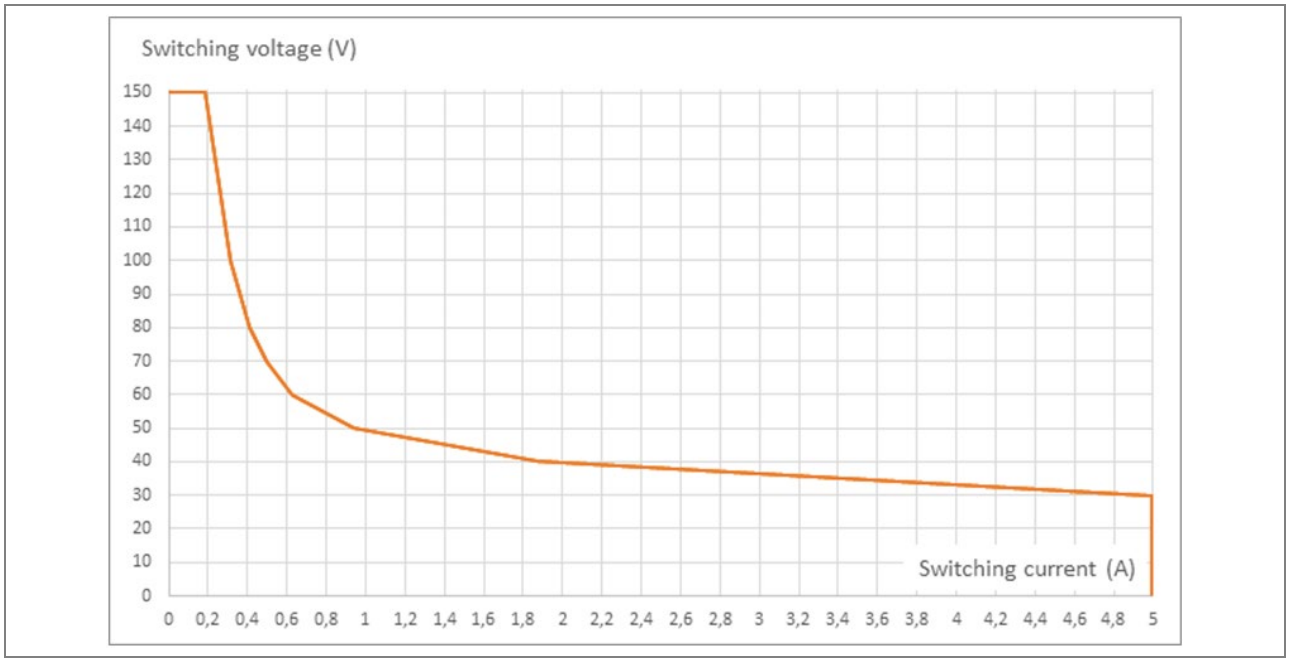


Figure 35: Switching voltage diagram

Wiring recommendations

For safety reasons and for compliance with the European Commission Low Voltage Directive (2014/35/EU), the authorised voltage rating to be applied on the "Fault signal connector" is limited to 150 V_{DC} or 150 V_{AC} and does not exceed 5 A.

Due to the proximity of the port N°4 Ethernet connector, it is strongly recommended that the “Fault signal connector” connections are visually checked before any handling of the Ethernet connectors.

Particular attention is to be paid not to damage the cable’s isolation during the wiring phase.

4.14.5 IRIG-B CONNECTOR DESCRIPTION

The SRP board receives the IEEE 1588 V2 (PTP) time-synchronisation signal via the PRP Ethernet network. The IRIG-B connector on the SRP2xx board is an SMB output connector used to distribute time synchronization to the CPU board.

IRIG-B cable characteristics:

- Length: 20 cm
- SRP end: Male SMB connector

Note:
In system version 7.0.1, this connector cannot be used to synchronise the unit.

4.15 HSR ETHERNET SWITCH UNIT – SRP292/SRP294

These boards are Ethernet switches with 3 electrical links and 2 optical links for a redundant ring.

The picture below shows connections to an SRP29x board fitted in a DS Agile C26x unit.

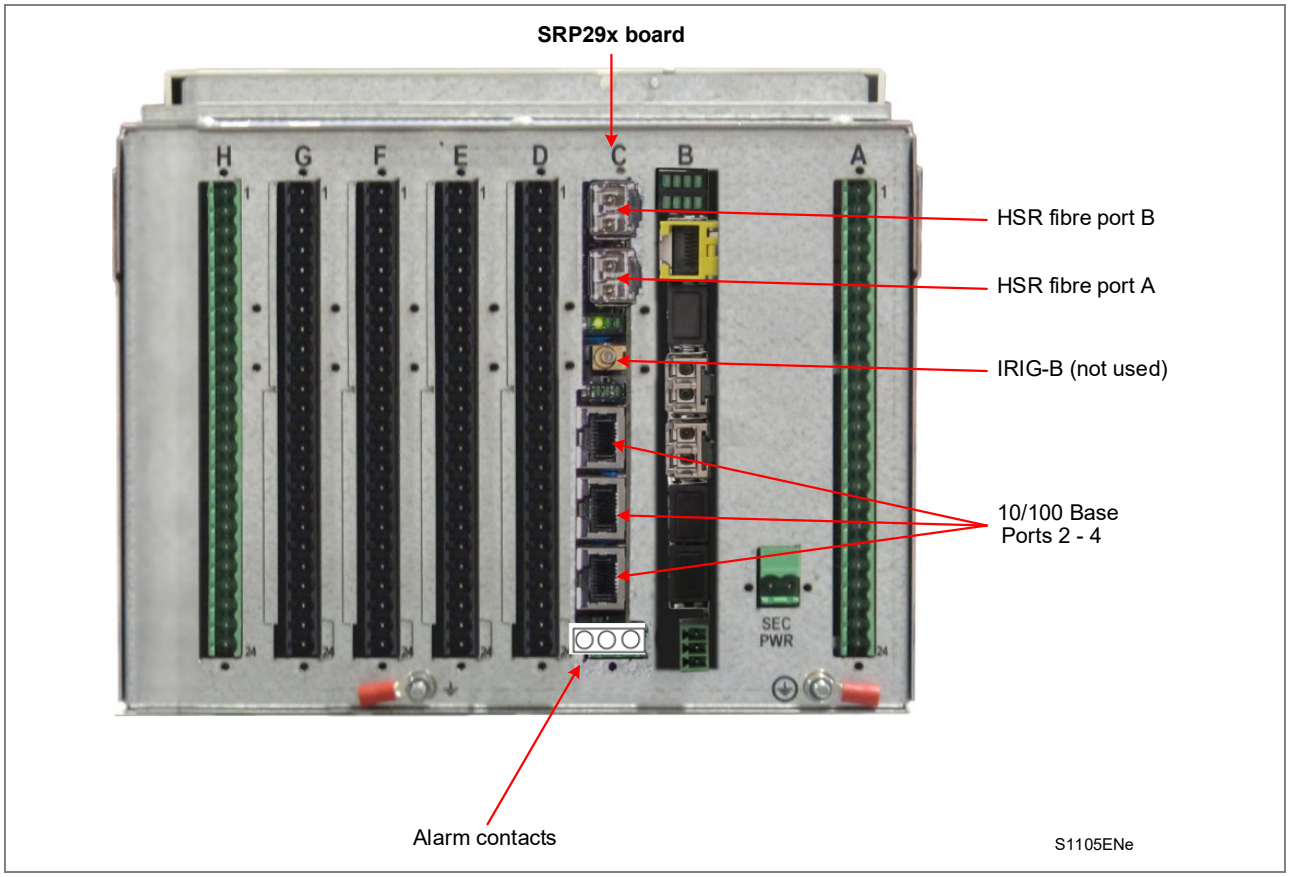


Figure 36: Example SRP29x User connections

4.15.1 BLOCK DIAGRAM

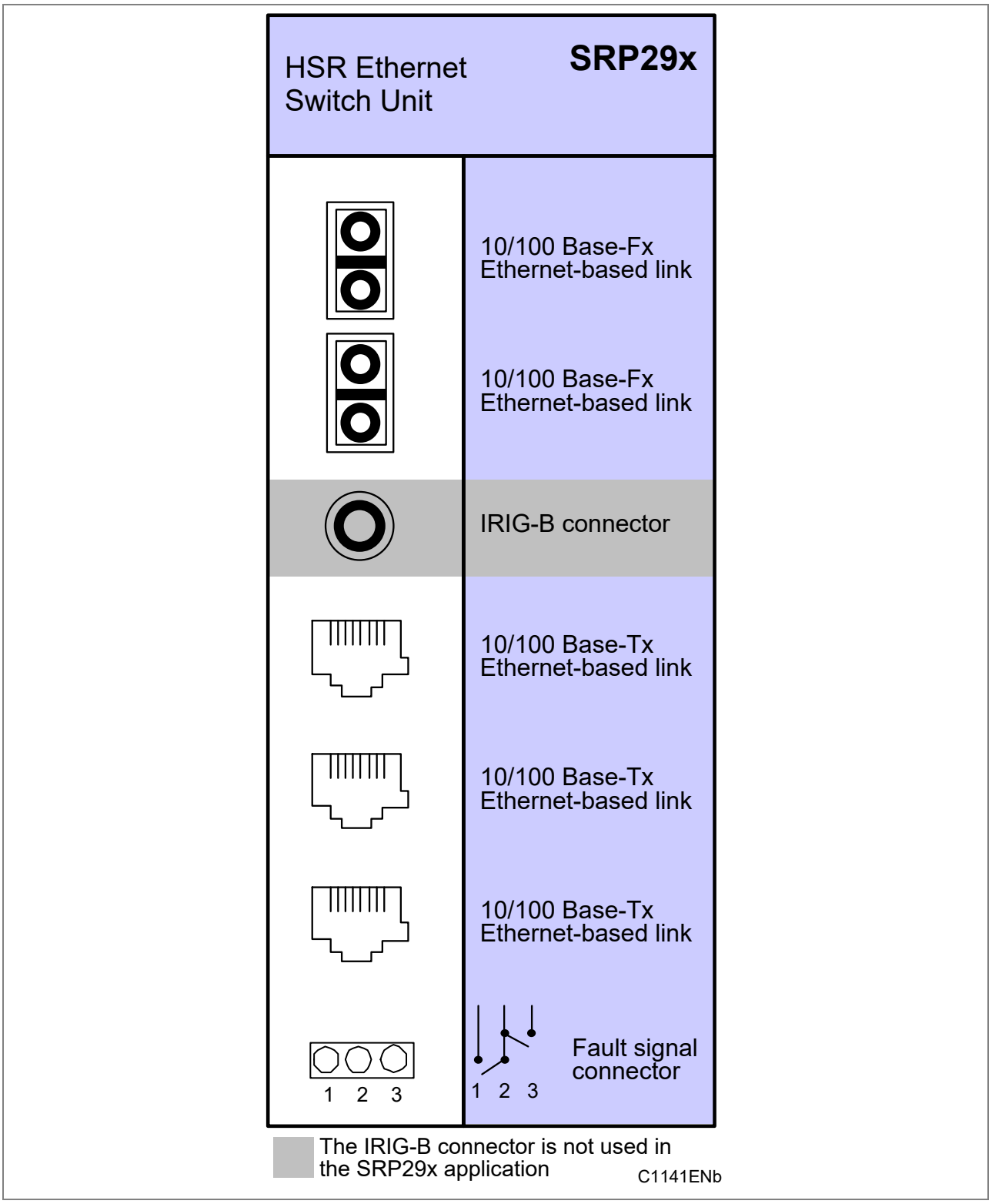


Figure 37: SRP29x Board – Block diagram

4.15.2 HIGH-AVAILABILITY SEAMLESS REDUNDANCY PROTOCOL (HSR) FIBRE-OPTIC CONNECTION

The SRP29x HSR ports use type **LC** connectors as shown in the figure below.



Figure 38: Ethernet optical fibre – LC connections

Warning about Laser Rays



Caution:
NEVER look into optical fibers. Always use optical power meters to determine operation or signal level.

Non–observance of this rule could possibly result in personal injury.

Signals transmitted via optical fibres are unaffected by interference. The fibres guarantee electrical isolation between the connections.

If electrical to optical converters are used, they must have management of character idle state capability (for when the fibre optic cable interface is "Light off").

The SRP29**2** variant provides two 100BASE-FX **multi-mode** optical links.

The SRP29**4** variant provides two 100BASE-FX **single-mode** optical links.

In both variants, the optical fibre connectors are LC-type small form-factor pluggable (SFP) transceivers that can use both single and multi mode fibre.

Centre wavelength: 1310 nm.

Compatibility

LC/ST or LC/SC optical patch cords may be used to connect the board to devices fitted with ST or SC connectors.

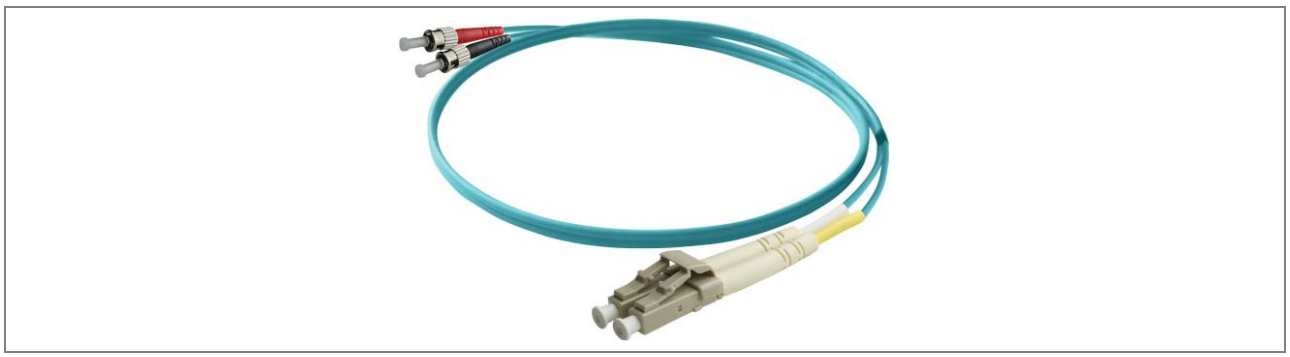
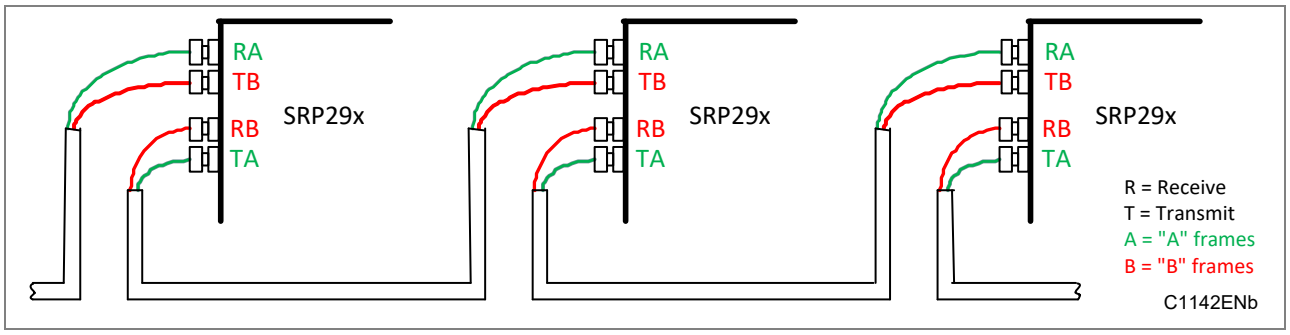


Figure 39: Optical patch cord example (multimode duplex LC/ST)

Connection for Seamless Redundancy

When using SRP29x boards, the optical rings should be connected as follows:



4.15.3 RJ45 ETHERNET CONNECTIONS

The user-accessible copper Ethernet communication ports use 4 twisted pair cable.

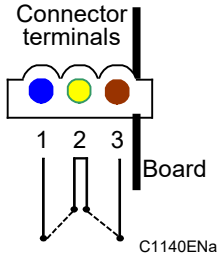
If connected devices are located a long distance away from the switch (>100 m), or if the cables run through a harsh electrical environment, then copper to fibre converters should be used in conjunction with optical fibres.

Ethernet cable type

Category 5 (FTP: Foil Twisted Pair) or insulated (STP – Shielded Twisted Pair) with RJ45 connectors should be used.

4.15.4 FAULT SIGNAL CONNECTOR DESCRIPTION

The status of the two HSR links is indicated on contacts at the rear of the board according to the diagram and table below: The alarm contacts share a common terminal.



Terminal number	Assignment	Meaning
1	HSR link B status	Open = Link healthy Close = Link failure (contact 1 and 2 are closed)
2	Common	
3	HSR link A status	Open = Link healthy Close = Link failure (contact 2 and 3 are closed)

A closed contact indicates an alarm or a fault.

The characteristics of the alarm contacts are presented below.

- Connections — 2 normally closed (NC) contacts - potential free
- Max. switching voltage — 70 V_{DC}/33 V_{AC}
- Max. switching current — 5 A
- Max. switching power — 150 W / 165 VA

Wiring recommendations

For safety reasons and for compliance with the European Commission Low Voltage Directive (2014/35/EU), the authorised voltage rating to be applied on the "Fault signal connector" is limited to 70 V_{DC} or 33 V_{AC} and does not exceed 5 A.

Due to the proximity of the port N°4 Ethernet connector, it is strongly recommended that the “Fault signal connector” connections are visually checked before any handling of the Ethernet connectors.

Particular attention is to be paid not to damage the cable’s isolation during the wiring phase.

The figure below shows the allocation of the SRP29x alarm contacts.

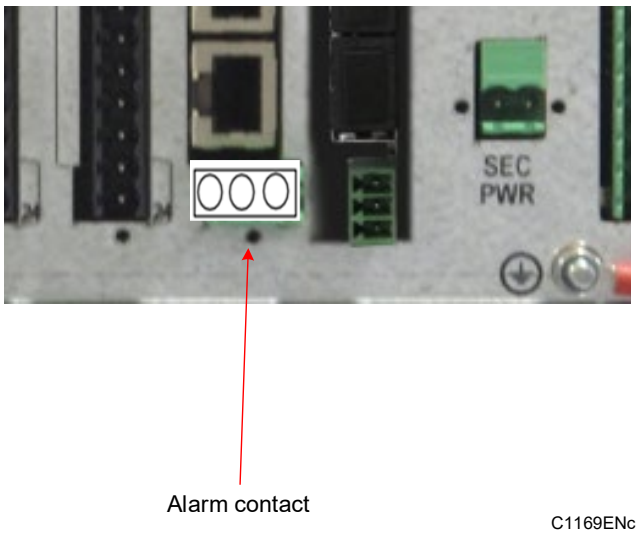


Figure 40: SRP29x HSR Alarm Contact connections

The characteristics of the alarm connectors (prior to SRP29x-2.x.x.x) are presented below:



Figure 41: Alarm Contact connections

- Connections — 2 normally closed (NC) contacts - potential free
- Max. switching voltage: — 70 VDC/33 VAC
- Max. switching current — 5 A

Wiring recommendations

For safety reasons and for compliance with the European Commission Low Voltage Directive (2014/35/EU), the authorised voltage rating to be applied on the "Fault signal connector" is limited to 70 V_{DC} or 33 V_{AC} and does not exceed 5 A.

Due to the proximity of the port N°4 Ethernet connector, it is strongly recommended that the “Fault signal connector” connections are visually checked before any handling of the Ethernet connectors.

Particular attention is to be paid not to damage the cable’s isolation during the wiring phase.

The characteristics of the alarm connectors (From SRP29x-2.x.x.x) are presented below:



Figure 42: Alarm Contact connections

- Connections — 2 normally closed (NC) contacts - potential free
- Max. switching voltage: — 150 V_{DC}/150 V_{AC} (From SRP29x-2.x.x.x)
- Max. switching current — 5 A

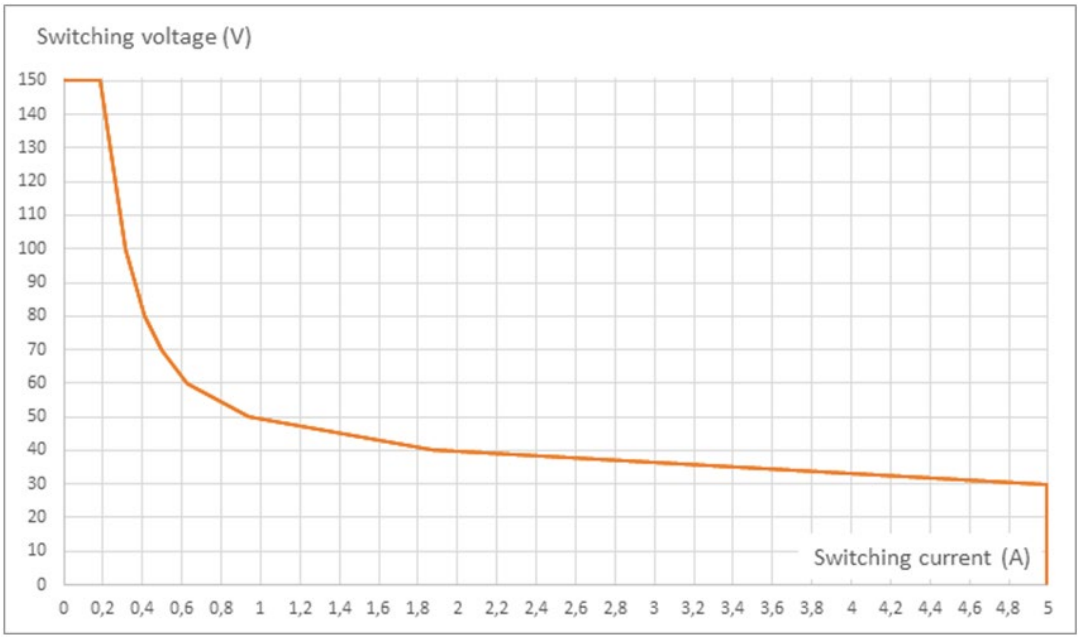


Figure 43: Switching voltage diagram

Wiring recommendations

For safety reasons and for compliance with the European Commission Low Voltage Directive (2014/35/EU), the authorised voltage rating to be applied on the "Fault signal connector" is limited to 150 V_{DC} or 150 V_{AC} and does not exceed 5 A.

Due to the proximity of the port N°4 Ethernet connector, it is strongly recommended that the “Fault signal connector” connections are visually checked before any handling of the Ethernet connectors.

Particular attention is to be paid not to damage the cable’s isolation during the wiring phase

4.15.5 IRIG-B CONNECTOR DESCRIPTION

The IRIG-B connector is not used in the SRP29x application.

4.16 DETACHABLE FRONT PANEL

The front panel includes a serial RS232 interface that is not galvanically isolated and is intended for maintenance purposes only.



Warning:
The front serial port is not intended for user connection and ESD precautions should be taken when accessing it.

The properties of the serial link (DB9 female connector) for the maintenance dialogue are:

- Baud rate: CPU3: 19200 bit/s; CPU4: 115200 bit/s
- Data bits: 8
- Parity: No
- Stop bit: 1
- Control Xon/Xoff

Connector description:

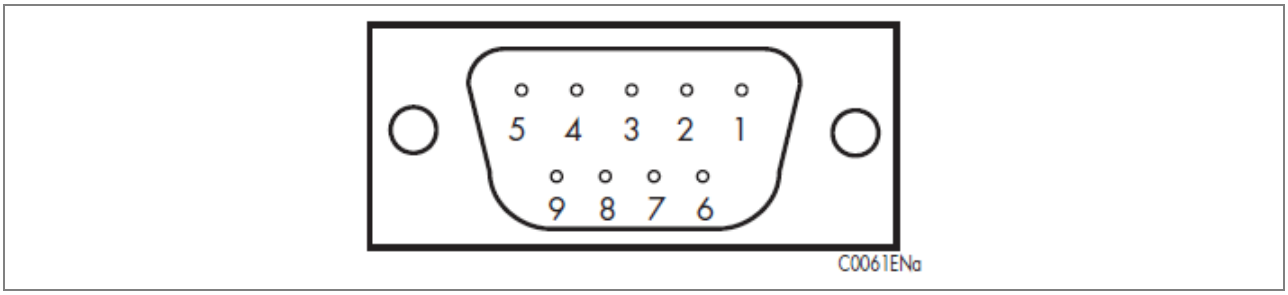


Figure 44: Front panel connector view

Pin N°.	Signal
1	Data Carrier Detect (DCD) – input
2	Receive Data (RxD) – input
3	Transmit data (TxD) – output
4	Data Terminal Ready (DTR) – output
5	Signal Ground (SG) - 0V
6	Data Set Ready (DSR) – input
7	Ready To Send (RTS) – input
8	Clear To Send (CTS) – input
9	NC

4.17 LOCAL FRONT PANEL

The front panel includes a B-Type USB port intended for maintenance purpose only.

Warning:
The front serial USB port is intended for maintenance purpose only. It is isolated to ELV level and is not intended for user connection. ESD precautions should also be taken when accessing it.

The properties of the connector for the maintenance dialogue are:

- Baud rate: 115200 bit/s
- Data bits: 8
- Parity: No
- Stop bit: 1
- Control Xon/Xoff

Connector description:

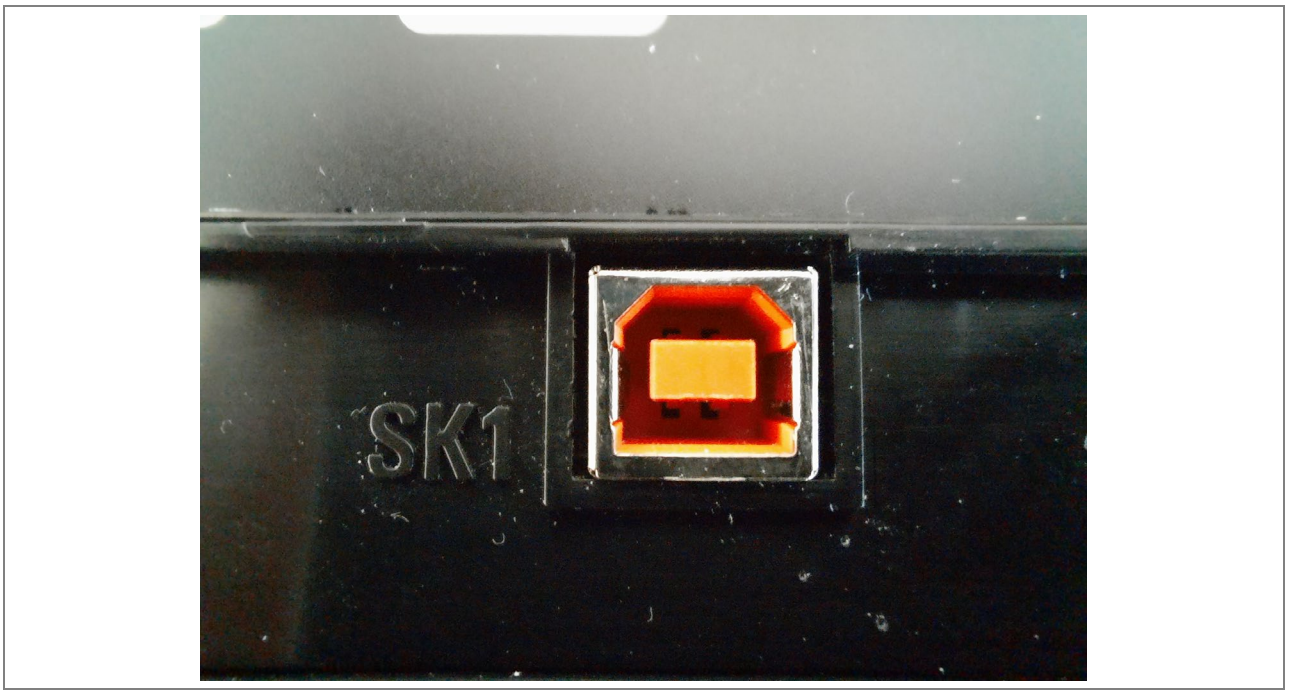


Figure 45: Front panel connector view

COMMUNICATIONS

C26X/EN CT/E72A

Contents

1	**SCOPE OF THE DOCUMENT**	**3**
2	**STATION BUS COMMUNICATIONS**	**4**
2.1	**Inputs**	**4**
2.1.1	Information: C26x application ➔ SCP	4
2.1.2	Information SCP ➔ C26x application	4
2.2	**Supported services**	**4**
3	**PROCESS BUS COMMUNICATIONS**	**5**
3.1	**Overview**	**5**
3.2	**IEC 61850-8-1 GOOSE communications**	**5**
3.3	**IEC 61850-9-2 LE communications**	**5**
3.4	**Architecture examples**	**7**
4	**COMMUNICATIONS WITH THE SCADA**	**12**
4.1	**Overview**	**12**
4.2	**SCADA common functionality**	**12**
4.2.1	Interface to SCADA	12
4.2.2	C26x BCU	12
4.2.3	Behaviour and specific treatments	13
4.2.4	Data sent to the SCADA	15
4.2.5	Data sent to the C26x	17
4.3	**Slave IEC 60870-5-101 profile**	**18**
4.3.1	System or device	18
4.3.2	Network configuration	18
4.3.3	Physical layer	18
4.3.4	Link layer	19
4.3.5	Application layer	19
4.3.6	Basic application functions	23
4.3.7	Protocol Requirements	27
4.3.8	Application Functions	27
4.3.9	Frame example	29
4.4	**Slave IEC 60870-5-104 Server profile**	**30**
4.4.1	System or device	30
4.4.2	Network configuration (Network-specific parameter)	30
4.4.3	Physical layer (Network-specific parameter)	30
4.4.4	Link layer (Network specific parameter)	31
4.4.5	Protocol Requirements	32
4.4.6	Application layer	32
4.4.7	Basic application functions	37
4.4.8	Frame example	41
4.5	**Slave Modbus (MODICON) profile**	**42**
4.5.1	Introducing Modbus	42
4.5.2	Slave responses	43
4.5.3	Serial transmission mode	44
4.5.4	Modbus Functions	45

4.5.5 Function 01 / 02: Read Coil Status – Read Input Status 47
4.5.6 Function 03 / 04: Read Holding Registers / Input Registers 48
4.5.7 Function 05: Force Single Coil 49
4.5.8 Function 06: Preset single register 50
4.5.9 Function 08: Diagnostic [Sub-function 0 only] 50
4.5.10 Function 15: Force Multiple Coils 51
4.5.11 Function 16: Preset multiple registers 51

5 COMMUNICATIONS WITH LEGACY IEDS 52

5.1 Overview 52
5.2 IED Common functionality 53
5.2.1 Interface to IEDs 53
5.2.2 Behaviour 53
5.2.3 Data received from IEDs 57
5.2.4 Data sent to IEDs 58
5.3 Modbus communications 60
5.3.1 Scope of this section 60
5.3.2 Polling cycles 60
5.3.3 Generic Modbus communications 60
5.3.4 Legacy Modbus communications 63
5.4 IEC 60870-5-103 communications 92
5.4.1 Scope of this section 92
5.4.2 Interface to IEDs 92
5.4.3 Behaviour 93
5.4.4 Data received from IEDs 94
5.4.5 Data sent to IEDs 96
5.5 IEC 60870-5-101 communications 98
5.5.1 Purpose 98
5.5.2 Master IEC 60870-5-101 profile 98

1 SCOPE OF THE DOCUMENT

This document is a chapter of the DS Agile C26x documentation. It describes the various standard communication protocols implemented in the C26x.

The DS Agile C26x supports different types of communications:

- **Station Bus Communications**: communications with IEDs and system devices using the IEC 61850-8-1 protocol over an Ethernet network
- **Process Bus Communications**: communications with power system devices using the IEC 61850-8-1 and IED 61850-9-2 LE protocols over Ethernet networks
- **Communications with the SCADA**: communications with an upper level SCADA system using various protocols (IEC 60870-5-101, IEC 60870-5-104, MODBUS),
- **Communications with legacy IEDs**: The C26x acts as a master (IEC 60870-5-103, MODBUS, IEC 60870-5-101).

2 STATION BUS COMMUNICATIONS

The DS Agile C26x BCU communicates over the Station Bus with other DS Agile sub-systems such as the Substation Control Point (DS Agile aView), the Gateway, etc. as well as IEC 61850-8-1-compliant IEDs such as protection units by means of GOOSE and Report messages.

This section describes IEC61850-8-1 implementation in the C26x for communications over the Station Bus.

2.1 INPUTS

2.1.1 INFORMATION: C26X APPLICATION ➔ SCP

The types of information that can be transmitted are:

- Changes of binary input states
- Measurements (Analogue or CT/VT)
- Counters
- Controls
- Control acknowledgements
- Time synchronisation message
- Records (event, fault, disturbance)
- C26x information (Init. report, Operating mode, control mode, Date)

2.1.2 INFORMATION SCP ➔ C26X APPLICATION

The type of information that can be transmitted are:

- Changes of binary input states
- Measurements (Analogue or CT/VT)
- Counters
- Controls
- Control acknowledgements
- Time synchronisation message
- Request for records
- Database downloading

2.2 SUPPORTED SERVICES

Services supported by the IEC 61850-8-1 SBUS Agency integrated in the C26x are listed in the ACSI service conformance statement defined in Table A.3 of the document DS Agile C26x PICS.

Supported Common Data Classes: refer to C26x/EN FT.

3 PROCESS BUS COMMUNICATIONS

3.1 OVERVIEW

This section describes how the Process Bus is applied to the DS Agile digital control system. It is not a description of the IEC 61850 standard itself. The level at which this section is written assumes that the reader is already familiar with the IEC 61850 standard.

IEC 61850 is the international standard for Ethernet-based communication in substations. It enables integration of all protection, control, measurement and monitoring functions within a substation, and additionally provides the means for interlocking and inter-tripping. It combines the convenience of Ethernet with the security that is so essential in substations today.

The Process Bus is an Ethernet network linking the substation's IEDs to the primary electrical process devices, such as circuit-breakers, power transformers and instrument transformers, conventional or not.

The process bus combines several standard protocols depending on the information that transits on it. The 2 types of transmitted information are:

- Binary state signals are transmitted inside IEC 61850-8-1 GOOSE frames.
- Sampled values, i.e. digitised power system measurements, are transmitted inside IEC 61850-9-2 LE frames.

Both signals are transmitted over Ethernet networks. IEC 61850-8-1 GOOSE frames transmission can use the redundant PRP protocol for enhanced security. This lowers the installation cost by replacing low voltage copper wiring with the Process Bus Local Area Network (LAN). For example, an open air high-voltage yard needs a network of wiring trenches, taking several instrument transformer signals and control wires to a substation control room. In the Process Bus system, the wiring could be reduced to three or four network rings. Two rings are for dc power with one as a redundant backup for the breakers. The third and fourth rings are fibre-optic Ethernet LANs that carry the Process Bus.

3.2 IEC 61850-8-1 GOOSE COMMUNICATIONS

In the DS Agile system process bus implementation, GOOSE messages are used by the C26x BCU to communicate with switchgear control units (e.g. C26x SCU) located near circuit-breakers. One of the major advantages of this type of configuration is that it allows reducing the amount of copper wiring used in the substation, thus minimising failure risks and optimising operation costs.

The DS Agile C26x can remotely operate switchgear through the switchgear control units' wired outputs, either the DS Agile C26x SCU or IEC 61850-8-1-compatible switchgear control units made by other manufacturers. It also receives binary state indications acquired by the remote units' wired inputs and transparently integrates them into its own processes.

Control and information single/double datapoints are transmitted in both directions inside GOOSE messages.

The DS Agile C26x BCU can manage SCU redundancy thus ensuring data security.

3.3 IEC 61850-9-2 LE COMMUNICATIONS

The IEC 61850-9-2LE protocol allows measured values of voltage, current and frequency to be sampled and time-stamped from a single clock source so they can be synchronised and digitised for transfer over the Process Bus. These signals may originate from standard CTs and VTs, or from NCITs(1). Information from both types of measurement devices is sampled by merging units and is transferred on the Process Bus.

The IEC 61850-9-2LE protocol allows the DS Agile C26x BCU to communicate with the Process Bus and receive IEC 61850-9-2LE data from analogue merging units (e.g. Reason MU320) that digitise analogue values from conventional CTs and VTs, thus replacing wired analogue inputs. It also allows the C26x BCU to

receive current and voltage sampled data from non-conventional instrument transformers such as optical and Rogowski devices through digital merging units.

The DS Agile implementation has been designed to be especially resilient and reliable in the presence of interference, such as latency, jitter and missing or suspect data.

Merging unit

The merging unit (MU) is the interface device which takes signals from the instrument transformer sensors and performs digital signal processing to generate and distribute output sampled value streams according to IEC 61850-9-2LE standardised definitions for communication with substation IEDs and controllers.

As well as connecting with Non Conventional Instrument Technology (NCIT(1)) such as optical sensors and Rogowski coils, merging units can also work with conventional CTs and VTs to provide digital values of power system currents and voltages over communication buses.

For details on GE Grid Merging Units, please refer to the documentation for the AMU, XMU and NXMU ranges.

(1) Conventional wound current transformers (CTs) and wound or capacitor-coupled voltage transformers (VTs) are limited by the iron core and analogue secondary circuits. The core needs to be magnetised, but not saturated by overfluxing, causing flux remanence effects, flux leakage and Eddy currents. Conventional 1A/5A CTs are thermally limited, made worse by long connection distances. Conventional VT circuits can be subject to ferroresonance, causing thermal overstressing.

Alternatively, smaller and lighter CT and VT transducers can be used, known as Non Conventional Instrument Transformers (NCITs), which use the magneto-optic Faraday effect. Light from an LED is refracted and polarised by an electromagnetic field. The extent of this distortion of the monochromatic light beam is detected by a photodiode, which measures light intensity. This analogue signal is then digitised with an Analogue to Digital Convertor (ADC) and sampled with a Digital Signal Processor (DSP) in synchronisation with a standard clock signal. The DSP sends the Sampled Values of the signal to the merging unit through an optical fibre. A DSP in the merging unit, also synchronised to the same clock source, makes the Sampled Values of the currents available on the IEC 61850 Process Bus.

3.4 ARCHITECTURE EXAMPLES

Single star on Station Bus and double star on Process Bus

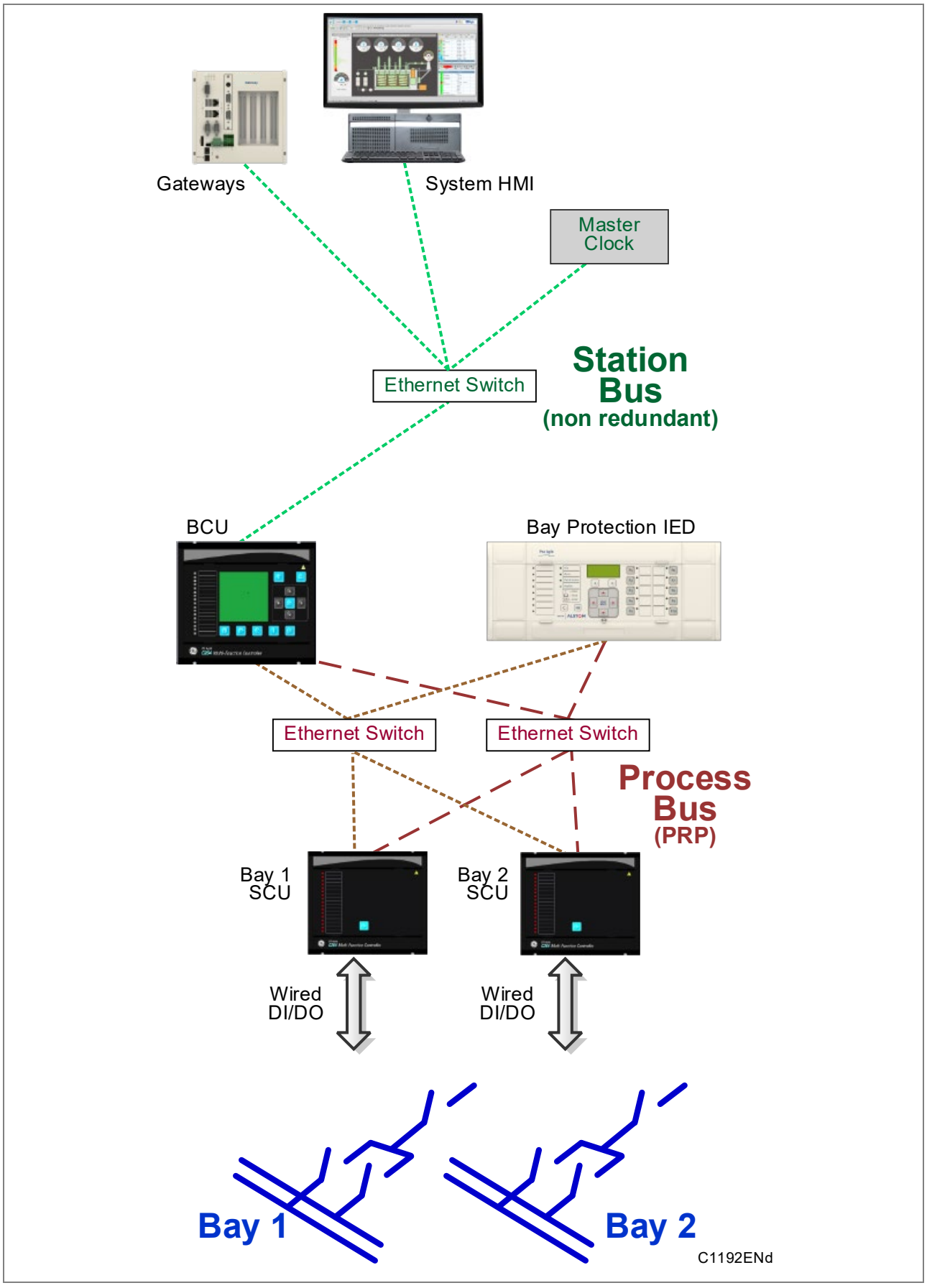

Gateways
System HMI
Master Clock
Ethernet Switch
Station Bus
(non redundant)
BCU
Bay Protection IED
Ethernet Switch
Ethernet Switch
Process Bus
(PRP)
Bay 1 SCU
Bay 2 SCU
Wired DI/DO
Wired DI/DO
Bay 1
Bay 2
C1192ENd

Figure 1: Single star architecture on Station Bus

Double star on Station Bus and on Process Bus

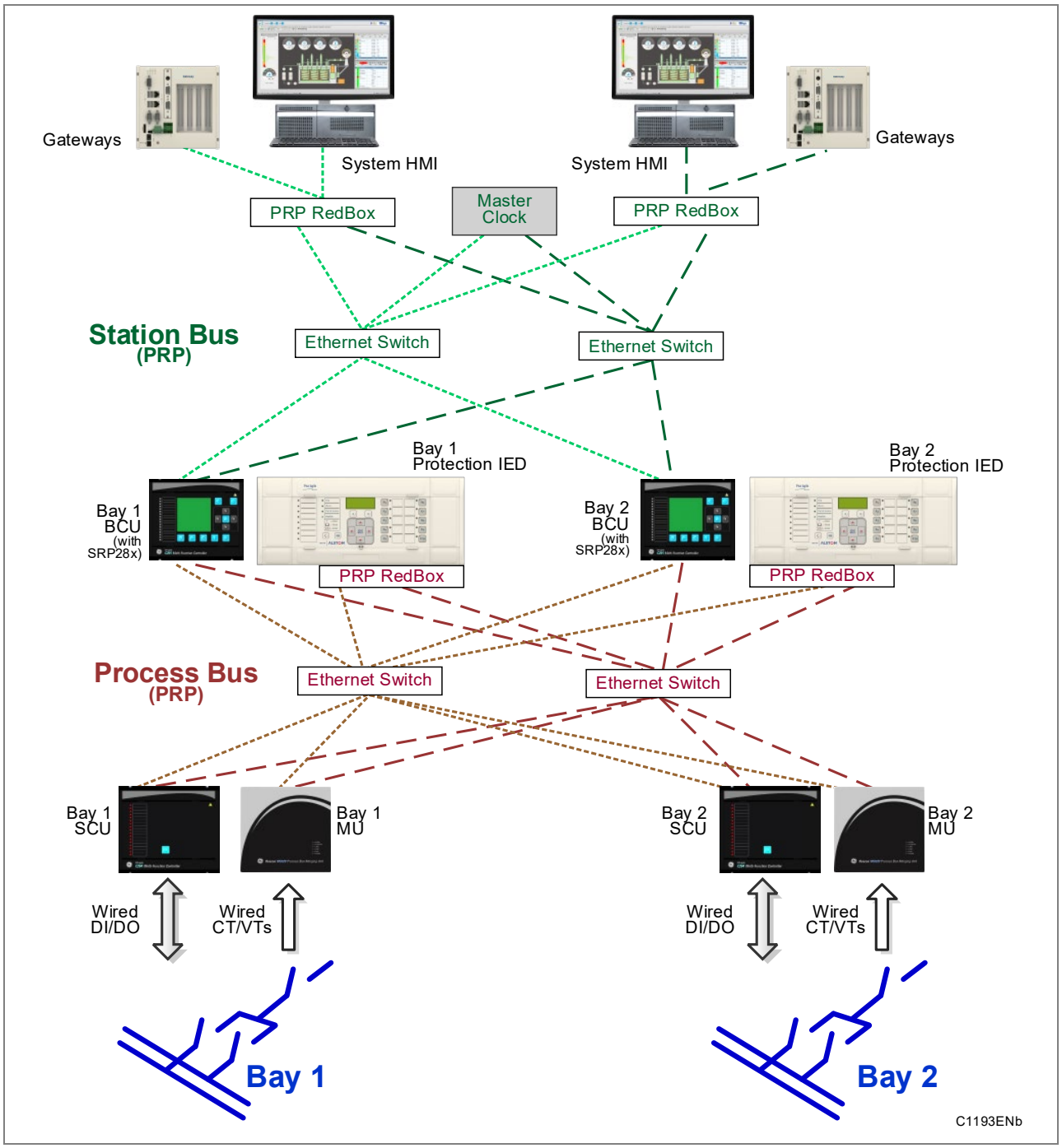


Figure 2: Double star architecture on Station Bus

Double ring on Station Bus and double star on Process Bus

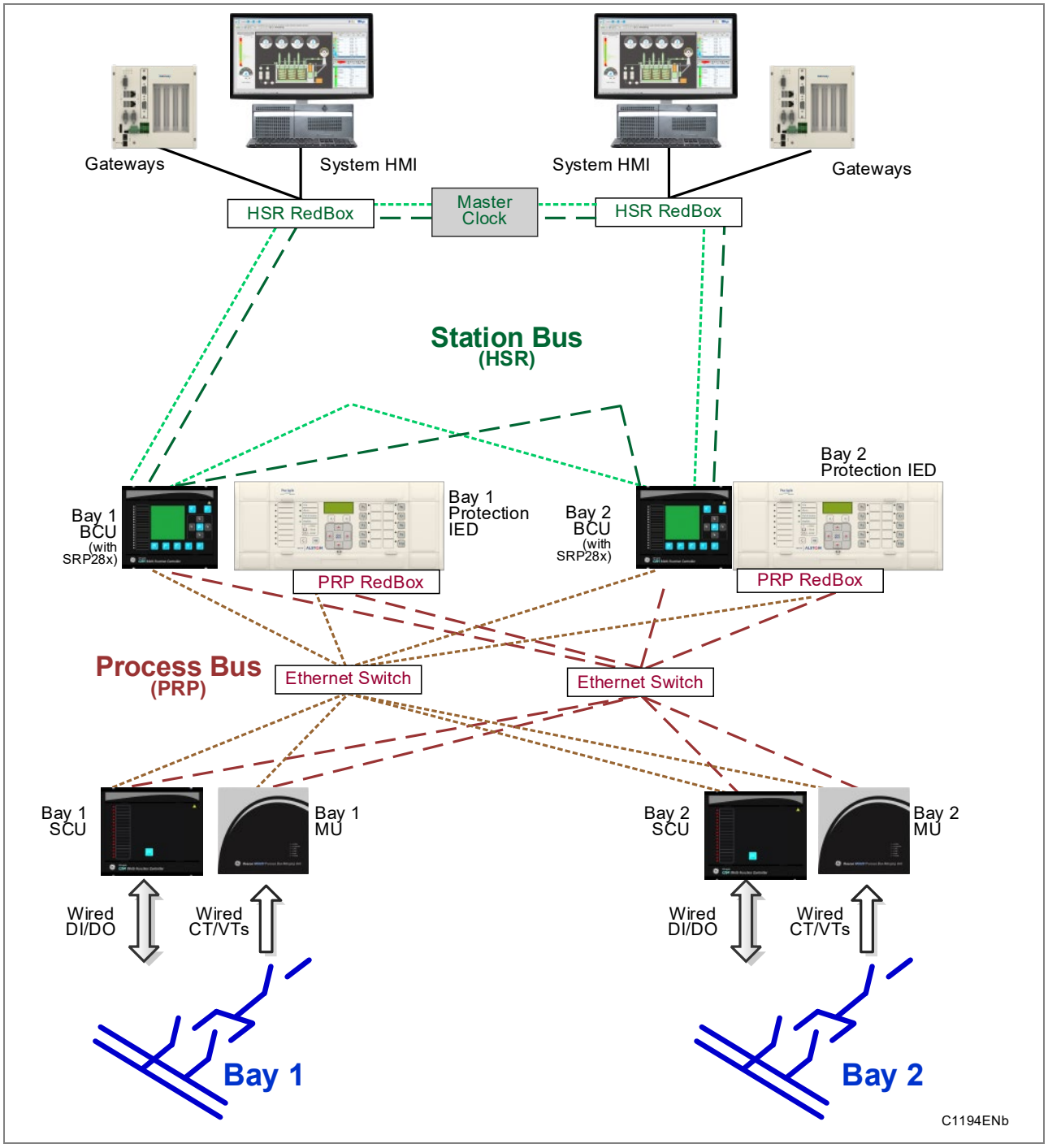


Figure 3: Double star architecture on Station Bus

Double star on Station Bus and Point-to-Point connection on Process Bus

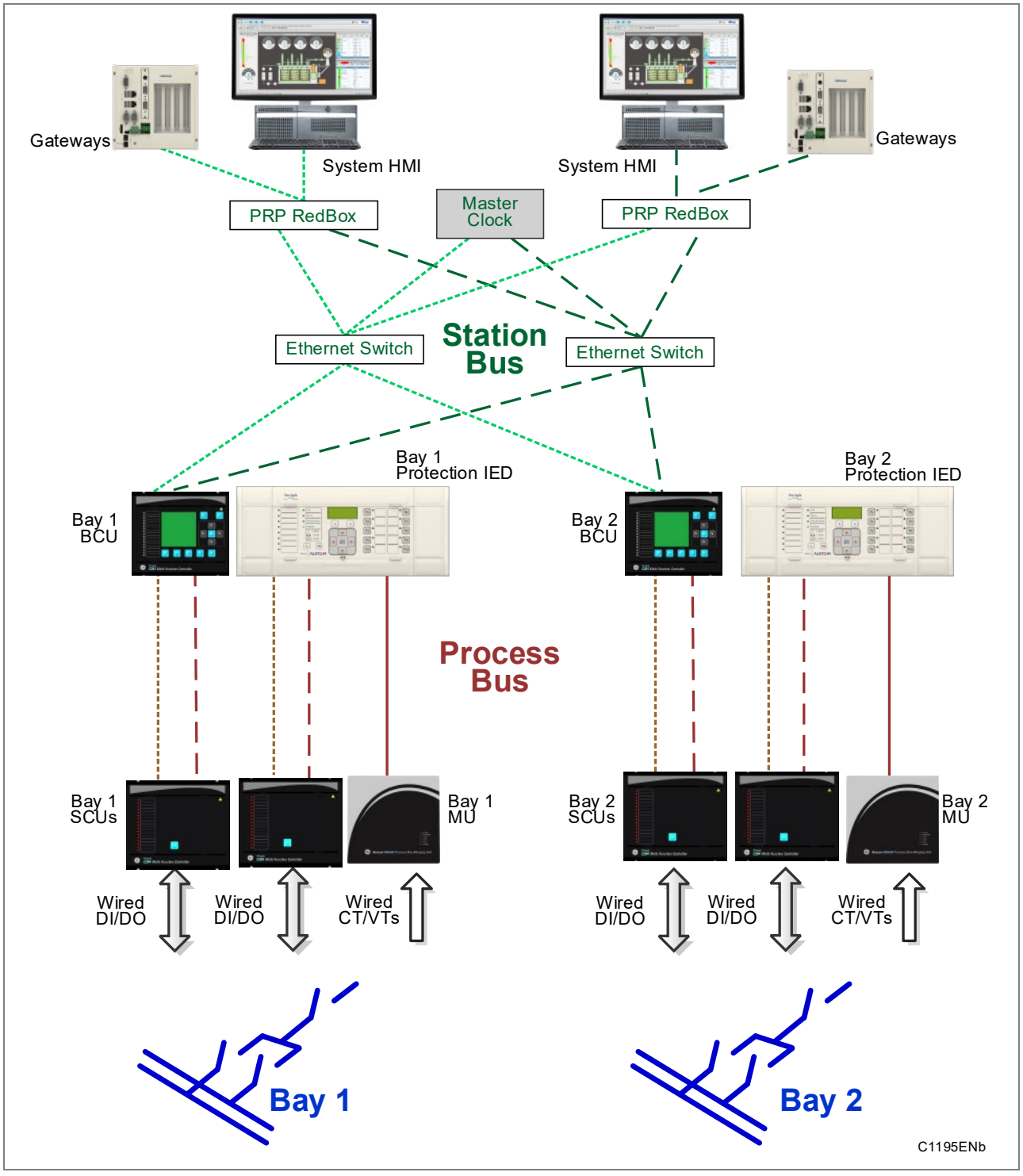


Figure 4: Point-to-point architecture

4 COMMUNICATIONS WITH THE SCADA

4.1 OVERVIEW

A C26x can be directly connected to a SCADA through networks using various protocols:

Protocol	C26x BCU
Modbus	Serial
IEC 60870-5-101 (T101)	Serial
IEC 60870-5-104 (T104)	Over IP

It is possible to have:

- Two different protocols running in parallel on different serial links
- Four different protocols running in parallel on Ethernet communications
- The same protocol on two links (redundant mode). Not supported by Modbus.
- For protocols running on TCP/IP link, there is only one Ethernet port. So, redundancy is not available for those protocols, and they all are running on the same physical network (including IEC 61850-8-1 protocol).
- In T104 protocol the C26x (server) can manage four client channels (SCADA front end ports) simultaneously. These four channels are configured separately but may have same data. On the SCADA side, up to 4 ports can be defined, corresponding to 1 active port and 3 standby ports. So, up to 4 IP addresses will be defined during the configuration of each T104 protocol connection.

Common features to all SCADA communication and all protocols are specified below.

Specific features of each protocol are specified in subsequent paragraphs.

4.2 SCADA COMMON FUNCTIONALITY

4.2.1 INTERFACE TO SCADA

This paragraph describes the exchange of data between the “SCADA communication” function and the Master SCADA. It includes two sub-paragraphs:

- Inputs: data received from SCADA.
- Outputs: data sent from the “SCADA communication” function to SCADA.

For each kind of protocol, it is indicated if the data is treated or not.

4.2.2 C26X BCU

4.2.2.1 INPUT

Data	T101	T104	MODBUS
Remote link initialisation	Treated	Treated	Treated
General interrogation	Treated	Treated	Not Treated
Control	Treated	Treated	Treated
Setpoint	Treated	Treated	Treated
Time synchronisation	Treated	Treated	Not Treated
Database (download)	Not Treated	Not Treated	Not Treated

4.2.2.2 OUTPUT

Data		T101	T104	MODBUS
Digital input		Treated	Treated	Treated
Dated Digital input		Treated	Treated	Not Treated
Measurement (Events)		Treated	Treated	Not Treated
Measurement (Cyclical)		Treated	Treated	Treated
Counter		Treated	Treated	Treated
Tap position		Treated	Treated	Treated
Control acknowledgement		Treated	Treated	Treated
Setpoint acknowledgement		Treated	Treated	Treated
C26x Disturbance		Slow waveform only	Slow waveform only	Not Treated
Sequence Of Event file		Treated	Treated	Not Treated

4.2.3 BEHAVIOUR AND SPECIFIC TREATMENTS

Note:
In subsequent sections, the master station (e.g.: SCADA) is referred to as the controlling station.

4.2.3.1 INITIALISATION

There is a running database for each SCADA link. Upon initialisation, a GI is performed on the application in order to initialise these databases.

The GI sequence consists of different requests to the C26x application in order to get the value and state of all data (binary input, measurement, counter, step position indication).

4.2.3.2 GENERAL INTERROGATION

The Outstation interrogation function is used for updating the controlling station after the internal station initialisation procedure, or when the controlling station detects a loss of information, or when the link layer connection has been re-established. The general interrogation function of the controlling station requests the C26x to transmit the actual values of all addressed datapoints.

The C26x marks the end of the general interrogation procedure by sending an indication to the controlling station when the protocols allow it.

In a multirack application and in redundant configuration, the main rack becomes the master rack on General Interrogation reception.

4.2.3.3 CLOCK SYNCHRONISATION

The clock in the C26x may be synchronised by the controlling station.

Note:
The clock can be synchronised by other means: external clock, Master Clock, operator. Only one source will be selected at a given time. This selection is performed by the clock synchronisation function based on configuration and priority level. However, the controlling station is not informed of this fact and must continue to send clock synchronisation commands.

The controlling station must perform the correction made on the time sent in synchronisation commands.

4.2.3.4 DATABASE UPLOADING AND SWITCHING

This function is only implemented with the T101 and T104 protocols. The SCADA can upload one database only. Then the file type is 1 (Transparent file) and the IOA (information object address) must be 1. The uploaded database will become the standby database.

To switch that database to current, the SCADA must send a reset process command (C_RP_NA_1 (105)) with the cause of transmission equal to *6* (activation) and the QRP field set to *1* (general reset of process).

4.2.3.5 LOCAL/REMOTE MODE

There are 2 types of L/R modes:

- "Substation" L/R mode, at station bus level,
- "Bay" L/R mode, at each controller level, applicable independently to each bay that the controller manages.

For information on Local/Remote operating modes, see the Functional Description chapter (C26x/EN FT).

Each L/R mode can be switched to Local or Remote by wiring the datapoint on a binary input.

4.2.3.6 TAKING CONTROL

A Substation can be configured in taking control mode. This means:

- At a given time, only one SCADA can send controls to the substation (the one which has the control).
- To be allowed to send controls, a SCADA must take control of the substation by sending a specific command to the C26x.

On each SCADA link, there is a binary input indicating if the corresponding SCADA has the control of the substation.

On reception of a Taking Control command, the C26x:

- Puts the substation in Remote mode (if it was in Local Mode)
- Gives the control to the (last) SCADA which asks for it
  - Reset the “Taking Control Binary input” of the SCADA which had previously the control
  - Set the “Taking Control Binary input” of the SCADA which asks the control

If the take control command is set for a SCADA, C26x should refuse all commands from other SCADAs.

4.2.3.7 SBMC MODE

This mode is used to test a substation while it is in Remote mode. As this mode is a test mode, the C26x will not send all the state changes to SCADA.

When a bay switches to SBMC mode, the C26x will send to SCADA all concerned data (configured Bay Based in the SCE) at specific states defined in the SCE for the management of SBMC.

For those data, state changes will not be transmitted, but will be saved in the C26x memory while the Bay is in SBMC mode.

When the Bay switches back to Non-SBMC mode, the C26x sends the current state of any data that changed while the Bay was in SBMC mode.

4.2.3.8 REDUNDANCY

Serial links can be configured as redundant. In this case, SCADA can send requests on both serial links: “main link “or “redundant link”.

The C26x always responds on the link used by SCADA for requesting the slave.

4.2.4 DATA SENT TO THE SCADA

After the initialisation sequence, the C26x Slave sends the state of all of its data to the SCADA. The current state of data is sent as state or as state change messages, depending on the protocol.

The data, which can be sent to SCADA, is detailed in the paragraphs below.

4.2.4.1 BINARY INPUTS

Binary inputs can be sent as states or as state changes depending on the protocol.

A binary input can be associated with a single point or a double point.

Note:
Multipoint status is not treated.

4.2.4.2 MEASUREMENTS

Measurements can be sent in various formats: float, integer, normalised, scaled…

Measurements can be sent as periodical messages or as state changes: variation, threshold, and invalidity.

The choices of format and mode of transmission are done by configuration according to the protocol.

4.2.4.3 COUNTERS

Counters can be sent as spontaneous messages (state changes) or on demand (counter General Interrogation).

The choice whether to use spontaneous messages for a counter is done by configuration, according to the protocol.

4.2.4.4 TAP POSITION

Tap position indication (TPI) can be sent to SCADA as states or as state changes. The choice between state and state change depends on the protocol. If the protocol allows both, the choice is made by configuration.

A digital input can be associated with a single point or a double point.

4.2.4.5 C26X DISTURBANCE FILE

Only Slow WaveForm recordings may be transmitted to the SCADA using the T101 or T104 protocols. A maximum of 5 slow waveform files can be simultaneously available. The IOA (Information Object Address) of the first file is configured and the others are consecutive; the file type is 1 (Transparent file). When a slow waveform file is available, an ASDU Directory (F_DR_TA_1 (126)) is sent by the C26x with cause of transmission spontaneous (3). The file remains available until a new file is created and replaces it. The SCADA can identify the file only by its date. The file size must be lower or equal to the size of one section.

Note:
Slow waveform files are stored in volatile memory (in the "/RAMDEV/" folder) and are deleted whenever the C26x is powered off or rebooted.

4.2.4.6 SEQUENCE OF EVENTS FILE (SOE)

The SOE record is a circular file in which C26x Events are stored. There is one SOE recorder per SCADA link.

The Events, which can be stored in the SOE file, are Binary Input states and measurements. The choice is made by configuration.

The following information in the C26x configuration is used to manage the SOE file:

- For each SCADA protocol
  - A flag indicating whether the SOE file must be managed
  - The identifiers of the SOE file on the link (Name, Address, …)
  - The maximum size of the file
  - The fill rate triggering the transmission of the SOE file
- For each BI / measurement
  - A flag indicating whether it must be stored in the SOE file

The rules for SOE management are as follows:

- When the C26x starts up, the SOE file is Empty
- When the SOE file is full, the oldest Event is deleted and the new one is added
- As soon as the fill rate set in configuration (**'full' SOE file nb of events**) is reached, the C26x tries to transmit the SOE file
- Once a SOE file has been successfully transmitted, all the Events included in the transmission are deleted from the SOE file.

Note:
SOE files are stored in volatile memory (in the "/RAMDEV/SOE/" folder) and are deleted whenever the C26x is powered off or rebooted.

4.2.4.7 SYNCHRONISATION STATUS

The C26x can inform the controlling station about its synchronisation status.

Depending on the protocol, this may be done by a specific message or by a binary input.

4.2.4.8 EVENTS BUFFER FOR T101 AND T104

During a SCADA disconnection, some events might be generated at Substation level. The C26x buffer records these events in order to transfer them spontaneously (COT=3) to the related SCADA at reconnection time. Refer to C26x/EN AP for buffer management.

A buffer overflow information is an optional extra with a SCADA address. The type of datapoint is ASDU30, SPS with Time stamp at date of the detection of overflow and is set to "OFF" in General and Group Interrogation.

Events are recorded in the Master and Backup C26x. Only events issued and dated from extension racks are synchronized.

Recorded events:

- DI (SPS and DPS)
- AI (MV normalized, adjusted, short float, normalized unipolar)
- Counter reported as spontaneous change,
- Step position information
- Unrecorded events:
  - Information transmitted cyclically or as background scan,
  - Acknowledgement of command,
  - Information transmitted in GI.

4.2.4.9 COMMUNICATIONS LINK STATUS

In the case of a redundant T101 link, when one of the channels is lost, the C26x can send a failure signal to the SCADA over the remaining healthy channel through 2 configurable datapoints.

4.2.5 DATA SENT TO THE C26X

SCADA can send data to the C26x. The type of data is described in subsequent paragraphs.

4.2.5.1 DIGITAL CONTROLS OR SETPOINTS

A control is transmitted to the handling of control sequences function.

At the end of the control sequence an acknowledgement is sent to SCADA if protocol allows it.

4.2.5.2 COUNTER COMMANDS

The commands allowed on counters are:

- Reset of a group of Counters
- Reset of all Counters
- Freeze of a group of counters
- Freeze of all counters
- Read (frozen value) of a group of Counters
- Read (frozen value) of all Counters

4.2.5.3 SYNCHRONISATION

Depending on the configuration, the C26x can be synchronised by a SCADA.

4.2.5.4 C26X REBOOT

If a new database had been downloaded and not switched yet, the C26x performs a database switch before rebooting.

4.3 SLAVE IEC 60870-5-101 PROFILE

The companion standard presents a set of parameters and alternatives from which subsets have to be selected to implement particular telecontrol systems. Certain parameters values, such as the number of bytes in the COMMON ADDRESS of ASDUs represent mutually exclusive alternatives. This means that only one value of the defined parameters is admitted per system.

Other parameters, such as the listed set of different process information in command and in monitor direction allow the specification of the complete set or subsets, as appropriate for given applications. This clause summarizes the parameters of the previous clauses to facilitate a suitable selection for a specific application. If a system is composed of equipment stemming from different manufacturers it is necessary that all partners agree on the selected parameters.

The selected parameters should be marked in the white boxes as follows:

☐ Function or ASDU is not used

☒ Function or ASDU is used as standardized (default)

The possible selection (blank, X) is specified for each specific clause or parameter.

Note:
In addition, the full specification of a system may require individual selection of certain parameters for certain parts of the system, such as the individual selection of scaling factors for individually addressable measured values.

4.3.1 SYSTEM OR DEVICE

(system specific parameter, indicates the definition of a system or a device by marking one of the following with '**X**')

☐ System definition

☐ Controlling station definition (Master)

☒ Controlled station definition (Slave)

4.3.2 NETWORK CONFIGURATION

(network specific parameter, all configurations that are used are to be marked 'X')

☒ Point-to-point ☒ Multipoint-party line

☒ Multiple point-to-point ☒ Multipoint-star

4.3.3 PHYSICAL LAYER

(network specific parameter, all interfaces and data rates that are used are to be marked '**X**')

Transmission speed (control direction)

Unbalanced interchange Circuit V24/V28				**Balanced interchange Circuit X24/X27**			
Standard		**Recommended if > 1200 bits/s**					
☐	100 bits/s	☒	2400 bits/s	☒	2400 bits/s	☐	56000 bits/s
☐	200 bits/s	☒	4800 bits/s	☒	4800 bits/s	☐	64000 bits/s
☒	300 bits/s	☒	9600 bits/s	☒	9600 bits/s		
☒	600 bits/s	☒	19200 bits/s	☒	19200 bits/s		
☒	1200 bits/s			☒	38400 bits/s		

Transmission speed (monitor direction)

Unbalanced interchange Circuit V24/V28				Balanced interchange Circuit X24/X27			
Standard		Recommended if > 1200 bits/s					
☐	100 bits/s	☒	2400 bits/s	☒	2400 bits/s	☐	56000 bits/s
☐	200 bits/s	☒	4800 bits/s	☒	4800 bits/s	☐	64000 bits/s
☒	300 bits/s	☒	9600 bits/s	☒	9600 bits/s		
☒	600 bits/s	☒	19200 bits/s	☒	19200 bits/s		
☒	1200 bits/s			☒	38400 bits/s		

4.3.4 LINK LAYER

(network specific parameter, all options that are used are to be marked '**X**'. Specify the maximum frame length. If a non-standard assignment of class 2 messages is implemented for unbalanced transmission, indicate the type ID and COT of all messages assigned to class 2.)

Frame format FT 1.2, single character 1 and the fixed time out interval are used exclusively in this companion standard.

Link transmission procedure

☒ Balanced transmission

☒ Unbalanced transmission

Address field of the link

☐ Not present (balanced transmission only)

☒ One octet

☒ Two octets

☐ Structured

☒ Unstructured

Frame length (number of bytes)

255 Maximum length L in control direction

up to 255 Maximum length L in monitor direction – configurable

4.3.5 APPLICATION LAYER

Transmission mode for application data

Mode 1 (Least significant octet first), as defined in clause 4.10 of IEC 870-5-4, is used exclusively in this companion standard.

Common address of ASDU

(system-specific parameter, all configurations that are used are to be marked 'X')

☒ One octet ☒ Two octets

Information object address

(system-specific parameter, all configurations that are used are to be marked 'X')

☒ One octet ☒ Structured

☒ Two octets ☒ Unstructured

☒ Three octets

Cause of transmission

(system-specific parameter, all configurations that are used are to be marked 'X')

☒ One octet ☒ Two octets (with originator address)

Selection of standard ASDUs

Process information in monitor direction

(station-specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☒	<1>	:=	Single-point information	M_SP_NA_1
☒	<2>	:=	Single-point information with time tag	M_SP_TA_1
☒	<3>	:=	Double-point information	M_DP_NA_1
☒	<4>	:=	Double-point information with time tag	M_DP_TA_1
☒	<5>	:=	Step-position information	M_ST_NA_1
☒	<6>	:=	Step-position information with time tag	M_ST_TA_1
☐	<7>	:=	BitString of 32 bits	M_BO_NA_1
☐	<8>	:=	BitString of 32 bits with time tag	M_BO_TA_1
☒	<9>	:=	Measured value, normalized value	M_ME_NA_1
☒	<10>	:=	Measured value, normalized value with time tag	M_ME_TA_1
☒	<11>	:=	Measured value, scaled value	M_ME_NB_1
☒	<12>	:=	Measured value, scaled value with time tag	M_ME_TB_1
☒	<13>	:=	Measured value, short floating-point value	M_ME_NC_1
☒	<14>	:=	Measured value, short floating-point value with time tag	M_ME_TC_1
☒	<15>	:=	Integrated totals	M_IT_NA_1
☒	<16>	:=	Integrated totals with time tag	M_IT_TA_1
☐	<17>	:=	Event of protection equipment with time tag	M_EP_TA_1
☒	<18>	:=	Packed start events of protection equipment with time tag	M_EP_TB_1
☒	<19>	:=	Packed output circuit transmission of protection equipment with time tag	M_EP_TC_1
☐	<20>	:=	Packed single-point information with status change detection	M_PS_NA_1
☐	<21>	:=	Measured value, normalized value without quality descriptor	M_ME_ND_1
☒	<30>	:=	Single-point information with time tag CP56Time2a	M_SP_TB_1
☒	<31>	:=	Double-point information with time tag CP56Time2a	M_DP_TB_1
☒	<32>	:=	Step-position information with time tag CP56Time2a	M_ST_TB_1
☐	<33>	:=	BitString of 32 bits with time tag CP56Time2a	M_BO_TB_1
☒	<34>	:=	Measured value, normalized with time tag CP56Time2a	M_ME_TD_1
☒	<35>	:=	Measured value, scaled with time tag CP56Time2a	M_ME_TE_1
☒	<36>	:=	Measured value, short floating-point number with time tag CP56Time2a	M_ME_TF_1
☒	<37>	:=	Integrated totals with time tag CP56Time2a	M_IT_TB_1
☐	<38>	:=	Event of protection equipment with time tag CP56Time2a	M_EP_TD_1
☒	<39>	:=	Packed start events of protection equipment with time tag CP56Time2a	M_EP_TE_1
☒	<40>	:=	Packed output circuit information of protection equipment with time tag CP56Time2a	M_EP_TF_1

Process information in control direction

(station-specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☒	<45>	:=	Single command	C_SC_NA_1
☒	<46>	:=	Double command	C_DC_NA_1
☒	<47>	:=	Regulating step command	C_RC_NA_1

☒	<48>	:=	Set point command, normalized value	C_SE_NA_1
☒	<49>	:=	Set point command, scaled value	C_SE_NB_1
☒	<50>	:=	Set point command, short floating-point value	C_SE_NC_1
☐	<51>	:=	BitString of 32 bits	C_BO_NA_1

System information in monitor direction

(station-specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☒	<70>	:=	End of initialisation	M_EI_NA_1

System information in control direction

(station-specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☒	<100>	:=	Interrogation command	C_IC_NA_1
☒	<101>	:=	Counter Interrogation Command	C_CI_NA_1
☐	<102>	:=	Read command	C_RD_NA_1
☒	<103>	:=	Clock synchronisation command	C_CS_NA_1
☒	<104>	:=	Test command	C_TS_NB_1
☐	<105>	:=	Reset process command	C_RP_NC_1
☒	<106>	:=	Delay acquisition command	C_CD_NA_1

Parameter in control direction

(station-specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☐	<110>	:=	Parameter of measured value, normalized value	P_ME_NA_1
☐	<111>	:=	Parameter of measured value, scaled value	P_ME_NB_1
☐	<112>	:=	Parameter of measured value, short floating-point value	P_ME_NC_1
☐	<113>	:=	Parameter activation	P_AC_NA_1

File transfer

(station-specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☒	<120>	:=	File ready	F_FR_NA_1
☒	<121>	:=	Section ready	F_SR_NA_1
☒	<122>	:=	Call directory, select file, call file, call section	F_SC_NA_1
☒	<123>	:=	Last section, last segment	F_LS_NA_1
☒	<124>	:=	Ack file, ack section	F_AF_NA_1
☒	<125>	:=	Segment	F_SG_NA_1
☒	<126>	:=	Directory	F_DR_TA_1

Special use (private range)

(station-specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☒	<136>	:=	Database version	M_DB_NA_1
☒	<137>	:=	Regulating delay command	C_RC_NB_1

Type identifier and cause of transmission assignments

(station-specific parameters)

Shaded boxes are not required.

Blank = function or ASDU is not used

Mark type identification/cause of transmission combinations:

'X' if used only in the standard direction

'R' if used only in the reverse direction

'B' if used in both directions

Type ID		Cause of transmission																		
		1	2	3	4	5	6	7	8	9	10	11	12	13	20 to 36	37 to 41	44	45	46	47
<1>	M_SP_NA_1		X	X								X			X					
<2>	M_SP_TA_1			X								X								
<3>	M_DP_NA_1		X	X								X			X					
<4>	M_DP_TA_1			X								X								
<5>	M_ST_NA_1		X	X								X			X					
<6>	M_ST_TA_1			X								X								
<7>	M_BO_NA_1																			
<8>	M_BO_TA_1																			
<9>	M_ME_NA_1	X	X	X											X					
<10>	M_ME_TA_1			X																
<11>	M_ME_NB_1	X	X	X											X					
<12>	M_ME_TB_1			X																
<13>	M_ME_NC_1	X	X	X											X					
<14>	M_ME_TC_1			X																
<15>	M_IT_NA_1			X												X				
<16>	M_IT_TA_1			X												X				
<17>	M_EP_TA_1																			
<18>	M_EP_TB_1			X																
<19>	M_EP_TC_1			X																
<20>	M_PS_NA_1																			
<21>	M_ME_ND_1																			
<30>	M_SP_TB_1			X								X	X							
<31>	M_DP_TB_1			X								X	X							
<32>	M_ST_TB_1			X								X	X							
<33>	M_BO_TB_1																			
<34>	M_ME_TD_1			X																
<35>	M_ME_TE_1			X																
<36>	M_ME_TF_1			X																
<37>	M_IT_TB_1			X												X				
<38>	M_EP_TD_1																			
<39>	M_EP_TE_1			X																
<40>	M_EP_TF_1			X																

Type ID		Cause of transmission																	
<45>	C_SC_NA_1						X	X	X	X	X						X	X	X
<46>	C_DC_NA_1						X	X	X	X	X						X	X	X
<47>	C_RC_NA_1						X	X	X	X	X						X	X	X
<48>	C_SE_NA_1						X	X	X	X	X						X	X	X
<49>	C_SE_NB_1						X	X	X	X	X						X	X	X
<50>	C_SE_NC_1						X	X	X	X	X						X	X	X
<51>	C_BO_NA_1															X			
<70>	M_EI_NA_1				X														
<100>	C_IC_NA_1						X	X	X	X	X						X	X	X
<101>	C_CI_NA_1						X	X			X						X	X	X
<102>	C_RD_NA_1															X			
<103>	C_CS_NA_1						X	X									X	X	X
<104>	C_TS_NA_1						X	X									X	X	X
<105>	C_RP_NA_1															X			
<106>	C_CD_NA_1						X	X								X			
<110>	P_ME_NA_1															X			
<111>	P_ME_NB_1															X			
<112>	P_ME_NC_1															X			
<113>	P_AC_NA_1															X			
<120>	F_FR_NA_1													X			X	X	X
<121>	F_SR_NA_1													X			X	X	X
<122>	F_SC_NA_1													X			X	X	X
<123>	F_LS_NA_1													X			X	X	X
<124>	F_AF_NA_1													X			X	X	X
<125>	F_SG_NA_1													X			X	X	X
<126>	F_DR_TA_1			X		X													
<136>	M_DB_NA_1															X			
<137>	C_RC_NB_1						X	X	X	X	X						X	X	X

4.3.6 BASIC APPLICATION FUNCTIONS

Station initialisation

(station-specific parameter, mark ‘X’ if function is used)

☐ Remote initialisation

between Reset User ASDU’s

Cyclic data transmission

(station-specific parameter, mark each type ID ‘X’ if it is only used in the standard direction, ‘R’ if only used in the reverse direction, and ‘B’ is used in both directions)

☒ Cyclic data transmission

Read procedure

(station-specific parameter, mark each type ID ‘X’ if it is only used in the standard direction, ‘R’ if only used in the reverse direction, and ‘B’ is used in both directions)

☐ Read procedure

Spontaneous transmission

(station-specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☒ Spontaneous transmission

Link state between Controlling and Controlled Station

☒ Management of the COM lost (Problem detecting on the link)

☒ Management of the COM recovering (Problem not detecting on the link)

General interrogation

(station-specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☒ global

☒ group 1	☒ group 7	☒ group 13
☒ group 2	☒ group 8	☒ group 14
☒ group 3	☒ group 9	☒ group 15
☒ group 4	☒ group 10	☒ group 16
☒ group 5	☒ group 11	Addresses per group have to be defined
☒ group 6	☒ group 12	

Counter General interrogation

(station-specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☒ global

☒ group 1	☒ group 2	☒ group 3
☒ group 4		

Clock synchronisation

(station-specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☒ Clock synchronisation

Notes:
– The controlled station does not report the change of hour by sending a clock synchronisation message (ASDU 103) to the controlling station.
– When the controlling station send to controlled station a clock synchronisation and if the system (includes controlled station), is not synchronized by another source: the clock synchronisation response is positive.
– When the controlling station send to controlled station a clock synchronisation and if the system (includes controlled station), is synchronized by another source: the clock synchronisation response is negative.

Command transmission

(object -specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☒ Direct command transmission

☒ Direct set-point command transmission

☒ Select and execute command

☒ Select and execute set-point command

☒ C_SE ACTTERM used

☒ No additional definition

☐ Short pulse duration (duration determined by a system parameter in the outstation)

☐ Long pulse duration (duration determined by a system parameter in the outstation)

☐ Persistent output

Transmission of integrated totals

(object -specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☒ Mode A: local freeze with spontaneous transmission

☐ Mode B: local freeze with counter interrogation

☒ Mode C: freeze and transmit by counter interrogation commands

☐ Mode D: freeze by counter interrogation command, frozen values reported spontaneously

Counter General interrogation

(object -specific parameter)

☒ Counter read

☒ Counter freeze without reset

☒ Counter freeze with reset

☒ Counter reset

☒ General request counter

☒ Request counter group 1

☒ Request counter group 2

☒ Request counter group 3

☒ Request counter group 4

Parameter loading

(object-specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☐ Threshold value

☐ Smoothing factor

☐ Low limit for transmission of measured value

☐ High limit for transmission of measured value

Parameter activation

(object-specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☐ Act-/deact-ivation of persistent cyclic or periodic transmission of the addressed object

Test procedure

(station-specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☒ Test procedure

File transfer

(station-specific parameter), mark 'X' if function is used)

File transfer in monitor direction

☒ Transparent file

☐ Transmission of disturbance data of protection equipment

☒ Transmission of sequences of events

☐ Transmission of sequences of recorded analogue values

File transfer in control direction

☐ Transparent file

Background scan

(station-specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☒ Background scan

Acquisition of transmission delay

(station-specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☐ Acquisition of transmission delay

Management events priorities

(station-specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

Digitals Inputs and Analog Inputs, management events priorities.
See T101 standard Amendment 2, section 7.2.2.2

4.3.7 PROTOCOL REQUIREMENTS

Class 1 data

The following types of information must be configured at the controlled station to be Class 1:

- Single point information with or without time tag (on change)
- Double point information with or without time tag (on change)
- Step position information with or without time tag (on change)
- Measured value, normalised with or without time tag (on change)
- Measured value, scaled with or without time tag (on change)
- Measured value, floated with or without time tag (on change)
- Integrated totals with or without time tag (on change)
- Time messages
- All command responses (ACT_CONF, and ACT_TERM)

Class 2 data

The following types of information must be configured at the controlled station to be Class 2:

- Single point information (GI scan, or BackGroundScan cycle)
- Double point information (GI scan, or BackGroundScan cycle)
- Step position information (GI scan, or BackGroundScan cycle)
- Measured values, normalised (GI scan, or Periodic cycle, or BackGroundScan cycle)
- Measured values, scaled (GI scan, or Periodic cycle, or BackGroundScan cycle)
- Measured values, floated (GI scan, or Periodic cycle, or BackGroundScan cycle)
- Integrated totals (Counter GI scan)

4.3.8 APPLICATION FUNCTIONS

The following IEC-60870-5-5 standard application processes are supported.

Station Initialisation

Station initialisation consists of a reset of the communications link (a Reset CU frame and Time Synchronisation message are sent to the station), followed by a general interrogation of the controlled station. Once this initialisation sequence is performed the controlling station can start the polling for data report.

Communications failure

Communications to the controlled station must be re-initialised by the controlling station when the frame repeat process has completed without successfully transmitting the frame (ie the frame time-out period times the number of repeats).

If the controlled station fails to communicate with the controlling station, then the controlling station should perform a communications system initialisation for that controlled station.

Controlled station failure

The controlled station shall indicate to the controlling station that it has initialised by sending a frame indicating End of Initialisation with a Cause Of Initialisation (COI) field, which will identify the reason for the initialisation in unbalanced mode only).

Data Acquisition by Polling

The default for all analogue values shall be reporting as Class 2 data (COT=1, periodic/cyclic, or COT = 2, BackgroundScan cyclic).

Values returned as Class 2 data do not have a time tag (since they are constantly repeated).

The controlled station may return Class 1 data in response to a Class 2 request if no Class 2 data is available and Class 1 data is awaiting transmission.

At the controlled station, if a request for Class 2 data is received and no data is available, a negative response, data not available, is returned to the controlling Station. The negative response might be a fixed length frame (FC=9), which in this event is treated as a NACK.

Normal Acquisition of Events

The default for all status changes are reported as Class 1 data (COT=3, spontaneous).

Values returned as Class 1 data have a time tag (either CP24Time2a, or CP56Time2a).

Status changes at the controlled station causes the ACD bit to be set in the next Class 1 or Class 2 data response. The controlling station responds to ACD set by inserting a scan for Class 1 (spontaneous) data as the next scan.

The response to a Class 1 data request has also the ACD bit set if more Class 1 data is awaiting transmission. In this case a further scan for Class 1 data is scheduled by the controlling station.

Abnormal Acquisition of Events

At the controlled station, if a request for Class 1 data is received and no data is available an error must be raised and a negative response, data not available, returned to the controlling Station. The negative response is a fixed length frame (FC=9), which in this case is treated as a NACK.

At the controlling station, if a response to a scan for Class 1 data indicates no data is available an error is raised, and scanning returned to Class 2 data requests.

General Interrogation

The GI returns the current status information directly from the C26x database.

Time tags are not used for data items returned as part of the GI response.

The GI groups are supported so, these are set up in the C26x configuration and each of the (up to 16) groups is requested/reported individually.

Clock synchronisation

The System (including the controlled station) may have different synchronisation sources (IRIG-B, SCADA).

When the controlling station sends to controlled station a clock synchronisation:

- if the system is not synchronized by another source: clock synchronisation response is positive
- if the system is synchronized by another source: clock synchronisation response is negative

All Class 1 data are time-tagged with:

- either the 3 bytes time-stamp (CP24Time2a), giving minutes & millisec within the hour,
- or the 7 bytes time-stamp (CP56Time2a), giving minutes, milliseconds, hours, day, month and year according to the C26x configuration.

The invalid bit in the time-stamp is set when the C26x is not synchronised.

Command transmission

All control commands are Select before Execute, or Direct Execute.

For only the control commands: Activation termination is returned to the controlling station to signal the end of a control sequence.

The QU field of the Qualifier of Command is set to zero (0), no additional definition.

Test procedure

A test command may be issued by the controlling station to ensure the availability of the communications link and the commands subsystem.

Test commands are received at the controlled station on the active link. The controlled station mirrors the test command, on the link from which it was received, with a cause of transmission indicating activation confirmation.

An error response must be sent if the command is incorrect, with a cause of transmission indicating negative activation confirmation.

4.3.9 FRAME EXAMPLE

ASDU1: Single-point information without time tag

TYPE IDENT 1: M_SP_NA_1

Sequence of information objects (SQ = 0)

8	7	6	5	4	3	2	1	Bit		
0	0	0	0	0	0	0	1		TYPE IDENTIFICATION	
SQ	Number i of objects								VARIABLE STRUCTURE QUALIFIER	DATA UNIT
T	P/N	2^5	Cause				2^0		CAUSE OF TRANSMISSION	
1 byte (can be two) 1..254, 255 = global address									COMMON ADDRESS OF ASDU	IDENTIFIER
B^7							B^0		INFORMATION OBJECT ADDRESS	
B^{15}							B^8			INFORMATION
IV	NT	SB	BL	0	0	0	SPI		SIQ = Single-point information with quality descriptor, see below.	OBJECT 1

B^7							B^0		INFORMATION OBJECT ADDRESS	
B^{15}							B^8			INFORMATION
IV	NT	SB	BL	0	0	0	SPI		SIQ = Single-point information with quality descriptor, see below.	OBJECT i

M_SP_NA_1 := CP{Data unit identifier, i(Information object address, SIQ)}

i := number of objects defined in the variable structure qualifier

Quality descriptor

BL = BLOCKED/NOT BLOCKED

The value of the INFORMATION OBJECT is blocked for transmission; the value remains in the state that was acquired before it was blocked. Blocking and deblocking may be initiated e.g. by a local lock or a local automatic cause.

SB = SUBSTITUTED/NOT SUBSTITUTED

The value of the INFORMATION OBJECT is provided by input of an operator (dispatcher) or by an automatic source.

NT = NOT TOPICAL/TOPICAL

A value is topical if the most recent update was successful. It is not topical if it was not updated successfully during a specified time interval or it is unavailable.

IV = INVALID/VALID

A value is valid if it was correctly acquired. After the acquisition function recognises abnormal conditions of the information source (missing or non-operating updating devices), the value is then marked invalid. The value of the INFORMATION OBJECT is not defined under this condition. The mark INVALID is used to indicate to the destination that the value may be incorrect and cannot be used.

4.4 SLAVE IEC 60870-5-104 SERVER PROFILE

This companion standard presents sets of parameters and alternatives from which subsets have to be selected to implement particular telecontrol systems. Certain parameter values, such as the choice of "structured" or "unstructured" fields of the INFORMATION OBJECT ADDRESS of ASDU represent mutually exclusive alternatives. This means that only one value of the defined parameters is admitted per system. Other parameters, such as the listed set of different process information in command and in monitor direction allow the specification of the complete set or subsets, as appropriate for given applications. This clause summarises the parameters of the previous clauses to facilitate a suitable selection for a specific application. If a system is composed of equipment stemming from different manufacturers it is necessary that all partners agree on the selected parameters.

Paragraph in grey are those which are not applicable for the IEC 60870-5-104 profile.

The selected parameters should be filled up (❍ --> ●).

Note:
In addition, the full specification of a system may require individual selection of certain parameters for certain parts of the system, such as the individual selection of scaling factors for individually addressable measured values.
To simplify the PID, we use the following conventions:
❍ *Not supported*
● *Supported*

4.4.1 SYSTEM OR DEVICE

❍ System definition

❍ Controlling station definition (Master)

● Controlled station definition (Slave)

4.4.2 NETWORK CONFIGURATION (NETWORK-SPECIFIC PARAMETER)

❍ Point-to-point ❍ Multipoint-party line

❍ Multiple point-to-point ❍ Multipoint-star

4.4.3 PHYSICAL LAYER (NETWORK-SPECIFIC PARAMETER)

Transmission speed (control direction):

Unbalanced interchange circuit V.24/V.28 Standard	Unbalanced interchange circuit V.24/V.28 Recommended if >1 200 bit/s	Balanced interchange circuit X.24/X.27, V35
❍ 100 bit/s	❍ 2 400 bit/s	❍ 2 400 bit/s
❍ 200 bit/s	❍ 4 800 bit/s	❍ 4 800 bit/s
❍ 300 bit/s	❍ 9 600 bit/s	❍ 9 600 bit/s
❍ 600 bit/s	❍ 19 200 bit/s	❍ 19 200 bit/s
❍ 1 200 bit/s		❍ 38 400 bit/s
		❍ 56 000 bit/s
		❍ 64 000 bit/s

Transmission speed (monitor direction):

Unbalanced interchange circuit V.24/V.28 Standard	Unbalanced interchange circuit V.24/V.28 Recommended if >1 200 bit/s	Balanced interchange circuit X.24/X.27, V35
❍ 100 bit/s	❍ 2 400 bit/s	❍ 2 400 bit/s
❍ 200 bit/s	❍ 4 800 bit/s	❍ 4 800 bit/s
❍ 300 bit/s	❍ 9 600 bit/s	❍ 9 600 bit/s
❍ 600 bit/s	❍ 19 200 bit/s	❍ 19 200 bit/s
❍ 1 200 bit/s		❍ 38 400 bit/s
		❍ 56 000 bit/s
		❍ 64 000 bit/s

4.4.4 LINK LAYER (NETWORK SPECIFIC PARAMETER)

(Network-specific parameter, all options that are used should be filled up (❍ --> ●). Specify the maximum frame length. If a non-standard assignment of class 2 messages is implemented for unbalanced transmission, indicate the type ID and COT of all messages assigned to class 2.)

Frame format FT 1.2, single character 1 and the fixed time out interval are used exclusively in this companion standard.

Link transmission procedure	Address field of the link
❍ Balanced transmission	❍ Not present (balanced transmission only)
❍ Unbalanced transmission	❍ One octet
	❍ Two octets
	❍ Structured
	❍ Unstructured

Frame length

_255_ Maximum length L (number of bytes)

When using an unbalanced link layer, the following ASDU types are returned in class 2 messages (low priority) with the indicated causes of transmission:

❍ The standard assignment of ASDUs to class 2 messages is used as follows:

Type Identification	Cause of transmission
9,11,13,21	<1>

❍ A special assignment of ASDUs to class 2 messages is used as follows:

Type Identification	Cause of transmission
1,3,5	<20> to <41>

Note:
In response to a class 2 poll, a controlled station prevent the controlling station with ACD parameter, when there is no class 2 data available.

4.4.5 PROTOCOL REQUIREMENTS

4.4.5.1 EVENT

The following types of information are to be configured at the controlled station to be Event:

- Single point information with or without time tag (on change)
- Double point information with or without time tag (on change)
- Step position information with or without time tag (on change)
- Measured value, normalised with or without time tag (on change)
- Measured value, scaled with or without time tag (on change)
- Measured value, floated with or without time tag (on change)
- Integrated totals with or without time tag (on change)

4.4.5.2 STATIC

The following types of information are to be configured at the controlled station to be Static:

- Single point information (GI scan, or BackGroundScan cycle)
- Double point information (GI scan, or BackGroundScan cycle)
- Measured values, normalised (GI scan, or Periodic cycle, or BackGroundScan cycle)
- Measured values, scaled (GI scan, or Periodic cycle, or BackGroundScan cycle)
- Measured values, floated (GI scan, or Periodic cycle, or BackGroundScan cycle)
- Step position values (GI scan, or BackGroundScan cycle)
- Integrated totals (Counter GI scan)

4.4.6 APPLICATION LAYER

Transmission mode for application data

Mode 1 (Least significant octet first), as defined in clause 4.10 of IEC 870-5-4, is used exclusively in this companion standard.

Common address of ASDU

(System specific parameter)

The address field of the link and the common address of ASDU could have a different number of bytes

❍ One octet	● Two octets

Information object address

(System specific parameter)

❍ One octet	● Structured
❍ Two octets	● Unstructured
● Three octets	

Cause of transmission

(System-specific parameter)

❍ One octet	● Two octets (with originator address)

Length of APDU

(System-specific parameter)

The maximum length of APDU is 253 (default). The maximum length may be reduced by the system.

Configurable	Maximum length of APDU per system

Selection of standard ASDUs

Process information in monitor direction

(Station-specific parameter)

●	<1>: =	Single-point information	M-SP-NA-1
❍	<2>: =	Single-point information with time tag	M-SP-TA-1
●	<3>: =	Double-point information	M-DP-NA-1
❍	<4>: =	Double-point information with time tag	M-DP-TA-1
●	<5>: =	Step position information	M-ST-NA-1
❍	<6>: =	Step position information with time tag	M-ST-TA-1
❍	<7>: =	Bit-string of 32 bit	M-BO-NA-1
❍	<8>: =	Bit-string of 32 bit with time tag	M-BO-TA-1
●	<9>: =	Measured value, normalised value	M-ME-NA-1
❍	<10>: =	Measured value, normalised value with time tag	M-ME-TA-1
●	<11>: =	Measured value, scaled value	M-ME-NB-1
❍	<12>: =	Measured value, scaled value with time tag	M-ME-TB-1
●	<13>: =	Measured value, short floating-point value	M-ME-NC-1
❍	<14>: =	Measured value, short floating-point value with time tag	M-ME-TC-1
●	<15>: =	Integrated totals	M-IT-NA-1
❍	<16>: =	Integrated totals with time tag	M-IT-TA-1
❍	<17>: =	Event of protection equipment with time tag	M-EP-TA-1
❍	<18>: =	Packed starts events of protection equipment with time tag	M-EP-TB-1
❍	<19>: =	Packed output circuit information of protection equipment with time tag	M-EP-TC-1
❍	<20>: =	Packed single-point information with status change detection	M-PS-NA-1
❍	<21>: =	Measured value, normalised value without quality descriptor	M-ME-ND-1

Process information in monitor direction with the Extension of time tag

(Station-specific parameter)

●	<30>: =	Single-point information with time tag CP56Time2a	M-SP-TB-1
●	<31>: =	Double-point information with time tag CP56Time2a	M-DP-TB-1
●	<32>: =	Step position information with time tag CP56Time2a	M-ST-TB-1
❍	<33>: =	Bit-string of 32 bit with time tag CP56Time2a	M-BO-TB-1
●	<34>: =	Measured value, normalised value with time tag CP56Time2a	M-ME-TD-1
●	<35>: =	Measured value, scaled value with time tag CP56Time2a	M-ME-TE-1
●	<36>: =	Measured value, short floating-point value, time tag CP56Time2a	M-ME-TF-1
●	<37>: =	Integrated totals with time tag CP56Time2a	M-IT-TB-1
❍	<38>: =	Event of protection equipment with time tag CP56Time2a	M-EP-TD-1
●	<39>: =	Packed start event of protection equipment, time tag CP56Time2a	M-EP-TE-1
●	<40>: =	Packed output circuit information of protection equipment with time tag CP56Time2a	M-EP-TF-1

Process information in control direction

(station specific parameter)

●	<45>: =	Single command	C-SC-NA-1
●	<46>: =	Double command	C-DC-NA-1
●	<47>: =	Regulating step command	C-RC-NA-1
●	<48>: =	Set point command normalised value	C-SE-NA-1
●	<49>: =	Set point command scaled value	C-SE-NB-1
●	<50>: =	Set point command, short floating-point value	C-SE-NC-1
❍	<51>: =	Bit-string of 32 bit	C-BO-NA-1
●	<58>: =	Single command with time tag CP56Time2a	C_SC_TA_1
●	<59>: =	Double command with time tag CP56Time2a	C_DC_TA_1
●	<60>: =	Regulating step command with time tag CP56Time2a	C_RC_TA_1
●	<61>: =	Set point command normalized value with time tag CP56Time2a	C_SE_TA_1
●	<62>: =	Set point command scaled value with time tag CP56Time2a	C_SE_TB_1
●	<63>: =	Set point command short floating-point value with time tag CP56Time2a	C_SE_TC_1
❍	<64>: =	Bitstring of 32 bits with time tag CP56Time2a	C_BO_TA_1

Note:
Time tag command (ASDU 58 to 63) are managed as standard command (ASDU 45 to 50), i.e. the time tag is not used.

System information in monitor direction

(station specific parameter)

●	<70>: =	End of initialisation	M-EI-NA-1

System information in control direction

(station-specific parameter)

●	<100>: =	Interrogation commands	C-IC-NA-1
●	<101>: =	Counter interrogation command	C-CI-NA-1
❍	<102>: =	Read command	C-RD-NA-1
●	<103>: =	Clock synchronisation command	C-CS-NA-1
❍	<104>: =	Test command	C-TS-NA-1
●	<105>: =	Reset process command	C-RP-NA-1
❍	<106>: =	Delay acquisition command	C-CD-NA-1
●	<107>: =	Test command with time tag CP56time2a	C-TS-TA-1

Parameter in control direction

(station specific parameter)

❍	<110>: =	Parameter of measured value, normalised value	P-ME-NA-1
❍	<111>: =	Parameter of measured value, scaled value	P-ME-NB-1
❍	<112>: =	Parameter of measured value, short floating-point value	P-ME-NC-1
❍	<113>: =	Parameter activation	P-AC-NA-1

File transfer

(station specific parameter)

- <120>: = File ready F-FR-NA-1
- <121>: = Section ready F-SR-NA-1
- <122>: = Call directory, select file, call file, call section F-SC-NA-1
- <123>: = Last section, last segment F-LS-NA-1
- <124>: = Ack file, ack section F-AF-NA-1
- <125>: = Segment F-SG-NA-1
- <126>: = Directory F-DR-TA-1

File transfer is only implemented in PC-hosted gateway.

Special use

(private range)

- <136>: = Data base version M-DB-NA-1
- <137>: = Regulating delay command C-RC-NB-1
- <138>: = Regulating delay command with time tag CP56Time2a C-RC-TB-1

Type identifier and cause of transmission assignments

(station specific parameters)

X	Mark type identification/cause of transmission combinations: 'X' if used
	Shaded boxes are not required
	Blank = function or ASDU is not used
~~X~~	Required in 1995 standard, suppressed in 2000.

Type ID		Cause of transmission																		
		1	2	3	4	5	6	7	8	9	10	11	12	13	20 to 36	37 to 41	44	45	46	47
<1>	M_SP_NA_1		X	X								X	X		X					
<2>	M_SP_TA_1																			
<3>	M_DP_NA_1		X	X								X	X		X					
<4>	M_DP_TA_1														~~X~~					
<5>	M_ST_NA_1		X	X								X	X		X					
<6>	M_ST_TA_1														~~X~~					
<7>	M_BO_NA_1																			
<8>	M_BO_TA_1																			
<9>	M_ME_NA_1	X	X	X											X					
<10>	M_ME_TA_1																			
<11>	M_ME_NB_1	X	X	X											X					
<12>	M_ME_TB_1																			
<13>	M_ME_NC_1	X	X	X											X					
<14>	M_ME_TC_1																			
<15>	M_IT_NA_1			X												X				
<16>	M_IT_TA_1																			
<17>	M_EP_TA_1																			
<18>	M_EP_TB_1																			

Type ID		Cause of transmission																		
<19>	M_EP_TC_1																			
<20>	M_PS_NA_1																			
<21>	M_ME_ND_1																			
<30>	M_SP_TB_1			X								X	X							
<31>	M_DP_TB_1			X								X	X							
<32>	M_ST_TB_1			X								X	X							
<33>	M_BO_TB_1																			
<34>	M_ME_TD_1			X																
<35>	M_ME_TE_1			X																
<36>	M_ME_TF_1			X																
<37>	M_IT_TB_1			X												X				
<38>	M_EP_TD_1																			
<39>	M_EP_TE_1			X																
<40>	M_EP_TF_1			X																
<45>	C_SC_NA_1						X	X	X	X	X							X	X	X
<46>	C_DC_NA_1						X	X	X	X	X							X	X	X
<47>	C_RC_NA_1						X	X	X	X	X							X	X	X
<48>	C_SE_NA_1						X	X	X	X	X							X	X	X
<49>	C_SE_NB_1						X	X	X	X	X							X	X	X
<50>	C_SE_NC_1						X	X	X	X	X							X	X	X
<51>	C_BO_NA_1																			
<58>	C_SC_TA_1						X	X	X	X	X							X	X	X
<59>	C_DC_TA_1						X	X	X	X	X							X	X	X
<60>	C_RC_TA_1						X	X	X	X	X							X	X	X
<61>	C_SE_TA_1						X	X	X	X	X							X	X	X
<62>	C_SE_TB_1						X	X	X	X	X							X	X	X
<63>	C_SE_TC_1						X	X	X	X	X							X	X	X
<64>	C_BO_TA_1																			
<70>	M_EI_NA_1				X															
<100>	C_IC_NA_1						X	X	X	X	X							X	X	X
<101>	C_CI_NA_1						X	X			X							X	X	X
<102>	C_RD_NA_1																			
<103>	C_CS_NA_1						X	X										X	X	X
<104>	C_TS_NA_1																			
<105>	C_RP_NA_1																			
<106>	C_CD_NA_1																			
<107>	C_TS_TA_1						X	X										X		
<110>	P_ME_NA_1																			
<111>	P_ME_NB_1																			
<112>	P_ME_NC_1																			
<113>	P_AC_NA_1																			
<120>	F_FR_NA_1													X				X		
<121>	F_SR_NA_1													X				X		
<122>	F_SC_NA_1					X								X				X		

Type ID		Cause of transmission																		
<123>	F_LS_NA_1												X				X			
<124>	F_AF_NA_1												X				X			
<125>	F_SG_NA_1												X				X			
<126>	F_DR_TA_1			X		X														
<136>	M_DB_NA_1																			
<137>	C_RC_NB_1						X	X	X	X	X							X	X	X
<138>	C_RC_TB_1						X	X	X	X	X							X	X	X

- COT <45>:= Unknown Cause of Transmission

4.4.7 BASIC APPLICATION FUNCTIONS

Station initialisation

(Station specific parameter)

- Remote initialisation

(Between Reset User ASDU's).

Cyclic data transmission

(Station specific parameter)

- Cyclic data transmission

(It's the same cyclic for all data).

Read procedure

(Station specific parameter)

- Read procedure

Spontaneous transmission

(Station-specific parameter)

- Spontaneous transmission

Double transmission of information objects with cause of transmission spontaneous

(station specific parameter), each information is marked where both a Type ID without time and corresponding Type ID with time are issued in response to a single spontaneous change of a monitored object

The following type identifications may be transmitted in succession caused by a single status change of an information object. The particular information object addresses for which double transmission is enabled are defined in a project-specific list.

Single point information	M_SP_NA_1, M_SP_TA_1, M_SP_TB_1, M_PS_NA_1
Double point information	M_DP_NA_1, M_DP_TA_1 and M_DP_TB_1
Step position information	M_ST_NA_1, M_ST_TA_1 and M_ST_TB_1
Bitstring of 32 bits	M_BO_NA_1, M_BO_TA_1 and M_BO_TB_1 (if defined for a specific project)
Measured value, normalized value	M_ME_NA_1, M_ME_TA_1, M_ME_ND_1 and M_ME_TD_1
Measured value, scaled value	M_ME_NB_1, M_ME_TB_1 and M_ME_TE_1
Measured value, short floating-point number	M_ME_NC_1, M_ME_TC_1 and M_ME_TF_1

General interrogation

(System or station-specific parameter)

- ● Global
- ● Group 1
- ● Group 2
- ● Group 3
- ● Group 4
- ● Group 5
- ● Group 6
- ● Group 7
- ● Group 8
- ● Group 9
- ● Group 10
- ● Group 11
- ● Group 12
- ● Group 13
- ● Group 14
- ● Group 15
- ● Group 16

Information Object Addresses assigned to each group must be shown in a separate table

Counter General interrogation

(System or station specific parameter)

- ● Global
- ● Group 1
- ● Group 2
- ● Group 3
- ● Group 4

Clock synchronisation

(Station specific parameter)

- ● Clock synchronisation

Command transmission

(Object specific parameter)

- ● Direct command transmission
- ● Direct set point command transmission
- ● Select and execute command
- ● Select and execute set point command
- ● C-SE ACTTERM used

- ● No additional definition
- ❍ Short pulse duration (duration determined by a system parameter in the outstation)
- ❍ Long pulse duration (duration determined by a system parameter in the outstation)
- ❍ Persistent output

Transmission of integrated totals

(Station or object-specific parameter)

- ● Mode A: local freeze with spontaneous.
- ❍ Mode B: local freeze with counter.
- ● Mode C: freeze and transmit by counter interrogation.
- ❍ Mode D: freeze by counter interrogation command, frozen values reported.
- ● Counter read
- ● Counter freeze without reset
- ● Counter freeze with reset
- ● Counter reset
- ● General request counter
- ● Request counter group 1
- ● Request counter group 2
- ● Request counter group 3
- ● Request counter group 4

Parameter loading

(Object-specific parameter)

- ❍ Threshold value
- ❍ Smoothing factor
- ❍ Low limit for transmission of measured value
- ❍ High limit for transmission of measured value

Parameter activation

(Object-specific parameter)

- ❍ Act/Desactivation of persistent cyclic or periodic transmission of the addressed object

Test procedure

(Station-specific parameter)

- ● Test procedure

File transfer

(Station-specific parameter)

File transfer in monitor direction

- ● Transparent file
- ❍ Transmission of disturbance data of protection equipment
- ● Transmission of sequences of events
- ❍ Transmission of sequences of recorded analogue values

Only in PC-hosted gateway

File transfer in control direction

- ● Transparent file

Background scan

(Station-specific parameter)

- ● Background scan

Acquisition of transmission delay

(Station-specific parameter)

- ❍ Acquisition of transmission delay

Management events priorities

(Station-specific parameter)

- ❍ Digital Inputs, Step-position, Analogues Inputs and Integrated Totals, management events priorities.

Definition of time outs

Parameter	Default value	Remarks	Selected value
t0	30s	Time out of connection establishment	configurable
t1	15s	Time out of send or test APDUs	configurable
t2	10s	Time out for acknowledges in case of no data messages t2 < t1	configurable
t3	20s	Time out for sending test frames in case of a long idle state	configurable

Maximum range of values for all time outs: 1 to 255 s, accuracy 1 s

Maximum number of outstanding I format APDUs k and latest acknowledge

Parameter	Default value	Remarks	Selected value
K	12 APDUs	Maximum difference receive sequence number to send state variable	configurable
W	8 APDUs	Latest acknowledge after receiving w I-format APDUs	configurable

Maximum range of values k: 1 to 255 APDUs, accuracy 1 APDU

Maximum range of values w: 1 to 255 APDUs, accuracy 1 APDU (Recommendation: w should not exceed 2/3 of k).

Portnumber

Parameter	Value	Remarks
Portnumber	2404	In all cases, but configurable in Registry (only for Gateway PC)

RFC 2200 suite

RFC 2200 is an official Internet Standard which describes the state of standardization of protocols used in the Internet as determined by the Internet Architecture Board (IAB). It offers a broad spectrum of actual standards used in the Internet. The suitable selection of documents from RFC 2200 defined in this standard for given projects has to be chosen by the user of this standard.

- ● Ethernet 802.3
- ❍ Serial X.21 interface
- ❍ Other selection from RFC 2200

4.4.8 FRAME EXAMPLE

Binary counter reading
BCR:= CP40{Counter reading, Sequence notation}
Counter reading:= I32[1..32]<–231..+231–1> (Type 2.1)
Sequence notation:= CP8{SQ,CY,CA,IV}

bit		description	type	value
0…4	SQ	SeQuence number	UI5[33..37]<0..31> (Type 1.1)	
5	CY	CarrY (counter overflow occurs when the value increments from +231–1 to zero or from –231 to zero)	BS1[38]<0..1> (Type 6)	<0>:= no counter overflow occurred in the corresponding integration period
				<1>:= counter overflow occurred in the corresponding integration period
6	CA	Counter Adjustment (the counter is considered to have been adjusted if it is initialized to some value, e.g. set to zero or another value at startup).	BS1[39]<0..1> (Type 6)	<0>:= counter was not adjusted since last reading
				<1>:= counter was adjusted since last reading
7	IV	invalid	BS1[40]<0..1> (Type 6)	<0>:= counter reading is valid
				<1>:= counter reading is invalid

Example: Adjusted, valid => 0x40

Note: CA, CY and IV are only modified when the value is determined. This may be in response to a counter interrogation command or in response to an automatic internal function that performs the counter freeze or freeze and reset command.

4.5 SLAVE MODBUS (MODICON) PROFILE

The purpose of this chapter is to describe the support of the MODBUS RTU protocol in the DS Agile system.

The MODBUS RTU protocol defines a message structure that controllers will recognise and use. It describes the process a controller uses to request access to another device, how it will respond to requests from other devices, and how errors will be detected.

4.5.1 INTRODUCING MODBUS

Controllers communicate using a master-slave scheme, in which only the master (called SCADA) can initiate requests. The MODBUS gateway is a slave device that responds by supplying the requested data to the master.

Transmission mode used is the MODBUS RTU. Queries and replies have the same format on a master-slave query-response cycle:

Query message from Server		Response message from Slave
Function code		Function code
Eight-bit Data bytes		Eight-bit data bytes
Error check		Error check

4.5.1.1 DEVICE ADDRESS FIELD

The device address field of a message frame contains eight bits. Valid slave device addresses in queries are in the range 0 – 247, but individual slave devices are assigned addresses in the range 1- 247 and address 0 is reserved for broadcast operations.

The device address field of a message frame always identifies a slave (slave destination in master to slave queries and slave source in slave to master responses).

If the gateway receives a frame with a broadcast device address, no reply is returned.

If the gateway receives a frame with a not expected device address, no reply is returned.

4.5.1.2 FUNCTION CODE FIELD

The function code field of a message frame contains eight bits. Valid codes are in the range 1-255.

In master to slave queries, the function code identifies the operation that is to be executed by the slave.

In slave to master responses, the function code is used to indicate either a normal (error-free) response or a failure of the operation execution (called an exception response). For a normal response, the slave simply echoes the original function code. For an exception response, the slave returns a code that is equivalent to the original function code with its MSB set to 1. In addition to the modification of the function code the slave places a unique code into the data field of the response message, which identifies the reason for the exception.

4.5.1.3 DATA FIELD

The data field of a message frame is constructed using sets of two hexadecimal digits, in the range 00h to FFh.

In master to slave queries, the data field contains additional information to be used by the slave to execute the operation defined by the function code.

In slave to master responses, the data field contains the data requested by the master.

The data field can be non-existent in some kind of messages.

4.5.1.4 ERROR CHECK FIELD

The error-checking field contains a 16-bit value implemented as two 8-bit bytes [low significant byte first]. The error check value is the result of a Cyclical Redundancy Check [CRC] calculation performed on the message contents.

The gateway does not reply to corrupted data messages, i.e when the CRC is not correct or when parity is not correct.

4.5.2 SLAVE RESPONSES

4.5.2.1 WHEN THE SLAVE ANSWERS

Except for broadcast messages (no response in this case), when a master device sends a query to a slave device it expects a normal response.

One of four possible events can occur from the master's query:

- If the slave device receives the query without communication error, and can handle the query normally, it returns a normal response.
- If the slave does not receive the query due to a communication error, no response is returned. The master program will process a timeout condition for query.
- If the slave receives the query, but detect a communication error [bad CRC or framing error for example], no response is returned. The master program will process a timeout condition for query.
- If the slave device receives the query without communication error, but cannot handle it, the salve will return an exception response informing the master of the nature of the error.

4.5.2.2 EXCEPTION RESPONSES CODES

The exception code is sent as an 8-bit data, the range of valid codes is 1-8 in the protocol.

Supported exception responses codes are:

Code	Name	Meaning
01	ILLEGAL FUNCTION	The function code received in the query is not an allowable action for the slave. An illegal function will be sent in the main following cases: An unsupported request [see after, the table with the functions supported] An unsupported sub-function code for Diagnostic request
02	ILLEGAL DATA ADDRESS	The data address received in the query is not an allowable address for the slave. An illegal data address will be sent in the main following cases: A read coil / input status starting to a none existent point in configuration A read holding registers / input registers starting to a none existent point in configuration A force coil / multiple coils request starting on a non-configured address. A preset single / multiple register(s) on a non-configured point
03	ILLEGAL DATA VALUE	A value contained in the query data field is not an allowable value for the slave. An illegal data value exception will be sent in the main following cases: An illegal value received in force coils request (so value different from FF00h and 0000h) Illegal count value for multiple pre-set registers
04	SLAVE DEVICE FAILURE	Not used in the gateway
05	ACKNOWLEDGE	Not used in the gateway
06	SLAVE DEVICE BUSY	Not used in the gateway
07	NEGATIVE ACKNOWLEDGE	The slave cannot perform the program function received in the query. A negative acknowledge will be send in the main following cases: Some errors in the frame A read coil / input status on more than 2000 points Force coil refused if command is incorrect or cannot be executed (equipment absent, invalid, in local, …)
08	MEMORY PARITY ERROR	Not used in the gateway

4.5.3 SERIAL TRANSMISSION MODE

When messages are transmitted on standard MODBUS serial networks, each byte is sent LSB first.

The format for each byte in MODBUS RTU mode is:

- Coding system: 8-bit binary, hexadecimal 0-9, A-F
  Two hexadecimal characters contained in each 8-bit field of the message
- Bits per Byte: 1 start bit8 data bits,
  LSB sent first2 stop bits if no parity, or 1 parity bit and 1 stop bit)
- Error Check Field: Cyclical Redundancy Check (CRC-16)

4.5.4 MODBUS FUNCTIONS

MODBUS defines 24 functions; valid codes are in the range of 1-24.

4.5.4.1 SUPPORTED FUNCTIONS

Code	Function name	Supported
01	READ COIL STATUS [identical to function code 02]	YES
02	READ INPUT STATUS [identical to function code 01]	YES
03	READ HOLDING REGISTERS [identical to function code 04]	YES
04	READ INPUT REGISTERS [identical to function code 03]	YES
05	FORCE SINGLE COIL	YES
06	PRESET SINGLE REGISTER	YES
07	READ EXCEPTION STATUS	YES
08	DIAGNOSTICS [only sub function 0 is supported]	YES
09	PROGRAM 484	NO
10	POLL 484	NO
11	FETCH COMM. EVENT CTR.	NO
12	FETCH COMM. EVENT LOG	NO
13	PROGRAM CONTROLLER	NO
14	POLL CONTROLLER	NO
15	FORCE MULTIPLE COILS [identical to function code 05, one point only]	YES
16	PRESET MULTIPLE REGISTERS [identical to function code 06, one point only]	YES
17	REPORT SLAVE ID	NO
18	PROGRAM 884/M84	NO
19	RESET COMM. LINK	NO
20	READ GENERAL REFERENCE	NO
21	WRITE GENERAL REFERENCE	NO
22	MASK WRITE 4X REGISTER	NO
23	READ/WRITE 4X REGISTERS	NO
24	READ FIFO QUEUE	NO

4.5.4.2 GENERAL FORMAT OF MODBUS FUNCTIONS

A query message typically contains some of the following 8-bit fields:

- Starting Address Hi
- Starting Address Lo
- No. of Registers / Points Hi
- No. of Registers / Points Lo
- Force / Preset Data Hi
- Force / Preset Data Lo

A response message typically contains some of the following fields:

- Byte Count *
- Data
- Data Hi
- Data Lo
- No. of Registers / Points Hi
- No. of Registers / Points Lo
- Force / Preset Data Hi
- Force / Preset Data Lo

(*) Byte Count Field:A Byte Count Field is used in slave responses to indicate the number of 8-bit bytes in the Data field; the value is exclusive of all other field contents, including the Byte Count field.

4.5.4.3 MODBUS DATA ADDRESSES

Point addresses in the data field are 16-bit values in the range 0 – 65535 for each item type.

That's means that you can have a coil item configured at address 100 for example, and a holding register item configured at address 100 too.

Starting addresses in queries from SCADA may begin from address 0.

Example: request to read the 16 first coils on device 17.

Slave address	11
Function	01
Starting Address HI	00
Starting address LO	00
Number of points HI	00
Number of points LO	10
CRC	XX

4.5.5 FUNCTION 01 / 02: READ COIL STATUS – READ INPUT STATUS

The request function 01 or 02 reads the ON / OFF status of digital inputs in the slave. These statuses may be any digital points (physical, automations, system information, grouping, …).

These two functions are the only way to read digital points with the MODBUS protocol. Sequence of events, digital flags (validity, topical..) are not supported.

This is equal using the Read Coil Status request or the Read Input Status request.

Broadcast is not supported.

Addresses in frames may start from 0…65535.

Query:

Slave Address	Function Code = 01	Starting Address (H)	Starting Address (L)	No. of Points (H)	No. of Points (L)	CRC (L)	CRC (H)

The query message specifies the starting coil address and the quantity of coils to be read.

Response:

Slave Address	Function Code = 01	Byte Count = <nbytes>	Data Byte #1	Data Byte #i	Data Byte #nbytes	CRC (L)	CRC (H)

The coil or status in the response message is packed as one coil per bit of the data field.

Digital inputs can be single (coded on one bit) or double (in this case 1 or 2 bits defined in configuration).

For Single DI or Double DI coded on one bit, status is indicated as: 1 = ON, 0 = OFF.

For double DI coded on two bits, status indicates: [open contact, closed contact] = [0,1] for open, [1,0] for closed, [0,0] for jammed], [1,1] for the other states

The less significant bit of the first data byte contains the coil addressed in the query. The other coils follow toward the high order end of this byte, and from 'low order to high order' in subsequent bytes, as described in the frame example.

Important notes:

- If the returned coil quantity is not a multiple of eight, the remaining bits in the final byte will be padded with zeros (toward the high order end of the byte). The Byte Count Field specifies the quantity of complete bytes of data.
  For easiest understanding between the gateway and the SCADA, it is recommended to read a number of points which is a multiple of 8.
- If the starting address is not a point in configuration, the message will be not be accepted, and an error exception 2 will be returned.
- If the starting address is in configuration and if there are some “holes” (addresses not in configuration) theses holes will be padded with 0 (i.e value OFF).

4.5.6
4.5.6

4.5.6 FUNCTION 03 / 04: READ HOLDING REGISTERS / INPUT REGISTERS

The request function 03 or 04 reads the values of analogue inputs, tap position and counters values in the slave.

In case of tap position and counters values, only natural coding is supported.

These two functions are the only way to read registers points with the MODBUS protocol. Flags (validity, topical..) are not supported in the MODBUS protocol base.

This is equal using the Read Holding Registers request or the Read Input Registers request.

Broadcast is not supported.

Addresses in frames may start from 0…65535.

Query:

Slave Address	Function Code = 03	Starting Address (H)	Starting Address (L)	No. of Points (H)	No. of Points (L)	CRC (L)	CRC (H)

The query message specifies the starting register and the quantity of registers to be read.

Response:

Slave address	Function code = 03	Byte Count = <nbytes>	Data (H) #1	Data (L) #1	Data (H) #i	Data (L) #i	Data (H) #nbytes/ 2	Data (L) #nbytes/2	CRC (L)	CRC (H)

The register data in the response message are packed as two bytes per register, with the binary contents right justified within each byte. For each register, the first byte contains the high order bits and the second contains the low order bits.

Important notes:

- If the starting address is not a point in configuration, the message will be not be accepted, and an error exception 2 will be returned.
- If the starting address is in configuration and if there is some “holes” (addresses not in configuration) theses holes will be padded with the value 0

4.5.6.1 SIGNED NORMALISED CODING

The signed normalised coding is used to encode the 16 bits-registers. Analogue maximal value will be coded 7FFFh (decimal value + 32767), and minimal value will be coded 8000h (decimal value –32768).

For this mode, the gateway may now code the value on 8 to 16 bits [low part of the register will be used]. But, 16 bits is normally the standard to use the full-scale conversion.

Example:

in configuration the maximal value for an analogue point is +3000 and minimum value for this analogue is 0.

That means that when the analogue is received with value 0 from the system, the gateway will send to the SCADA the register with 8000h value. If this analogue is equal to the maximal value +3000, the value sent to the SCADA is 7FFFh. Calculation is linear for the coding between the min and max values.

4.5.6.2 UNSIGNED NORMALISED CODING

The unsigned normalised coding is used to encode the 16 bits-registers. Analogue maximal value will be coded FFFFh (decimal value + 65535), and minimal value will be coded 0000h (decimal value 0).

For this mode, the gateway may now code the value on 8 to 16 bits [low part of the register will be used]. But, 16 bits is normally the standard to use the full-scale conversion.

Example:

in configuration the maximal value for an analogue point is +3000 and minimum value for this analogue is 0.

That means that when the analogue is received with value 0 from the system, the gateway will send to the SCADA the register with 0h value. If this analogue is equal to the maximal value +3000, the value sent to the SCADA is FFFFh. Calculation is linear for the coding between the min and max values.

4.5.6.3 NATURAL CODING

The natural coding is used to encode data without any calculation. That's means that integer value will be send.

Example:

if the gateway receives the value 10.xxxx, the value 0Ah will be set in the appropriate register. The gateway receives the value –10,xxxx the value FFF6h will be coded. Sent values are considered as signed values which are included between –32768 and +32767.

When minimum and maximum values are reached values FFF6h and FFFFh are respectively sent.

4.5.7 FUNCTION 05: FORCE SINGLE COIL

This request function 05 is used to realise a control on an address point.

When broadcast, the function forces the same coil reference in all attached slaves.

Query:

Slave Address	Function Code = 05	Point Address (H)	Point Address (L)	Force Data (H)	Force Data (L)	CRC (L)	CRC (H)

The query message specifies the coil reference to be forced. Points addresses are between 0…65535. The requested ON / OFF state is specified by a constant in the query data field.

A value of FF00h requests the coil to be ON.

A value of 0000h requests it to be OFF.

Response:

Slave Address	Function Code = 05	Point Address (H)	Point Address (L)	Force Data (H)	Force Data (L)	CRC (L)	CRC (H)

The normal response is an echo of the query, returned after the command has been sent to the system.

Note:
If value is incorrect, or if the control is refused for any reason (equipment missing, equipment present and in local mode, equipment invalid, …) an exception error 7 is returned.

4.5.8 FUNCTION 06: PRESET SINGLE REGISTER

This request function 06 is used to preset a value in a register.

Query:

Slave Address	Function Code = 06	Point Address (H)	Point Address (L)	Force Data (H)	Force Data (L)	CRC (L)	CRC (H)

The query message specifies the register address to be preset. Points addresses are between 0…65535. The requested value is specified by in the query data field.

Response:

Slave Address	Function Code = 06	Point Address (H)	Point Address (L)	Force Data (H)	Force Data (L)	CRC (L)	CRC (H)

The normal response is an echo of the query, returned after the register has been preset.

Note:
Only natural setpoints are managed by this function (no scaling is done)

4.5.9 FUNCTION 08: DIAGNOSTIC [SUB-FUNCTION 0 ONLY]

This request function 08 sub-function 0 is used to test the transmission.

Query:

Slave Address	Function Code = 08	Sub Function code (H)	Sub Function code (L)	Data (H)	Data (L)	CRC (L)	CRC (H)

The query message specifies the data that will be echoed.

Response:

Slave Address	Function Code = 08	Sub Function code (H)	Sub Function code (L)	Echoed Data (H)	Echoed Data (L)	CRC (L)	CRC (H)

The normal response is an echo of the query with the same data send in the request.

Note:
If the sub-function is different from 0, an exception error "illegal function" is returned.

4.5.10 FUNCTION 15: FORCE MULTIPLE COILS

Normally, this request function 15 is used to realise a control on several contiguous addresses.

This function can be used, but only one control can be sent at the same time.

Note:
Only a count number equal to 1 is allowed, otherwise an exception error 3 will be replied.

4.5.11 FUNCTION 16: PRESET MULTIPLE REGISTERS

Normally, this request function 16 is used to preset on several contiguous addresses.

This function can be used, but only one preset can be send at the same time.

Note:
Only a count number equal to 1 is allowed, otherwise an exception error 3 will be replied.

5 COMMUNICATIONS WITH LEGACY IEDS

5.1 OVERVIEW

Different types of IEDs are connected to a C264 through networks using various legacy protocols:

- Modbus (Serial and TCP/IP network protocol),
- IEC 60870-5-103 (T103) serial protocol for protection data acquisition
- IEC 60870-5-101 (T101)

All these networks use a serial link to communicate with IEDs. As there are several serial links on a C26x, It is possible to have:

- Different protocols running in parallel on different links
- The same protocol on several links

The C26x is the Master. So, there are two kinds of exchange:

- **Request / reply**: Master emits a request to a slave of its choice and wait for the response. Between master and slave, only one transaction can be initiated. Then, in order to transmit the same request to two different slaves, two transactions are required.
- **Broadcast / no reply**: Master transmits a command to all of slaves connected to the network. They perform it without send any response.

Common features to all IEDs and all protocols are specified below.

Specific features to each protocol are specified in subsequent paragraphs.

5.2 IED COMMON FUNCTIONALITY

5.2.1 INTERFACE TO IEDS

5.2.1.1 INPUT

Data	Note
Digital input	Treated
Measurement	Treated
Default position	Depending on the protocol
Counter	Treated
Tap position	Treated
Control acknowledgement	Treated
Setpoint acknowledgement	Treated
Alarm	Not Treated
Disturbance record	Depending on the protocol

5.2.1.2 OUTPUT

Data	Note
Control	Treated
Setpoint	Depending on the protocol
Alarm acknowledgement	Not Treated
Time synchronisation	Treated

5.2.2 BEHAVIOUR

5.2.2.1 NETWORK SUPERVISION

The number of networks and IEDs is known by configuration.

Each network is managed independently of the other networks.

The management of a network consists of:

- Initialising the serial line
  At start-up of the network monitoring, the serial line has to be initialised according to the configuration.
- Synchronising the IEDs connected to the network.
- Polling the IEDs
  This polling allows to connect IEDs, to exchange data with IEDs and to monitor the connection of IEDs.
- Performing the monitoring of the each IED connected to this network.
  Each IED is managed independently of the other IEDs. The state of each IED, i.e. connected, disconnected, is monitored and every state change is signalled to the C26x management function.

5.2.2.2 TIME SYNCHRONISATION

If the network has to be synchronised, the synchronisation is performed in one of two ways:

1 At connection of an IED, a synchronisation frame is sent to this IED.

2 Regularly, a synchronisation frame is broadcasted on the network.

When this is supported by the IEDs, the calculation of the transmission delay is performed.

Note:
The synchronisation is a network attribute [not an IED attribute]. That means, that the synchronisation is either sent to all the IEDs or is not sent.

5.2.2.3 POLLING OF IEDS

Once the line is initialised, the C26x has to try to connect IEDs and to manage exchanges of data with each IEDs.

That's done by polling: cyclically the C26x questions each IED one after the other.

The polling manages the following items:

- Sequencing the interrogation of the IEDs
- Connection of an IED [when a disconnected IED responds, it becomes Connected]
- Repetitions [if an IED does not reply to a request, this request will be repeated the next cycle]
- Disconnection of an IED [after N questions without answer, an IED becomes Disconnected]
- Maximum time to wait for a response
- Minimum time between two frames on the network
- Sending functional requests to IEDs

Optimisation of polling may be done according to the following ideas:

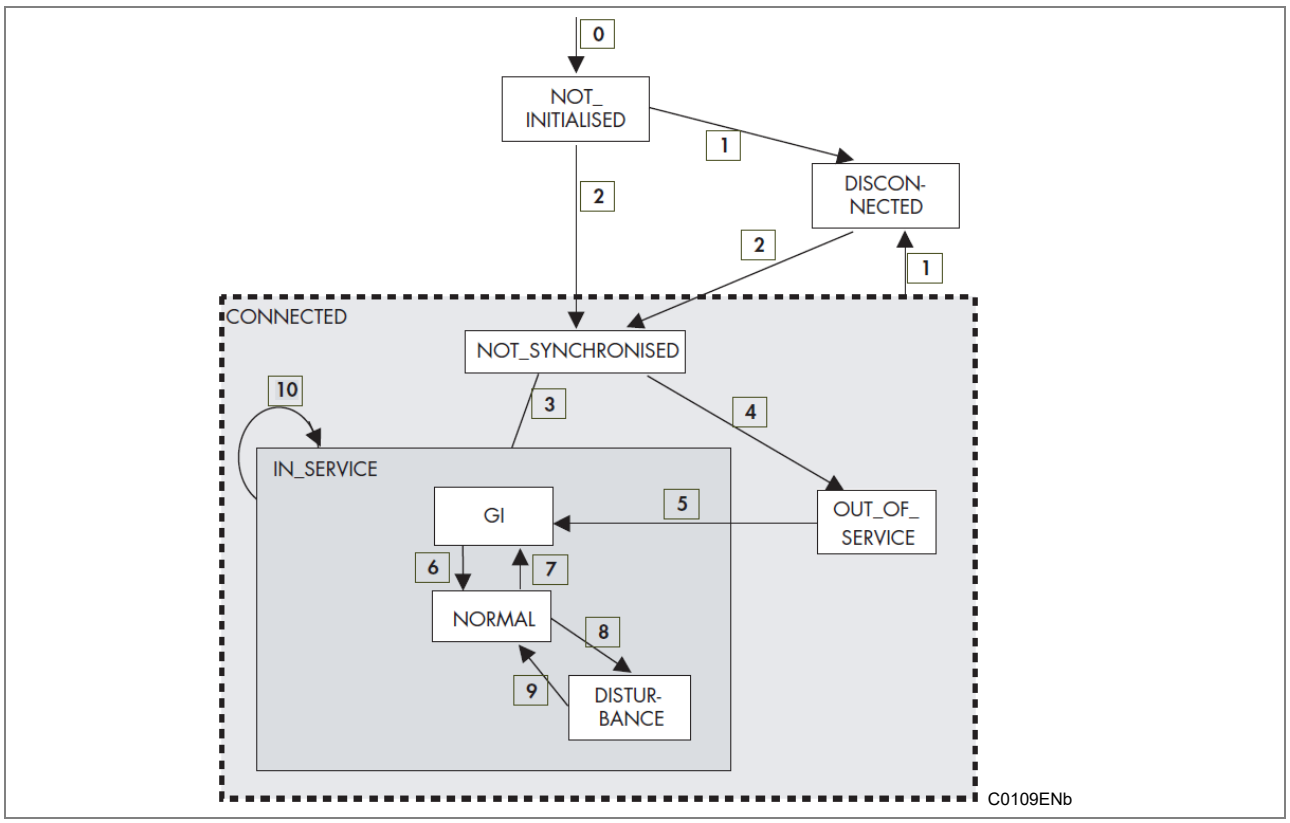
- When an IED is disconnected, it may be questioned only time to time [not all cycles]
- When an IED has important data to transmit [DI], it may be questioned successively several times
- The maximum time to wait an answer may be configurable

The polling sequencing may be only stopped in the two following cases:

- Time synchronisation
  Synchronisation is done periodically by sending a broadcast frame. After the synchronisation frame has been sent, the polling starts again.
- Remote control to transmit to a slave
  Control is a priority request. So, when a control must be sent to an IED, the polling is stopped, the control is sent, and the polling starts again.

5.2.2.4 MONITORING OF AN IED

Each IED is managed according to the following graph:



Description of the possible states of an IED:

- NOT_INITIALISED: That's the initial state of an IED. The C26x polls the IED every cycle in order to connect it.
  If the IED responds, it becomes CONNECTED [2].
  If after some attempts the IED does not respond, it becomes DISCONNECTED [1].
- DISCONNECTED: The IED is disconnected. The C26x polls the IED time to time in order to connect it.

  If the IED responds, it becomes CONNECTED [2].
- CONNECTED: The IED is connected. This state includes several states. When an IED becomes Connected, it goes to the NOT_SYNCHRONISED state.
- NOT_SYNCHRONISED: The IED has just became Connected. It must be synchronised. Once it is synchronised, according to the information given by the IED, it becomes IN_SERVICE [3] or OUT_OF_SERVICE [4]. (This information is not available for some protocols. In this case, the IED becomes IN_SERVICE by default).
- OUT_OF_SERVICE: The IED is connected and says it is Out of service. The C26x polls the IED time to time waiting for the IED to become IN_SERVICE [5].
- IN_SERVICE: The IED is connected and it says it is In Service. This state includes several states. When an IED becomes In Service, it goes to the GI state.
- GI: The IED is In Service and a General Interrogation is in process.
  For each information received during the GI, the information becomes available and its state is

transmitted to the application [see below for more information on GI treatment].
At the end of the GI, the IED goes in the NORMAL state [6].

- NORMAL: The IED is In Service and the monitoring of DI, AO and DO are performed.
  If a disturbance record becomes present and the C26x have enough places to store the file, the IED goes in the DISTURBANCE state [8].
  Time to Time, a GI may be done. In this case the IED goes in the GI state [7].
- DISTURBANCE: The IED is In Service and a disturbance record is being uploaded.
  When the uploading of the disturbance file is finished, the IED goes back in the NORMAL state [9].

That shows that GI and Disturbance uploading are mutually exclusive. That is done to limit the overload of the network

Description of the transitions between states:

- [0]: Initialisation of the transmission.
- [1]: The IED becomes DISCONNECTED.
  The disconnection is signalled to the application.
  Every data normally received from the IED is marked as unknown and a state change is signalled for each one.
- [2]: The IED becomes CONNECTED.
  A synchronisation frame is sent to it and after, the status of the IED is red.
- [3]: The status of the IED indicates that the IED is In Service.
  A General Interrogation is activated.
- [4]: The status of the IED indicates the IED is Out Of Service.
- [5]: see [3]
- [6]: The general Interrogation is finished.
- [7]: A general Interrogation is activated [cyclical GI].
- [8]: A disturbance file is available in the IED and there is enough available space to store it in the C26x.
  A disturbance upload is initiated.
- [9]: End of disturbance file upload.
- [10]: Request to send a control command to the IED.
  Polling is interrupted and the command is sent as soon as possible.

Initialisation procedure

Initially, all data normally received from an IED is marked as unknown. When an IED is first connected, a general interrogation request is sent. A table is updated with data received in response to the general interrogation. When the general interrogation is finished, the content of the table is sent to the processing functions: binary inputs processing and measurement treatment. Messages received subsequently are checked against the content of the table and a state change message is sent when there is a difference.

General interrogation

A general interrogation is performed:

- at initialisation time,
- upon reconnection,
- cyclically [optional].

Messages received during the initial general interrogation are not sent to the processing function. Instead the content of the table is sent at the end of the sequence.

Messages received during a general interrogation performed after the initialisation sequence are immediately sent to the processing function.

Some IEDs send a message indicating the end of the response to a general interrogation. When this message is received, the sequence is considered as complete. If the IED does not send this message, the C26x must check that all of the data is received.

If not all of the data is received within a given time another request is sent. This process can be repeated N times. If the response is still not received after N times a fault message is sent, however the IED is still polled.

Disturbance File Management

The following rules apply for the management of the Disturbance Files of the IED:

- For each IED, there is a parameter in the configuration indicating whether disturbance files should be automatically downloaded. This parameter may be overruled by a command from the application.
- When the C26x detects that an IED has a Disturbance File ready for download and that automatic download is enabled, it downloads and stores it. When the download is complete, an indication is sent to the Upper level transmission management task to inform it that a Disturbance file is ready for upload.
- When there is not enough available space to store a Disturbance File, the oldest file is overwritten.
- Only Disturbance files stored in the C26x can be transmitted to the upper level. Once a file has been uploaded, it is deleted.

Note:
IED disturbance files are stored in volatile memory (in the "/RAMDEV/PERT_IED/" folder) and are deleted whenever the C26x is powered off or rebooted.

5.2.3 DATA RECEIVED FROM IEDS

After the initialisation sequence, IEDs are polled regularly. Depending on the type of IED the current state of data can be received as state messages, or as state change messages.

When a state message is received, the content is checked against the table and if there is a difference a message is sent to processing functions and the table is updated. In this case, the C26x time stamps the change.

When a state change message is received, the table is updated, and the message is transmitted to processing functions. In this case, the time stamping is made by the IED.

The data, which can be received from IEDs, are detailed in the paragraphs below.

5.2.3.1 DIGITAL INPUTS

Digital inputs can be received as states or as state changes. The choice between state and state change depends on the IED and on the protocol. This is known by configuration.

Even if digital inputs are received as state change, it is still possible to request data as states for general interrogations.

The conversion from digital input to binary input is performed by the binary input processing function. A digital input can be associated with a single point or a double point.

5.2.3.2 MEASUREMENTS

Measurements can be received in various formats: float, binary, BCD, etc. The received value is converted into an internal format, which is common to all measurements in the C26x.

Measurements can be received as periodical messages or as state changes: variation, threshold, and invalidity.

A message is sent to the processing function whenever a measurement is received from an IED.

5.2.3.3 TAP POSITION

Tap position are treated like measurements

5.2.3.4 DISTURBANCE FILE

The C26x stores disturbance files as they are sent by IEDs without control of the format of the Disturbance Files (Comtrade, …).

5.2.4 DATA SENT TO IEDS

After the initialisation sequence, data can be sent to IEDs. The type of data, which can be sent to IEDs, is described in subsequent paragraphs.

5.2.4.1 CONTROLS

Controls are priority message. The polling sequence must be interrupted in order to send the control as soon as possible.

Not all IEDs send control acknowledgement. If they do not, an acknowledgement is simulated and sent to the handling of control sequences function.

When an IED is disconnected [or out of service] a negative acknowledgement is sent.

If the command is a “select before operate” command, the application must send two commands to the transmission software: the first one for the selection and the second for the execution.

If the command is a double command, the application sends one order, and depending on the protocol, two cases have to be distinguished:

- The Double command is referenced only once in the IED Mapping. In this case, if an OPEN (respectively CLOSE) command is received from the application, the master sends an OFF (respectively ON) order to the IED at the corresponding address.
- The double command is referenced by two addresses in the IED Mapping: one refers to the Open Contact and the other to the Close Contact. In this case, if an OPEN (respectively CLOSE) command is received from the application, the master sends an ON order to the IED, at the address corresponding to the Open Contact (respectively Close Contact).

5.2.4.2 SETPOINTS

SP controls are priority message. The polling sequence must be interrupted in order to send the SP control as soon as possible.

Not all IEDs send SP control acknowledgement. If they do not, an acknowledgement is simulated and sent to the handling of SP control sequences function.

When an IED is disconnected [or out of service] a negative acknowledgement is sent.

If the SP commands are always "direct execute" command (no “select before operate”).

For an IED, only one SP command is possible at a time.

5.3 MODBUS COMMUNICATIONS

5.3.1 SCOPE OF THIS SECTION

MODBUS is a legacy bus master/slave protocol that is used by many devices such as relays, controllers or monitoring devices. The aim of this section is not to describe the protocol itself and its mechanisms, but to describe the functions implemented in the C26x:

- available function numbers
- the way in which each type of data is internally or externally updated
- general mechanisms used for the synchronisation

The protocol is implemented in various ways:

- Generic: this implementation allows connecting most types of IED to a MODBUS network
- Legacy: this implementation is based on the legacy rules (M300, Px2x series, Px4x series)
- Particular IEDs: M230, Rish Pro M10, ABB-Flexgate, Sepam 40 and 80, WAGO

5.3.2 POLLING CYCLES

IEDs' measured values:

The time interval between general interrogations is of at least 1 second. It could be longer if the number of polled IEDs is such that polling takes more than 1 s.

Datapoint values:

The time interval between general interrogations is of at least 200 ms. It could be longer if the number of polled datapoints is such that polling takes more than 200 ms.

5.3.3 GENERIC MODBUS COMMUNICATIONS

The generic communications function is the common base to most IEDs. The following MODBUS functions are implemented in the C26x:

Function No.	Sub-code	Used to	Details
1 – 2	/	Read DIs	Read N bits
3 – 4	/	Read AIs /DIs	Read N words
5	/	Write DO	Write 1 bit
15	/	Write DOs	Write N bits Restriction: write DOs after one another
7	/	Poll status	Read status byte Used to detect a DI state change
8	0	Poll presence	Echo Alternative to detect if a device is connected or not

The disturbance files are not treated. Function 7 cannot be used fully or at all with a number of IEDs (e.g.Rish Pro M10, Flexgate); they require a specific treatment.

5.3.3.1 POLLING AND CONNECTION TEST

All the slaves are polled after one another. This means that the C26x waits for the answer to each polling request sent to a device before sending a new request to the same or another device.

There are 2 types of polling:

- the polling for the measurements and the digital inputs (functions 1 to 4) or the byte status (function 7)
- the polling for IEDs presence (low level polling)

If an IED does not correctly answer after a user-configurable timeout, the C26x repeats the request.

If the IED does not correctly answer after a defined number of retries, it is considered as disconnected. This status is updated by low-frequency polling.

Depending on configuration, the C26x tests the connections with:

- function 7
- functions 1 to 4 (DIs)
- functions 3 to 4 (AIs)
- function 8 (mirror frame)

or uses a user-defined frame.

5.3.3.2 DATA RECEIVED FROM IEDS

5.3.3.2.1 AIs

The C26x polls the AIs at a defined frequency.

A block of measurements is a set of measurements mapped at consecutive addresses. As a result, all of them are read in one exchange.

The C26x supports 18 formats of Analogue Inputs:

<table>
<tr><th>Format</th><th>Description</th><th>Comment</th></tr>
<tr><td>INT8_LB</td><td rowspan="2">Signed integer on 8 bits</td><td rowspan="4">Modbus does not provide a ‘Read byte’ function. So, a ‘Read word’ function is used.
LB and HB indicate which byte in the word is used (resp., Low/High)</td></tr>
<tr><td>INT8_HB</td></tr>
<tr><td>UINT8_LB</td><td rowspan="2">Unsigned integer on 8 bits</td></tr>
<tr><td>UINT8_HB</td></tr>
<tr><td>INT16</td><td colspan="2">Signed integer on 16 bits</td></tr>
<tr><td>UINT16</td><td colspan="2">Unsigned integer on 16 bits</td></tr>
<tr><td>INT32_LW_LB</td><td rowspan="4">Signed integer on 32 bits</td><td rowspan="12">The first pair of letters indicates which word is sent first: the lower word (LW) or the higher word (HW).
The second pair of letters indicates which byte is sent first in a word: the lower byte (LB) or the higher byte.</td></tr>
<tr><td>INT32_LW_HB</td></tr>
<tr><td>INT32_HW_LB</td></tr>
<tr><td>INT32_HW_HB</td></tr>
<tr><td>UINT32_LW_LB</td><td rowspan="4">Unsigned integer on 32 bits</td></tr>
<tr><td>UINT32_LW_HB</td></tr>
<tr><td>UINT32_HW_LB</td></tr>
<tr><td>UINT32_HW_HB</td></tr>
<tr><td>REAL32_LW_LB</td><td rowspan="4">Float IEEE754 on 32 bits</td></tr>
<tr><td>REAL32_LW_HB</td></tr>
<tr><td>REAL32_HW_LB</td></tr>
<tr><td>REAL32_HW_HB</td></tr>
</table>

5.3.3.2.2 DIs

A block of DIs is a set of DIs mapped to consecutive addresses. As a result, all of them are read in one exchange.

By default, the function 1-2 polls for DI blocks. the C26x compares each DI state with the latest state and time stamps the potential state change.

5.3.3.3 DATA SENT TO IEDS

5.3.3.3.1 Connection check

Generic IEDs

Each device on the network is regularly polled with a specific frame to know if it is connected or not. This frame could be the status byte polling frame if it exists, the measurement polling frame if it exists, the BI polling frame if it exists, the mirror frame if it has been implemented in the device or a user defined frame. This choice is performed through the configuration options.

IEDs

The “Read status byte” frame is used for checking the connection of the device.

5.3.3.3.2 Clock synchronisation

All the devices connected to a given network must use the same synchronisation method (and the same address and time-date format) because the C26x synchronises them through a broadcast frame.

Synchronisation is not specified generically, and no calculation of the transmission delay is performed.

5.3.3.3.3 DOs

Commands are sent to the IED and have the highest priority level.

They have to be transmitted to the destination device as fast as possible.

The C26x waits for an acknowledgement (answer of the IED).

If the acknowledgement is not received after a defined timeout, the C26x considers that the command has not been taken into account.

5.3.3.4 ERROR MANAGEMENT

The MODBUS protocol handles a mechanism of exception answer. This means that an IED answers with an exception frame if it does not understand the request. There are different exception codes:

Exception code	Description	C26x processing
01	Illegal function	Reports a "Configuration error” and continues
02	Illegal data address	Reports a “Configuration error” message and continues
03	Illegal data value	Reports a “Configuration error” message and continues
04	Slave device failure	Reports an “IED error” message
05	IED busy due to a long processing duration	Retries after a defined time-out
06	IED busy	Retries after a defined time-out
07	Processing not possible	Reports an “IED error”
08	IED memory parity error	Reports an “IED error”

5.3.3.5 LIMITS AND SPECIFICATIONS

The specifications depend a lot on the number of devices connected on the network. It is advised to connect devices that have similar specifications on a given network, i.e. the same reply time for instance.

Each device on a MODBUS network must have the same synchronisation mode.

5.3.4 LEGACY MODBUS COMMUNICATIONS

Three ranges comply with the legacy rules:

- M300: Energy analyzer and measurement central unit
- Px2x: S20 IEDs
- Px4x: S40 IEDs

Function No.	Sub-code	Used to	Details
1 – 2	/	Read DIs	Read N bits
3 – 4	/	Read AIs /DIs	Read N words
5	/	Write DO	Write 1 bit
15	/	Write DOs	Write N bits Restriction: write DOs after one another
7	/	Poll status	Read status byte. Used to detect a DI state change and the presence of disturbance files
8	0	Poll presence	Echo Alternative to detect if a device is connected or not

5.3.4.1 STATUS BYTE

The connection is tested using the function 7.

Bit No	Description	Detail	Event generated
b0	General state of the device	1 = active, 0 = not active	Yes
b1	Presence of a minor failure (*)	1 = present / 0 = absent	Yes
b2	Presence of a not acknowledged time-stamped event	1 = present / 0 = absent	No
b3	State of synchronisation (**)	1= synchronised, 0= out of synchronisation Compatible with relays OPN7000, MODN	Yes
b4	Presence of a not extracted Disturbance record	1= present, 0 = absent Compatible with relays OPN7000, MODN	Yes on Set
b5	Presence of a not extracted Fault record	1 = present / 0 = absent	Yes on Set
b6	Trip Alarm Set	1= a trip has occurred, not acknowledged	No
b7	Alarm Set	1= at least one alarm bit in the front panel alarm cell not acknowledged	No

If a bit of this status has no significance for the equipment, this bit is fixed to 0.

Any state change generates an event. Except for b2 set/reset, b4 and b5 reset, b6 and b7 set/reset.

* indicates a device failure ("SRAM Failure"…) and generates an event.

** 0 indicates that synchronisation was not received or not understood since 1 min, according to protection criteria (by MODBUS or IRIG-B synchronism). This rule covers potential drift of 10 ms of non synchronised device. “Loss of synchronisation” has a major impact in all events treatment. All the events coming from a device that has lost its synchronisation need special treatment in substation chronological list of events. This particular event helps determine also any network disconnection in the device history.

5.3.4.1.1 Events buffer management

The IEDs store the events, Fault Records, Disturbance files in a circular buffer of various sizes.

When the C26x acknowledges an event, a FREC or Disturbance file, the IED clears the memory for future events, FREC …

When all events, FREC, DR have been cleared from buffer, the corresponding bit is reset in the status byte without generating any event.

If a device is disconnected, the buffering function saves all of history. If one of its buffers gets filled up then the IED:

- generates an event to inform that this buffer is full,
- erases the oldest event if the queue is full
- sends a saturation reset event when the buffer is not full any more.
- replaces the oldest data in the full buffer by the newest ones (event, FREC, Disturbance file).

5.3.4.1.2 M300

The bits have other meanings:

- Bit 0: Availability of a Disturbance record [0 = not available; 1= available]
- Bit 4: 0 = active; 1 = inactive
- Bit 5: 1 = Presence of Event
- Bit 6: 1 = Presence of Alarm.

5.3.4.1.3 S40 (Px4x series)

The status can be read with function 3 or 4 in register 3x00001 (@ 0).

The table below shows this 16-bit status:

Bit No	Value/bit mask	Meaning	Conform
0	0x0001	Presence Status (1 = present / 0 = mute)	OK
1	0x0002	Minor Self Test Failure (1 = Failure / 0 = No failure)	OK
2	0x0004	New event available (1 = Available / 0 = Not Available)	OK
3	0x0008	Clock synchronization (=1 after Modbus sync. Resets to 0 after 5 minutes unless it is synced again. Other time sources do not affect this bit)	OK
4	0x0010	New auto extraction disturbance record available (1 = Available / 0 = Not available)	OK
5	0x0020	Fault (Not used - always 0).	NOK
6	0x0040	Trip LED status (1 = LED on, 0 = LED off)	-
7	0x0080	Alarm status summary (logical OR of all alarm status bits)	-
8	0x0100	Unused	-
9	0x0200	Unused	-
10	0x0400	Unused	-
11	0x0800	Unused	-
12	0x1000	Unused	-
13	0x2000	Unused	-
14	0x4000	Unused	-
15	0x8000	Unused	-

Even if the access function (3 or 4 instead of 7) does not comply with the internal MODBUS rules, the events can still be managed, as far as the bits 2 and 3 are compliant with them.

5.3.4.2 DATA RECEIVED FROM IEDS

5.3.4.2.1 AIs

The formats supported by the C26x include:

- IEEE STD 754 (recommended)
- integer signed or not on 1 Byte
- integer signed or not on 2 Bytes
- integer signed or not on 4 Bytes (for energy metering precision)

It is desirable that all the AIs have the same format (type and byte number); otherwise, divide them in several groups, each with a given format.

The values must be directly usable. Single scaling (e.g. x1000) is accepted. As complex computation use boundary, scaling is forbidden for measurements.

AIs are mapped at consecutive MODBUS addresses to increase the acquisition efficiency. Or, they can be in a fundamental data area.

The transmission of the measurements in double word must start with the most significant byte, which is not a common practice:

	Bytes order			
Intel products	1	2	3	4
Motorola products	4	3	2	1
Most common (2 consecutive addresses)	2	1	4	3
Recommended transmission with MODBUS	4	3	2	1

The units of the readings must be identical throughout a range of products. If possible, stick to the list of the recommended units. The format for encoding IEEE makes unit coding easy, as it makes possible to treat at system level the large or small values without using derived units (example: tenths of Amperes, tens of Volts, MW).

Description	Units
Volts	V
Amperes	A
Kilowatt	kW
Kilo Volt Ampere	kVA
Kilo VAR	kVAR
Kilo Watt . Hour	kWh
Kilo Volt Ampere Hour	kVAh
Kilo VAR Hour	kVARh
Hertz	Hz
Celsius or centigrade Degree	°C
Mho	1/Ω
Ohms	Ω
Seconds of closing time	s
Degree of angle	Angular degree
Without unit	–

For all the quality descriptors used for the measurements or counters, split quality descriptor indication (like CP8(i+1) Info + Quality from IEC 870-5-4) from the value in separate address groups.

Some IEDs encode Valid/Invalid quality statuses with binary values. For such IED, map the AI Statuses in consecutive words.

M300

The measurements are periodically polled for. The available formats include:

	Format to configure	Comments
T1	UINT16 (5)	16 bit unsigned value: "12345" (0x3039) represents 12345
T3	UINT16 (5)	16 bit unsigned value with 2 decimals: "12345" (0x3039) represents 123,45
T8	INT16 (4)	16 bit signed value with 3 decimals: "-12345" (0xCFC6) represents -12,345
T9	UINT32_HW_HB (13)	32 bit signed value: “big Endian” *
T10	UINT32_HW_HB (13)	32 bit signed value with 2 decimals: “big Endian”*
T11	UINT32_HW_HB (13)	32 bit signed value with 3 decimals: “big Endian”*
T13	UINT32_HW_HB (13)	32 bit signed value with 5 decimals: “big Endian”*
T20	Energy: T09 for the primary values (base unit kWh),T11 for the secondary (base unit Wh)	
T21	Power: T10 for the primary values (base unit kW),T12 for the secondary values (base unit W)	
T39	Voltage: T10 for the primary values (base unit V),T11 for the secondary values (base unit V)	
T40	Current: T10 for the primary values (base unit A), T13 for the secondary values (base unit A)	
T53	Idem T1	

* the higher word is transmitted first, the higher byte in the word is transmitted first

These formats do not take into account the multiplying factor. Moreover, the next table gives a non exhaustive list of measurements (in secondary mode):

Meas.	C26x type	Scaling factor	Address	Formats
Va	UINT32_HW_HB	0.001	0x01C6	T39 (=T11 for the secondary mode)
Vb	UINT32_HW_HB	0.001	0x01C8	T39 (=T11 for the secondary mode)
Vc	UINT32_HW_HB	0.001	0x01CA	T39 (=T11 for the secondary mode)
Uab	UINT32_HW_HB	0.001	0x01CC	T39 (=T11 for the secondary mode)
Ubc	UINT32_HW_HB	0.001	0x01CE	T39 (=T11 for the secondary mode)
Uca	UINT32_HW_HB	0.001	0x01D0	T39 (=T11 for the secondary mode)
Ia	UINT32_HW_HB	0.0001	0x01D2	T40 (=T12 for the secondary mode, mistaken as T11 in the manual R8605C2)
Ib	UINT32_HW_HB	0.0001	0x01D4	T40 (=T12 for the secondary mode, mistaken as T11 in the manual R8605C2)
Ic	UINT32_HW_HB	0.0001	0x01D6	T40 (=T12 for the secondary mode, mistaken as T11 in the manual R8605C2)
In	UINT32_HW_HB	0.0001	0x01D8	T40 (=T12 for the secondary mode, mistaken as T11 in the manual R8605C2)
Freq.	UINT32_HW_HB	0.001	0x01DA	T11
Power	UINT32_HW_HB	0.0001		T21 (=T12 for the secondary mode, mistaken as T11 in the manual R8605C2)
Energies	UINT32_HW_HB	0.001		T20 (=T11 for the secondary mode)

The addresses 0x01DB, 0x01DC, 0x01DE and 0x01DF generate an exception frame with code number 2.

Px2 series and Px4 series

Measurements are read through the Modbus functions 3 or 4 (read word functions). Select the correct format for the measurement: 16 or 32 bits.

Notice that the lower word of 32-bit values is generally transmitted first and, in each word, the higher byte is transmitted first (use formats such as YYYY32_LW_HB for 32 bit values).

- Basic Address (Mapping address) 0xyyyyy
- Extra Address 1: not used
- Extra Address 2: Modbus function (3 or 4)
- Extra Address 3: not used
- Format: See table

5.3.4.2.2 DIs

5.3.4.2.2.1 IED synchronised

Same as generic Modbus (block mode)

5.3.4.2.2.2 IED NOT synchronised

The status byte is regularly polled at low level and compared with the latest one. The status byte in a legacy IED contains the indication that at least one DI change has occurred.

If a change is detected, the C26x reads the event queue inside the IED, checks out which data have changed, checks if the data have been configured and reads the information itself.

In this case, the DI changes are time-stamped in the IED and the C26x downloads their date and time.

Any DI change generates an event. For any event, there is a DI address that can be retrieved.

All the DIs have two states (0/1, on/off, open/closed, synchronised/out of synchronisation). Each DI generates 2 events (Reset to 0 at this time, Set to 1 at that time).

The DIs are stored at consecutive addresses. In consequence, all the DIs can be read in only one request (except if the number of DIs exceeds the capacity of a MODBUS message, and except may be for fast status word).

DIs at connection

At connection or periodically, the C26x can fetch the global states of one device in a single message. Automation can start at once as it is based on states. Event reading can be delayed due to the need to get the disconnection history and time stamp the current state.

A transient DI is in fact an event not associated to a real state but to a transition (e.g. Trip order). It is only SET never RESET. The practice shows that state approach is more commonly used than the transition approach and help know the global status at connection. For this purpose, a transient DI like the trip order is held for a configurable time (300ms), and results in 2 events (set and reset). The IED translates an inner transient DI to a pulsed indication over the network (with a configurable time e.g. 100 to 300ms).

M300 read request

The time-stamped events of the M300 are NOT treated (there is no indication on the state of synchronisation of the M300). In consequence, the C26x acquires the DIs of the M300 by polling and time stamps them.

The DIs are read through the Modbus function 4 (read words) with the values that follow:

- mapping address in the basic address field
- 4 in the extra address 2 field
- bit number in the extra address 1 field

Example for reading the 2 DIs of an M300 device:

- BI0:
  - Base address: 28d
  - Extra address 1: 0
  - Extra address 2: 4

- Extra address 3: /

- BI1:
  - Basic address: 28d
  - Extra address 1: 1
  - Extra address 2: 4
  - Extra address 3: /

Example for reading alarm status of an M300 device (@30030):

- BI16:
  - Base address: 30d
  - Extra address 1: 0 “Error EEPROM: alarm group 4”
  - Extra address 2: 4
  - Extra address 3: /
- BI17:
  - Base address: 30d
  - Extra address 1: 1
  - Extra address 2: 4
  - Extra address 3: /
- BI23:
  - Base address: 30d
  - Extra address 1: 7 “serial port default Analogue output”
  - Extra address 2: 4
  - Extra address 3: /
- BI0:
  - Base address: 31d
  - Extra address 1: 0 “Test timeout for watchdog”
  - Extra address 2: 4
  - Extra address 3: /
- BI1:
  - Base address: 31d
  - Extra address 1: 1
  - Extra address 2: 4
  - Extra address 3: /
- BI15:
  - Base address: 31d
  - Extra address 1: 15 “Error EEPROM: alarm group 3”
  - Extra address 2: 4
  - Extra address 3: /

To read bit fields in 32-bit values, configure at least one BI in each part of the long value (lower word and higher word) as described in the previous example.

Px2 series and Px4 series read request

The C26x acquires the DIs through the function Nr 3 or 4 (read word functions).

- Base Address (Mapping Address) 0x0010
- Extra Address 1 (bit Number) 0
- Extra Address 2 (Modbus function) 4
- Extra Address 3 (Not Used) X

To improve the process, the events are handled in the C26x. This means that each action on the relay activates an event that is uploaded and decoded in the relay. If the DI corresponding to the event has been configured, the C26x reports the new DI value.

5.3.4.2.3 Disturbance files

The disturbance record includes any transfer of file of measurements sampled at high frequency:

- conventional disturbance
- monitoring data (pressure in GIS, harmonics, brush distance in CB closing ..)

Such a file is breakdown into limited size blocks (defined by MODBUS) to be uploaded.

Any file data format can be used as far as it can be converted to a standard file format, COMTRAD or at least CSV format (Excel, Matlab…).

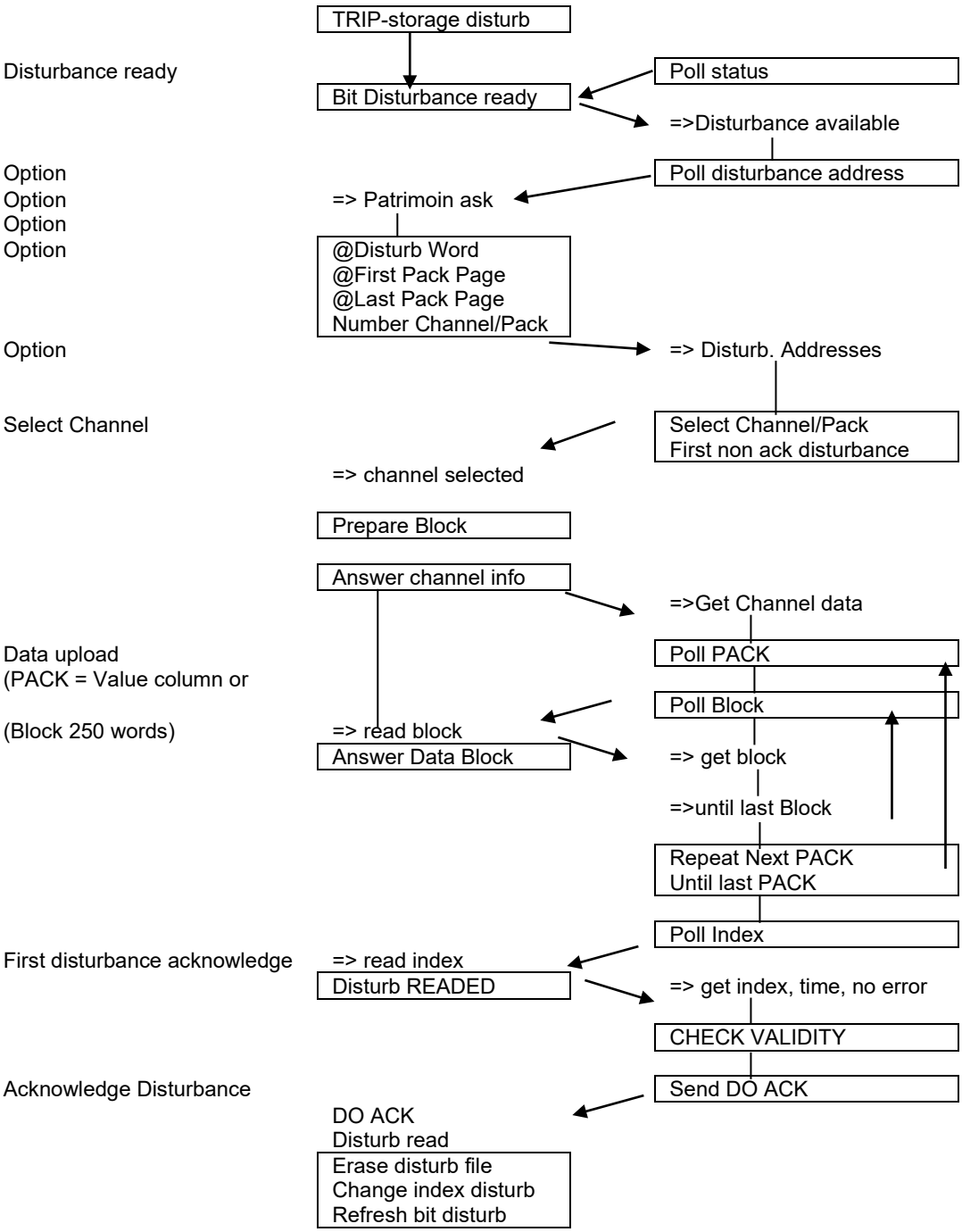
Regardless of the kind of transmission, a header must define the kind of data transfer (file or column values) and the required file reader. The name of the exploitation files (usually COMTRAD) is based on the configured device, master reference, IED MODBUS reference, and cyclic disturbance number.

C26x is informed that a disturbance is stored by reading the bit b4 in the Status byte. Each block is transmitted on the C26x request. At the global end of transfer, after a check-up of the file, the C26x sends the “Ack.DO” and the device can erase its disturbance file. If another “disturbance file” is still present, the bit b4 remains set (e.g. EPAC multi disturbance upload).

The date in disturbance file must be the same as in events (for trip indication…). The device is compliant with:

- the file upload mechanism (Stream of data)
- the disturbance upload mechanism (Column of values); example: series P20

Comment	LED	Net	Master	



5.3.4.2.3.1 M300

There are 2 types of Disturbance record:

- Waveform Analysis Record (max = 1 file)
- Disturbance Record (max = 4 files)

The detection of the availability of a disturbance record in the M300 is done by regularly polling the status of the M300 (bit “Presence of a Disturbance record”).

The disturbance record of an IED is uploaded only if the maximum number of simultaneous disturbance uploading is not reached for the Modbus line and the opening of a disturbance file on the C26x is possible.

Uploading

The C26x opens a file to store disturbance data. If it is not possible, the treatment ends.

The type of disturbance record to upload is selected by writing to register @40567 (0x0237):

- ‘0’ for a Waveform Analysis
- ‘1’ for a Disturbance Record

The record number is selected by writing to register@40568 (0x0238) the value ‘0’ in order to select the last one.

The C26x reads the general information and writes the information that follows to the file:

- Serial number of the IED — 8 words at @30001 (0x0001)]
- Frequency — [@40572 (0x023C)]
- Trigger date — [@30055 (0x0037) ➔@30060 (0x003C)]
- Available channels — [@30061 (0x003D)]
- Type of channels — @30062 (0x003E)]
- Number of samples by channel — [@30063 (0x003F)]
- Number of pages [of sample] by channel — @30064 (0x0040)]
- Number of samples by cycle — [@40560 (0x0230)]
- Trigger position — [@30066 (0x0042)]
- Time base — [@30067 (0x0043)]
- Scaling factors of analogue channels — [@30068 (0x0044) ➔@30081 (0x0044)]
- Names of analogue channels
- Names of TOR channels

The disturbance data are uploaded channel by channel, starting with channel ‘0’ which is the time channel, and for each channel, page by page.

Lastly, the C26x closes the disturbance file.

The bit 7 of register @40047 allows to erase ALL the disturbance records.

For mapping information, refer to the Service manual volume 2, ref. R8605C2.

5.3.4.2.3.2 Px4 series

No disturbance files.

5.3.4.2.3.3 Px2 series

The Px2x can store up to five Disturbance records. The number of channels depends on the kind of Px2x (6 to 9).

The C26x detects the presence of a disturbance record in the Px2x by regularly polling for the status of the Px2x (bit “Presence of a Disturbance record”).

Uploading

C26x:

1 opens a file to store disturbance data; if this is not possible, the treatment ends

2 reads the number of Disturbance records and the associated information (Read of 36 words at @0x3D00); this information enables to know the number (between 0 and 4) of the latest unacknowledged disturbance records. If there is no unacknowledged disturbance record, the treatment ends

3 reads all the IED identification model based on the pattern “Px2x” in order to determine the number of channels and the selection size (Read of 5 words at @0x0000) and after, it writes this information to the disturbance file

4 uploads the disturbance data channel by channel, and for each channel page by page.

5 reads the index frame of the disturbance (Read 7 words at @ 0x2200) and writes this information to the disturbance file

6 closes the disturbances file

7 acknowledges the disturbance records in the Px2x by setting the bit @0x4032 to 1; another disturbance record can be uploaded from the IED.

Differences between Px2x Models:

Products	Number of analogue channels	Number of TOR channels	Overall channels number	selection information size Pages 0x38-0x3C
P120	No disturbance management			
P121	No disturbance management			
P122	5 (IA, IB, IC, I0, Frequency)	1 (3 Inputs, 7 Outputs)	6	11 Words
P123	5 (IA, IB, IC, I0, Frequency)	1 (5 Inputs, 9 Outputs)	6	11 Words
P124D	5 (IA, IB, IC, I0, Frequency)	1 (5 Inputs, 9 Outputs)	6	11 Words
P124S	No disturbance management			
P125	No disturbance management			
P126	6 (IA, IB, IC, I0, V, Frequency)	1 (7 Inputs, 9 Outputs)	7	19 Words
P127	8 (IA, IB, IC, I0, VA, VB, VC, Frequency)	1 (7 Inputs, 9 Outputs)	9	19 Words
P220	5 (IA, IB, IC, I0, Frequency)	1 (5 Inputs, 6 Outputs)	6	11 Words
P225	6 (IA, IB, IC, I0, UAC, Frequency)	1 (6 Inputs, 6 Outputs)	7	19 Words
P226C	6 (IA, IB, IC, I0, UAC, Frequency)	1 (6 Inputs, 6 Outputs)	7	19 Words
P521	7 (IA, IB, IC, I0, timing)	2 (5 Inputs, 9 Outputs, 9 internal data)	9	11 Words
P920	No disturbance management			
P921	No disturbance management			
P922	5 (Voltage, Frequency)	1 (5 Inputs, 9 Outputs)	6	19 Words
P923	5 (Voltage, Frequency)	1 (5 Inputs, 9 Outputs)	6	19 Words

Products	Number of analogue channels	Number of TOR channels	Overall channels number	selection information size Pages 0x38-0x3C
P925	No disturbance management			

@ Mapping	Modbus Function	Words	Format	Description
Pages 0x09 to 0x21: Disturbance Data. Each page contains the samples [250 data word] of the selected channel				
0x0900 ➔ 0x09FA	3	250	INT16	Up to 250 samples
0x0A00 ➔ 0x0AFA	3	250		Up to 250 samples
…				
0x2100 ➔ 0x21FA	3	250		Up to 250 samples
Page 0x22: Index of the Disturbance				
0x2200	3	1	UINT16	Disturbance record Number
0x2201 ➔ 0x2204	3	4	Time Stamp	Disturbance record finish date
0x2205	3	1	UINT16	Disturbance record starting condition
0x2206	3	1	UINT16	Frequency at post-time beginning

@ Mapping	Modbus Function	Words	Format	Description
Page 0x3D: Number of disturbance records available				
0x3D00	3	1	UINT16	Number of disturbance records [1 .. 5]
0x3D01	3	1		Oldest disturbance record (n)
0x3D02 ➔ 0x3D05	3	4	Time Stamp	disturbance record Date
0x3D06	3	1		disturbance record starting origin
0x3D07	3	1		0 ⇔ Not Acknowledged 1 ⇔ 1 Acknowledged
0x3D08	3	1		Preceding disturbance record (n+1)
0x3D09 ➔ 0x3D0C	3	4	Time Stamp	disturbance record Date
0x3D0D	3	1		disturbance record starting origin
0x3D0E	3	1		0 ⇔ Not Acknowledged 1 ⇔ 1 Acknowledged
….				
0x3D1D	3	1		Preceding disturbance record (n+4)
0x3D1E ➔ 0x3D21	3	4	Time Stamp	disturbance record Date
0x3D22	3	1		disturbance record starting origin
0x3D23	3	1		0 ⇔ Not Acknowledged 1 ⇔ 1 Acknowledged

Pages 0x38 to 0x3C: Selection of the Disturbance and channel [Each page corresponds to one out of the 5 Disturbance records]. The second header line is the number of words uploaded for each access reading:

@map-ping	Modbus function	Words number	P122/P123/ P124D/P220	P126	P127	P225/P226C	P521	P922/P923
			11 words	19 words			11 words	19 words
Pages 0x38 to 0x3C: selection of the Disturbance and channel [Each page corresponds to 1 of the 5 Disturbance record]								
0x..00	3	1	Ia	Ia	Ia	Ia	Ia	Ua
0x..01	3	1	Ib	Ib	Ib	Ib	Ib	Ub
0x..02	3	1	Ic	Ic	Ic	Ic	Ic	Uc
0x..03	3	1	Io	Io	Io	Io	Io	Vo
0x..04	3	1	Frequency	reserved	Ua	Frequency	Timing	Frequency
0x..05	3	1	TOR	reserved	Ub	TOR	TOR1	TOR
0x..06	3	1	unavailable	Uo	Uc/Uo	Uac	TOR2	unavailable
0x..07	3	1		frequency	frequency	unavailable	unavailable	
0x..08	3	1		TOR	TOR			

For each register read request, the following information is uploaded. This information describes the selected channel:

Word	P122/P123/ P124D/P220	P126	P127	P225 / P226C	P521	P922/P923
0	Total samples number					
1	Sample number in pre-time					
2	Sample number in post-time					
3	Primary phase CT ratio					
4	Secondary phase CT ratio					
5	Earth primary CT ratio					
6	Earth secondary CT Ratio					
7	Phase internal CT ratio					
8	Earth internal CT Ratio					
9	Last page Number	Reserved	Primary phase VT Ratio [LB]		Last page nb	Primary phase VT Ratio [LB]
10	Last page word number	Reserved	Primary phaseVT Ratio [HB]		Last pg word nb	Primary phaseVT Ratio [HB]
11	Unavailable	Reserved	Secondary phase VT ratio		Unavailable	Secondary phase VT ratio
12		Earth primary VT ratio [LB]	Reserved			Earth primary VT ratio [LB]
13		Earth primary VT ratio [HB]	Reserved			Earth primary VT ratio [HB]
14		Earth secondary VT ratio	Reserved			Earth secondary VT ratio
15		Internal VT ratio – numerator 100				Internal VT ratio–num. 100
16		Internal VT Ratio – denominator				Internal VT Ratio – denom.
17		Last page Number				Last page Number

18		Last page words number		Last page words number

Specific treatments

P126: the channels are not consecutive; the 5th & 6th channels must be skipped.

P127: the mapping address 0x0127 must be read. It gives the voltage wiring of the IED. This value must be written in the file (but it does not change the uploading process).

P922 &P923: the mapping address 0x0126 must be read. It gives the voltage wiring of the IED. This value must be written in the file. This value changes the uploading process: in some cases, the channels must be skipped.

Wiring value	Voltage wiring of the IED	Used channels	
0	3Vpn (3 phase-to-neutral voltages)	0	Ua
		1	Ub
		2	Uc
		3	Not used
		4	Frequency
		5	TOR
1	3Vpn + Vr (3 phase-to-neutral voltages + residual voltage)	0	Ua
		1	Ub
		2	Uc
		3	Vo
		4	Frequency
		5	TOR
2	2Vpp + Vr (2 phase-to-phase voltages + residual voltage)	0	Uab
		1	Ubc
		2	Not used
		3	Vo
		4	Frequency
		5	TOR
3	3Vpp + Vr (3 phase-to-phase voltages + residual voltage)	0	Uab
		1	Ubc
		2	Uca
		3	Vo
		4	Frequency
		5	TOR

5.3.4.2.4 Events

An event is a time-stamped state change of a logical data.

When the IED gets connected, the C26x reads the current status of logical information, then manages the status changes from the file of the time-stamped events.

The time-stamped events are gathered in one file. The bit b2 of the status indicates the presence of at least one event not extracted. Events are stored by IED, and are read one by one by the master, starting from the oldest event.

The C26x's reading of one event does not withdraw it from the file. An IED withdraws an event from its list:

- when the C26x acknowledges it
- when the file of the events gets saturated (the queue sheds the oldest event)
- directly after the C26x reads whether an automatic event retrieval is set on IED. The event can be read again at address @event +1 (3601h if the latest event address is 3600h). Event reply is 0 if the events list is empty.
- the C26x reads one event, and then sends “DO ok“ if it correctly receives the event. When receiving this acknowledgement, the IED deletes its latest event, and updates its events list (and resets the event bit in status word if applicable: refer to IED documentation). This makes sure that no event is lost. DO acknowledgement is bit 13 (0400h).
- IEDs and C26xs are configured for automatic event retrieval (at start-up the C26x checks the bit b12 at 0400h). The C26x reads the latest event.
  The IED shifts this event to the next address in the event list. If the C26x detects a transmission error, it reads again the event at address +1.

Any event includes the information that follows:

- Date - Time, using inverse order as per IEC 870-5-4 CP56T2a format (no short format, no CP16, same format as clock synchronisation).
- MODBUS mapping address of logical information that has changed.
- New state value of the transmitted data (new value of the word, stored at the MODBUS mapping address).

The C26x extracts the events meant for upper functions and sends them to the corresponding service: automation, alarms, textual message converter, event & logging printing….).

Note: all textual information associated to events are not needed by a system master as customers have their own labels, wording, or writing (Cyrillic, Cantonese …). A separate device is in charge of textual logging. The text only reduces communication bandwidth.

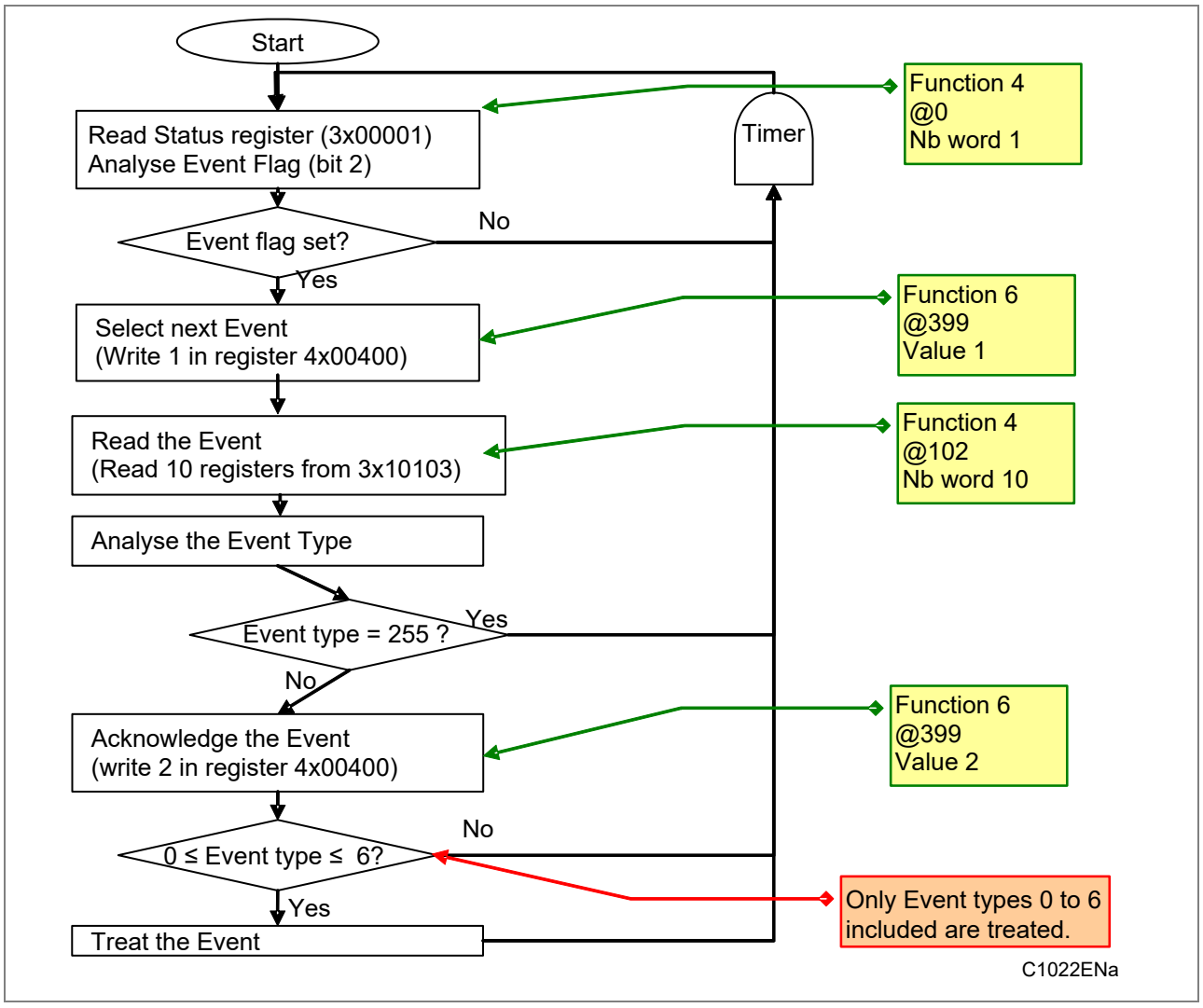
The C26x can manage several state changes in one event (for changes in same time accuracy period, to increase transfer…), even if each event has only one state change. Then, one state change is linked to one event and one event is linked to several possible state changes (if they are at the same MODBUS address).

Px4 series

The command register can be written with Modbus function 6 in register 4x00400 [@ 399]. Each action is activated when a ‘1’ is written to the corresponding bit.

Bit No.	Value / bit mask	Used to
0	0x0001	Select the next event
1	0x0002	Accept event
2	0x0004	Select the next disturbance record
3	0x0008	Accept disturbance record
4	0x0010	Select the next disturbance record page
x	x	Other bits are unused

Automatic event-record extraction allows records to be extracted as they occur. Event records are extracted in sequential order:



The C26x determines whether the Px4x has any events stored that have not yet been extracted by reading the Px4x's status register 3x00001 (G26 data type). If the event bit is set, the Px4x contains event records that have not yet been extracted.

To select the next event for sequential extraction, the C26x writes 1 to the command register 4x00400 (G18 data type). The event data together with any fault/maintenance data can be read from the registers as specified in the flow chart and table.

Once the data has been read, the event record can be marked as read by writing 2 to register 4x00400.

Alternatively, since the G18 data type consists of bit fields, it is possible to both marks the current record as having been read and to automatically select the next unread record by writing 3 to the register.

When the latest (most recent) record has been accepted, the event flag in the status register (3x00001) is reset.

If the latest record was accepted by writing 3 to the command register (4x00400), a dummy record appears in the event record registers, with an "Event Type" value of 255.

Attempting to select another record, when none are available, results in a Modbus exception code 3 – "Invalid value".

Event formats:

<table>
<tr><th>Modbus Register /Address</th><th>Contents</th><th>Description</th><th>Nb Register</th></tr>
<tr><td>3x00103…3x00106
102 … 105</td><td>(G12) Time stamp of the event</td><td>IEC870 Time & Date</td><td>4</td></tr>
<tr><td>3x00107
106</td><td>(G13)
Event type</td><td><table><tr><td>0,1,2, 3</td><td>alarm</td></tr><tr><td>4</td><td>output contact</td></tr><tr><td>5</td><td>opto input</td></tr><tr><td>6</td><td>protection</td></tr><tr><td>255</td><td>dummy event</td></tr></table></td><td>1</td></tr>
<tr><td>3x00108…3x00109
107 ... 108</td><td>(G27)
Event value</td><td>New values of the 32 bits register containing the BI(s) which have changed.</td><td>2</td></tr>
<tr><td>3x00110
109</td><td>(G1)
32-bit Register reference</td><td>Modbus address of the 32-bit register containing the BI(s) that have changed.
CAUTION: real Modbus address must be recomputed by subtracting 30001 !!!<table><tr><td>Event type</td><td>Event index</td></tr><tr><td>0,1,2,3</td><td>11</td></tr><tr><td>4</td><td>723</td></tr><tr><td>5</td><td>725</td></tr><tr><td>6</td><td>727 to 785 (associated DDB status register)</td></tr></table></td><td>1</td></tr>
<tr><td>3x00111
110</td><td>Event Index</td><td><table><tr><td>Event type</td><td>Event index</td></tr><tr><td>0,1,2,3</td><td>Alarm ID</td></tr><tr><td>4, 5</td><td>Not used – set to 0</td></tr><tr><td>6</td><td>bit 16 = state, bits 1-15 DDB ID</td></tr></table></td><td>1</td></tr>
<tr><td>3x00112</td><td>Not used by C26x</td><td>–</td><td>1</td></tr>
</table>

According to the Event Type, the Event Index can be used – or not – to analyses the Event. Two cases have to be considered:

- Event of type 0,1,2,3 and 6. In this case, the Event Index can be used.
  - Bit16 of the Event Index indicates the new Digital Input state (0 or 1)
  - Bit1-15 of the Event Index [modulo 32] indicate the Bit Number of the Digital Input in the 32bits register
  - The 32bits register reference and the Digital Input Bit Number allows finding the Digital Input in the C26x DB (if configured).
- Event of type 4 and 5. In this case, the Event Index is not significant and cannot be used. The C26x DB has to be parsed against the Event Value, looking for a state change of all Digital Input of the 32-bit register reference.

5.3.4.2.5 File upload

A file is defined by a header, a parameter set and a stream of data. Each time the C26x reads a block of data, the IED shifts data to the next page (Repeat page) and replaces it by a new block of data. In event of transmission error, the C26x requests the block wrongly received to the repeat page.

Addresses	Function	Contents
FA00 to FAFA	Read 24 words	Read header
FB00 to FBFA	Read N words	Read N words of file parameters and shift parameter stream
FC00 to FCFA	Read N words	Read N words again of file (repeat)
FD00 to FDFA	Read N words	Read N words of file data and shift data stream
FE00 to FEFA	Read N words	Read N words again of file (repeat)

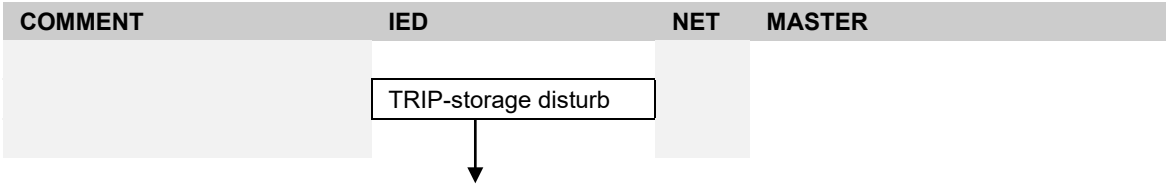
The header defines data to transmit and file treatment to trigger by the C26x on data reception:

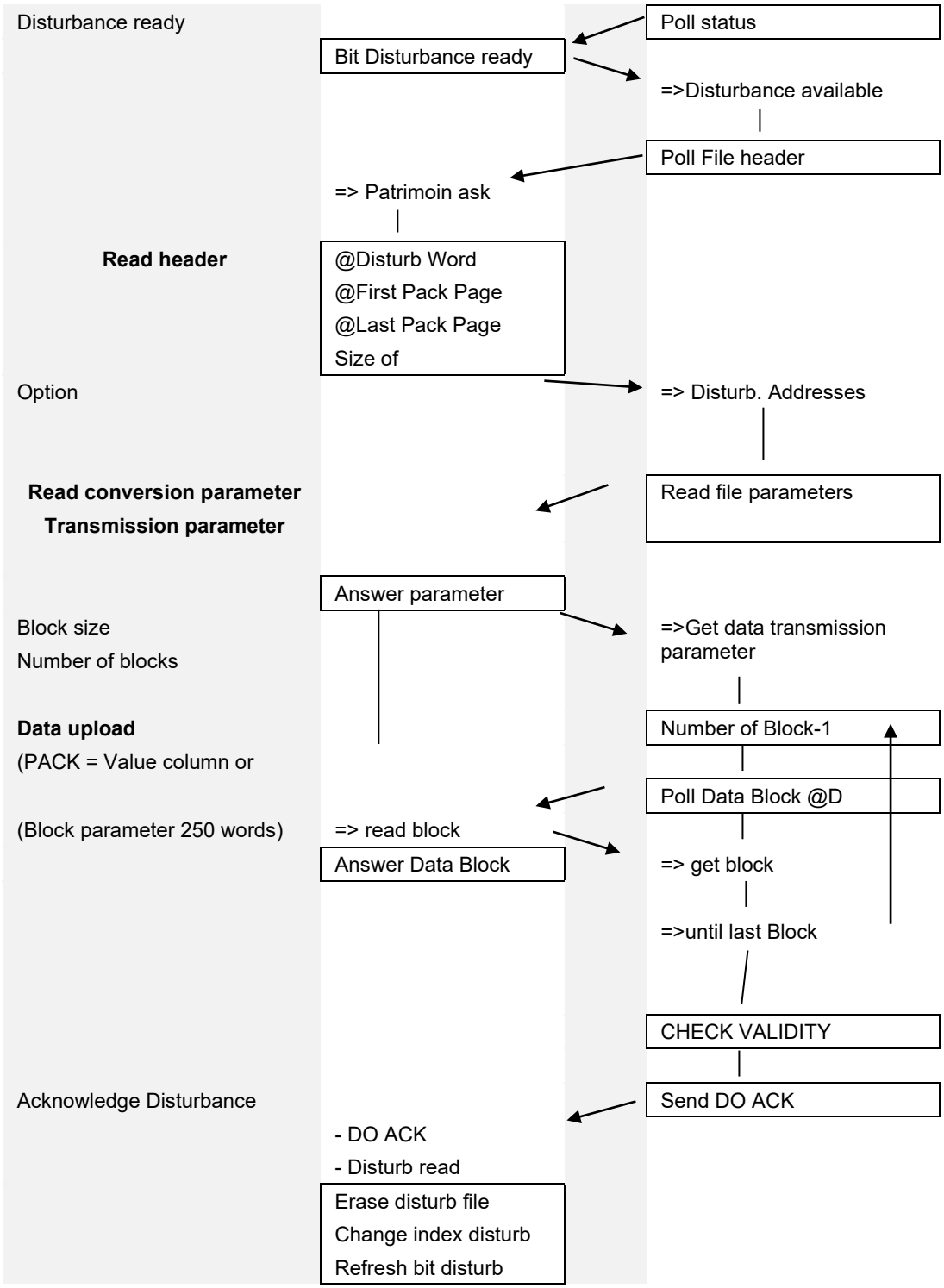
Word	Description	Format
1	Kind of file transfer	0 for the following mechanism, 1 for a future one
2-3	Number of words in parameter field	Nb_Byte_Para
4-5	Number of words in data field	Nb_Byte_Data
6	Manufacturer	1 « GE » (for M7xx)
7-8	Product reference	4 ASCII {« M710 », « M711 » , « M720 », « M721 »… }
9	Transmission product version	1 First version or A
10-13	Product serial number	8 ASCII characters: SS Week AA Year NNNN Number in week (shift left + blank).
14	Kind of File transfer used below by the product	0 very short time 1 short time 2 quality events 3 disturbance 4 compressed disturbance
15-18	First element time tag	IEC 840-5-4 (64 bits = 4 x 16-bit words)
19	Reserved e.g. sampling, trigger timer	0x0000
…	…	…
24	Reserved	0x0000

All the data samplings are transmitted after one another without compression.

Word	Description for decoding software
0-1	First value of first sampling
2-3	Second value of first sampling
Nb_Byte_Data	Last word

Algorithm:





Downloading is done using function 15 or 16 at specific address. Acceptance is signalled.

To speed up the global downloading, writing can be done to several consecutive addresses.

5.3.4.3 DATA SENT TO IEDS

5.3.4.3.1 Clock synchronization

Type of synchronization: GE Grid Solutions (proprietary)

All the devices connected to a given network must have the same synchronization procedure (address and time and date format) because the synchronization order is broadcast.

Date and time comply with the inverted IEC 870-5-4 CP56Time2a format:

Word	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
1	0	0	0	0	0	0	0	0	0	Year: 00…99						
2	0	0	0	0	Month: 1...12				DayOfWeek:1..7			DayOfMonth:1..31				
3	su	0	0	Hour: 0…23					iv	0	Minutes: 0…59					
4	Milliseconds (High)								Milliseconds (Low)							

Su (=0 for Standard, =1 for Summer Time)

iv (=0 for valid, =1 for non valid or out of synchronisation for a system)

First day of the week: Monday

Date and time is set at address 0800h with function 16. No calculation of transmission delay.

If an IED does not have (this) synchronisation, it must be unaware of these synchronisation messages (no error indication, no failure).

If an IED that does not stick to the rule, the C26x supplies out-of-synchronisation devices with its own time stamp. The time accuracy is deeply degraded.

An IED does not generate any event when receiving the synchronisation, or when missing one broadcast message.

Synchronisation comes from a specialised clock device like GPS. The first bit is the reference. The C26x transmits time corrected by its treatment delay. It sends a synchronic message periodically (e.g. 3 times per minutes). The absence of reception within 1 minute results in a “Loss of synchronisation” event.

A “Loss of synchronisation” event requires a set/reset. Synchronisation information is also signalled by the IV bit in the event time stamp: 0 means that when the event occurred, the IED was out of synchronisation.

Any IED with 2 clocks systems (MODBUS synchronization mechanism AND an IRIG B or other) must have an inner setting to deactivate each clock.

If the C26x has lost its own synchronisation, it still time stamps events (but with IV bit set) to still synchronise the IEDs with a same reference (relative time tagging).

M300

The M300 supports 2 time formats:

- The GE Grid Solutions (proprietary) synchronization format, which is used only to set the Date & Time
- The M300 format which is used to set the Date & Time in the M300 or for time stamping in the M300 (e.g. Disturbance time stamping)

The synchronisation according to the Modbus legacy rules is accepted by the M300 only if the bit “summer” is NOT set.

Px2 series

The Px2x support 2 time formats:

- the GE Grid Solutions (proprietary) synchronization format, which is used only to set the Date & Time in the Px2x
- the Px2x format which is used for time stamping in the Px2x (e.g. Event & Disturbance time stamping)

Time stamping format:

Word	Description
0	Lower word of Seconds
1	Higher word of Seconds
2	Lower word of MilliSeconds
3	Higher word of MilliSeconds

The number of seconds given in the previous table (32-bit value in word 0 and 1) is the number of seconds elapsed since 1994 January 1st.

Since the V4C version of the PX2X relays, a private format and the IEC format are both available. Select the IEC format to obtain a correct event decoding.

Moreover, a PX2X relay goes out of synchronization after a 1 min delay. As a result, select a synchronization period lesser than 60 seconds.

Px4 series

The Px4x support the GE Grid Solutions (proprietary) format. To keep the Px4x synchronized, the C26x sends a synchronization frame at least once every 5 minutes.

It is possible to use both Px2x and Px4x relays on the same communication channel and to activate the synchronization.

The register 4x00306 is used to configure the time format managed by the relay:

- Writing value '0' in this register selects the 'standard IEC' time format (default value).
- Writing value '1' in this register selects the 'reverse IEC' time format (Modbus GE Grid Solutions (proprietary) time format used by the C26x).

So, at Px4x connection, value "1" must be written in register @305 [4x00306] to signal the Px4x to use the GE Grid Solutions (proprietary) time format.

If the 'Modbus GE Grid Solutions (proprietary) format' is selected (see above), the time tag format in events is as show below:

Word No.	Byte No.	Data (MSB first)	Mask
0	0	Dummy byte (set to 0)	0x00
	1	Years	0x7F
1	2	Month	0x0F
	3	Day of week / Day of Month	0xE0, 0x1F
2	4	Summertime / Hours	0x80, 0x1F
	5	Validity / Minutes	0x80, 0x3F
3	6	Milliseconds MSB	0xFF
	7	Milliseconds LSB	0xFF

5.3.4.3.2 Commands

Any control sent from the C26x to an IED is called a Digital Output:

- Logical control: DO to acknowledge a Disturbance record, a time stamped event, DO to activate or inhibit a specific protective function.
- Physical control: DO to open or close a feeder circuit breaker, or specific output.

To simplify Master MODBUS configuration and run time, it is desirable to gather controls at consecutive addresses.

Communication DOs or controls are transmitted by Modbus writing functions:

- function 5 (write 1 bit)
- function 6 (write 1 word)
- function 15 (write N bits)

If the function 6 or 15 are used, the word of control must be formatted in fields of bits.

The DO used to acknowledge reception of dated events must always be accepted by the IED, even if it is in local mode (no protection mode filtering on this particular DO).

For a single control on a bits field, there is no special need or common description of “Control accepted”. The DI changes subsequent to a control action are sufficient to control execution.

For other controls, reserve a special word on IED for all the device acknowledgements.

If there are several devices on IED, a more elaborate control message sequence between the C26x & IED are required. For a control message, keep the Modbus acknowledgement rules.

On reception of a control request, an IED sends 0 (OK) if function/address/data are correct.

If its inner algorithm forbids it to initiate ordered sequence with physical Digital Output (because of interlock, locking, running control, invalid position…), the IED transmits an “application” error code via an event DI configured in the C26x. the C26x determines if the sequence is acceptable, and runs correctly (for higher control algorithm or protocol conversion).

When operating control is implemented on IED (OBS, Cx2x, P4xx) a lot of failure cases are defined, and over several plants.

At least use for each controlled plant only one word (4 control bits set by the C26x and reset by IED, and 12 main informative bits). Extra words can be defined for further automation indication.

Case 1: Switching device may need to be split into synchronised CB and disconnections:

CONTROL *				**MONITORING**												
				Control Plant State					**Plant secondary DI**							
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
													0	0	0	Plant position MOTION
													0	0	1	Plant position OPEN
													0	1	0	Plant position CLOSE
													0	1	1	Error!
													1	0	0	Plant positionINVALID(DBI00)
													1	1	1	PlantpositionINVALID(DBI11)
													1	0	1	Other INVALID (polarity…)
													1	1	0	Reserve other INVALID
												0/1				(opt) Plant inLOCAL/REMOTE
											0/1					(opt) Plant LOCKED (WITHDRAW)
										0/1						(opt) DI select in SBO
									0/1							(opt) Synchro-check OK
								1								Control Fail Abnormal termination
							1									Control Fail mismatch plant position
						1										Control Fail Lock (pressure…)
					1											Control Fail Interlock
				1												Control accepted Latch (any control)
	0	0	1													OPEN control
	0	1	0													CLOSE control

CONTROL *				MONITORING												
				Control Plant State					Plant secondary DI							
	1	0	0													(opt) CLOSE2 control (Forced)
1																(opt) SELECT control

* All DOs latched by the C26x, the front panel cell is reset at the sequence end by IED.

Case 2: Transformer with TPI position on other word

CONTROL				MONITORING												
				ControlPlant St				Plant secondary DI								
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
															0/1	Plant position MOTION / FIXE
														0/1		Mini CB OPEN/CLOSE
													1			Plant position INVALID
												0/1				(opt) AVRegulation ON/OFF
											0/1					(opt) Plant LOCKED
										x						Reserve
									1							Low Tap Reach
								1								High Tap Reach
							1									Control Fail Abnormal termination
						1										Control Fail Lock (oil,..)
					1											Control Fail Interlock (unusual)
				1												Control accepted Latch (any control)
	0	0	1													Tap RAISE control
	0	1	0													Tap CLOSE control
	1	0	0													(opt)Regulation ON Control
1																(opt) Regulation OFF Control

* All DOs latched by the C26x, the front panel cell is reset at the sequence end by IED

Several kinds of control are defined to manage any measurement that can be frozen (Maintenance counter, metering, or classical measurement). The following “control structure” byte can be used for each measurement:

CONTROL				MONITORING				
7	6	5	4	3	2	1	0	
							0/1	AI Valid/Invalid
						0/1		AI not Frozen/Frozen
					x			Reserve Topical, saturated…
				x				Reserve
			1					Unitary reset
		1						Unitary reset & start
	1							Unitary restart
1								Unitary freeze

Any IED has kind of alarm management that deeply differs from the one used at system or SCADA level. An alarm is any indication given to an operator to warn against a non standard condition, usually by LED indications on IED (2 states ON/OFF), alarm list at upper level (with 4 states defined by STANDING/RESET, NOT_ACK/ACKNOWLEDGE).

It is asked that IED alarms indication be accessed in one address. A DO can globally acknowledge/reset alarms (but one alarm is maintained if condition is still present). In the cell words, a first byte is dedicated to indicating alarm, a byte+8 to resetting each alarm.

M300

There is one command register in the M300 [@40047 (0x002F)]. This register is set using the function 6. Each bit of the register corresponds to a different command:

Basic Address (Mapping Address) 0x002F

Extra Address 1 (bit Number) Bit number to write

Extra Address 2 (Modbus function) 6

Extra Address 3 (Not Used) x

Px2 series

There are 3 command registers in the Px2x [@0x0400, @0x0402, 0x0403]. This register is set using the function 5, 6 or 15. Each bit of the register corresponds to a different command:

@ Mot	@Bit	Usable Function	Comment
0x0400	0x4000 ➔ 0x400F	5, 6, 15	Remote control Word N° 1
0x0402	0x4020 ➔ 0x402F	5, 6, 15	Remote control Word N° 2
0x0403	0x4030 ➔ 0x403F	5, 6, 15	Remote control Word N° 3

Configuration using function 5 of the bit4 [Remote closing] of register 0x0400:

- Basic Address (Mapping Address) 0x4003
- Extra Address 1 (bit Number) X
- Extra Address 2 (Modbus function) 5
- Extra Address 3 (Not Used) X

Configuration using function 6 of the bit4 of register 0x0402:

- Basic Address (Mapping Address) 0x0402
- Extra Address 1 (bit Number) 4
- Extra Address 2 (Modbus function) 6
- Extra Address 3 (Not Used) X

Special commands used by the C26x:

@Bit	Comment
0x400C	Set in order to switch to manual acknowledgement mode for Event and Disturbance uploading
0x400D	Set in order to acknowledge the latest Event
0x4032	Set in order to acknowledge the latest uploaded Disturbance

Px4 series

No specific treatment.

5.3.4.3.3 AOs

The analogue control or AO or Set point, or control reference is a value transmitted by the C26x to device using the function 6 or 16. They can be used to define a reference (for physical output in regulation scheme, generator…) or to define a protection parameter (threshold…).

The values to write must comply with formats and units described for Analogues Inputs (IEEE signed 754, Integer / not signed on 1/2/4 bytes).

When several values at consecutive addresses can be written, IED must support writing to this block of addresses.

5.3.4.3.4 Settings of the current relays

In order to parameterize the remote relays, a setting software is necessary.

The tool is Modbus connected on the rear (as commonly used by system in run time).

A front connection with the same software and same framing protocol at both customer validation and after sale phase is recommended.

Setting software requirements:

- Interface with at least a DLL for Emission / Acceptance of messages developed by the supervisor system, in order to use the tool with other link than serial port. Modbus messages are encapsulated by system sub-station protocol to be used in system architecture.
- Possibility of inhibiting some options of the menu (pooling, disturbance upload …).
- Complete management of the function by the application (Timer on failure to reply, causes of failure…).
- Off-line setting before download
- In run-time the Modbus master is the only master. The tool should not disturb the standard polling of events and data.

5.3.4.3.5 Error management

5.3.4.3.5.1 Faults records

The processing of recommended Fault records is as follows:

- Creation of a zone dedicated to describing Fault, apart from the Fault proper
- Sorting of information according to the type of data.

The Fault Record has the same Modbus address for a whole range of products – that means, for all the IEDs in the series the same address for the latest not acknowledged fault. A good practice is to have the same address for all products (e.g. 0x003E for not acknowledged FREC).

To access to the Fault Record, use the functions 3 or 4.

5.3.4.3.5.2 Alarms

Most IED LEDs can be configured for alarms. In most cases they are managed in a two-state way that differs a lot from an IED to another or to the system (5 states).

An alarm is a standard event (time-stamped state change managed by event rules), stored in the IED till acknowledgement, and that aims at warning the operator via a LED.

There are 2 kinds of alarm:

- TRIP (signalling that a control is sent to a breaker when a particular protective function is triggered)
- ALARM (other information intended for the operator)

Each alarm/trip indication is controlled by a bit in a set of consecutive cells (like Digital Inputs). Each bit retains that alarm condition has been set (even if the condition is no more fulfilled). A global Digital Output

acknowledgement ‘Alarm/trip’ is used to reset all alarm indications. If one alarm condition is still fulfilled, the corresponding bit is not changed by the IED, else it is reset (with an event generation).

When at least one alarm is set in alarm cells (single alarm appearance), the bit 7 of fast status byte is set.

When at least one Trip function is set in trip cells, the bit 6 of fast status byte is set.

Each bit is reset when all the alarm/trip appearance conditions have disappeared and a global ACK alarm Digital Output is received.

A global ALARM/TRIP_ACK_DO is mapped (reset bit). IED mapping must explicitly give the list of cells/bits indicating alarm/trip and effect on bits b6 and b7.

The answer to global ALARM_ACK_DO or global TRIP_ACK_DO (if applicable) to the C26x can never be BUSY (no applicative mechanism, only transport error code).

The bits b6 and b7 are directly linked to LEDs on the front face. The rule manages only 2 states for LED ON or OFF, and no third state is managed. The state ON can be fixed or blinking. The current mechanism is a global acknowledgement AND clearance of alarm list if the alarm appearance condition has been reset.

5.3.4.3.6 Limits and specifications

It is mandatory that within the same range, each piece of equipment has the same operation as others:

- Management of events file (event format/file address/address of acknowledgement DO).
- Management of Fault records (fault format, base fault addresses, address descriptive zone, address of acknowledgement DO…).
- DIs, DOs, AIs are grouped at identical base addresses.
- Format of AI.
- Format of Status.
- Address range of the fundamental data.

In order to use information coming from IED in fast automation, or to answer to the SCADA inquiries, or in alarm tagging, the following specifications are recommended:

- Operating time, answering time to the various requests < 20 ms.
- Low-level address filtering of the irrelevant requests.
- Respect of MODBUS protocol control (correct CRC, parity check, separate message silence of 3.5-char time, continuous flow in one message i.e. a silence limited to 1.5-char transmission time).
- Speed of communication: at least 19200 bauds (38400 is usual, 128000 is a future standard).
- If it is overbooked, a device must answer BUSY (exception code 06) or at least not answer (it is reputed disconnected to be reconnected).
- An IED must answer with a delay lesser than 20ms.
- An IED can ask to implement a FAR BUSY (code 05) to solve an SRAM access problem. The C26x repeats the request at N times its polling period. After 10 BUSY answers, the IED is disconnected.

The official number of devices on Modbus is 32, 16 on PSCN3020 and future system. Typically the application engineers must not include more 8 IEDs to comply with common customer needs (triggered analogues < 500ms, triggered DI < 100ms, physical ping as control/Digital Output/bi-stable/Digital Input/alarm < 300ms, network avalanche profiles, …).

Particular Modbus IEDs

Summary:

IED	Read status	Extra functions	Synchroniz.	DI	AI	Commands	Setting software
M230		4, address 1, length 3	–	–	6 new formats	–	ISDP
RishM10	–	–	not specified	Generic	Generic	Generic	
Flexgate	x		Flexgate	Generic	Generic	Generic	
SEPAM	x		Sepam	Generic	Generic	Generic	SFT
WAGO	x	–		Generic	Generic	SP: 15 bits	

No disturbance files.

M230

In addition to the generic Modbus, to test IED communication, the function code 4, address 1, length 3 can be used.

Data received from M230

No DIs.

Analogue Inputs are regularly polled.

The C26x supports six 32-bit extra formats of Analogue Inputs:

Format	Value	Bit 31 to 24	Bit 23 to 16	Bit 15 to 00
M230_T5_TYPE	Unsigned.meas	decimal exponent (signed)	Binary value unsigned	
M230_T6_TYPE	Signed meas.	decimal exponent (signed)	Binary value unsigned	
M230_T7_TYPE	Power factor	signed: Import/ Export (00/FF)	Signed: Inductive/ capacitive (00/FF)	Unsigned value (16 bytes)
ION_MODULUS_10000_UNSIGNED	10000RH+RL	Reg. High: unsigned value/10000		Reg. Low: unsigned value modulus 10000
ION_MODULUS_10000_SIGNED	10000RH+RL	Reg. High: signed value/10000		Reg. Low: signed value modulus 10000
KITZ202_K8	Refer to KITZ202 documentation			

The byte transmission order is: 4-3-2-1.

5.3.4.3.7 Data sent to M230

The M230 is NOT synchronized using Modbus.

Setting software: IDSP application can NOT be used to set Date and Time, only the front panel can.

The M230 does NOT process the commands.

5.3.4.4 RISH PRO M01

5.3.4.4.1 Initialization sequence

To establish a communication with the relay (upon start-up of the C26x), the C26x reads registers 202, 221, 222 (table of measurements) and registers 300 to 392 (scaling factors table).This initialization sequence is done after each disconnection (i.e. loss of communication or communication error with the IED).

Without interruption:

Step	C26x			Rish Pro M01	
	State	Request		Frame	State
1			←	connection	
2		read "table of measurements"	→		
3			←	measurements	
4		read "scaling factors table"	→		
5	Wait TimeOut				
5bis			←	error	
5ter	Stand by				
go to 2					
6			←	end Time Out	
7		Writes general status	→		RUNNING
8	Stand by				
Timeout					Ready

Disconnection:

	State	Request		Frame	State
5	Wait TimeOut				
6				disconnection	
7	Stand by				
8		Writes general status	→		DCNX

5.3.4.4.2 Polling

The beginning of Digital Inputs and Analogue Inputs polling is delayed by a time-out starting at the end of the Rish Pro M01 initialization. The C26x can send a synchronous frame during the initialization phase. Depending on the function and the read use in this frame, the M01 answers with a correct frame or an exception frame but does not invalidate the initialization.

5.3.4.4.3 Error management

The Rish Pro M01 has no register to read status value and the function 7 is not supported. So, to detect a problem, the C26x uses the exception codes sent by the Rish Pro M01. Rish Pro M01 generates the error codes that follow:

Code	Description
01h	Unsupported function code
02h	Invalid memory register address: use of invalid register number or attempt to write to a memory protected register
03h	Invalid data, i.e. an invalid number of registers
06h	Device is busy. This code signals that the relay is occupied with functions performed via the local RS232 interface (changing configuration, simulation or calibration of analogue outputs..)

Code	Description
0Ah	Possible change of rated values. The device configuration has been modified since the latest request for measurements or this is the first request for measurements since the relay was switched on. Read the table of measurements and the scaling factors table.

Error code 06h and 0Ah must be treated as a disconnection of the IED and a new initialization phase must be completed before reading the Rish Pro M01 data. Other codes can be treated as usually.

Only errors from initialization sequence or polling DIs and AIs report an error code. Errors from synchronous frame only generate an error message, but do not cause a new initialization sequence.

At reception of the message error code 0x6h or 0xAh, if the mode polling is active, reauthorize future polling. The IED general status goes to INIT and the C26x goes to state "STAND BY" and extracts the event "RISHM01 CNX".

In event of trouble, the IED sends the Modbus exception 'Busy'. The C26x considers the IED as disconnected (that will force the initialization sequence to be redone) but DOES NOT PUT the IED information to unknown.

5.3.4.5 FLEXGATE

5.3.4.5.1 Polling

Upon start-up of the C26x, a polling request is sent to determine the status (function 7). A response means that the Flexgate IED is connected.

No Digital Inputs polling: a DI change is signaled by an event.

The C26x polls for fields ‘Internal status bits’ at address 18993 to 19000 with function 2:

Fields	Address	Description
Events pending bit	18993	Is there a new event ?
Time is not sent from Modbus master within last 16 minutes	18994	Is Flexgate IED synchronized with C26x ?
Time is not synchronized by minute pulse within last 1.5 min	18995	Not used

5.3.4.5.2 Other data received from Flexgate

If an event is received (flag at Modbus address 18993), the C26x reads the events queue.

To read the events, the C26x realize an alternative reading between addresses 39001 and 39011, which allows reading next event.

If the C26x reads the same address – without any other request in between – it gives the same event.

The Flexgate sends a response on six words. Refer to the converter documentation.

The C26x continues to read the event file until there is no new event. Then, it polls for the ‘Internal status bits’.

Sequence numbers

In the event response, the sequence number is between 1 and 65535.

Reserved numbers:

- 0 indicates that there is no event anymore
- 1 indicates that the converter (Flexgate) has been reinitialized
- 50 indicates the re-initialization of the converter (Flexgate)
- 51 indicates an overflow events buffer. The event buffer size is 200. The Flexgate does not allow to add new events until the event 51 is read. At this time, the C26x considers that one or more events

have been lost. Then it repeats the General Interrogation, and the cycle continues starting with the internal status bits polling.

If a gap appears in the sequence number, the C26x considers that an event has been lost. Then it repeats the General Interrogation; the cycle continues polling the internal status bits.

5.3.4.5.3 Data sent to Flexgate

The C26x sends Date and Time in one request with function 16 at Modbus addresses 49001…49007 (2328h to 232Eh).

The following format is used to write the date: [year/month/day/hour/minutes/milliseconds since midnight] to two words by data except for milliseconds which takes four words.

The C26x periodically sends the date to synchronize the Flexgate. The time must be sent with a period smaller than 16 minutes.

As they are sent to a specific address, there can be only one Flexgate on the legacy bus.

5.3.4.5.4 Error management

Flexgate generates the following error code:

Code	Description
03h	Illegal data value, i.e. invalid number of register (send a “Configuration error” message to the application and continue). Also used to indicate a hardware malfunction like an interlock condition not ok on a protective relay

5.3.4.6 SEPAM

As for standard Modbus, three modes are available:

- ‘General Interrogation’: The C26x waits for the end of initialization, the disappearance of data loss signal. Then, it polls for all the DIs.
- 'Desynchronized': events are NOT managed. The DIs are updated by polling. DIs are read and decoded group by group. The status is read and decoded when all the groups have been read.
- 'Synchronized': events are managed. The C26x reads the status word, then the events. The DIs are updated when the events are decoded.

5.3.4.6.1 Data received from Sepam

DIs

- Modes GI and ‘not synchronized’:
  - The C26x reads DI group with function 3 at address that follow:

Mode	Address Sepam 40	Address Sepam 80
GI	0x100 to 0x10A	0xC10 to 0xC16
‘not synchronized’	0x100 to 0x10A	0xC90 to 0xC9F

  - When it receives a data, it decodes the status frame and the DI group frame.

- Mode ‘synchronized’:
  - The C26x reads the status frame (function 7) till it detects a data
  - it checks event and reads the event table using function 3 at address 0x40 with size 33.
  - it decodes the event frame and acknowledges using function 6 at address 0x40 with value ‘ExchangeNumber’ at 0.

5.3.4.6.2 Data sent to Sepam

Date and time format: [Day/month/Year Hour.Min:Ms] [14/5/38 6.43:16785] for the 38th year since 1970 (ie. 2008), the 14th May at 6 hours 43 minutes and 16785 milliseconds.

Address for synchronization: 0x0002.

5.3.4.7 WAGO

The Wago relay behaves generically except for the setpoints that are integers not signed on 15 bits.

5.4 IEC 60870-5-103 COMMUNICATIONS

5.4.1 SCOPE OF THIS SECTION

The purpose of this chapter is not to describe the T103 but to specify the use of the T103 protocol on a legacy bus of the C26x.

As the C26x is the master on the legacy bus – with regards to protection relays and IEDs - this protocol is referenced as “Master T103” in the C26x.

Here are described:

- Specific behaviours attached to the protocol T103
- Restrictions and enhancements
- Part of the T103 protocol used and not used
- Specific behaviours attached to implementation of Private Range of T103

5.4.2 INTERFACE TO IEDS

5.4.2.1 INPUT

ASDU	Data	Note
1	Dated Digital input (absolute dating) Control acknowledgement	Treated
2	Dated Digital input (relative dating)	Treated
3	Measurement	Treated
4	Measurement: Default position	Treated
5	Identification	Not treated
6	Time synchronisation acknowledgement	Treated
8	End of GI	Treated
9	Measurement	Treated
10	General Data	Not treated (some measurements only)
11	General Identification	Not treated
17	Measurement	Reg D only
23 … 31	Disturbance file management	Treated
45	Ack of Single Command	Px3x only
46	Ack of Double Command	Px3x only
49	Analog protection signal Only adress 0 which is DVICE: Device type	Px3x only
65	Single Point	Px3x only
66	Single Point with Time Tag	Px3x only

ASDU	Data	Note
67	Double Point	Px3x only
68	Double Point with Time Tag	Px3x only
71	BitString 32 Bit without time tag pair FUN /TYP computed: F8h / 70h: State of the IED F8h / 74h: Request Station Interlock	Px3x only
72	BitString 32 Bit with time tag – see ASDU 71	Px3x only
73	Measurement, Normalised value	Px3x only
77	Measurement	Px2x only
79	Energy Counter	Px3x only

5.4.2.2 OUTPUT

ASDU	Data	Note
6	Time synchronisation	Treated
7	Request a GI	Treated
20	Command	Treated
23 … 31	Disturbance file management	Treated
45	Single Command	Px3x only
46	Double Command	Px3x only
140	Read protection parameter Only address 0 which is DVICE: Device type	Px3x only
144	Setpoint	Reg D only

5.4.3 BEHAVIOUR

5.4.3.1 SYNCHRONISATION

The “Master T103” link is always synchronised by the C26x. No calculation of the transmission delay is performed.

5.4.3.2 POLLING

To connect an IED, a “Reset CU” frame is sent to the IED.

By default an IED is polled by a “Polling C2” frame, allowing to get “non priority information”.

If an IED signals it has “priority information”, it is polled with a “Polling C1” frame.

5.4.3.3 STATION INTERLOCKING

This functionality is only available on relay P139 in private T103 range (D protocol variant)

After GI, and only if IED is Px3x, we send a read on Px3x parameter adress 0 which corresponds to Device Type. If Px3x relay responds with analog parameter set to 139, we activate Station Interlocking Management.

Case of local control (front panel of the P139 relay) with Station interlock:

As soon as a user will try to control a switchgear by the front panel, the P139 relay will send an ASDU 72 with FUN/TYP = F8h/74h in order to request to DS Agile system the station interlock conditions. The DS Agile system should check whether the command is allowed (specific treatment done by CONDUITE of the C26x) and respond to the P139.

Case of remote control (from DS Agile system) with Station interlock:

As soon as a user tries to control a device managed by the P139 relay by DS Agile system through T103 communication, the P139 sends an ASDU 72 with FUN/TYP = F8h/74h in order to request to DS Agile system the station interlock conditions. The DS Agile system should respond to the P139 with a positive acknowledgement (checks have already been done before)

If station Interlock is de-activated on the P139 relay, the control of a switchgear on the P139 by DS Agile system through T103 communication is done by an EXECUTE ORDER (selection will be refused by the P139)

5.4.3.4 REG D

The Reg D equipment manages 2 ASDU (144 and 17), for control of setpoints (144) and setpoint value feedback (17), which is treated as a measurement in the C26x. Setpoints managed by the Reg D are "Direct Execute" only, there is no SBO management. The Reg D setpoint command sequence is like the command sequence (ASDU20). The C26x sends the setpoint (ASDU 144), with the setpoint value, the Reg D sends its acknowledge (ASDU1), if the acknowledge is OK, the Reg D sends the setpoint value feedback (ASDU17).

5.4.3.5 TAPCON260

The Tapcon260 equipment supports ASDU 204 / FUN TYP=110/ INF=54 for TPI acquisition. Nevertheless, the object type in SCE must be MV, not TPI.

5.4.4 DATA RECEIVED FROM IEDS

5.4.4.1 DIGITAL INPUTS

An ASDU number [(1,2) in public Range],[(66,67,68,69) in private Range]

A DI is identified by a pair (Function Type, Information Number).

Digital inputs are received as state changes.

Special DI may be managed:

- DI 20: Lock of the communication. A GI must be done when the communication is unlocked
- DI 23 to 26: Change of configuration number
- DI which are not transmitted during a GI. For these DI, the IED signals only state change from OFF to ON. The C26x must generate by itself the change from ON to OFF.

5.4.4.2 MEASUREMENTS

A Measurement is identified by:

- An ASDU Number [(3,4,9) in public range, (10, 21, 73,77) in private range]
- a pair (Function Type, Information Number)
- the rank of the Measurements in the ASDU
- the kind of Measurements [Current, Voltage, Power, Frequency, Other]
- the common address of ASDU

ASDU 21 and 10 provide the acquisition of the following measurements coming from P44x relay:

- Current tripping values
- Residual voltages and currents
- Sum of trips
- Sum of cut amperes

The C26x polls regularly the cells containing the measurement values.

It reads by ASDU 21 a single entry:

Description	TI	VSQ	COT	ADR	FUN	INF	RII	NOG	GIN	KOD
Measurement	15H	81H	2AH	CAD	FEH	F4H	x	1	Courier cell number	1

TI = Type identification
VSQ = variable structure qualifier
COT = cause of transmission
ADR = CAD = common address
FUN = function number
INF = information number
RII = Return information identifier
NOG = Number Of Generic identification
GIN = Generic Identification Number

ASDU 10 provides the response.

5.4.4.3 BITSTRING 32-BITS:

The state of the IED is identify by the ASDU 71 or 72 with pair FUN / TYP = F8h / 70h. This ASDU describes the status of the IED (Station Interlocking active or not …)

A request to check station interlocking is identify by the ASDU 71 or 72 with pair FUN / TYP = F8h / 74h. In this request, the pair FUN/TYP of the command to spend is defined.

5.4.4.4 ANALOG PROTECTION SIGNAL (ASDU 49):

Only for Px3x relays, an analogue protection signal is received after GI

Only address 0 is managed. It is used to recognise the P139 relay in order to activate station interlocking management.

5.4.4.5 ENERGY COUNTER (ASDU 79):

Only for Px3x relays, four energy counters are available.

Energy counters are identified by:

- An ASDU number (79) in private range
- a pair Function Type, Information number
- the rank of the counter in the ASDU
- the common address of the ASDU

Description	TI	VSQ	COT	ADR	FUN	INF	DB0-DB4	DB5-DB9	DB10-DB14	DB15-DB19
Energy counter	4FH	04H	01H	CAD	F8H	6CH	Active +	Active -	Reactive +	Reactive -

TI = Type identification

VSQ = variable structure qualifier

COT = cause of transmission

ADR = CAD = common address

FUN = function number

INF= information number

DB0-DB4 = active energy output

DB5-DB9 = active energy input

DB10-DB14 = reactive energy output

DB15-DB19 = reactive energy input

Format of the energy counter value

Value			
Value			
Value			
S	Value		
IV	CA	CY	Sequence number

S: 0 Value positive, 1 = value negative

CY: 0 = no carry, 1= carry

CA: 0 = not adjusted, 1 = adjusted

5.4.5 DATA SENT TO IEDS

5.4.5.1 CONTROLS

An ASDU Number and a pair (Function Type, Information Number) identify a control.

The acknowledgement of a control is to be waited as:

- A DI with the same (Function Type, Information Number) as the control and with a ‘Cause Of Transmission’ equals to ‘positive return’ or ‘negative return’ in public range
- An ASDU 45 or 46 with a ‘Cause Of Transmission’ equals to ‘end of activation OK’ or ‘en of activation KO’, or ‘deactivation OK’, or ‘deactivation KO’ in private range

5.4.5.2 SETPOINTS CONTROLS:

A setpoint control is identified by an ASDU Number plus a pair (Function Type, Information Number). In the case of the Reg D equipment the ASDU is 144.

The acknowledgement of a setpoint control is to be waited as:

- A DI (ASDU 1) with the same (Function Type, Information Number) as the control and with a ‘Cause Of Transmission’ equals to ‘positive return’ or ‘negative return’ in public range.
- An ASDU 17 with a ‘Cause Of Transmission’ equals to ‘Local Operation’ in public range. The ASDU is a measurement which contains the setpoint feedback value.

5.4.5.3 READ PROTECTION PARAMETER:

Only for Px3x relays, a read of protection parameter (ASDU 140) address 0 (Device Type) is sent to IED

The IED responds with ASDU 49 in which Device Type is set (139 if IED is a P139 for example).

5.4.5.4 ASDU 232 / 105 MANAGEMENT

It allows to send control to IEC60870-5-103 legacy IED. It requires to manage also the ASDU 105 as response to ASDU 232.

Comparing ASDU232 & ASDU20

ASDU232			ASDU20	
Field	**Value**		**Field**	**Value**
ASDU No	E8H		ASDU No	14H
VSQ	81H		VSQ	81H
COT	14H		COT	14H
Device address	@ied		Common Address of ASDU	@ied
DN2	Cfg		Function type	Cfg
DN3	Cfg		Information Number	Cfg
DC0	1=OFF; 2=ON		DC0	1=OFF; 2=ON
X	0		RII	Set by master

Comparing ASDU105 & ASDU01

ASDU105			ASDU01	
Field	**Value**		**Field**	**Value**
ASDU No	69H		ASDU No	01H
VSQ	81H		VSQ	81H
COT	45H, 46H, 47H, 7FH		COT	14H, 15H, 0BH
Device address	@ied		Common Address of ASDU	@ied
DN2	Idem ASDU232		Function type	Idem ASDU20
DN3	Idem ASDU232		Information Number	Idem ASDU20
DPI	1=OFF; 2=ON		DPI	1=OFF; 2=ON
X	0		msLow	Four octet binary time CP32Time2a
msLow	Four octet binary time CP32Time2a		msHigh	
msHigh			IV 0 mmmmmm	
IV 0 mmmmmm			SU 00 hhhhhh	
SU 00 hhhhhh			SIN	Idem RII ASDU20

Configuration

Management of commands through ASDU 232.

- The ASDU number [232]
- DN2 & DN3 (respectively ‘y’ & ‘x’ component of PID)

Management of state through ASDU 105.

- The ASDU number [232]
- DN2 & DN3 (respectively ‘y’ & ‘x’ component of PID)

DN2 & DN3 will be given – respectively – as ‘Function type’ & ‘Information Number’.

5.5 IEC 60870-5-101 COMMUNICATIONS

5.5.1 PURPOSE

The purpose of this chapter is not to describe the T101 protocol but to specify the implementation of T101 protocol on a legacy bus inside the C26x.

5.5.2 MASTER IEC 60870-5-101 PROFILE

The companion standard presents a set of parameters and alternatives from which subsets have to be selected to implement particular telecontrol systems. Certain parameters values, such as the number of bytes in the COMMON ADDRESS of ASDUs represent mutually exclusive alternatives. This means that only one value of the defined parameters is admitted per system.

Other parameters, such as the listed set of different process information in command and in monitor direction allow the specification of the complete set or subsets, as appropriate for given applications. This clause summarises the parameters of the previous clauses to facilitate a suitable selection for a specific application. If a system is composed of equipment stemming from different manufacturers it is necessary that all partners agree on the selected parameters.

The selected parameters should be marked in the white boxes as follows:

☐ Function or ASDU is not used

☒ Function or ASDU is used as standardised (default)

The possible selection (blank, X) is specified for each specific clause or parameter.

Note: In addition, the full specification of a system may require individual selection of certain parameters for certain parts of the system, such as the individual selection of scaling factors for individually addressable measured values.

5.5.2.1 SYSTEM OR DEVICE

(system specific parameter, indicates the definition of a system or a device by marking one of the following with ‘X’)

☐ System definition

☐ Controlling station definition (Master)

☒ Controlled station definition (Slave)

5.5.2.2 NETWORK CONFIGURATION

(network specific parameter, all configurations that are used are marked ‘X’)

☒	Point-to-point	☒	Multipoint-party line
☒	Multiple point-to-point	☒	Multipoint-star

5.5.2.3 PHYSICAL LAYER

(network specific parameter, all interfaces and data rates that are used are marked 'X')

Transmission speed (control direction)

Unbalanced interchange Circuit V24/V28				Balanced interchange Circuit X24/X27			
Standard		Recommended if > 1200 bits/s					
☒	100 bits/s	☒	2400 bits/s	☒	2400 bits/s	☐	56000 bits/s
☒	200 bits/s	☒	4800 bits/s	☒	4800 bits/s	☐	64000 bits/s
☒	300 bits/s	☒	9600 bits/s	☒	9600 bits/s		
☒	600 bits/s	☒	19200 bits/s	☒	19200 bits/s		
☒	1200 bits/s			☒	38400 bits/s		

Transmission speed (monitor direction)

Unbalanced interchange Circuit V24/V28				Balanced interchange Circuit X24/X27			
Standard		Recommended if > 1200 bits/s					
☒	100 bits/s	☒	2400 bits/s	☒	2400 bits/s	☐	56000 bits/s
☒	200 bits/s	☒	4800 bits/s	☒	4800 bits/s	☐	64000 bits/s
☒	300 bits/s	☒	9600 bits/s	☒	9600 bits/s		
☒	600 bits/s	☒	19200 bits/s	☒	19200 bits/s		
☒	1200 bits/s			☒	38400 bits/s		

5.5.2.4 LINK LAYER

(network specific parameter, all options that are used are marked 'X'. Specify the maximum frame length).

Frame format FT 1.2, single character 1 and the fixed time out interval are used exclusively in this companion standard.

Link transmission procedure

☒ Balanced transmission

☒ Unbalanced transmission

Address field of the link

☐ Not present (balanced transmission only)

☒ One octet

☒ Two octets

☒ Structured

☒ Unstructured

Frame length (number of bytes)

255 Maximum length L in control direction

up to 255 Maximum length L in monitor direction – configurable

5.5.2.5 APPLICATION LAYER

Transmission mode for application data

Mode 1 (Least significant octet first), as defined in clause 4.10 of IEC 870-5-4, is used exclusively in this companion standard.

Common address of ASDU

(system-specific parameter, all configurations that are used are to be marked 'X')

☒ One octet ☒ Two octets

Information object address

(system-specific parameter, all configurations that are used are to be marked 'X')

☒ One octet ☒ Structured

☒ Two octets ☒ Unstructured

☒ Three octets

Cause of transmission

(system-specific parameter, all configurations that are used are to be marked 'X')

☒ One octet ☒ Two octets (with originator address)
Set to zero in case of no originator address.

Selection of standard ASDUs

Process information in monitor direction

(station-specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☒	<1>	:=	Single-point information	M_SP_NA_1
☒	<2>	:=	Single-point information with time tag	M_SP_TA_1
☒	<3>	:=	Double-point information	M_DP_NA_1
☒	<4>	:=	Double-point information with time tag	M_DP_TA_1
☒	<5>	:=	Step-position information	M_ST_NA_1
☒	<6>	:=	Step-position information with time tag	M_ST_TA_1
☐	<7>	:=	BitString of 32 bits	M_BO_NA_1
☐	<8>	:=	BitString of 32 bits with time tag	M_BO_TA_1
☒	<9>	:=	Measured value, normalized value	M_ME_NA_1
☒	<10>	:=	Measured value, normalized value with time tag	M_ME_TA_1
☒	<11>	:=	Measured value, scaled value	M_ME_NB_1
☒	<12>	:=	Measured value, scaled value with time tag	M_ME_TB_1
☒	<13>	:=	Measured value, short floating-point value	M_ME_NC_1
☒	<14>	:=	Measured value, short floating-point value with time tag	M_ME_TC_1
☒	<15>	:=	Integrated totals	M_IT_NA_1
☒	<16>	:=	Integrated totals with time tag	M_IT_TA_1
☐	<17>	:=	Event of protection equipment with time tag	M_EP_TA_1
☐	<18>	:=	Packed start events of protection equipment with time tag	M_EP_TB_1
☐	<19>	:=	Packed output circuit transmission of protection equipment with time tag	M_EP_TC_1
☐	<20>	:=	Packed single-point information with status change detection	M_PS_NA_1
☒	<21>	:=	Measured value, normalized value without quality descriptor	M_ME_ND_1
☒	<30>	:=	Single-point information with time tag CP56Time2a	M_SP_TB_1
☒	<31>	:=	Double-point information with time tag CP56Time2a	M_DP_TB_1

☒	<32>	:=	Step-position information with time tag CP56Time2a	M_ST_TB_1
☐	<33>	:=	BitString of 32 bits with time tag CP56Time2a	M_BO_TB_1
☒	<34>	:=	Measured value, normalized with time tag CP56Time2a	M_ME_TD_1
☒	<35>	:=	Measured value, scaled with time tag CP56Time2a	M_ME_TE_1
☒	<36>	:=	Measured value, short floating-point number with time tag CP56Time2a	M_ME_TF_1
☒	<37>	:=	Integrated totals with time tag CP56Time2a	M_IT_TB_1
☐	<38>	:=	Event of protection equipment with time tag CP56Time2a	M_EP_TD_1
☐	<39>	:=	Packed start events of protection equipment with time tag CP56Time2a	M_EP_TE_1
☐	<40>	:=	Packed output circuit information of protection equipment with time tag CP56Time2a	M_EP_TF_1

Process information in control direction

(station-specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☒	<45>	:=	Single command	C_SC_NA_1
☒	<46>	:=	Double command	C_DC_NA_1
☒	<47>	:=	Regulating step command	C_RC_NA_1
☒	<48>	:=	Set point command, normalized value	C_SE_NA_1
☒	<49>	:=	Set point command, scaled value	C_SE_NB_1
☒	<50>	:=	Set point command, short floating-point value	C_SE_NC_1
☐	<51>	:=	BitString of 32 bits	C_BO_NA_1

System information in monitor direction

(station-specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☒	<70>	:=	End of initialisation	M_EI_NA_1

System information in control direction

(station-specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☒	<100>	:=	Interrogation command	C_IC_NA_1
☒	<101>	:=	Counter Interrogation Command	C_CI_NA_1
☐	<102>	:=	Read command	C_RD_NA_1
☒	<103>	:=	Clock synchronisation command	C_CS_NA_1
☒	<104>	:=	Test command	C_TS_NB_1
☐	<105>	:=	Reset process command	C_RP_NC_1
☐	<106>	:=	Delay acquisition command	C_CD_NA_1

Parameter in control direction

(station-specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☐	<110>	:=	Parameter of measured value, normalized value	P_ME_NA_1
☐	<111>	:=	Parameter of measured value, scaled value	P_ME_NB_1
☐	<112>	:=	Parameter of measured value, short floating-point value	P_ME_NC_1
☐	<113>	:=	Parameter activation	P_AC_NA_1

File transfer

(station-specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☒	<120>	:=	File ready	F_FR_NA_1
☒	<121>	:=	Section ready	F_SR_NA_1
☒	<122>	:=	Call directory, select file, call file, call section	F_SC_NA_1
☒	<123>	:=	Last section, last segment	F_LS_NA_1
☒	<124>	:=	Ack file, ack section	F_AF_NA_1
☒	<125>	:=	Segment	F_SG_NA_1
☒	<126>	:=	Directory	F_DR_TA_1

Special use

- (station-specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)
- None

Type identifier and cause of transmission assignments

(station-specific parameters)

Shaded boxes are not required.

Blank = function or ASDU is not used

Mark type identification/cause of transmission combinations:

'X' if used only in the standard direction

'R' if used only in the reverse direction

'B' if used in both directions

Type ID		Cause of transmission																		
		1	2	3	4	5	6	7	8	9	10	11	12	13	20 to 36	37 to 41	44	45	46	47
<1>	M_SP_NA_1		X	X								X	X		X					
<2>	M_SP_TA_1			X								X	X							
<3>	M_DP_NA_1		X	X								X	X		X					
<4>	M_DP_TA_1			X								X	X							
<5>	M_ST_NA_1		X	X								X	X		X					
<6>	M_ST_TA_1			X								X	X							
<7>	M_BO_NA_1																			
<8>	M_BO_TA_1																			
<9>	M_ME_NA_1	X	X	X											X					
<10>	M_ME_TA_1			X																
<11>	M_ME_NB_1	X	X	X											X					
<12>	M_ME_TB_1			X																
<13>	M_ME_NC_1	X	X	X											X					
<14>	M_ME_TC_1			X																
<15>	M_IT_NA_1			X												X				
<16>	M_IT_TA_1			X																
<17>	M_EP_TA_1																			

Type ID		Cause of transmission																		
<18>	M_EP_TB_1																			
<19>	M_EP_TC_1																			
<20>	M_PS_NA_1																			
<21>	M_ME_ND_1	X	X	X																
<30>	M_SP_TB_1			X								X								
<31>	M_DP_TB_1			X								X								
<32>	M_ST_TB_1			X								X								
<33>	M_BO_TB_1																			
<34>	M_ME_TD_1			X																
<35>	M_ME_TE_1			X																
<36>	M_ME_TF_1			X																
<37>	M_IT_TB_1			X																
<38>	M_EP_TD_1																			
<39>	M_EP_TE_1																			
<40>	M_EP_TF_1																			
<45>	C_SC_NA_1						X	X	X	X	X						X	X	X	X
<46>	C_DC_NA_1						X	X	X	X	X						X	X	X	X
<47>	C_RC_NA_1						X	X	X	X	X						X	X	X	X
<48>	C_SE_NA_1						X	X	X	X	X						X	X	X	X
<49>	C_SE_NB_1						X	X	X	X	X						X	X	X	X
<50>	C_SE_NC_1						X	X	X	X	X						X	X	X	X
<51>	C_BO_NA_1																			
<70>	M_EI_NA_1				X															
<100>	C_IC_NA_1						X	X			X									
<101>	C_CI_NA_1						X	X			X									
<102>	C_RD_NA_1																			
<103>	C_CS_NA_1						X	X												
<104>	C_TS_NA_1						X	X												
<105>	C_RP_NA_1																			
<106>	C_CD_NA_1																			
<110>	P_ME_NA_1																			
<111>	P_ME_NB_1																			
<112>	P_ME_NC_1																			
<113>	P_AC_NA_1																			
<120>	F_FR_NA_1													X						
<121>	F_SR_NA_1													X						
<122>	F_SC_NA_1													X						
<123>	F_LS_NA_1													X						
<124>	F_AF_NA_1													X						
<125>	F_SG_NA_1													X						
<126>	F_DR_TA_1			X		X														

5.5.2.6 BASIC APPLICATION FUNCTIONS

Station initialisation

(station-specific parameter, mark 'X' if function is used)

☐ Remote initialisation

Cyclic data transmission

(station-specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☒ Cyclic data transmission

Read procedure

(station-specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☐ Read procedure

Spontaneous transmission

(station-specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☒ Spontaneous transmission

Link state between Controlling and Controlled Station

☒ Management of the COM lost (Problem detecting on the link)

☒ Management of the COM recovering (Problem not detecting on the link)

General interrogation

(station-specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☒ Global

☐	Group 1	☐	Group 7	☐	Group 13
☐	Group 2	☐	Group 8	☐	Group 14
☐	Group 3	☐	Group 9	☐	Group 15
☐	Group 4	☐	Group 10	☐	Group 16
☐	Group 5	☐	Group 11	Addresses per group have to be defined	
☐	Group 6	☐	Group 12		

Counter General interrogation

(station-specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☒ Global

☐ Group 1 ☐ Group 2 ☐ Group 3 ☐ Group 4

Clock synchronisation

(station-specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☒ Clock synchronisation

Notes: The controlled station reports the change of hour by sending a clock synchronisation message (ASDU 103) to the controlling station.

Command transmission

(object -specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☒ Direct command transmission

☒ Direct set-point command transmission

☒ Select and execute command

☒ Select and execute set-point command

☒ C_SE_ACTTERM used (returned to the controlling station to signal the end of a control sequence)

☒ No additional definition

☐ Short pulse duration (duration determined by a system parameter in the outstation)

☐ Long pulse duration (duration determined by a system parameter in the outstation)

☐ Persistent output

Transmission of integrated totals

(object -specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☐ Mode A: local freeze with spontaneous transmission

☐ Mode B: local freeze with counter interrogation

☐ Mode C: freeze and transmit by counter interrogation commands

☐ Mode D: freeze by counter interrogation command, frozen values reported spontaneously

☒	Counter read	☒	General request counter
☐	Counter freeze without reset	☐	Request counter group 1
☐	Counter freeze with reset	☐	Request counter group 2
☐	Counter reset	☐	Request counter group 3
		☐	Request counter group 4

Parameter loading

(object-specific parameter, mark each type ID ‘X’ if it is only used in the standard direction, ‘R’ if only used in the reverse direction, and ‘B’ is used in both directions)

☐ Threshold value

☐ Smoothing factor

☐ Low limit for transmission of measured value

☐ High limit for transmission of measured value

Parameter activation

(object-specific parameter, mark each type ID ‘X’ if it is only used in the standard direction, ‘R’ if only used in the reverse direction, and ‘B’ is used in both directions)

☐ Act/deact of persistent cyclic or periodic transmission of the addressed object

Test procedure

(station-specific parameter, mark each type ID ‘X’ if it is only used in the standard direction, ‘R’ if only used in the reverse direction, and ‘B’ is used in both directions)

☒ Test procedure

File transfer

(station-specific parameter), mark ‘X’ if function is used)

File transfer in monitor direction

☒ Transparent file

☒ Transmission of disturbance data of protection equipment

☒ Transmission of sequences of events

☐ Transmission of sequences of recorded analogue values

File transfer in control direction

☐ Transparent file

Background scan

(station-specific parameter, mark each type ID ‘X’ if it is only used in the standard direction, ‘R’ if only used in the reverse direction, and ‘B’ is used in both directions)

☒ Background scan

Acquisition of transmission delay

(station-specific parameter, mark each type ID ‘X’ if it is only used in the standard direction, ‘R’ if only used in the reverse direction, and ‘B’ is used in both directions)

☐ Acquisition of transmission delay

Management events priorities

(station-specific parameter, mark each type ID ‘X’ if it is only used in the standard direction, ‘R’ if only used in the reverse direction, and ‘B’ is used in both directions)

☐ Digital Inputs and Analog Inputs, management events priorities.
See: T101 standard Amendment 2 §7.2.2.2

5.5.2.7 APPLICATION FUNCTIONS

The following IEC-60870-5-5 standard application processes are required to be supported.

Station Initialisation

Station initialisation consists of a reset of the communications link (a “Reset CU” frame and a Time Synchronisation message are sent to the IED), followed by a general interrogation of the controlled station. Once this initialisation sequence is performed, the controlling station can start the polling for data report.

Communications failure

Communications to the controlled station must be re-initialised by the controlling station when the frame repeat process has completed without successfully transmitting the frame (i.e. the frame time-out period times the number of repeats).

If the controlled station fails to communicate with the controlling station, then the controlling station should perform a communications system initialisation for that controlled station.

Controlled station failure

The controlled station shall indicate to the controlling station that it has initialised by sending a frame indicating End of Initialisation with a Cause of Initialisation (COI) field, which will identify the reason for the initialisation.

Data Acquisition by Polling

The default for all analogue values shall be reporting as Class 2 data (COT=1, periodic/cyclic, or COT = 2, BackgroundScan cyclic).

Values returned as Class 2 data do not have a time tag (since they are constantly repeated).

The controlled station may return Class 1 data in response to a Class 2 request if no Class 2 data is available and Class 1 data is awaiting transmission.

At the controlled station, if a request for Class 2 data is received and no data is available a negative response, data not available, shall be returned to the controlling Station. The negative response is a fixed length frame (FC=9) or the Single Control Character (E5), which in this case is treated as a NACK.

By default, an IED is polled by a “Polling C2” frame, allowing to get “non priority information”. If an IED signals it has “priority information” (ACD bit set), it is polled with a “Polling C1” frame.

Normal Acquisition of Events

The default for all status changes are reported as Class 1 data (COT=3, spontaneous).

Values returned as Class 1 data shall have a time tag (either CP24Time2a, or CP56Time2a).

Status changes at the controlled station shall cause the ACD bit to be set in the next Class 1 or Class 2 data response. The controlling station shall respond to ACD set by inserting a scan for Class 1 (spontaneous) data as the next scan.

The response to a Class 1 data request shall also have the ACD bit set if more Class 1 data is awaiting transmission. In this case a further scan for Class 1 data shall be scheduled by the controlling station.

Abnormal Acquisition of Events

At the controlled station, if a request for Class 1 data is received and no data is available an error should be raised and a negative response, data not available, returned to the controlling Station. The negative response shall be a fixed length frame (FC=9) or the single Control Character (E5), which in this case is treated as a NACK (configurable).

At the controlling station, if a response to a scan for Class 1 data indicates no data is available, an error shall be raised, and scanning returned to Class 2 data requests.

General Interrogation

The GI returns the current status information directly from the C26x database.

Time tags are not used for data items returned as part of the GI response.

The GI groups are not supported, only the global general interrogation is supported.

Clock synchronisation

The System (including the controlled station) may have different synchronisation sources (IRIG-B, SCADA).

When the controlling station sends to controlled station a clock synchronisation and if the system is not synchronised by another source: the clock synchronisation response is positive.

When the controlling station send to controlled station a clock synchronisation and if the system (including the controlled station) is synchronised by another source: the clock synchronisation response is negative.

Time stamping

All Class 1 data are time-tagged with:

- either the 3 bytes time-stamp (CP24Time2a), giving minutes & millisec within the hour
- or the 7 bytes time-stamp (CP56Time2a), giving minutes, milliseconds, hours, day, month and year according to the C26x configuration.

In case of using relative time-Tag (CP24Time2a), the controlled station reports:

- the change of hour
- any time correction
- by sending a clock synchronisation message (ASDU 103) to the controlling station, as Class 1 data, with a cause of transmission spontaneous (3); the first frame is broadcast, the subsequent ones are sent point to point.

At initialisation or disconnection IEDs are not synchronised.

If the difference between IED time and C26x time is higher than 1s, the IED is considered to be not synchronised.

The invalid bit in the time-stamp is set when the time source is not available.

If the datapoint validity changes to “unknown” then it can be time-stamped as the latest received event or at the date of the change.

Command transmission

All control commands are Select Before Operate, or Direct Execute.

For only the control commands: Activation termination is returned to the controlling station to signal the end of a control sequence.

The QU field of the Qualifier of Command shall be set to zero (0), no additional definition.

Test procedure

A test command may be issued by the controlling station to ensure the availability of the communications link and the commands subsystem.

Test commands are received at the controlled station on the active link. The controlled station mirrors the test command, on the link from which it was received, with a cause of transmission indicating activation confirmation.

An error response is sent if the command is incorrect, with a cause of transmission indicating negative activation confirmation.

In the case of balanced mode, the controlled station may also send a test command to the controlling station, to ensure the availability of the communications link as there is no polling made by the controlling station.

NETWORK MONITORING

C26X/EN NM/E72C

Contents

1	**INTRODUCTION**	**3**
1.1	**Ethernet Switch boards in the DS Agile C26x**	**3**
1.2	**Ethernet Switch Board names**	**3**
1.3	**C26x Ethernet switch boards**	**3**
2	**CPU4 ETHERNET FEATURES**	**4**
3	**SRP28X RANGE – DUAL STAR ARCHITECTURE (PRP)**	**6**
3.1	**Functional Description**	**6**
3.1.1	Parallel Redundancy Protocol (PRP)	6
3.1.2	Time Synchronisation	6
3.1.3	Functional Design	9
3.1.4	Base-Tx Ethernet Switch function	9
3.1.5	Parallel Redundancy Protocol (PRP) management function	10
3.1.6	Time synchronisation function	10
3.1.7	Ethernet Management	11
3.1.8	Ethernet Port characteristics	11
3.1.9	SNMP Management	12
3.2	**Configuration and Settings**	**17**
3.2.1	MTU Configuration	17
3.2.2	SSH Communications	19
3.3	**Configuration via SSH**	**20**
3.3.1	SSH session	20
3.3.2	Login	20
3.3.3	Passwords and Authentication Levels for SNMP Access to MIB Data	22
3.3.4	Help command	22
3.3.5	Configuration commands	23
3.3.6	Management commands	25
3.3.7	Information retrieval commands	28
3.4	**Operating Modes**	**30**
3.5	**Firmware Upgrade**	**31**
3.6	**Cyber-Security**	**33**
3.6.1	Account and Profile Management	33
3.6.2	Password Policy	35
3.6.3	Authentication	36
3.6.4	Security Data Log	38
3.7	**LEDs and connections**	**38**
4	**SRP29X RANGE – SEAMLESS REDUNDANCY (HSR)**	**39**
4.1	**Functional Description**	**39**
4.1.1	High-availability Seamless Redundancy (HSR) Protocol	39
4.1.2	Functional Design	44
4.1.3	Base-Tx Ethernet Switch function	45
4.1.4	Ethernet Management	45
4.1.5	Ethernet Port characteristics	45
4.1.6	SNMP Management	46
4.2	**Settings**	**48**

4.2.1	SSH Communications	49
4.2.2	Configuration via SSH	49
4.3	**Firmware Upgrade**	**55**
4.4	**Cyber-Security**	**55**
4.4.1	Account and Profile Management	55
4.4.2	Password Policy	56
4.4.3	Authentication	56
4.4.4	Session timeout	57
4.4.5	Security Data Log	58
4.5	**LEDs and connections**	**58**

1 INTRODUCTION

DS Agile Ethernet switches are designed to address the needs of a wide range of electric plant. Emphasis has been placed on strong compliance to standards, scalability, modularity and open architecture.

These facilitate use in a range of applications from the most basic to the most demanding. They also ensure interoperability with existing components.

GE Grid Solutions' philosophy is to provide a range of Ethernet products such as switches that match all the general requirements needed in an electric substation: power supply, immunity to environmental constraints.

It provides also solutions to specific requirement like for example network redundancy management and high availability performances.

Each of these boards can be integrated to a Digital Control System (DCS) (such as DS Agile) or to various types of system and SCADA architectures.

1.1 ETHERNET SWITCH BOARDS IN THE DS AGILE C26X

Driven by the requirements around the world for advanced applications in SCADA, Digital Control Systems, Automation, control and monitoring, GE Grid Solutions has designed and continues to expand a comprehensive range of products that communicate via Ethernet links.

Electric plant requirements lead to constraints that are rarely met by standard Ethernet products: environmental, power supply, redundancy, etc.

The main processor board of the DS Agile C26x, the CPU4, offers switch capabilities. Depending on the bitstream loaded in its memory, it manages standard (non-redundant), PRP redundancy or HSR redundancy. In addition, GE Grid Solutions' ranges of dedicated Ethernet switches, the DS Agile/Reason Hxxx, as well as SRPxxx, are especially tailored for the DS Agile system. The DS Agile/Reason Hxxx and SRPxxx ranges are designed to address the needs of a wide range of installations, from small to large and customer applications.

1.2 ETHERNET SWITCH BOARD NAMES

Two dedicated switch boards are available:

- SRP28x Ethernet Switch board for Ethernet Dual Star PRP Architecture
- SRP29x Ethernet Switch board for Ethernet HSR Architecture

They are used complement the CPU4 Ethernet capabilities. Only one SRP2xx can be fitted in a DS Agile C26x.

1.3 C26X ETHERNET SWITCH BOARDS

The SRPxxx Ethernet switch board ranges is composed of managed switches, easy to install and operate, designed to be implemented in an electric plant environment (IEC 61000-4 & 60255-5).

On the media side, the range supports 10BaseT, 100BaseTX and 100BaseFX as specified by the IEEE 802.3 committee. Management of the full duplex is available for 100BaseTx or 100BaseFx.

To adapt the switch to your application you have to configure the necessary parameters with "jumpers" located on the board.

2 CPU4 ETHERNET FEATURES

Depending on the bitstream it operates on, the CPU4 has various communications configurations.

If optical redundancy is configured for ports 1 and 2 (for configuration details, refer to the *Application* chapter of the SCE user manual), the CPU4 can communicate on either a PRP (Parallel Redundancy Protocol) or an HSR (High-availability Seamless Redundancy Protocol) network.

RJ45 ports can be used to connect the C26x to a wired network or to allow it to serve as a Redbox for singly attached devices.

The following table shows which cable or fibre should be connected to what port depending on the case.

Use Case	Port 1 *	Port 2	Port 3	Port 4	Port 5	Port 6
Bitstream 2604 (BCU)	SAN	SAN	SAN	SAN	SAN	SAN
Bitstream 2511 *Reserved for future version.*	RED	RED	SAN	SAN	SAN	
Bitstream 2313 BCU & Redundancy (PRP/HSR)	RED	RED	SAN			
Bitstream 2233 BCU with SRPVx board	RED	RED				
Bitstream 2414 BCU & Redundancy (PRP/HSR)	RED	RED	SAN	SAN		
Bitstream 2610 C26x GTW & Redundancy (PRP/HSR)	RED	RED	SAN	SAN	SAN	SAN

***Note**: Port 1 is the first port starting from the LEDs on the top.

Note: a RED port can be configured as SAN port, but a SAN port cannot be configured as a RED port.

For further details on bitstream, refer to use case definition in the table below.

Bitstream ID definition:

Digit #	Description
1	Hardware version of the CPU board = 2 for ed "G"
2	Number of CPU external ports configured in bitstream (from 1 to 6)
3	Redundant Switch features: **0**: No redundant switch **1**: Redundant switch (always on the first 2 external CPU ports) **2**: HSBP port, and no redundant switch **3**: Redundant switch (always on the first 2 external CPU ports) and HSBP port
4	C26x features: **0**: No trip GOOSE, no Sample Value, no TMU **1**: Trip GOOSE only **2**: SVU only **3**: Trip GOOSE and SVU **4**: TMU only **5**: Trip GOOSE and TMU

3 SRP28X RANGE – DUAL STAR ARCHITECTURE (PRP)

3.1 FUNCTIONAL DESCRIPTION

The SRP28x facilitates connecting Ethernet equipped devices via a Parallel Redundancy Protocol (PRP in accordance with IEC 62439-3). Devices connect to the switch by copper connections using RJ45 connectors. These connections comply with 10/100Base-Tx. Three ports (ports 2, 3, & 4) are available for connecting external devices. Each port, independently, detects the speed of the connected device (10Mbps or 100Mbps) and whether the link is half-duplex or full-duplex. It then automatically adjusts to suit.

Ethernet copper links are limited in distance and subject to interference. You should keep them as short as possible.

The Parallel Redundancy Protocol connection uses fibre-optic inter-switch connections. A multi-mode fibre-optic version is available for short distance connections (typically up to around 2km), and a single-mode version is available for longer distances (potentially in excess of 15km). The PRP ports support 100Base-Fx using LC connectors.

The SRP28x also supports the Precision Time Protocol (PTP in accordance with IEEE1588), taking time synchronisation from a master clock and distributing it locally.

Time synchronisation is distributed using IRIG-B on a dedicated SMB connector.

An internal Ethernet connection is also provided (port 1). It provides a 10/100Base-Tx port on an RJ45 connector.

3.1.1 PARALLEL REDUNDANCY PROTOCOL (PRP)

The Parallel Redundancy Protocol (PRP) is implemented according to the definition in the standard IEC 62439-3.

PRP allows seamless communication in the face of a single network disruption (for instance cable, driver, switch or controller failure).

3.1.2 TIME SYNCHRONISATION

The SRP28x supports real-time clock synchronisation using either Precision Time Protocol (PTP in accordance with IEEE 1588 v2), or Network Time Protocol (NTP).

The SRP28x takes timing information presented over the network and distributes it locally.

A one pulse-per-second (PPS) signal is generated and is displayed on an LED.

3.1.2.1 PRECISION TIME PROTOCOL (PTP)

Time synchronisation from a master clock synchronised to the Global Positioning Satellite (GPS) system is accepted over the network and distributed locally according to IEEE 1588 v2 as demonstrated in the figure below:

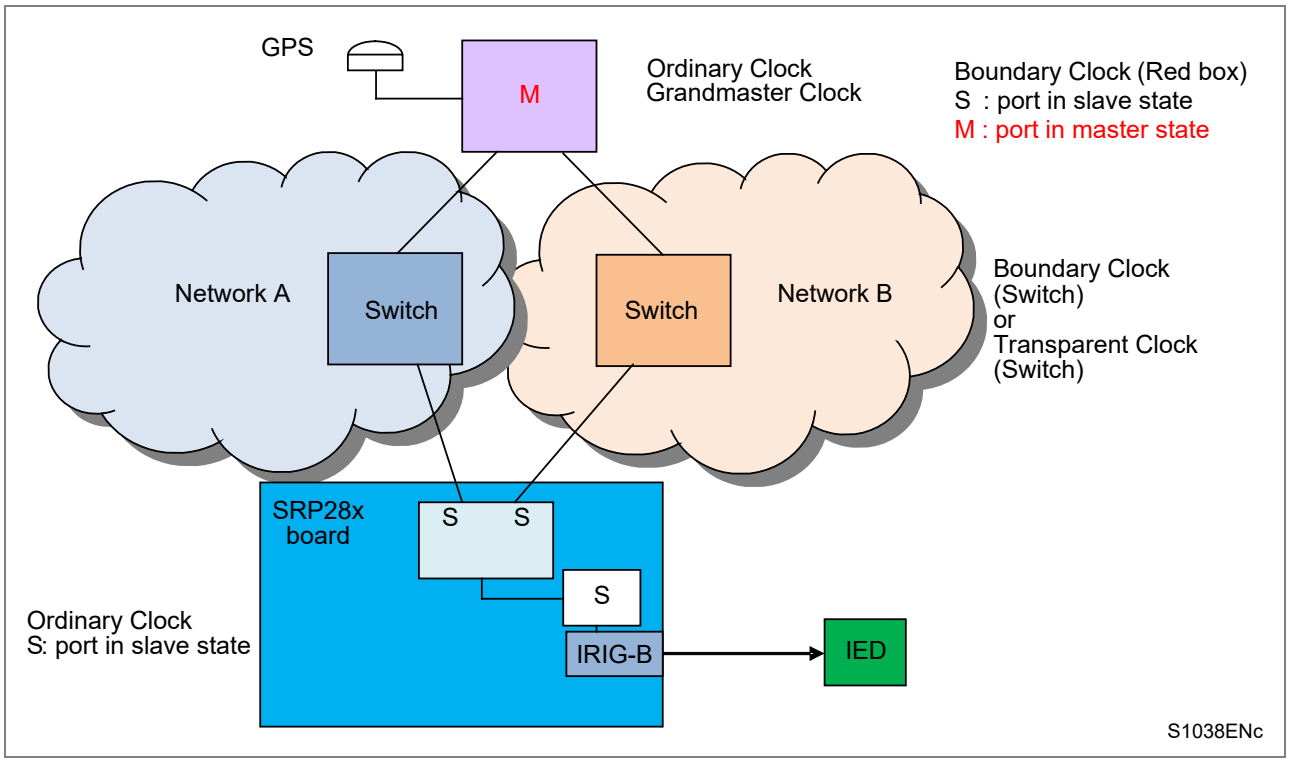


Figure 1: PTP architecture

PTP synchronises all clocks within a network by adjusting distributed clocks to a grandmaster clock. PTP enables distributed clocks to be synchronised and maintained to sub-microsecond accuracy.

The grandmaster clock is the primary time source. Boundary clocks create segmented synchronisation sub-domains. So-called 'ordinary' clocks can either act as time servers or as time clients.

The SRP28x board uses IEEE1588 to provide the IRIG-B output.

Note:
The SRP28x board does NOT forward the PTP data to the access ports.

3.1.2.2 NETWORK TIME PROTOCOL

Network Time Protocol (NTP) is a networking protocol for clock synchronisation between computer systems over packet-switched, variable-latency data networks.

NTP is supported by the SRP28x as shown diagrammatically in the figure below.

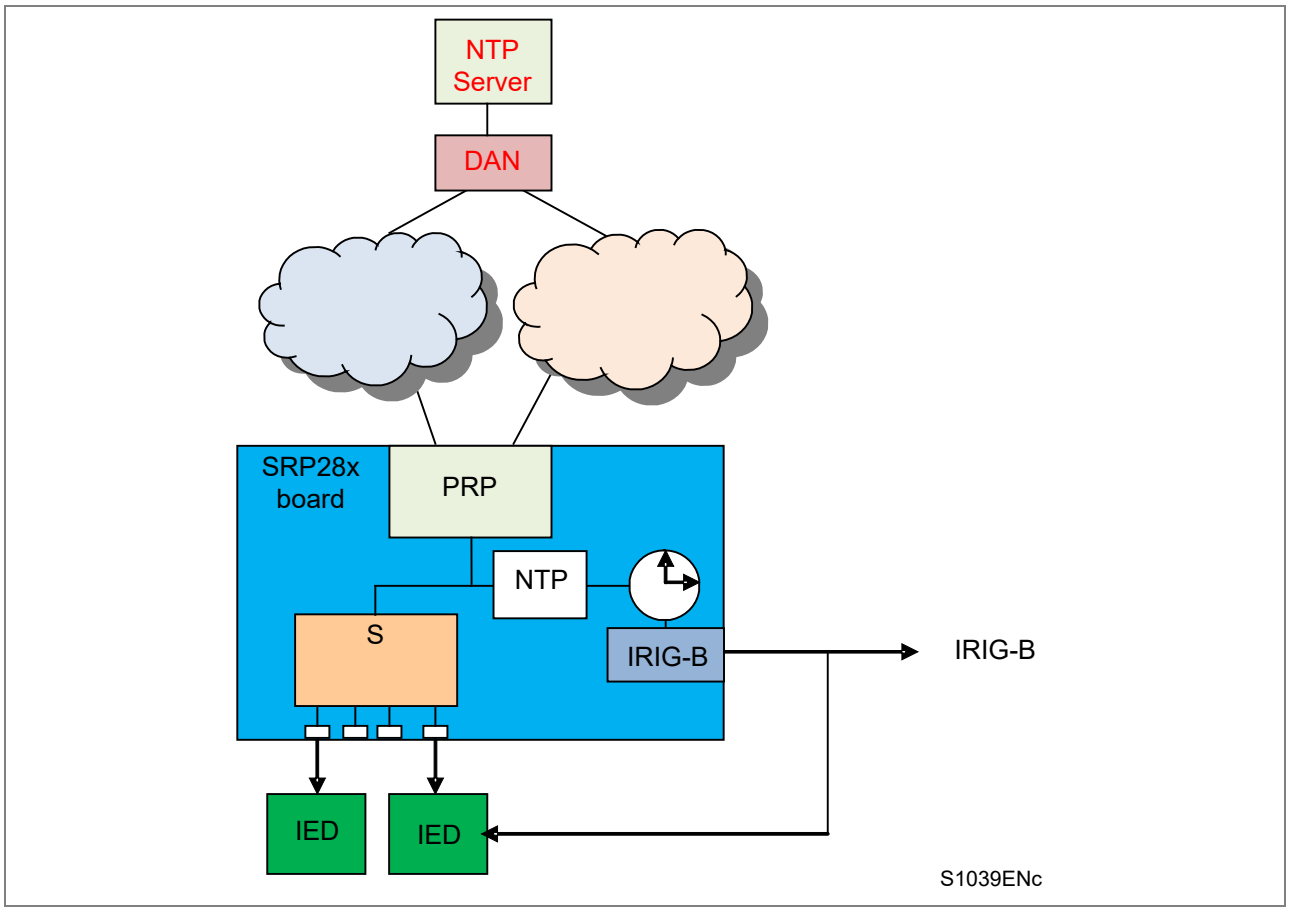


Figure 2: NTP architecture

3.1.2.3 TIME SYNCHRONISATION DISTRIBUTION

Time synchronisation is distributed via a dedicated IRIG-B connection or via Ethernet services.

3.1.2.4 IRIG-B

The clock reference for the SRP28x comes from either the PTP or the NTP services. It is used to generate a timing signal that is output to a connector at the rear of the unit.

The output is compliant with the Inter-Range Instrumentation Group time code B standard (IRIG-B).

The signal is in accordance with the standard IRIG-B 126: Sine wave carrier (amplitude modulated) at 1 kHz (1 ms resolution), Binary Coded Decimal (BCD). The IRIG-B time reference provided is the UTC time.

3.1.3 FUNCTIONAL DESIGN

The figure below shows the main functional blocks of the SRP28x:

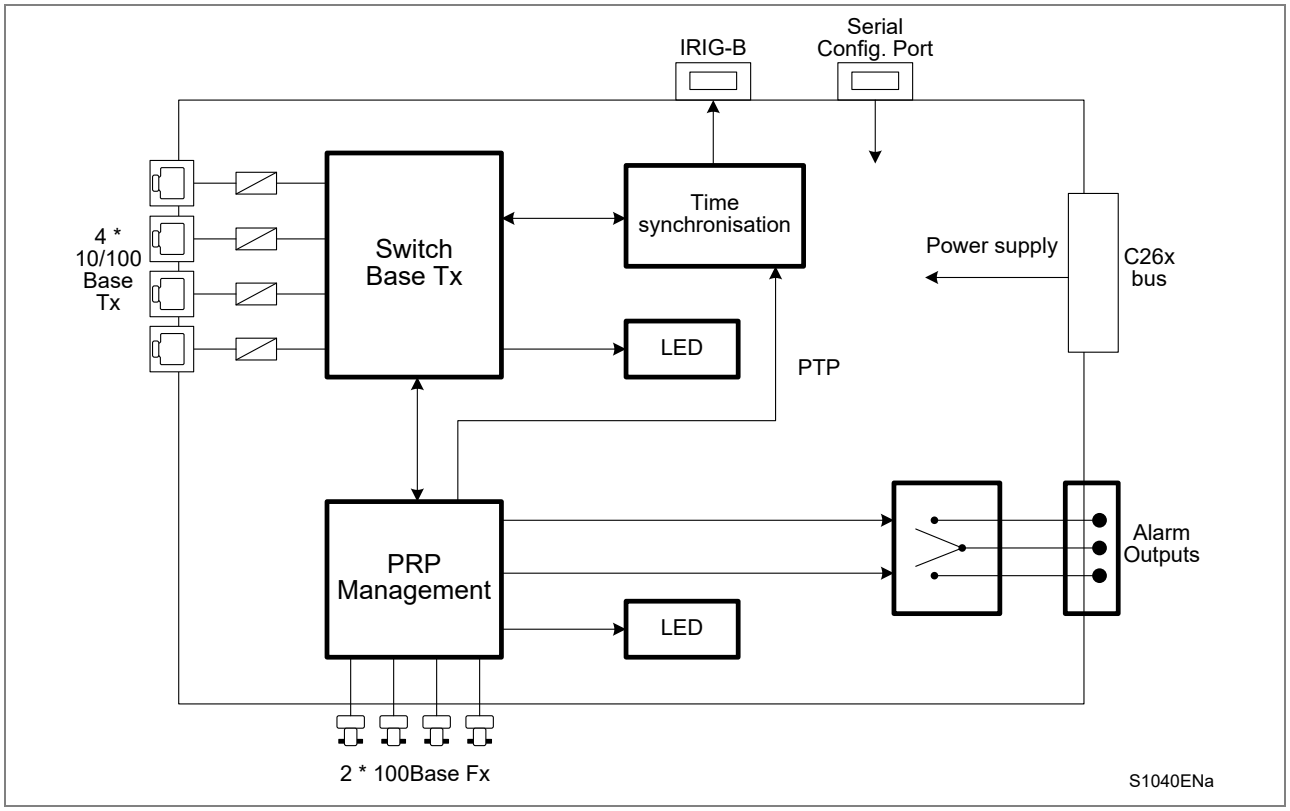


Figure 3: SRP28x functional diagram

The principal functional component parts are:

- The Base-Tx Ethernet Switch
- The Parallel Redundancy Protocol (PRP) management
- Time synchronisation management
- SNMP (Simple Network Management Protocol) management
- Light Emitting Diodes (LED) and alarm outputs.
- SSH/Telnet configuration port

3.1.4 BASE-TX ETHERNET SWITCH FUNCTION

The Base-Tx Ethernet Switch function manages three Ethernet ports presented for user connection (ports 2, 3, & 4), and two internal ports for service connection. The user ports are 10/100 Base-Tx using RJ45 connectors. Ports 2, 3, & 4 are located at the rear of the unit and are qualified by LED indications of link activity. Port 1 is a 10/100 Base-Tx internal service port using an RJ45 connector located at the front of the board. The other internal service connection port is Port 0, and is also located at the front of the board. It supports 10/100/1000 Base-Tx and uses a Samtec ERF8-RA connector. The port shares a connector with signals described under the time synchronisation section of this document.

If a cable is not connected to a port, most of the circuitry for that port is disabled to save power.

Using auto-negotiation, the SRP28x automatically determines the speed of transmission on the 10/100 Base-Tx ports according to the IEEE 802.3u standard. It also determines whether communication is half-duplex or full-duplex, and adapts accordingly.

Each Ethernet device inserts its unique “MAC address” into each message it sends. The receiving port on the SRP28x automatically recognises the MAC address in a received frame and stores it. Once an address is recognised and stored, the SRP28x will forward frames to the appropriate port. Up to 1024 MAC addresses can be stored and monitored at any time.

The SRP28x supports the store and forward mechanism of the IEEE 802.3 standard. It forwards messages with known addresses to the appropriate port. Messages with unknown addresses, broadcast messages, and multicast messages are forwarded out to all ports except the source port. It does not forward error packets or 802.3x pause frames.

Priority tagging according to IEEE 802.1p is enabled on all ports.

3.1.5 PARALLEL REDUNDANCY PROTOCOL (PRP) MANAGEMENT FUNCTION

The Parallel Redundancy Protocol (PRP) management function manages traffic over the dual redundant 100 Base-Fx fibre-optic Ethernet connections according to IEC 62439-3.

3.1.6 TIME SYNCHRONISATION FUNCTION

This product supports real-time clock synchronisation using either Precision Time Protocol (PTP in accordance with IEEE 1588 v2), or Network Time Protocol (NTP).

A one pulse-per-second (PPS) signal is generated and is displayed on an LED labelled as “Heartbeat” on the display.

Time synchronisation is available as an NTP service or via IRIG-B.

3.1.6.1 PRECISION TIME PROTOCOL (PTP)

Time synchronisation from a master clock synchronised to the global positioning satellite (GPS) system is accepted over the network according to IEEE 1588.

PTP synchronises all clocks within a network by adjusting distributed clocks to a grandmaster clock. PTP enables distributed clocks to be synchronised and maintained to sub-microsecond accuracy.

3.1.6.2 NETWORK TIME PROTOCOL (NTP)

Network Time Protocol (NTP) is a networking protocol for clock synchronisation between computer systems over packet-switched, variable-latency data networks.

NTP is supported by this product.

3.1.6.3 IRIG-B

A time synchronisation signal compliant with the Inter-Range Instrumentation Group time code B (IRIG-B) is generated within the product.

The signal is in accordance with the standard IRIG-B 126: Sine wave carrier amplitude modulated at 1 kHz (1 ms resolution), Binary Coded Decimal (BCD). The IRIG-B time reference provided is the UTC time.

The signal is presented on a connector located between the LEDs. An SMB connector is used which provides 2 kVrms isolation and >100 MOhms insulation resistance. Up to 10 devices can be connected for synchronisation.

3.1.7 ETHERNET MANAGEMENT

Standards	IEEE802.3, 802.3u, 802.3x, 802.1p
Forwarding mode	Store and forward
Memory bandwidth	2 Gbps
MAC Address	1K
Address learning	Automatic
Broadcast storm protection	Limited to 5%
Illegal frame	Dropped per 802.3
Late collision	Dropped after 512 bit times

3.1.8 ETHERNET PORT CHARACTERISTICS

3.1.8.1 10/100BASE-TX MODE

Connector type	Shielded RJ45 connector
Twisted pair cable	Cat 5
Max. cable length with Cat 5	100 m

3.1.8.2 100BASE-FX MULTIMODE MODE

Fiber port connector	LC
Optimal fiber cable	62.5/125 µm or 50/125 µm
Centre wavelength	1310 nm
TX output power	-20 dBm
RX input sensitivity	-31 dBm
Maximum distance	2000 m (Approximate. Refer to the *Fiber Optic Budget Calculation* from *PRP ETHERNET SWITCH SRP282/284* in Hardware Chapter section)

3.1.8.3 100BASE-FX SINGLE MODE MODE

Fiber port connector	LC
Optimal fiber cable	9/125 or 10/125 µm
Centre wavelength	1310 nm
TX output power	-15 dBm
RX input sensitivity	-31 dBm
Maximum distance	15 km (Approximate. Refer to the *Fiber Optic Budget Calculation* from *PRP ETHERNET SWITCH SRP282/284* in Hardware Chapter section)

3.1.9 SNMP MANAGEMENT

For this board, the GE Grid Solutions management information bases (MIB) use the following types of object identifiers (OID):

- System
- Interface
- Remote network monitoring (RMON)
- Parallel redundancy protocol (PRP)

These are defined in the tables below.

3.1.9.1 SYSTEM MIB STRUCTURE

Address								Name	Default Setting
0								ccitt	
1								iso	
	3							org	
		6						dod	
			1					internet	
				2				mgmt	
					1			mib-2	
						1		system	
							1	sysDescr	Redundant PRP switch
							2	sysObjectID	.0.1
							3	sysUpTime	Time (in hundredths of a second) since the switch was last reinitialised
							4	sysContact	user-configurable
							5	sysName	SRP (user-configurable)
							6	sysLocation	user-configurable
							7	sysServices	2
							8	sysORLastChange	
							9	sysORTable	

3.1.9.2 INTERFACE MIB STRUCTURE

Address										Name	Default Setting
0										ccitt	
1										iso	
	0									std	
	3									org	
		6								dod	
			1							internet	
				1						directory	
				2						mgmt	
					1					mib-2	
						1				system	

Address										Name	Default Setting
						2				interfaces	
							1			ifNumber	
							2			ifTable	
								1		IfEntry	
									1	ifIndex	
									2	ifDescr	
									3	ifType	
									4	ifMtu	
									5	ifSpeed	
									6	ifPhysAddress	
									7	ifAdminStatus	1: up, 2: down
									8	ifOperStatus	1: up, 2: down
									9	ifLastChange	time (in hundredths of a second) since the latest change
									10	ifInOctets	
									11	ifInUcastPkts	
									12	ifInNUcastPkts	
									13	ifInDiscards	
									14	ifInErrors	
									15	ifInUnknownProtos	
									16	ifOutOctets	
									17	ifOutUcastPkts	
									18	ifOutNUcastPkts	
									19	ifOutDiscards	
									20	ifOutErrors	
									21	ifOutQLen	
									22	ifSpecific	

3.1.9.3 RMON MIB STRUCTURE

Address											Name
0											ccitt
1											iso
	3										org
		6									dod
			1								internet
				2							mgmt
					1						mib-2
						1					system
						2					interfaces
						3					at
						4					ip
						5					icmp
						6					tcp
						7					udp

Address											Name
						8					egp
						10					transmission
						11					snmp
						16					rmon
							1				statistics
								1			etherStatsTable
									1		etherStatsEntry
										1	etherStatsIndex
										2	etherStatsDataSource
										3	etherStatsDropEvents
										4	etherStatsOctets
										5	etherStatsPkts
										6	etherStatsBroadcastPkts
										7	etherStatsMulticastPkts
										8	etherStatsCRCAlignErrors
										9	etherStatsUndersizePkts
										10	etherStatsOversizePkts
										11	etherStatsFragments
										12	etherStatsJabbers
										13	etherStatsCollisions
										14	etherStatsPkts64Octets
										15	etherStatsPkts65to127Octets
										16	etherStatsPkts128to255Octets
										17	etherStatsPkts256to511Octets
										18	etherStatsPkts512to1023Octets
										19	etherStatsPkts1024to1518Octets
										20	etherStatsOwner
										21	etherStatsStatus

3.1.9.4 PRP MIB STRUCTURE

The PRP MIB is accessible only through SNMPv3.

Address												Name
0												ccitt
1												iso
	0											std
		64239										iec62439
			1									mrp
			2									prp
				20								linkRedundancyEntityNotifications
				21								linkRedundancyEntityObjects
					0							lreConfiguration
						0						lreConfigurationGeneralGroup
							1					lreManufacturerName

Address												Name
							2					lreInterfaceCount
						1						lreConfigurationInterfaceGroup
							0					lreConfigurationInterfaces
								1				lreInterfaceConfigTable
									1			lreInterfaceConfigEntry
										1		lreInterfaceConfigIndex
										2		lreRowStatus
										3		lreNodeType
										4		lreNodeName
										5		lreVersionName
										6		lreMacAddress
										7		lrePortAdminStateA
										8		lrePortAdminStateB
										9		lrelinkStatusA
										10		lrelinkStatusB
										11		lreDuplicateDiscard
										12		lreTransparentReception
										13		lreHsrLREMode
										14		lreSwitchingEndNode
										15		lreRedBoxIdentity
										16		lreEvaluateSupervision
										17		lreNodesTableClear
										18		lreProxyNodeTableClear
					1							lreStatistics
						1						lreStatisticsInterfaceGroup
							0					lreStatisticsInterfaces
								1				lreInterfaceStatsTable
									1			lreInterfaceStatsEntry
										1		lreInterfaceStatsIndex
										2		lreCntTxA
										3		lreCntTxB
										4		lreCntTxC
										5		lreCntErrWrongLanA
										6		lreCntErrWrongLanB
										7		lreCntErrWrongLanC
										8		lreCntRA
										9		lreCntRxB
										10		lreCntRxC
										11		lreCntErrorsA
										12		lreCntErrorsB
										13		lreCntErrorsC
										14		lreCntNodes
										15		lreCntProxyNodes
										16		lreCntUniqueA

Address												Name
										17		lreCntUniqueB
										18		lreCntUniqueC
										19		lreCntDuplicateA
										20		lreCntDuplicateB
										21		lreCntDuplicateC
										22		lreCntMultiA
										23		lreCntMultiB
										24		lreCntMultiC
										25		lreCntOwnRxA
										26		lreCntOwnRxB
									2			lreNodesTable
										1		lreNodesEntry
											1	lreNodesIndex
											2	lreNodesMacAddress
											3	lreTimelastSeenA
											4	lreTimelastSeenB
											5	lreRemNodeType
									3			lreProxyNodeTable
										1		lreProxyNodeEntry
											1	lreProxyNodeIndex
											2	lreProxyNodeMacAddress
				22								linkRedundancyEntityConformance

3.1.9.5 SNMP CLIENT SOFTWARE

Readily available Management Information Bases (MIB) browser software enables you to perform all the basic Simple Network Management Protocol (SNMP) operations, such as GET, GETNEXT, and RESPONSE, by connecting to the switch.

3.1.9.6 SNMP TRAPS

A Simple Network Management Protocol (SNMP) trap is a change-of-state message. The board generates SNMP traps on coldstart, warmstart, linkup, linkdown. The version used is SNMP v1 and the traps are shown in the table below:

Trap Type	Name	Description
0	coldstart	The switch is booting
1	warmstart	The switch is rebooting
2	linkdown	An interface has gone down
3	linkup	An interface has come up

3.1.9.7 SNMP ACCESIBILITY

The Simple Network Management Protocol (SNMP) supports the versions 1 – 3 according to the rules below:

SNMP v1 and v2:

- Read community: Public
- Write community: Private

SNMP v3:

Level	System MIB	Other MIB
Operator	Read, encrypted	Read, encrypted
Administrator	Read/Write, encrypted	Read/Write, encrypted

An Administrator can change any user password. Other users can only change their own password.

3.2 CONFIGURATION AND SETTINGS

The SRP28x is configured using a series of dialogues between the board and a terminal emulator on a personal computer (PC) or similar device. Connection is made via an SSH connection over the Ethernet.

The connection is used to configure, manage, and monitor the board. LED indications provide complementary status information.

The connection can also be used to upgrade the firmware of the board should that be necessary.

There are 2 possible external access points:

- over an Ethernet network connected to any of the three RJ45 ports accessible on the back panel of the C26x,
- via SSH, over the HSR network connected to its redundant optical connectors.

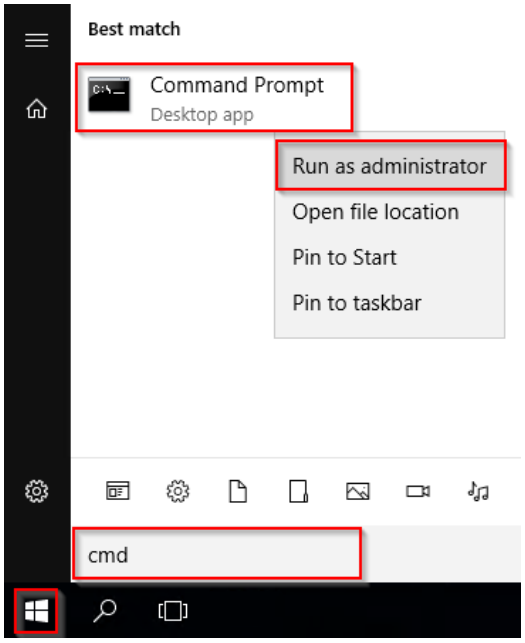
3.2.1 MTU CONFIGURATION

Note:
This section applies to Windows 10 LTSC 2019 for Enterprise 64-bits edition. It does not apply to older versions of Windows 7..

In order to connect an SSH terminal emulator running under Windows 10 to the board, it is necessary to adjust the size of the frames ("Maximum Transmission Unit") sent over the network. The default size is *1500*. It must be changed to *1494*.

To do this:

- First open a Command Prompt (**cmd.exe**) window, running it as administrator (right-click and select *Run as administrator*):



- Type the command line `netsh interface ipv4 show interface` and press **Enter**.
  This displays the networks and the setting for their MTU (*1500* by default).

```
C:\Windows\system32>netsh interface ipv4 show interface

Idx     Met         MTU          State                Name
---  ----------  ----------  ------------  ---------------------------
  1          50  4294967295  connected     Loopback Pseudo-Interface 1
 11          20        1500  connected     LowerNetwork
 13          20        1500  connected     UpperNetwork
```

- For each network, in this example: *LowerNetwork* and *UpperNetwork*, type the command line `netsh interface ipv4 set subinterface "x" mtu=1494 store=persistant` and press **Enter**.
  (with x = name of the network, see example below)
  This permanently changes the setting for the corresponding network's MTU to *1494*.

```
C:\Windows\system32>netsh interface ipv4 show interface

Idx     Met         MTU          State                Name
---  ----------  ----------  ------------  ---------------------------
  1          50  4294967295  connected     Loopback Pseudo-Interface 1
 11          20        1500  connected     LowerNetwork
 13          20        1500  connected     UpperNetwork

C:\Windows\system32>netsh interface ipv4 set subinterface "LowerNetwork" mtu=1494 store=persistent
Ok.
```

- Again, type the command line `netsh interface ipv4 show interface` and press **Enter**.
  This displays the networks to check that the setting for their MTU is effectively changed to *1494*.

```
C:\Windows\system32>netsh interface ipv4 show interface

Idx     Met         MTU          State                Name
---  ----------  ----------  ------------  ---------------------------
  1          50  4294967295  connected     Loopback Pseudo-Interface 1
 11          20        1494  connected     LowerNetwork
 13          20        1500  connected     UpperNetwork
```

3.2.2 SSH COMMUNICATIONS

An SSH access is provided to configure and manage the board.

SSH is a virtual terminal protocol of TCP/IP. It provides encrypted interconnectivity between elements of a network. The terminal is connected to the network like any other device as shown in the figure below.

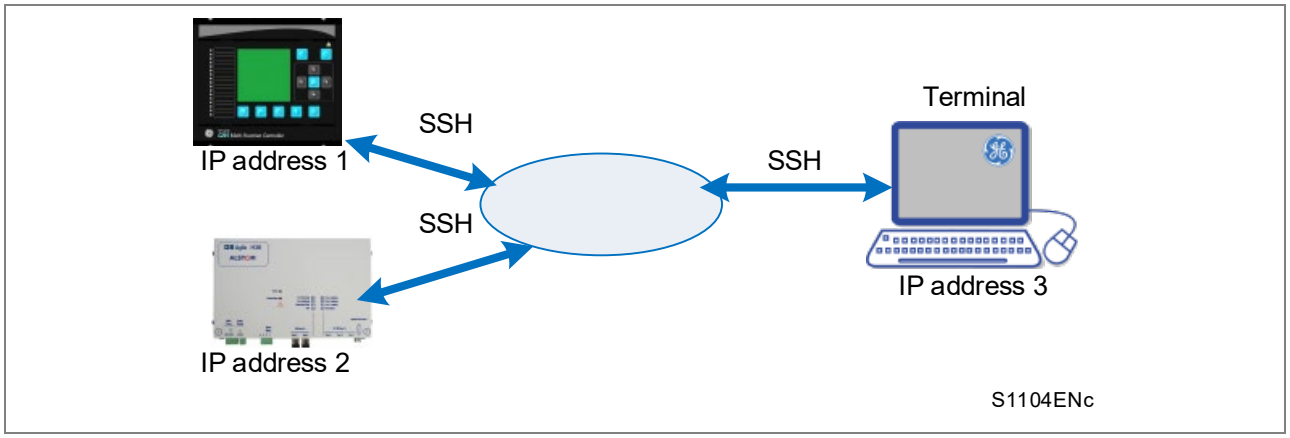


Figure 4: SSH connection example over the PRP network

Note:
The IP addresses must be part of the same network as the terminal and the subnet mask must not exclude them.

With the SSH connection, the terminal can be used to communicate with all functions of the SRP28x.

There are two default accounts:

- root
- user

Both have the same default password:

- changeit

The default IP address is:

- 192.168.254.100

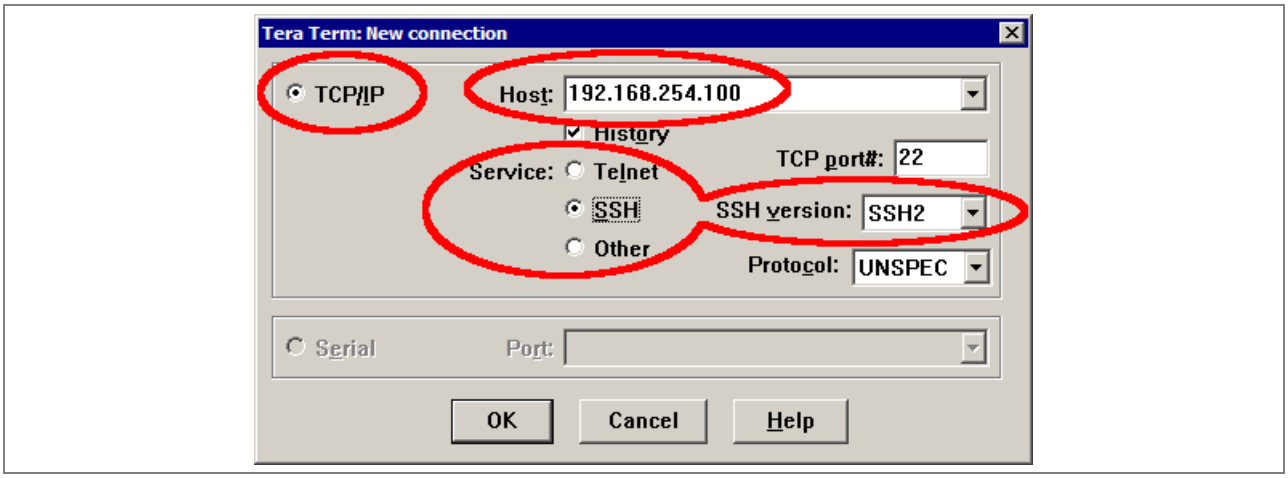
3.3 CONFIGURATION VIA SSH

Most of the available SSH commands are advanced configuration settings that will rarely be used, if ever, since the default settings should fit most applications.
HOWEVER, THE PASSWORDS AND IP ADDRESSES MUST BE CHANGED.

3.3.1 SSH SESSION

To open an SSH session with the board, use a standard SSH2-compatible client:

1 Launch the SSH client application.



2 Select the options *TCP/IP* and *SSH service*, *SSH version 2*.

3 Type the *IP address* of the board in the appropriate field.

4 Click **OK** or **Connect** (or equivalent, depending on the chosen SSH client).

A login window is displayed.

The board is supplied with a unique Media Access Control (MAC) address which should not be changed. It is supplied with a default Internet Protocol (IP) address of **192.168.254.100**.

3.3.2 LOGIN

Before the session is opened, you will have a login dialogue as shown in the figure below. You log in according to the role(s) associated with your user account.

Default accounts

The board is delivered with two pre-defined accounts:

- "root"
- "user"

The default password for both accounts is "changeit".

Note:
Upgrading a board's firmware does not reset accounts and passwords.

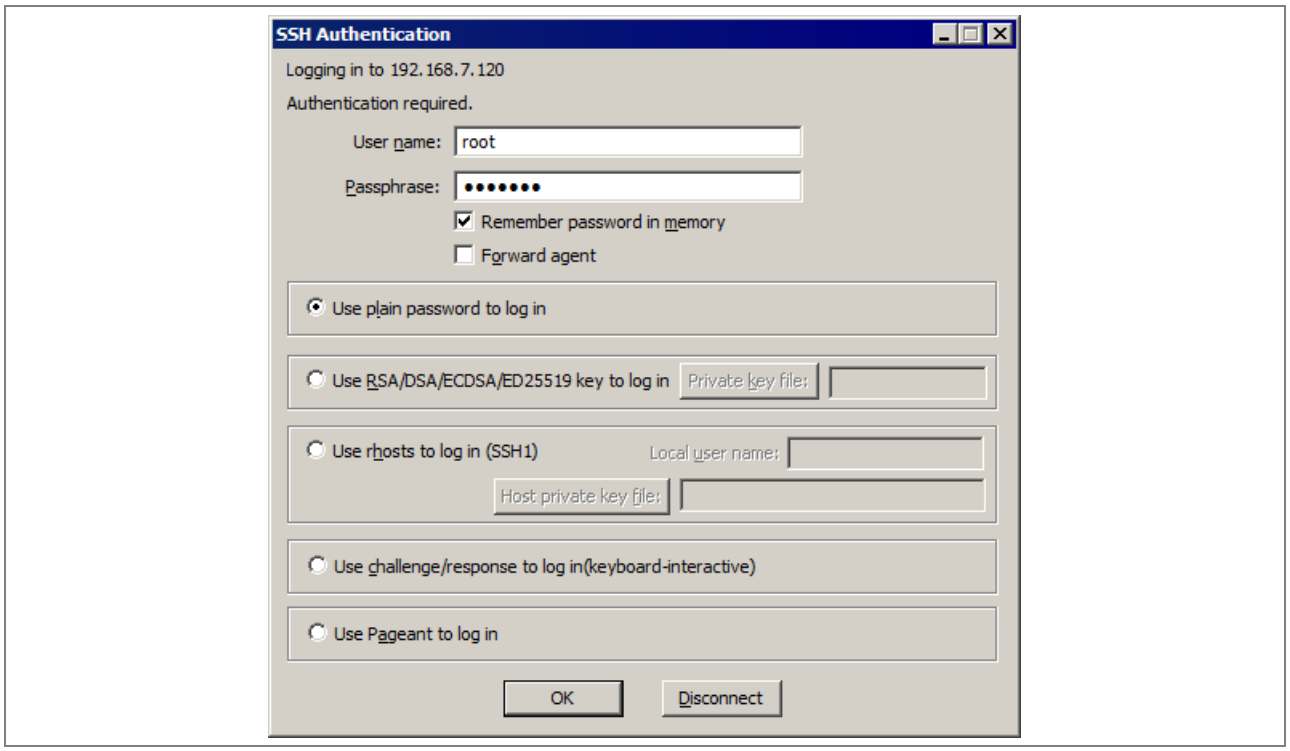


Figure 5: Example of Login window (may vary depending on the selected terminal emulator)

Note:
See Cyber-Security section for more information on user accounts.

Note 2.
The connection process on SSH may take up to 1 minute.

The connection is established and an SSH console is displayed. Once the session is in progress, your access level is indicated by either a # for Security administrator level, or a $ for non-administrator level (VIEWER/ENGINEER roles).



Caution:
Change the default passwords immediately.
To do so, log in as "root" and type the commands:
- `setPassword user` for the account "user"
- `setPassword` for the account "root" (currently logged in),
press Enter, and then follow the onscreen prompts.

3.3.3 PASSWORDS AND AUTHENTICATION LEVELS FOR SNMP ACCESS TO MIB DATA

There are three possible authentication levels for SNMP:

- Observer: Does not require login and password, can only read unencrypted data.
- Operator: Requires login and password, can read all data.
- Administrator: Requires login and password, can read and write all data.

SNMP V3 passwords must be a minimum of 8 characters long in accordance with the standard.

Examples of the dialogue to set the passwords are given in the below.

Setting the SNMP V3 Administrator/Operator Passwords

1 Type the command **# setSnmpPassword Administrator** or **setSnmpPassword Operator** and press **Enter**.

2 When prompted, type the name of the account for which you want to change the password: **Administrator** or **Operator**. Press **Enter**.

3 When prompted, type the new password (note that it is not displayed) and then press **Enter**.

4 Retype the new password (note that it is not displayed) and press **Enter**.

5 Repeat this procedure to change the password for the other account.

```
# setSnmpPassword Administrator
New password:
Retype the new password:
```

3.3.4 HELP COMMAND

To access the Help screen with the list of available commands, type the letter **h** and press enter.

The Command help screen shows all the options that can be used to configure and manage the SRP28x board. There are five types of commands:

- Configuration commands
- Management commands
- Informative commands
- PRP registers
- Information on the PRP and Ethernet switch ports

Command Line Syntax

To display a command line syntax, type in the command alone (without parameters) and press **Return**. The syntax and available parameters are then displayed, along with a setting example:

```
 ~ # setSnmpPassword
What account do you want to change the password ?
1 : Administrator
2 : Operator
--> Administrator

New password:
Retype the new password:
```

Command without parameters

3.3.5 CONFIGURATION COMMANDS

Configuration command	Syntax	Example
Enable/disable password policy	`passwdPolicy <options>`	`passwdPolicy 0 = disable` `passwdPolicy 1 = enable`
Set authentication timeout (in seconds) Time allowed to log in before the connection is terminated.	`setAuthenticationTimeout <time>`	`setAuthenticationTimeout 60`
Set session timeout (in seconds) If no command is sent for that duration, the session is automatically closed.	`setSessionTimeout <time>`	`setSessionTimeout 300`
Set Account locking parameters Number of failed attempts that trigger a lockout and duration of the lockout (in seconds).	`setLockAccount <login retries> <lock_time>`	`setLockAccount 3 60`
Set MAC address seen from the network (Do not change!)	`setMac <mac_addr>`	`setMac AA:BB:CC:DD:EE:FF`
Set board internal MAC address (Do not change!)	`setMacFunction <mac_addr>`	`setMacFunction AA:BB:CC:DD:EE:FF`
Set network addresses: Board IP address and sub-network mask, Gateway IP address if applicable	`setNetworkSettings`	`setNetworkSettings` then follow onscreen prompts
Set NTP parameters: NTP server activation, IP address of NTP client.	`setNtpSettings`	`setNtpSettings` then follow onscreen prompts
Set current user's own password	`setPassword`	`setPassword` then follow onscreen prompts
Set another user's password	`setPassword <user_name>`	`setPassword user` then follow onscreen prompts
Set SNMP Operator or Admin password	`setSnmpPassword <account_name>`	`setSnmpPassword admin` then follow onscreen prompts
Set IP address of the SNMP server that receives traps (events)	`setSnmpTrapIp <ip_addr>`	`setSnmpTrapIp 192.168.254.12`

IP Interfaces

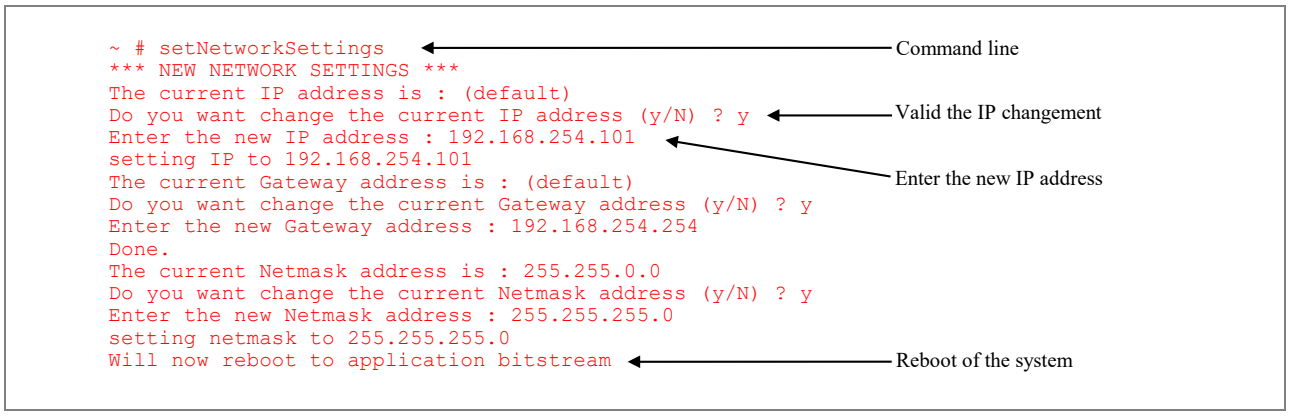
Assigning the IP address and Subnet mask is the responsibility of the Network Manager.



Caution:
A unique IP address should be applied.

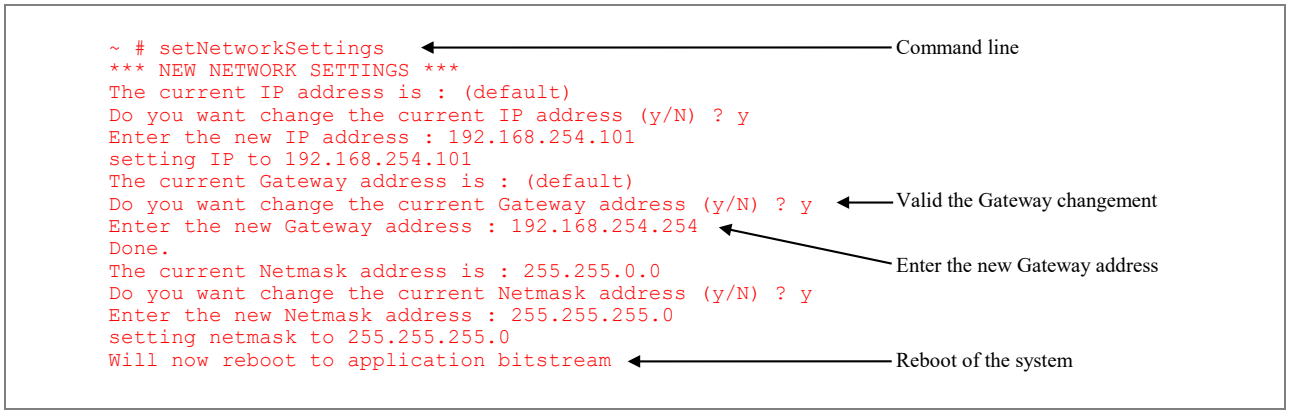
IP Address

The default IP address is 192.168.254.100. Use the “setNetworkSettings” command as shown in the figure below to change it.



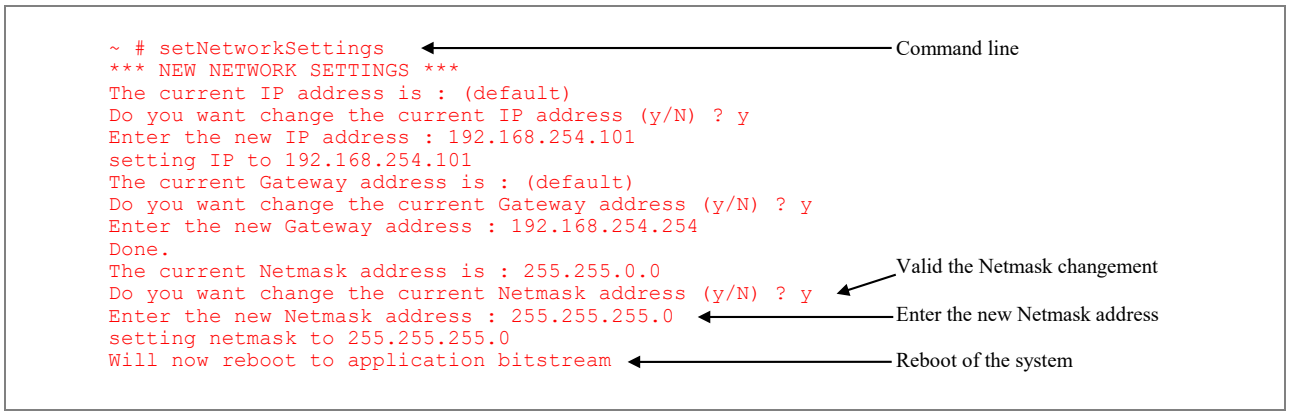
Subnet mask

Set the subnet mask numbers using the “setNetworkSettings” command. Typically subnetwork mask number fields are either 0 or 255 as in the figure below (255.255.255.0).



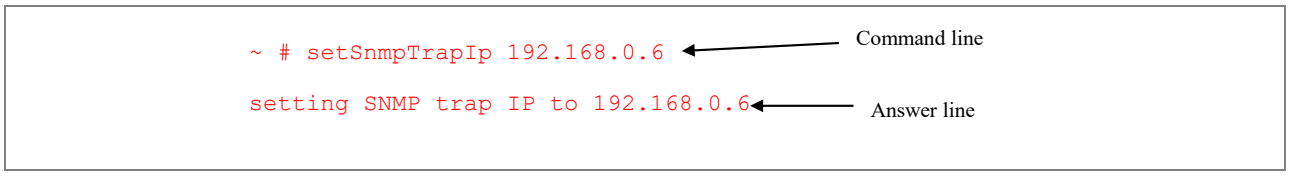
Gateway

The “setNetworkSettings” command defines the gateway IP address. The gateway address must be on the same IP subnet as the hosting device. An example is given below:



SNMP trap

The “setSnmpTrapIp” command sets the IP address for the SNMP trap. An example is given below:



3.3.6 MANAGEMENT COMMANDS

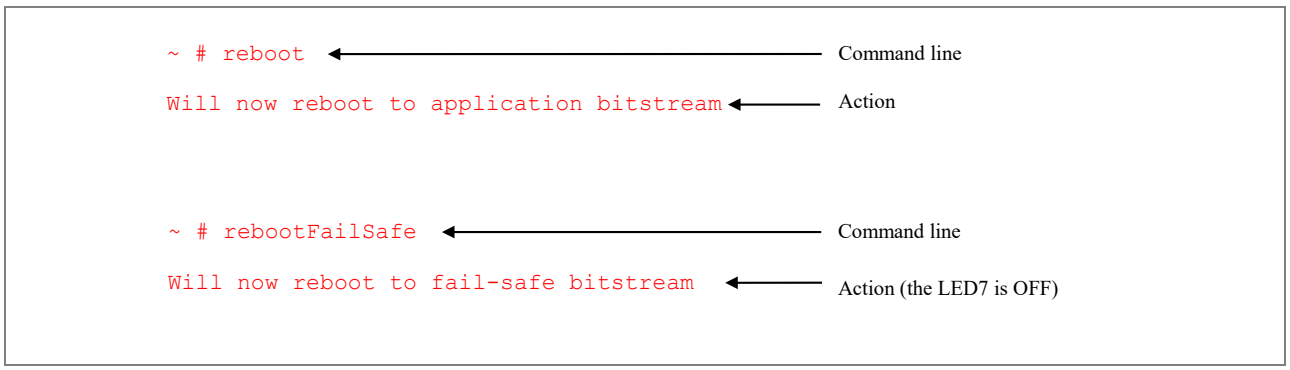
Management command	Syntax	Example
Management of user accounts Options: -c = Create new user, -d = Delete user -u = Unlock account -n = Change login name -r = Change role	AccountManagement <options>	AccountManagement –c then follow onscreen prompts
Force a value (0 or 1) on the relay1	forceRelay1 <0/1>	forceRelay1 0
Force a value (0 or 1) on the relay2	forceRelay2 <0/1>	forceRelay2 0
Turn a PRP core port On or Off	prpPortOnOff <port> <ON/OFF>	prpPortOnOff A OFF
Enable/Disable Optical Transceiver A 0 = Enable 1 = Disable	prpTransceiverADisable <0/1>	prpTransceiverADisable 0
Enable/Disable Optical Transceiver B 0 = Enable 1 = Disable	prpTransceiverBDisable <0/1>	prpTransceiverBDisable 0
Hard Reboot	reboot	reboot
Reboot in factory mode	rebootFailSafe	rebootFailSafe
Remote shell access Options: 0 = Telnet 1 = SSH 2 = Telnet and SSH The default value is 1	remoteShell <option>	remoteShell 0 (Telnet) Then, reboot the board to take this new configuration into account.
Enable/disable remote Syslog server	remoteSyslog 4 <1/0>	remoteSyslog 4 1
Configure remote Syslog server 0 = UDP (Port 514) 1 = TCP (Port 601)	remoteSyslog <ip_addr> <1/0>	remoteSyslog 192.168.254.12 0
Turn a switch port On or Off	switchPortOnOff <port> <ON/OFF>	switchPortOnOff 2 OFF
Reset all statistics of the switch	switchResetStats	switchResetStats
Remove forced value for the relay1	unforceRelay1	unforceRelay1
Remove forced value for the relay2	unforceRelay2	unforceRelay2
Update the firmware, available only in factory mode	update <FTP server ip_addr.>	update 192.168.254.12
Update the disclaimer banner text	updateBannerText <FTP server ip_addr> <your_text_file>	updateBannerText 192.168.254.12 disclaimer.txt

Note.

The SRP board is not reachable when Remote Shell Access is disabled (option 0). We recommend not to disable the Remote Shell Access.

Reboot commands

Two reboot commands are available. The command “reboot” forces a hard reboot equivalent to a power-up. The command “rebootFailSafe” forces a reboot to the factory mode and extinguishes LED7 as shown in the figures below:



Switch statistics

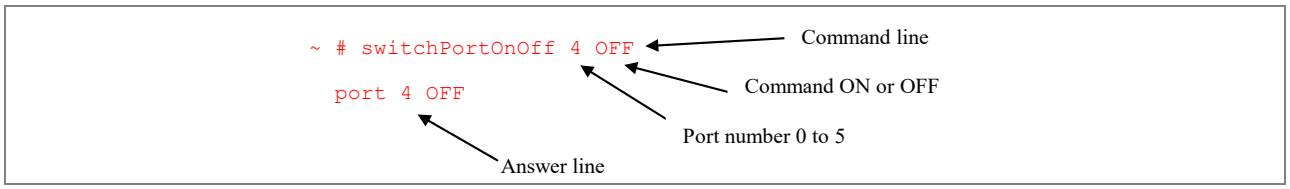
You can view switch statistics using the “getSwitchStats” command. The figure below shows the statistics available for each port.

```
InUnicasts     00000000
InBroadcasts   00000000
InPause        00000000
InMulticasts   00000000
InFCSErr       00000000
Undersize      00000000
Fragments      00000000
Jabber         00000000
Oversize       00000000
OutUnicasts    00000000
OutBroadcasts  00000000
OutPause       00000000
OutMulticasts  00000000
OutFCSErr      00000000
Late           00000000
Excessive      00000000
Multiple       00000000
Single         00000000
Deferred       00000000
InGoodOctet_l  00000000
InGoodOctet_h  00000000
InBadOctets    00000000
Hist64         00000000
Hist127        00000000
Hist255        00000000
Hist511        00000000
Hist1023       00000000
HistMax        00000000
OutOctets_l    00000000
OutOctets_h    00000000
RxErr          00000000
Collisions     00000000
Late           00000000
```

You can reset the switch statistics using the “switchResetStats” command.

Ethernet ports

You turn Ethernet switch ports on or off using the “switchPortOnOff” command. An example of turning port 4 off is given in the figure below.



There are three commands associated with controlling the PRP ports. They are outlined in the diagram below:

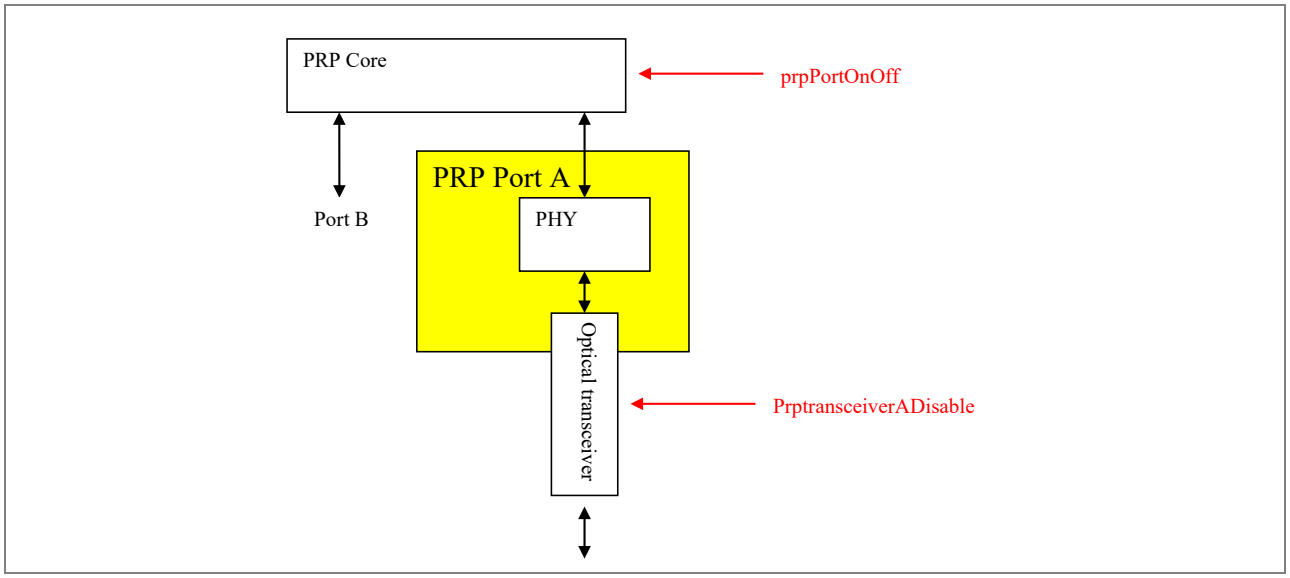
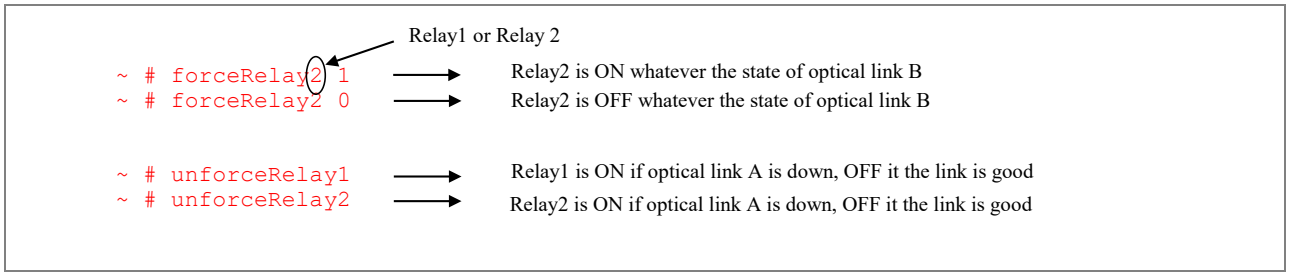


Figure 6: PRP Control

The command “prpPortOnOff” turns the core port on or off. The command “prpTransceiverADisable <0/1>” enables or disables optical transceiver A. The command “prpTransceiverBDisable <0/1>” enables or disables optical transceiver B. If set to ‘1’the port continues to receive data but does not transmit data. If set to ‘0’, the port is enable to transmit as well as receive.

Alarm contacts

Typing in the “forceRelay” and “unforceRelay” commands will drive the alarm contacts associated with the status of the PRP network optical links according to the figure below:



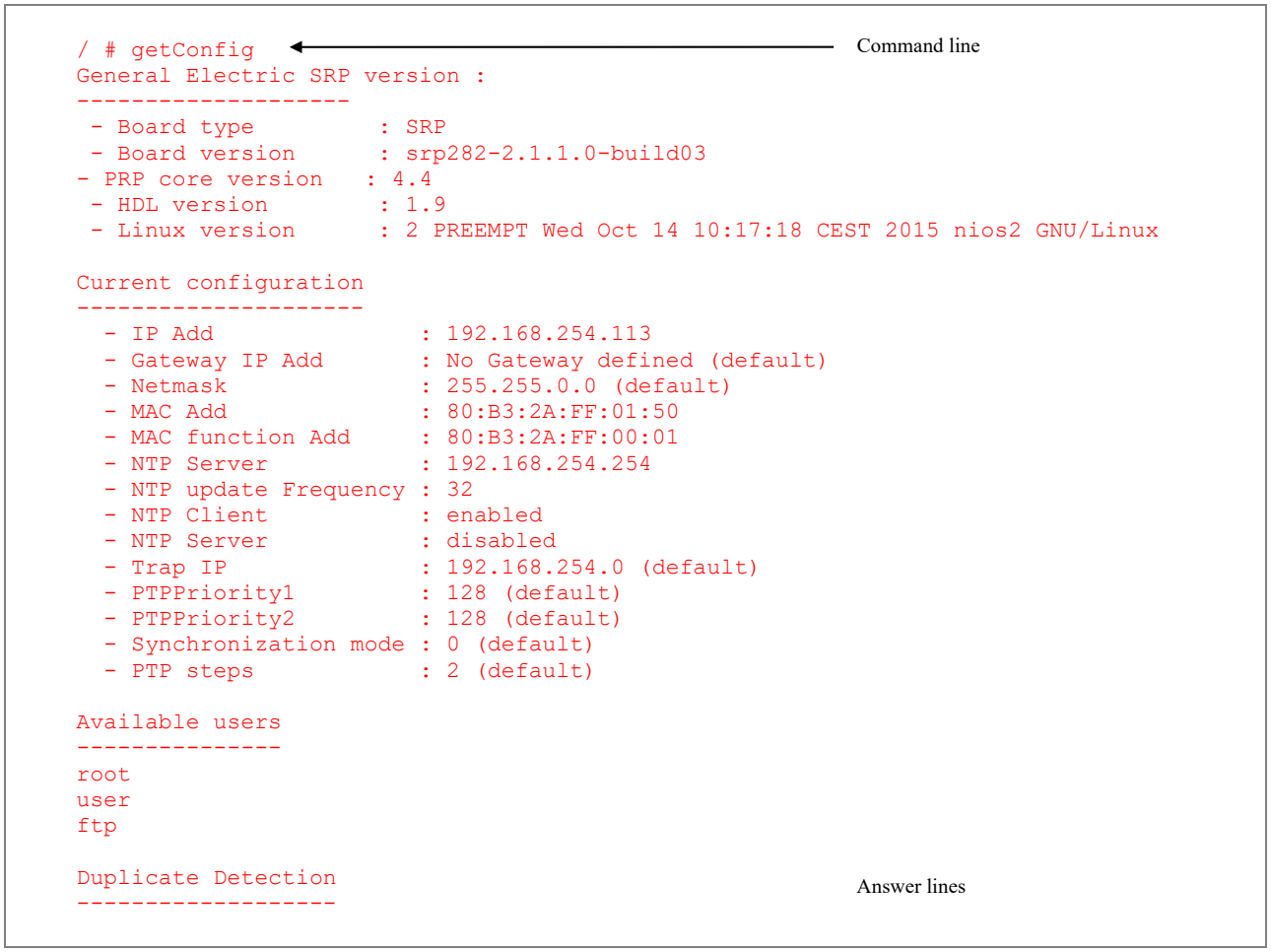
3.3.7 INFORMATION RETRIEVAL COMMANDS

The informative commands are given in the table below.

Informative command	Syntax	Example
Configuration summary	`getConfig`	`getConfig`
Status indication of various elements of the board	`getStatus`	`getStatus`
Print the proxy node table	`pn`	`pn`
Dumps the switch ATU table	`getSwitchATU`	`getSwitchATU`
Get all statistics of the switch	`getSwitchStats`	`getSwitchStats`

Configuration

Typing in the “getConfig” command will return the switch configuration, an example of which is shown in the figure below:



Status

Typing in the “getStatus” command will return the switch status, an example of which is shown in the figure below:

```
~ # getStatus

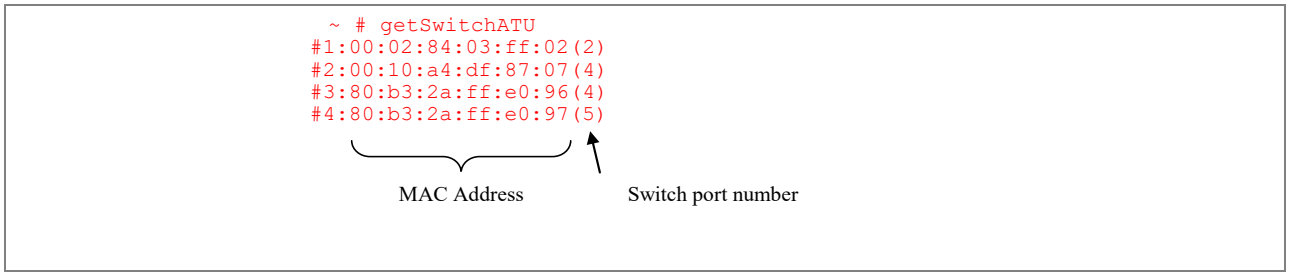
FPGA configuration used (Factory or Application mode) :
------------------------------------------------------ :
Mode: application with watchdog (or Fail-Safe (Factory))

Port status
-----------
sw0: down
sw1: down
sw2: up
sw3: down
sw4: up
lreA: up
lreB: up
lreI: always connected
sw5: always connected
```

Mac Address

Typing in the “getSwitchATU” command will return the switch Address Translation (ATU) table:

The Address Translation Unit (ATU) performs MAC address searching, learning, and ageing functions for all ports of the switch. By default, the ATU table allows a total of 1024 entries and an ageing time is 300 seconds for each entry. An example of using the “getSwitchATU” command is given in the figure below.



Current user

Typing the “whoami” command will return the login name of the current user, an example of which is shown in the figure below, for the user “root”:

```
# whoami
root
```

Proxy Node table

Typing “pn” returns the proxy node table. The proxy node table keeps track of peer PRP nodes. The key attribute of the node table is the MAC address of the source node as received in the PRP supervision frame sent by a PRP node. By default the proxy node entry is cleared after 60s although this time can be changed by changing the value in the PNT_AGT register.

An example of extracting a proxy node table is given in the figure below:

```
~ # pn
00:16:d3:b7:51:46
00:50:da:e4:e6:e0
2 entries in proxy node table
```

3.4 OPERATING MODES

The board has two operating modes: Failsafe mode and User mode.

The normal operating mode is User. The board switches to Failsafe mode:

- if the software watchdog is OFF (if there is a problem with the user mode),
- after a rebootFailSafe command,
- during a firmware upgrade operation.

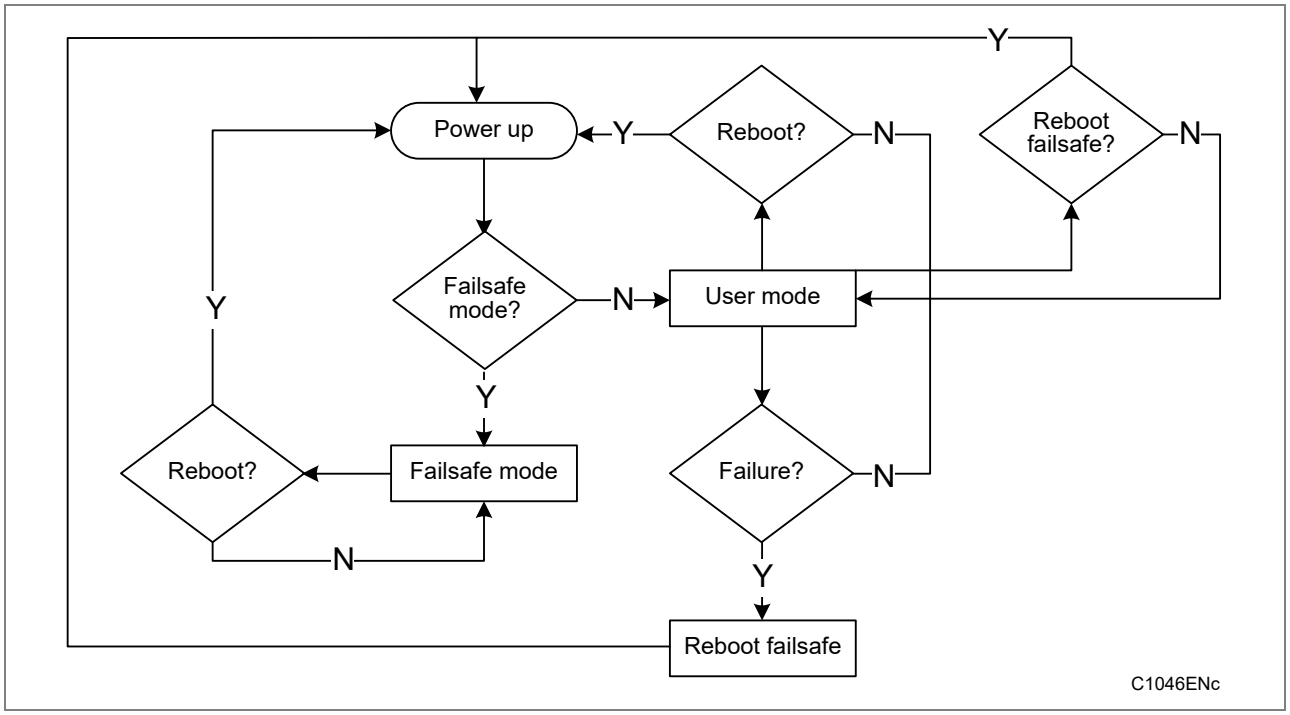


Figure 7: Power up and reboot functions of the SRP28x board

3.5 FIRMWARE UPGRADE

Upgrading the SRP28x to the latest firmware version may sometimes be necessary in order to take advantage of new features or bug fixes.

The link to be used to upgrade the SRP28x firmware differs depending on which version you are using and wish to migrate:

- From **srp_v2.0.0.0** (unsecured protocols), a telnet link is required
- From **srp_2.1.x** (secured protocols), an SSH link is required

Caution:
The failsafe firmware cannot be upgraded (only the application part).
Upgrading an SRPv2 firmware to a former version is not recommended.

The upgrade operation requires that the files of the application firmware, along with a correctly configured FTP server, be available on a computer with a network connection to the device to be upgraded.

Note:
To upgrade the firmware, the SRP28x board has to be in Failsafe mode (`rebootFailsafe` command)

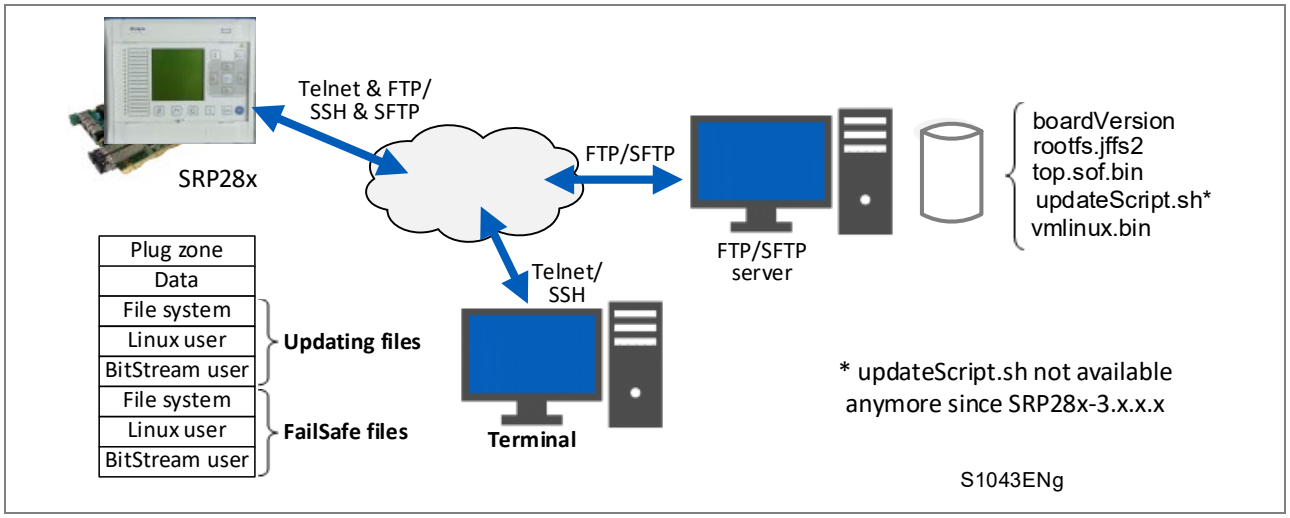


Figure 8: Standard SRP28x upgrade process

1 On the FTP server, copy the firmware files in the `<FTP Parent_Folder>` directory.

2 Use an FTP solution (FileZilla for instance) to select the root path of the folder `<FTP Parent_Folder>/` containing the firmware files:

- **rootfs.jffs2** (file system)
- **vmlinux.bin** (Linux kernel)
- **top.sof.bin** (VHDL bitstream)
- **updatescript.sh** (script to update the switch)
- **boardVersion** (firmware version)

Note:
updatescript.sh is not available anymore since srp28x-3.x.x.x.

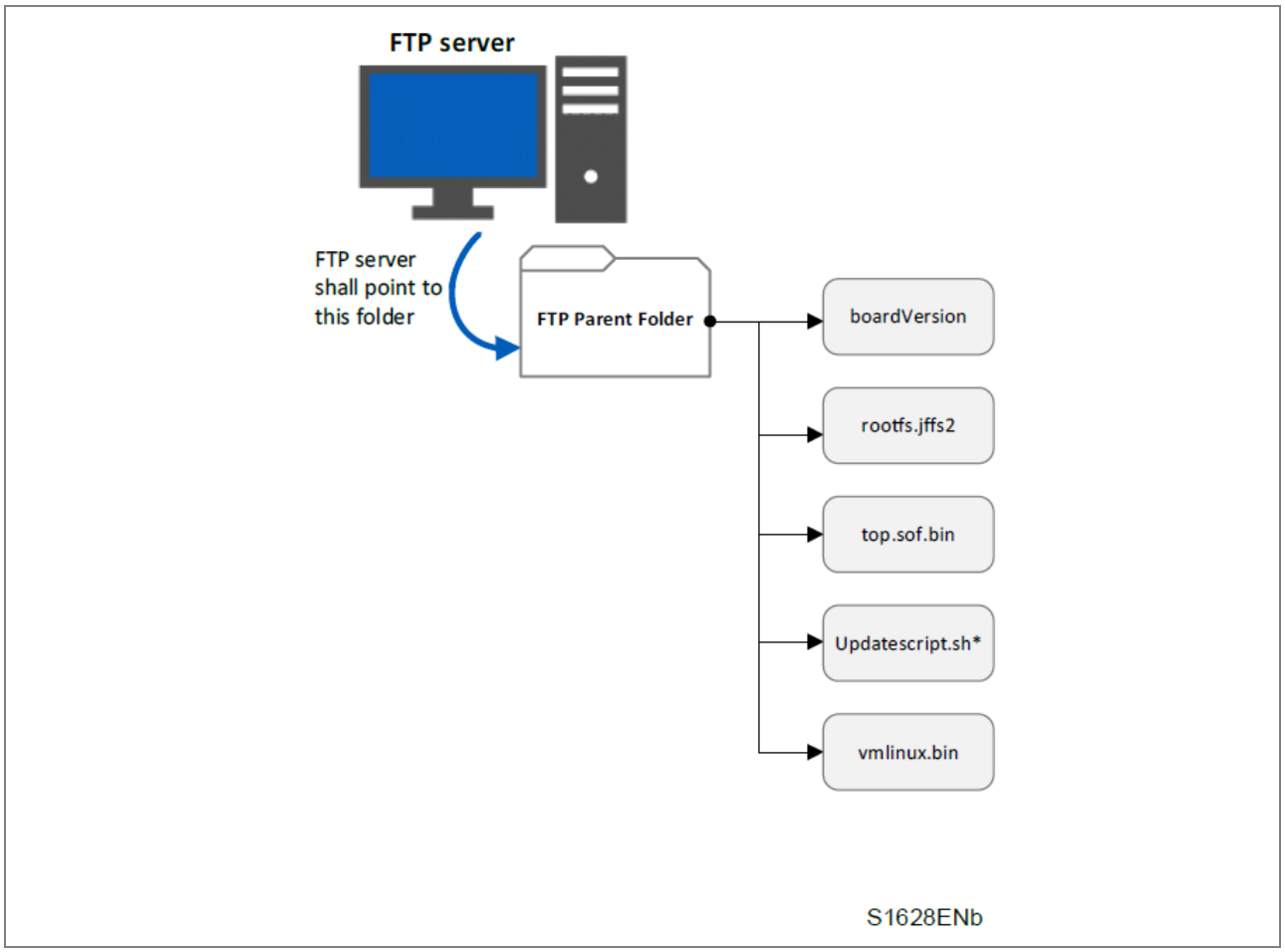


Figure 9: FTP parent folder containing the firmware files

3 Write down the IP address of the FTP server containing the new firmware.

4 Establish a console connection to the SRP28x board to be upgraded, using the Telnet or SSH protocol with a terminal emulator. The terminal and the FTP server can be installed on the same PC.

- The factory-set IP address is 192.168.254.100
- If you use an unsecured FTP server, it must be configured to be accessed without password ("anonymous" logon).

5 Run the **`rebootFailsafe`** command via the command-line console. This command causes the SRP28x board to reboot. Your Telnet/SSH connection might be lost.

6 Wait one minute before making the Telnet/SSH connection to the SRP28x board.

7 Then, run the command line

- `update <FTP server IP address>`

This will download the files to the SRP28x board. The board automatically reboots to normal user mode after the files have been successfully downloaded. In case of a download failure, it reboots to failsafe mode. The firmware files transferred to the server are stored in non-volatile memory.

8 Reboot the DS Agile C26x once the upgrade process is complete.

3.6 CYBER-SECURITY

In addition to supporting secure communications for settings and commands, the SRP board meets modern cyber-security requirements:

- User accounts can have differentiated roles depending on their functions.
- Password complexity can be enforced to prevent users to define easily “crackable” passwords.
- A timeout can be set so that sessions are automatically terminated after an inactivity period.
- A security data log keeps track of all security-related operations.
- The security log can be automatically sent to a remote log repository (“syslog” server).

3.6.1 ACCOUNT AND PROFILE MANAGEMENT

Each account is composed of a login name and a password. The login name is unique.

If an attempt is made to create a user account with an already existing login name, the creation is denied and the message “Login name already exists” is displayed.

Each user can change his/her own login name and password. The login name and password of all the accounts, including the predefined accounts, can be changed.

One of three roles, i.e. predefined sets of privileges can be assigned to new user accounts:

Roles	Privileges
Observer	This role only allows reading information. It does not allow changing any password except the user's own password. It does not give access to any security log.
System Engineer	This role only gives access to data useful to run the system. In addition to Observer privileges, it also allows setting parameters on the SRP board. It does not allow changing any password except the user's own password. It does not give access to any security log.
Security administrator	This role gives the user complete control over the board: In addition to System engineer privileges, it allows the user to upgrade the SRP software version, display data and change the board's operating mode. It is the only role that allows the user to configure its own role as well as the System engineer and Observer roles and display security logs.

Only users with the *Root* role can create new accounts on the SRP board and define their role. The same applies to user account deletion. It is not possible to assign the *Root* role to a new account.

The maximum number of user accounts is **10**.

Default commands per authentication level

Commands	Root	Security administrator	System engineer	Observer
Configuration commands				
passwdPolicy <options>	X			
setAuthenticationTimeout <time>	X	X		
setSessionTimeout <time>	X	X		
setLockAccount <login retries> <lock_time>	X			
setMac <mac_addr>	X		X	
setMacFunction <mac_addr>	X		X	
setNetworkSettings	X		X	
setNtpSettings	X		X	
setPassword (*)	X	X	X	X
setPassword <user>	X			
setSnmpPassword (**)	X	X		
setSnmpTrapIp <ip_addr>	X		X	
setSynchroMode <mode>	X		X	
setPTPPriority1 <priority>	X		X	
setPTPPriority2 <priority>	X		X	
setPTPSteps <steps number>	X		X	
Management commands				
AccountManagement <options>	X			
remoteShell <0/1/2/3>	X	X		
remoteSyslog	X	X		
reboot	X	X	X	
rebootFailSafe	X	X		
update <FTP server IP Addr>	X	X		
updateBannerText <FTP server IP Addr> <your_text_file>	X	X		
switchResetStats	X		X	
switchPortOnOff	X		X	
prpPortOnOff	X		X	
prpTransceiverADisable	X		X	
prpTransceiverBDisable	X		X	
forceRelay1	X		X	
forceRelay2	X		X	
unforceRelay1	X		X	
unforceRelay2	X		X	

Commands	Root	Security administrator	System engineer	Observer
Informative commands				
getConfig	X	X	X	X
getStatus	X	X	X	X
getSwitchATU	X		X	X
getSwitchStats	X		X	X
whoami	X	X	X	X
pn	X	X	X	X

(*) Set own password only. (**) Unique password to access the MIB data.

Default accounts

The board is delivered with two pre-defined accounts:

- **root**
- **user**

Both accounts are assigned the *Root* role, i.e. all access rights, by default.

The default password for both accounts is *changeit*. It is recommended to change both passwords immediately.

Note:
*The **root** account cannot be deleted nor have its role changed.*

3.6.2 PASSWORD POLICY

The Security administrator can force users to select passwords that comply with a minimum complexity using the setting **passwdPolicy**. If password policy is enabled, the passwords must comply with the following rules:

1 Contain at least 9 characters

2 All of these 4 types of characters must be used in the password:

a Uppercase letter

b Lowercase letter

c Digit

d ASCII non-alphanumeric character (such as @,!,#,{, etc.)

Passwords that do not comply with this rule are refused, an error message is displayed.

Note:
Password policy is enabled by default.

A forgotten or lost password cannot be recovered. A new password must be defined by a user with Security administrator privileges.

3.6.3 AUTHENTICATION

Concurrent logins

Concurrent logins are not allowed. Only one user can be logged in at any time. A current session cannot be overridden by another user, even one with administrator privileges.

Failed login

When authentication fails, the message "Login failed" is displayed.

Account lockout further to failed login attempts

A password locking policy is implemented:

1 After a settable number of consecutive failed login attempts (incorrect password), the account is locked for a settable period of time. The number of failed login attempts triggering a lockout is settable from 3 (default) to 10. The lockout period is settable from 1 hour to 24 hours (default setting: 1 hour) for accounts with the VIEWER and OPERATOR roles. For the accounts with the Security administrator role, the lockout duration is fixed to 5 minutes.

2 The account is unlocked when the first connection is successful after the lockout period has expired.

3 Only a user with the **Security administrator** privilege can unlock a locked user account before the end of the lockout period.

Authentication timeout

Open sessions are automatically terminated after a settable inactivity (no command sent) timeout. Default setting: 600 seconds (10 minutes) for all user accounts. Settable in steps of 60 seconds.

Only a user with the Security administrator privilege can change the setting for the authentication timeout.

This settable inactivity timeout is the same for all accounts.

Disclaimer banner text

Using the command **updateBannerText** a Security administrator can define a text that will be displayed when any user logs in. Due to storage capacity limits, we recommend using a text that does not exceed 1000 characters, including blank spaces.

Default banner text:

"Access to this system is limited to specifically users having received all training required by applicables laws, regulations, and by policies and procedures implemented by the legal hosting this system.
Unauthorized users may face criminal or civil liabilities and/or penalties. The use of this system may be recorded and monitored for system operations, security policy and intellectual property compliance related purposes and any information related to the use of this system may further be disclosed to third parties or law enforcement officials as necessary.
Disconnect now if you are not an authorized user or do not agree with the above terms."

Prompt: `Do you agree with these terms? [Y/n].`

To access the board's commands, the user only needs to press the **Enter** key. If the user does not wish to accept the terms, he must type N and enter. Not typing anything is equivalent to typing *Y* (yes).

Authentication on front face serial port

The access to the command line through the front face serial port is authenticated. However, there are two exceptions to this rule:

- The User can view the debug traces without authentication
- Bootrom mode serial port command line access is not authenticated

When the user is in “debug traces view” mode, he can hit any key to switch to the authentication prompt. If no input is provided for 30 seconds, the serial board switches back to “debug traces view” mode.

There are two possibilities to exit the serial port command line and switch back to “debug traces view” mode:

- Type “exit” and press enter
- No command is entered until the session timeout

When the user is in Bootrom mode serial port command line access, the BCU initialization sequence can be stopped by pressing the “Enter” key during the second downward counter. In this case, authentication is required to go further in sequence initialisation, otherwise a reboot will be necessary.

3.6.4 SECURITY DATA LOG

All important activity and system operations are logged in the `/mnt/config/log/SRPV2.log` file that only users with the role **Security administrator** can read. That file is not encrypted. It contains:

- Startup log (start, stop and reboot)
- Successful and failed login attempts with cause of failure
- Logouts
- User account (local) changes (creation, deletion, password reset, lockout/unlock, change of role)
- Firmware updates
- Setting changes
- Syslog server unavailability
- Configuration change
- Audit log access
- Date and time change

The `/mnt/config/log` folder and its contents are not affected by software updates and will not be deleted when they occur.

The maximum size of the log files is 524 kB. When that size is reached, the oldest entries are deleted. This file contains up to 2048 log messages.

Note:
Passwords are not logged.

The security logs can be automatically forwarded to a central repository (“Syslog” server) if one is available and configured on the SRP28x board (`remoteSyslog` management command). Whether logs occurr during a communication loss, the PC behaves differently depending on the communication protocol used:

- UDP: The SRP28x is not informed of the communication loss, therefore it continues to send the logs during the downtime. These logs are stored locally but are not received by the Syslog server.
- TCP: The SRP28x is informed of the communication loss. It stores its date and time and sends the intervening logs when the communications are restored.

3.7 LEDS AND CONNECTIONS

LEDs: refer to C26x/EN HW. Connections: refer to C26x/EN CO.

4 SRP29X RANGE – SEAMLESS REDUNDANCY (HSR)

The DS Agile C26x is an Ethernet communications board that is installed in DS Agile C26x BCU in order to add HSR capability.

The DS Agile C26x board is connected to the HSR ring using fibre optic communications. A multi-mode fibre-optic version is available for short distance connections (typically up to around 2 km), and a single-mode version is available for longer distances (potentially in excess of 15 km).

The HSR fibre-optic Ethernet ports have LC connectors.

The board is also fitted with three 100Base-TX RJ45 connector that can be used to attach up to 2 non-HSR-compliant devices, effectively making the DS Agile C26x a RedBox.

4.1 FUNCTIONAL DESCRIPTION

4.1.1 HIGH-AVAILABILITY SEAMLESS REDUNDANCY (HSR) PROTOCOL

The HSR protocol is implemented according to the definition in the standard IEC 62439-3-5.

HSR allows seamless communication in the face of a single network disruption (for instance cable, driver, switch or controller failure).

An HSR-compatible device has two ports operating simultaneously, both ports being connected to the same local area network (LAN) segment (usually a ring). Such devices are called DANH (Doubly Attached Node running HSR).

The figure below shows an example of an HSR network. The doubly attached nodes, the DS Agile C26x switch, DANH 1, and DANH 2 send and receive HSR frames in both directions, while the singly attached nodes SAN 1 and SAN 2 can only send and receive frames without HSR header. Singly attached nodes can, however, be connected to HSR network, via a device that converts a singly attached node into a doubly attached node. Devices performing this function are often referred to as redundancy boxes or RedBoxes. Devices with single network cards such as personal computers, printers, etc., are singly attached nodes that may be connected to the HSR network via a RedBox as shown in the figure. This is the case for SAN 1 and SAN 2. Because these SANs connect to the HSR network, they can be considered as Virtual Doubly Attached Nodes and described as VDANs.

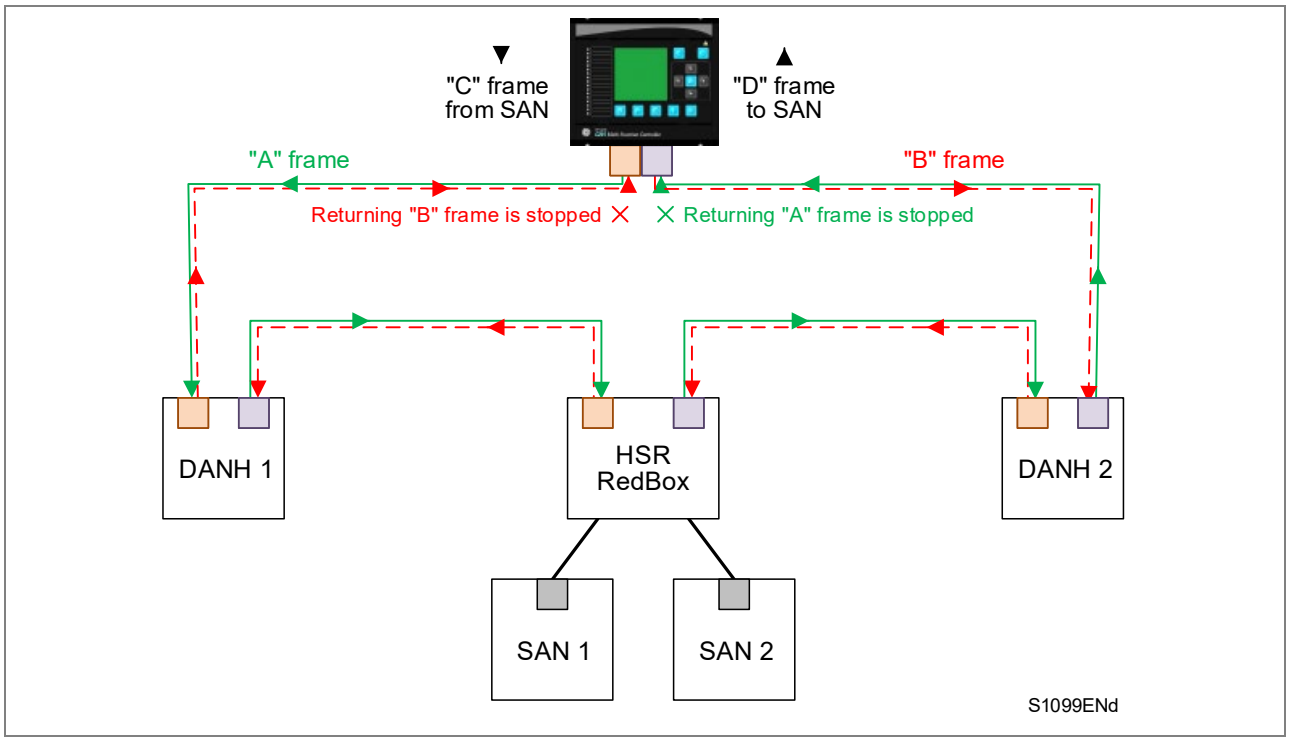


Figure 10: Example HSR Redundant Network

The SRP29x communications board is a DANH with optical connections to the network. The DANH can be connected to the C26x unit housing it and/or to any other compatible SANs.

To achieve high-availability configuration the first optical interface sends the frames in the “A” direction and the second sends the same frames in the “B” direction. Frames are forwarded in both directions by the connected DANH devices.

The frames are identified as “A” and “B” and also by their sender: When the SRP29x or any other DANH receives a frame that it originally sent or that is specifically destined to it, it does not forward it.

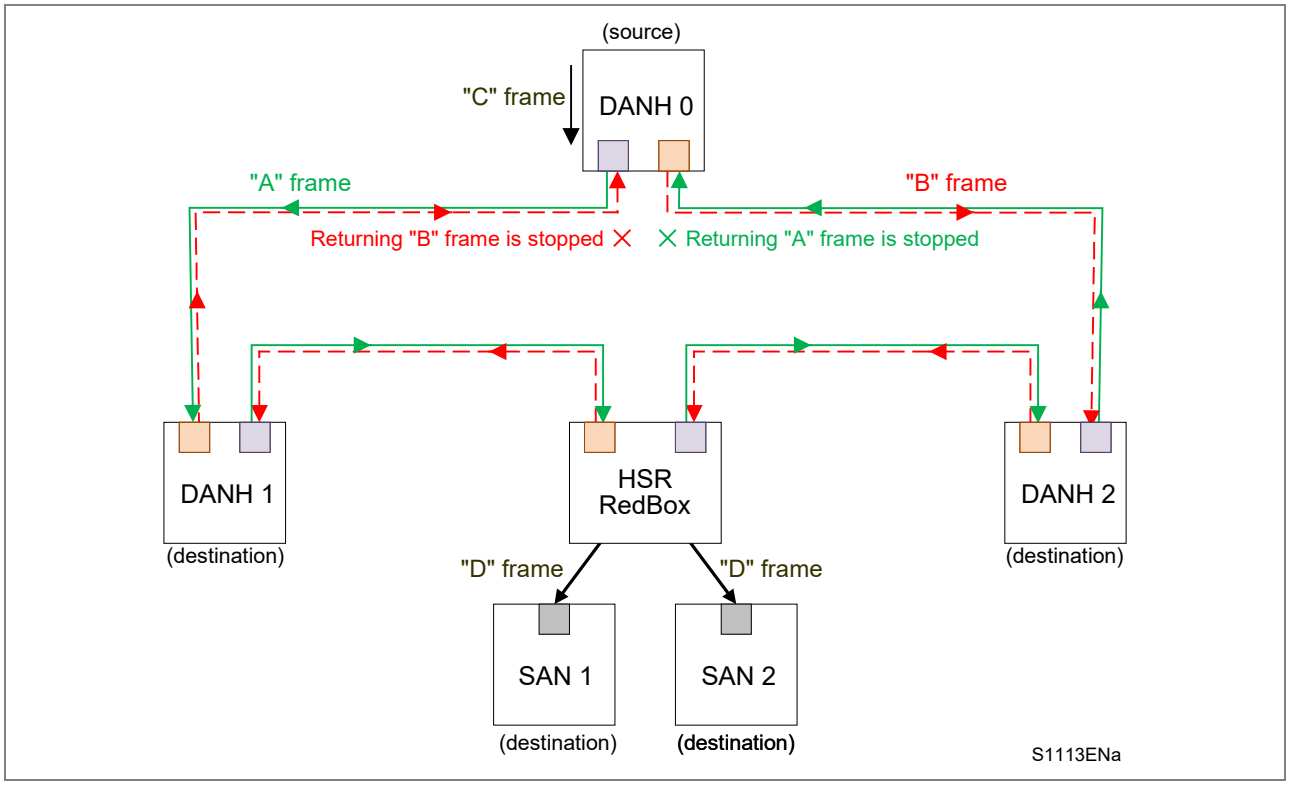
When an already received frame is received again from the other direction the DANH or RedBox does not process it. It only moves the frame forward in the ring, unless it is itself the frame’s unicast recipient.

Frames sent by the PC (“C” frames) are converted into 2 “A” and “B” frames and sent over the HSR network.

Received frames that are addressed to a SAN managed by the board (such as MMS messages) are not forwarded on to the HSR network.

There are two basic operation principles, depending on whether the broadcasted frames are multicast (e.g. GOOSE) or unicast (e.g. MMS reports).

Multicast frames (e.g. GOOSE)



Key:
dotted arrows: “A” frames
cross-hatched arrows: “B” frames
black arrows: non-HSR frames exchanged between ring and host
cross: frame is removed from the ring by the next node

Figure 11: HSR example of ring configuration for multicast traffic (e.g. GOOSE)

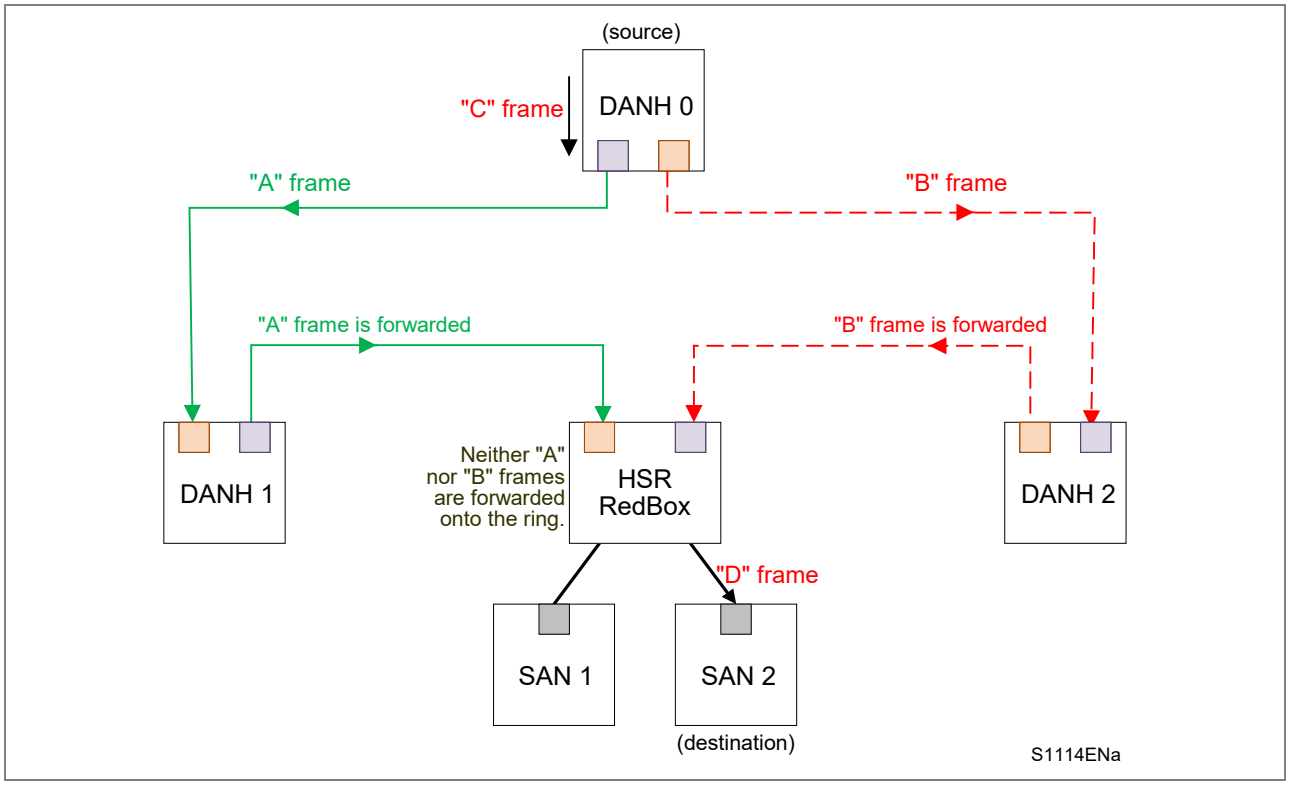
A source DANH, e.g. a DS Agile C26x, sends a frame passed from its upper layers (“C” frame), prefixes it by an HSR tag to identify frame duplicates and sends the frame over each port (“A”-frame and “B”-frame).

A destination DANH receives, in the fault-free state, two identical frames from each port within a certain interval, removes the HSR tag of the first frame before passing it on to its upper layers and, if it is a RedBox, to its SANs (“D”-frame). It discards any duplicate.

The nodes support the IEEE 802.1D bridge functionality and forward frames from one port to the other, except if they already sent the same frame in that same direction.

In particular, the node will not forward a frame that it injected into the ring.

Unicast (e.g. MMS reports)



Key:
dotted arrows: “A” frames
cross-hatched arrows: “B” frames
black arrows: non-HSR frames exchanged between ring and host
cross: frame is removed from the ring by the next node

Figure 12: HSR example of ring configuration for unicast traffic (e.g. MMS reports)

A destination node of a unicast frame does not forward a frame for which it is the only destination:
For example, if the SRP29x board (HSR RedBox) receives a report destined to the C264 or another of its VDANs (for instance SAN 2 in the above diagram), it will not forward it onto the HSR ring.

Frames circulating in the ring carry the HSR tag inserted by the source, which contains a sequence number. The doublet {source MAC address, sequence number} uniquely identifies copies of the same frame.

SRP29x RedBox principle

The SRP29x acts a RedBox with optical connections to the dual HSR network and electrical connexion to SAN devices that then become VDANs connecting a device to the HSR network, as illustrated below.

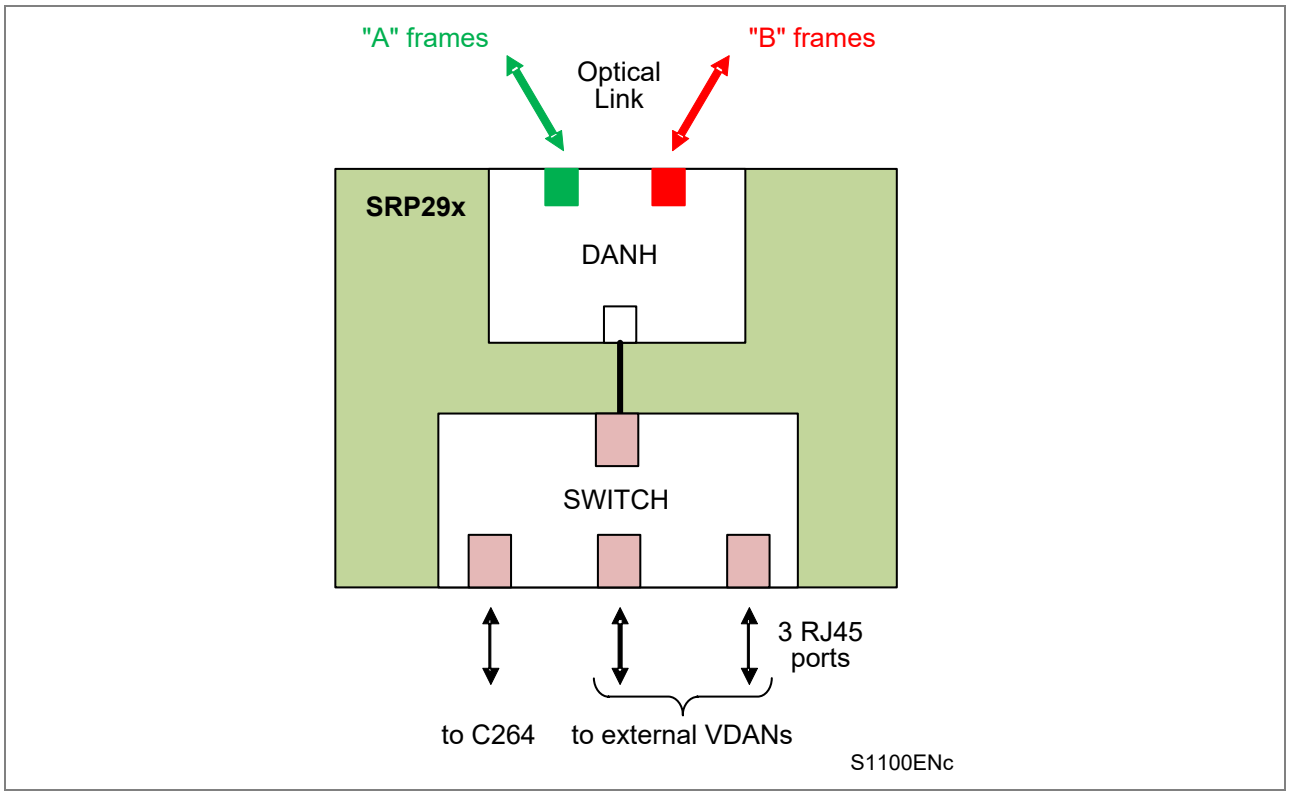


Figure 13: SRP29x connecting singly attached nodes to a dual HSR network

For products that connect directly to the HSR LAN, the two ports of the DANH operate simultaneously. They are attached to the same upper layers of the communication stack through a link redundancy entity (LRE) as shown in the figure below.

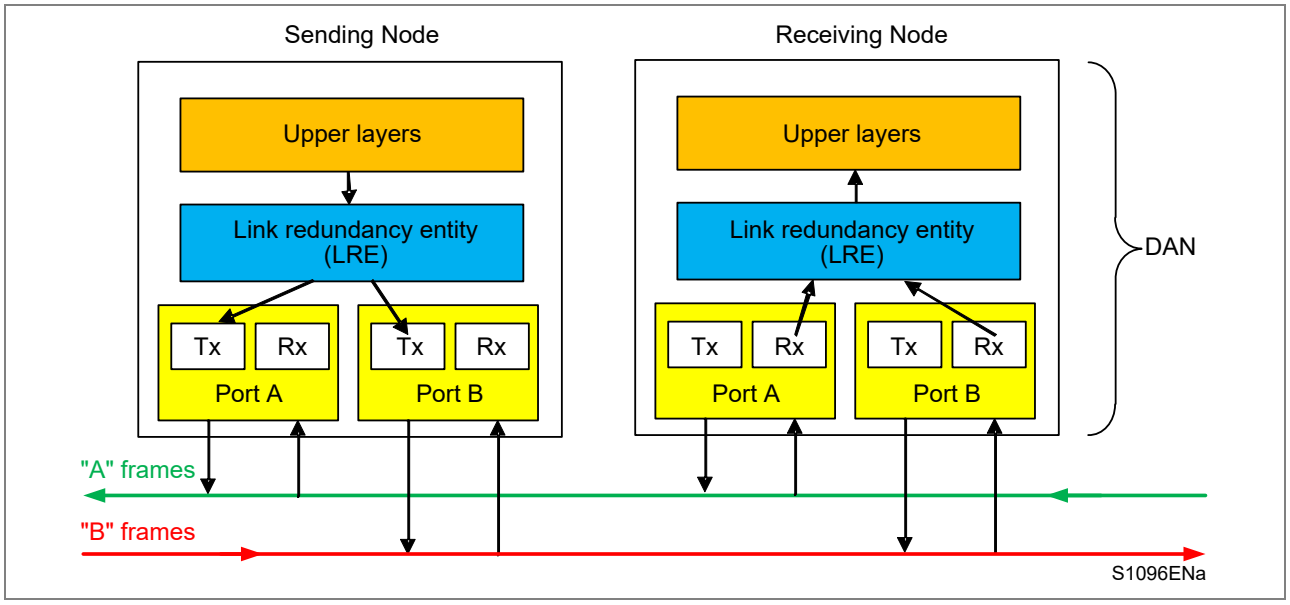


Figure 14: DANH structure

HSR ring characteristics

The transmission latency introduced to the HSR network depends on the transmitted frame size and on the number of “hops” (IEDs) the frames go through.

Note:
The board can support the same maximum number of IEDs as the DS Agile system: 250. Nevertheless, bandwidth vs the data traffic in the HSR ring, as well as the node forwarding time are important metrics to consider in term of limit and this is even more true with HSR 100Mbps network.
HSR frames are duplicated and sent on the ring in both direction impacts the HSR ring’s bandwidth.
In addition, HSR supervision frames (Multicast sent by each DAN every 2 seconds) also increase the data traffic.
As example, for IEC61850 use case, 20 devices for “station bus” and 6 devices for the “process bus” are a reasonable limit recommendation at 100Mbits/s for HSR ring.

4.1.2 FUNCTIONAL DESIGN

The figure below shows the main functional blocks of the SRP29x:

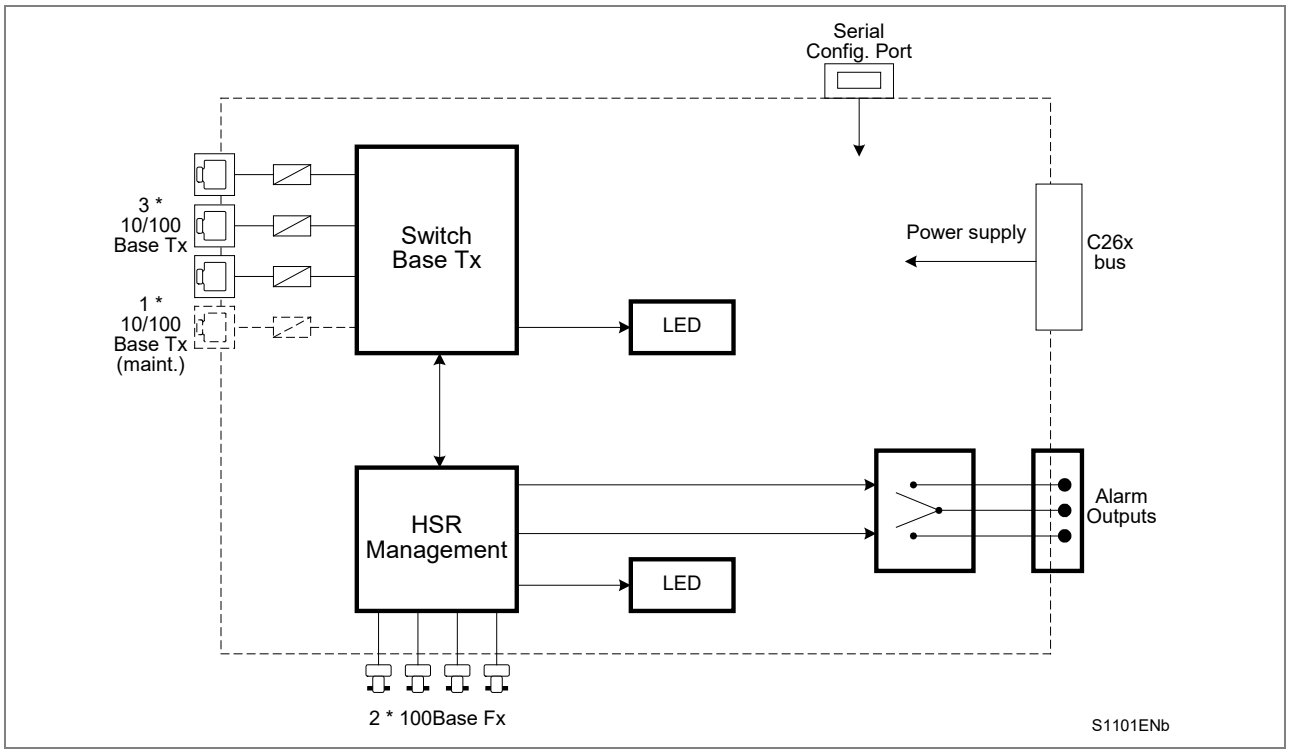


Figure 15: SRP29x functional diagram

The principal functional component parts are:

- The Base-Tx Ethernet Switch
- The High-availability Seamless Redundancy protocol (HSR) management
- SNMP (Simple Network Management Protocol) management
- Light Emitting Diodes (LED) and alarm outputs.
- SSH configuration port

4.1.3 BASE-TX ETHERNET SWITCH FUNCTION

The Base-Tx Ethernet Switch function manages three Ethernet ports presented for user connection (ports 2, 3, & 4), and two internal ports for service connection. The user ports are 10/100 Base-Tx using RJ45 connectors. Ports 2, 3, & 4 are located at the rear of the unit and are qualified by LED indications of link activity. Port 1 is a 10/100 Base-Tx internal service port using an RJ45 connector located at the front of the board. The other internal service connection port is Port 0, and is also located at the front of the board. It supports 10/100/1000 Base-Tx and uses a Samtec ERF8-RA connector.

If a cable is not connected to a port, most of the circuitry for that port is disabled to save power.

Using auto-negotiation, the SRP29x automatically determines the speed of transmission on the 10/100 Base-Tx ports according to the IEEE 802.3u standard. It also determines whether communication is half-duplex or full-duplex, and adapts accordingly.

Each Ethernet device inserts its unique “MAC address” into each message it sends. The receiving port on the SRP29x automatically recognises the MAC address in a received frame and stores it. Once an address is recognised and stored, the SRP29x will forward frames to the appropriate port. Up to 1024 MAC addresses can be stored and monitored at any time.

The SRP29x supports the store and forward mechanism of the IEEE 802.3 standard. It forwards messages with known addresses to the appropriate port. Messages with unknown addresses, broadcast messages, and multicast messages are forwarded out to all ports except the source port. It does not forward error packets or 802.3x pause frames.

Priority tagging according to IEEE 802.1p is enabled on all ports.

4.1.4 ETHERNET MANAGEMENT

Standards	IEEE802.3, 802.3u, 802.3x, 802.1p
Forwarding mode	Store and forward
Memory bandwidth	2 Gbps
MAC Address	1K
Address learning	Automatic
Broadcast storm protection	Limited to 5%
Illegal frame	Dropped per 802.3
Late collision	Dropped after 512 bit times

4.1.5 ETHERNET PORT CHARACTERISTICS

4.1.5.1 10/100BASE-TX MODE

Connector type	Shielded RJ45 connector
Twisted pair cable	Cat 5
Max. cable length with Cat 5	100 m

4.1.5.2 100BASE-FX MULTIMODE MODE

Fiber port connector	LC
Optimal fiber cable	62.5/125 µm or 50/125 µm
Centre wavelength	1310 nm
TX output power	-20 dBm
RX input sensitivity	-31 dBm

Maximum distance	2000 m (Approximate. Refer to the *Fiber Optic Budget Calculation* from *PRP ETHERNET SWITCH SRP292/294* in Hardware Chapter section)

4.1.5.3 100BASE-FX SINGLE MODE MODE

Fiber port connector	LC
Optimal fiber cable	9/125 or 10/125 µm
Centre wavelength	1310 nm
TX output power	-15 dBm
RX input sensitivity	-31 dBm
Maximum distance	15 km (Approximate. Refer to the *Fiber Optic Budget Calculation* from *PRP ETHERNET SWITCH SRP292/294* in Hardware Chapter section)

4.1.6 SNMP MANAGEMENT

For this board, the GE Grid Solutions management information bases (MIB) use the following types of object identifiers (OID):

- System
- Interface
- Remote network monitoring (RMON)
- High-availability Seamless Redundancy protocol (HSR)

These are defined in the tables below.

4.1.6.1 SYSTEM MIB STRUCTURE

Address												Name	
0												Ccitt	
1												ISO	
	3											Org	
		6										DOD	
			1									Internet	
				2								mgmt	
					1							Mib-2	
						1						sys	
							1					sysDescr	Redundant switch HSR
							2					sysObjectID	TBD
							3					sysUpTime	Time (in hundredths of a second) since the switch was last reinitialised
							4					sysContact	user-configurable
							5					sysName	SRP29x (user-configurable)
							6					sysLocation	user-configurable
							7					sysServices	2

4.1.6.2 INTERFACE MIB STRUCTURE

Address												Name	
0												Ccitt	

Address												Name	
1												ISO	
	3											Org	
		6										DOD	
			1									Internet	
				2								mgmt	
					1							Mib-2	
						2						interfaces	Interface number
							1					ifNumber	Redundant switch HSR
							2					ifTable	TBD
								1				ifEntry	Time (in hundredths of a second) since the switch was last reinitialised
									7			ifAdminStatus	1: up, 2: down
									8			ifOperStatus	1: up, 2: down
									9			ifLastChange	time (in hundredths of a second) since the latest change

4.1.6.3 RMON MIB STRUCTURE

Address												Name
0												Ccitt
1												ISO
	3											Org
		6										DOD
			1									Internet
				2								mgmt
					1							Mib-2
						16						RMON
							1					stat
								1				etherstatsTable
									1			etherStatsIndex
									6			etherStatsBroadcastPkts
									7			etherStatsMulticastPkts
									8			etherStatsCRCAlignErrors
									9			etherStatsUndersizePkts
									10			etherStatsOversizePkts
									11			etherStatsFragments
									12			etherStatsJabbers
									13			etherStatsCollision
									14			etherStatsPkts64Octets
									15			etherStatsPkts65to127Octets
									16			etherStatsPkts128to255Octets
									17			etherStatsPkts256to511Octets
									18			etherStatsPkts512to1023Octets
									19			etherStatsPkts1024to1518Octets

4.1.6.4 HSR MIB STRUCTURE

Address												Name
0												Ccitt
1												ISO
	0											Standard
		64239										IEEE
			1									Redundancy Protocols HSR
			2									Redundancy Protocols MRP
			3									Redundancy Protocols PRP
				1								manufacturerName
				2								interfaceCount
				3								redundantInterfaces
					1							
					2							
						1						redundantInterfaceIndex
						2						nodeType
						3						nodeName
						4						versionName
						5						macAddressA
						6						macAddressB
						7						linkStatusA
						8						linkStatusB

4.1.6.5 SNMP CLIENT SOFTWARE

Readily available Management Information Bases (MIB) browser software enables you to perform all the basic Simple Network Management Protocol (SNMP) operations, such as GET, GETNEXT, and RESPONSE, by connecting to the switch.

4.1.6.6 SNMP CONFIGURATION

The Simple Network Management Protocol (SNMP) supports the versions 1 – 3 according to the rules below:

SNMP v1 and v2:

- Read community: Public
- Write community: Private

SNMP v3:

Level	System MIB	Other MIB
Operator	Read, encrypted	Read, encrypted
Administrator	Read/Write, encrypted	Read/Write, encrypted

An Administrator can change any user password. Other users can only change their own password.

4.2 SETTINGS

There are 2 possible external access points:

- over an Ethernet network connected to any of the three RJ45 ports accessible on the back panel of the C26x,
- via SSH, over the HSR network connected to its redundant optical connectors.

4.2.1 SSH COMMUNICATIONS

An SSH access is provided to configure and manage the board.

The terminal is connected to the network like any other device as shown in the figure below.

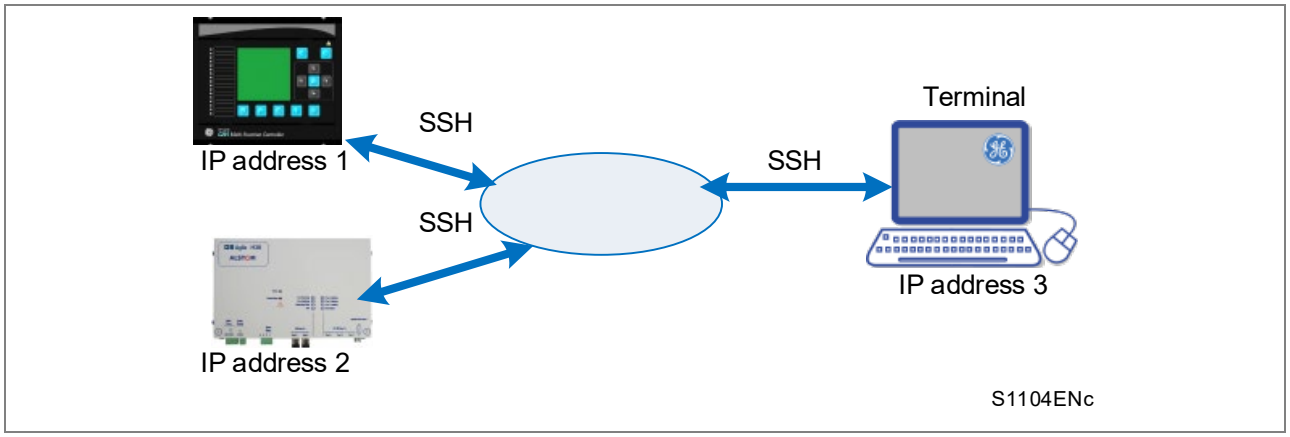


Figure 16: SSH connection example over the HSR network

Note:
The IP addresses must be part of the same network as the terminal and the subnet mask must not exclude them.

With the SSH connection, the terminal can be used to communicate with all functions of the SRP29x.

There are two default accounts:

- user
- root

Both have the same default password:

- changeit

The default IP address is:

- 192.168.7.1

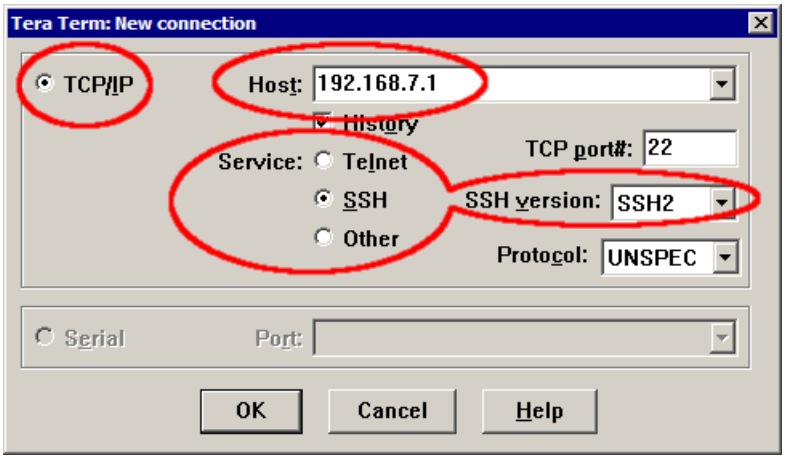
4.2.2 CONFIGURATION VIA SSH

Most of the available SSH commands are advanced configuration settings that will rarely be used, if ever, since the default settings should fit most applications.
HOWEVER, THE PASSWORDS AND IP ADDRESSES MUST BE CHANGED.

4.2.2.1 SSH SESSION

To open an SSH session with the board, use a standard SSH2-compatible client:

1 Launch the SSH client application.



2 Select the options *TCP/IP* and *SSH service*, *SSH version 2*.

3 Type the *IP address* of the board in the appropriate field.

4 Click **OK** or **Connect** (or equivalent, depending on the chosen SSH client).

A login window is displayed.

The board is supplied with a unique Media Access Control (MAC) address which should not be changed. It is supplied with a default Internet Protocol (IP) address of **192.168.7.1**.

4.2.2.2 LOGIN

Before the session is opened, you will have a login dialogue as shown in the figure below. You login according to the role(s) associated with your user account.

Default accounts

The board is delivered with two pre-defined accounts:

- "Root"
- "User"

The default password for both accounts is "changeit".

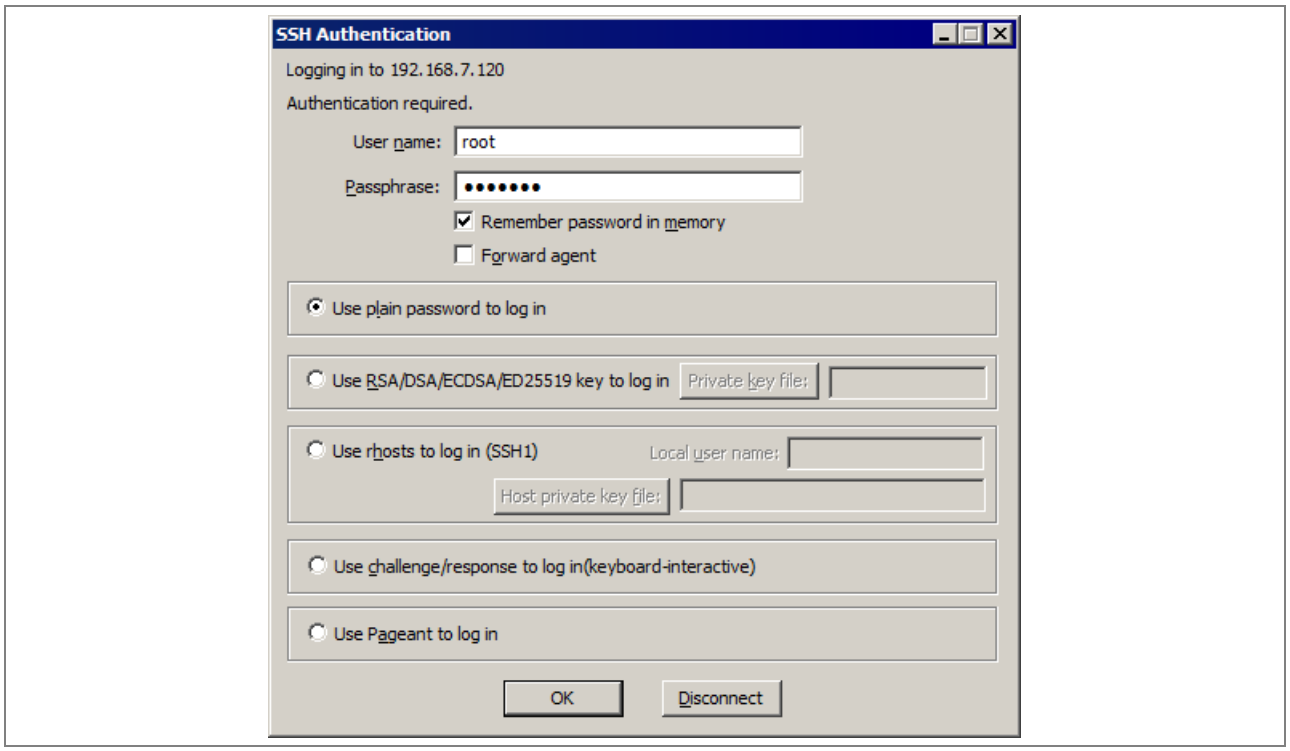


Figure 17: Example of Login window (may vary depending on the selected terminal emulator)

Note:
See Cyber-Security section for more information on user accounts.

The connection is established and an SSH console is displayed. Once the session is in progress, your access level is indicated by either a # for Security administrator level, or a $ for non-administrator level (VIEWER/OPERATOR roles).



Caution:
Change the default passwords immediately.
To do so, log in as "root" and type the commands:
- `setPassword <user>` for the account "user"
- `setPassword` for the account "root" (currently logged in).

4.2.2.3 PASSWORDS AND AUTHENTICATION LEVELS FOR SNMP ACCESS TO MIB DATA

There are three possible authentication levels for SNMP:

- Observer: Does not require login and password, can only read unencrypted data.
- Operator: Requires login and password, can read all data.
- Administrator: Requires login and password, can read and write all data.

SNMP V3 passwords must be a minimum of 8 characters long in accordance with the standard.

They must both be changed immediately when the board is delivered to the customer.

Setting the SNMP V3 Administrator/Operator Passwords

1 Type the command **# setSnmpPassword Administrator** or **setSnmpPassword Operator** and press **Enter**.

2 When prompted, type the name of the account for which you want to change the password: **Administrator** or **Operator**. Press **Enter**.

3 When prompted, type the new password (note that it is not displayed) and then press **Enter**.

4 Retype the new password (note that it is not displayed) and press **Enter**.

5 Repeat this procedure to change the password for the other account.

```
# setSnmpPassword Administrator
New password:
Retype the new password:
```

4.2.2.4 CONFIGURATION COMMANDS

Configuration command	Syntax	Example
Set session timeout (in seconds) If no command is sent for that duration, the session is automatically closed.	setSessionTimeout <time>	setSessionTimeout 300
Enable/disable password policy	passwdPolicy <options>	passwdPolicy 0 = disable passwdPolicy 1 = enable
Set Account locking parameters Number of failed attempts that trigger a lockout and duration of the lockout (in seconds).	setLockAccount <login retries> <lock_time>	setLockAccount 3 60
Set Mac address seen from the network	setMac <mac_addr>	setMac AA:BB:CC:DD:EE:FF
Set network addresses: Board IP address and sub-network mask, Gateway IP address if applicable	setNetworkSettings	setNetworkSettings then follow onscreen prompts
Set current user's own password	setPassword	setPassword then follow onscreen prompts
Set another user's password	setPassword <user>	setPassword bnufdp12
Set SNMP Operator or Admin password	setSnmpPassword	setSnmpPassword then follow onscreen prompts

IP Interfaces

Assigning the IP address and subnet mask is done by network managers, i.e. users with the OPERATOR role. A unique IP address should be applied.

All addresses are set using the **setNetworkSettings** command, as shown in the example below:

```
# setNetworkSettings
The current IP address is : 192.168.7.120
Do you want change the current IP address (y/N) ? y
Enter the new IP address : 192.168.7.120
INFO : /usr/bin/verificationIPaddress done, The IP address is valid
(192.168.7.120)
setting IP to 192.168.7.120
The current Gateway address is : (default)
Do you want change the current Gateway address (y/N) ? n
Gateway address hasn't changed
The current Netmask address is : 255.255.255.0
Do you want change the current Netmask address (y/N) ?
Netmask address hasn't changed
Unloading drivers: OK
Loading drivers: OK
Setup interfaces: OK
INFO : /usr/bin/setNetworkSettings Done
```

IP Address

The default IP address is 192.168.7.1.

Subnet mask

Typically subnet mask number fields are either 0 or 255 as in the figure below (255.255.255.0).

Gateway

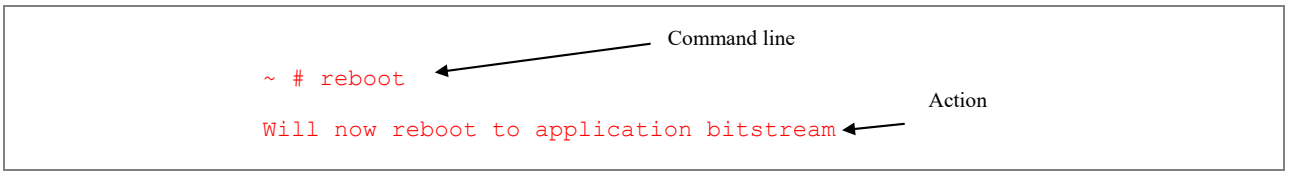
The gateway address must be on the same IP subnet as the hosting device.

4.2.2.5 MANAGEMENT COMMANDS

Management command	Syntax	Example
Management of user accounts Options: -c = Create a user account, -d = Delete a user account -u = Unlock a user account -n = Change a user name -r = Change a user role	AccountManagement <options>	AccountManagement –c then follow onscreen prompts
Hard Reboot	reboot	reboot

Reboot command

The command “reboot” forces a hard reboot equivalent to a power-up as shown in the figure below:



Note:
Only a user logged in with the root account or an account with Security Administrator privileges is allowed to send this command. If the account's rights are insufficient, an error message "Access Denied" is displayed and the command is not executed.

4.2.2.6 INFORMATION RETRIEVAL COMMANDS

The informative commands are given in the table below.

Informative command	Syntax	Example
Configuration summary	getConfig	getConfig
Current user information	whoami	whoami

Configuration

Typing in the "getConfig" command will return the switch configuration, an example of which is shown in the figure below:

```
# getConfig                                   Command line

Board version
--------------------
 - Board type          : SRH

Current configuration
---------------------
  - IP Add (default)      : 192.168.7.1

  - Gateway IP Add        : No Gateway defined (default)

  - Netmask               : 255.255.255.0 (default)

  - MAC Add               : 7E:63:AB:9C:55:4F (default)

  - MAC function Add      : (default)

Available users
---------------
root
user


INFO : /usr/bin/getConfig Done
#
```

Current user

Typing the "whoami" command will return the login name of the current user, an example of which is shown in the figure below, for the user "root":

```
# whoami
root
```

4.3 FIRMWARE UPGRADE

Upgrading the firmware may sometimes be necessary to take advantage of new features or bug fixes.

Note: If your board requires a firmware upgrade, please contact the GE Grid Solution Support team Department.

4.4 CYBER-SECURITY

The DS Agile C26x board provides security measures for system protection. They are described below.

4.4.1 ACCOUNT AND PROFILE MANAGEMENT

Each account is composed of a login name and a password. The login name is unique and cannot be changed.

If an attempt is made to create a user account with an already existing login name, the creation is denied and the message “Login name already exists” is displayed.

Each user can change his/her own login name and password. The password of all the accounts, including the default accounts, can be changed.

All the accounts can be deleted, except the “Root” account.

One of three roles, i.e. predefined sets of privileges can be assigned to each user account:

Roles	Privileges
Observer	This role only allows reading information. It does not allow changing any password except the user's own password. It does not give access to any security log.
System engineer	This role only gives access to data useful to run the system. In addition to Observer privileges, it also allows setting parameters on the board. It does not allow changing any password except the user's own password. It does not give access to any security log.
Security administrator	This role gives the user complete control over the board: In addition to System engineer privileges, it allows the user to upgrade the software version, display data and change the board's operating mode. It is the only role that allows the user to configure its own role as well as the System engineer and Observer roles and display security logs.

Only users with the *Root* role can create new accounts on the board and define their role. The same applies to user account deletion.

The maximum number of user accounts is **10**.

Default commands per authentication level

Commands	Root	Security administrator	System engineer	Observer
Configuration commands				
setSessionTimeout <time>	X	X		
passwdPolicy <options>	X			
setLockAccount <login retries> <lock_time>	X			
setMac <mac_addr>	X		X	
setNetworkSettings	X		X	
setPassword (*)	X	X	X	X
setPassword <user>	X			
setSnmpPassword (**)	X	X		

Commands	Root	Security administrator	System engineer	Observer
Management commands				
AccountManagement <options>	X			
reboot	X	X		
Informative commands				
getConfig	X	X	X	X
whoami	X	X	X	X

(*) Set the password for any account.
(**) Unique password to access the MIB data.

Default accounts

The board is delivered with two pre-defined accounts:

- "Root"
- "User"

Both these accounts are assigned the Security administrator role by default.

The default password for both accounts is "changeit". It is recommended to change it immediately.

Note:
The "root" account cannot be deleted.

4.4.2 PASSWORD POLICY

The Security administrator can force users to select passwords that comply with a minimum complexity using the setting **passwdPolicy**. If password policy is enabled, the passwords must comply with the following rules:

1 Contain at least 9 characters
2 All of these 4 types of characters must be used in the password:
  a Uppercase letter
  b Lowercase letter
  c Digit
  d ASCII non-alphanumeric character (such as @,!,#,{, etc.)

Passwords that do not comply with this rule are refused, an error message is displayed.

Note:
Password policy is enabled by default.

A forgotten or lost password cannot be recovered. A new password must be defined by a user with Security administrator privileges.

4.4.3 AUTHENTICATION

Concurrent logins

Concurrent logins are not allowed. Only one user can be logged in at any time. A current session cannot be overridden by another user, even one with administrator privileges.

Failed login

When authentication fails, the message "Login failed" is displayed.

Account lockout further to failed login attempts

A password locking policy is implemented:

1 After a settable number of consecutive failed login attempts (incorrect password), the account is locked for a settable period of time. The number of failed login attempts triggering a lockout is settable from 3 (default) to 10. The lockout period is settable from 1 hour to 24 hours (default setting: 1 hour) for accounts with the Observer, System engineer and Security administrator roles. For the account "root", the lockout duration is fixed to 5 minutes.

2 The account is unlocked when the first connection is successful after the lockout period has expired.

3 Only a user with the **Security administrator** privilege can unlock a locked user account before the end of the lockout period.

Authentication timeout

The login prompt is automatically terminated after a default inactivity (no command sent) timeout of 600 seconds (10 Minutes) for all user accounts.

Authentication on front face serial port

The access to the command line through the front face serial port is authenticated. However, there are two exceptions to this rule:

- The User can view the debug traces without authentication
- Bootrom mode serial port command line access is not be authenticated

When the user is in “debug traces view” mode, he can hit any key to switch to the authentication prompt. If no input is provided for 30 seconds, the serial board switches back to “debug traces view” mode.

There are two possibilities to exit the serial port command line and switch back to “debug traces view” mode:

- Type “exit” and press enter
- No command is entered until the session timeout

When the user is in Bootrom mode serial port command line access, the BCU initialization sequence can be stopped by pressing the “Enter” key during the second downward counter. In this case, authentication is required to go further in sequence initialisation, otherwise a reboot will be necessary.

4.4.4 SESSION TIMEOUT

A timeout disconnects the current user when no commands are sent to the board for a duration settable in steps of 60 seconds. The default timeout setting is 10 minutes (600 seconds).

4.4.5 SECURITY DATA LOG

All important activity and system operations are logged in the `/mnt/config/log/SRPV2.log` file that only users with the role **Security administrator** can read. This file contains:

- Startup log (boot and reboot)
- Successful and failed login attempts
- Syslog server down
- User account (local) changes (password reset, change of role)
- Configuration change
- Firmware change
- Audit log access
- Date and time change

The `/mnt/config/log` folder and its contents are not affected by software updates and will not be deleted when they occur.

The maximum size of the log files is 256 kB. When that size is reached, the oldest entries are deleted. This file contains up to 2048 log messages.

Note:
Passwords are not logged.

4.5 LEDS AND CONNECTIONS

LEDs: refer to C26x/EN HW. Connections: refer to C26x/EN CO.

INSTALLATION

C26X/EN IN/E72d

Contents

1	**SCOPE OF THE DOCUMENT**	**3**
2	**REQUIREMENTS**	**4**
2.1	**DS Agile C26x**	**4**
2.2	**Personal Computer**	**4**
3	**DELIVERY**	**5**
3.1	**Packing inspection and opening**	**5**
3.2	**Delivery form checking**	**5**
4	**MECHANICAL MOUNTING**	**6**
4.1	**Rack Mounting**	**6**
4.2	**Panel mounting**	**6**
5	**WIRING**	**7**
5.1	**General wiring**	**7**
5.2	**Power supply wiring**	**7**
5.3	**I/O board wiring**	**7**
5.4	**Network wiring**	**7**
6	**INSTALLING THE COMPUTER MAINTENANCE TOOL**	**9**
6.1	**Requirements for the PC**	**9**
6.1.1	Security	9
6.1.2	Hardware	9
6.2	**Installation on the PC**	**9**
6.2.1	Installation of multiple CMT versions on the same PC	9
6.2.2	Installing CMT	10
6.2.3	McAfee Embedded Control configuration	16
6.2.4	Installing the CA root certificate	17
7	**C264X FIRST POWER UP**	**20**
7.1	**Prequisites**	**20**
7.1.1	Ethernet connections	20
7.1.2	Serial port connections	20
7.1.3	Engineering workstation	22
7.1.4	TLS Certificates	22
7.2	**Loading the C26x firmware**	**24**
7.2.1	First connection to C26x	24
7.2.2	BootInstall Update	26
7.2.3	Checking C26x Settings	31
7.3	**Re-used (“Project”) board reboot and set-up**	**32**
7.3.1	Database Removal	32
7.3.2	Change the Host IP address	34
7.4	**Secure the maintenance port**	**35**

8	**SETTINGS**	**36**
8.1	**VLAN & MAC Address Filtering**	**36**
8.1.1	CPU4 Architecture & Port Distribution	37
8.1.2	Configuring VLAN & MAC Address Filtering	37
8.1.3	Structure of the sample configuration file	38
8.1.4	Uploading VLAN configuration to the C26x	41
9	**APPENDIX: CMT IN-DEPTH DESCRIPTION**	**42**
9.1	**Computer Maintenance Tool (CMT) overview**	**42**
9.1.1	General	42
9.1.2	Launching the software	42
9.1.3	CMT main window	43
9.1.4	Operations performed by the buttons in the left bar	51

1 SCOPE OF THE DOCUMENT

This document is a chapter of the DS Agile C26x documentation. It describes the product installation and start-up settings. Before any handling of the device, read carefully Safety information chapter.

This document is divided into the following parts:

- Delivery
- Mechanical mounting
- Wiring:
  - I/O board wiring
  - Network wiring
  - Power supply wiring
- Power-up without I/O
- Network setting
- Data Base Download

Use this document in conjunction with Commissioning chapter.

For details on HyperTerminal/Tera Term, refer to Maintenance chapter.

2 REQUIREMENTS

DS Agile C26x boot setting and software installation is carried out using a Windows PC with common utilities and serial/Ethernet link to the controller.

The DS Agile CD-ROM System installation is needed to run the C26x's install software on the Host PC.

2.1 DS AGILE C26X

The DS Agile C26x requires at least

- CPU board CPU4
- Power supply board BIU241 or BIU261
- Internal bus FBP24x (for 40TE case) or FBP28x (for 80TE case)

The BIU2x1 needs to be correctly wired to its voltage level as described in Connection Chapter.

Before any operational voltage is applied the shield, wiring should be checked following rules of the Safety Guide: SFTY/4L M/C11 (or later issue) and rules of chapter Safety & Handling.

The CPU board natively integrates factory parameters.

Before starting installation, the following information is required:

- C26x IP address
- C26x alias name (with the CMT, the network name must be less than 15 characters).

Both parameters are also defined in the DS Agile C26x database. If parameters inside database differ from the CPU settings, the IEC 61850-8-1 communication with other DS Agile pieces of equipment is not possible.

2.2 PERSONAL COMPUTER

A Personal Computer is used for setting and download. The required Windows operating system Windows 10 LTSC 2019 for Enterprise 64-bits edition.

The PC hardware requirement is:

- Ethernet port 10 Mb/s, 100 Mb/s or 1000 Mb/s
- 100 Mb of free space on hard disk

The PC software's needed is:

- Computer package named **Computer_cx66-*.*.*.*-build**.exe**

3 DELIVERY

The delivery is composed of:

- the hardware delivery: DS Agile C26x unit with CPU4 board
- the software delivery: **Computer_cx66-*.*.*.*-build**.exe**

3.1 PACKING INSPECTION AND OPENING

On receipt of the unit, inform the delivery agent if there is any sign of damage.

Check the box for documentation, or hardware options added to the delivery form, such as cables, screws, port extension etc.

3.2 DELIVERY FORM CHECKING

The delivery form is based on the order form created using the CORTEC. It lists the type of C26x, the boards (with power supply, serial numbers and position in the rack) and the options.

Check that the composition of the device is as ordered.

The C26x is delivered with the required connectors.

4 MECHANICAL MOUNTING

The chapter **C26x/EN HW** gives the size of DS Agile C26x rack, the mounting holes diameters and their position.

If an electrical screwdriver is used the torque limitation should be set to the small diameters of the screws.

The DS Agile C26x can be mounted in a rack or a panel.

4.1 RACK MOUNTING

The DS Agile C26x can be rack-mounted using single tier rack frames (our part number FX0021 001):



These frames are designed with dimensions in accordance with IEC60297. They are supplied pre-assembled and ready to use.

The two horizontal rails of the rack frame have holes drilled at approximately 26 mm intervals. The C26x cases are attached by their mounting flanges using M4 Taptite self-tapping screws with captive 3 mm thick washers to ensure a good earth contact (our part number ZB5865250).

It is possible to install two 40TE C26x side by side or one 80TE C26x in the rack.

Ensure that the devices are earthed, using the screw terminal on the rear of the unit.

4.2 PANEL MOUNTING

The DS Agile C26x can be flush-mounted into panels using M4 Taptite self-tapping screws with captive 3 mm thick washers to ensure a good earth contact (our part number ZB5865250).

Alternatively, tapped holes can be used if the panel has a minimum thickness of 2.5 mm.

Where several products are to be mounted in a single cut-out in the panel, mechanically group them together horizontally or vertically into rigid assemblies before mounting in the panel.

Note:
Fastening DS Agile C26x devices with pop rivets is not advised because it does not allow easy removal if repair is necessary.

5 WIRING

Wiring has to be prepared before installation. The DS Agile C26x is delivered with required connectors for I/O boards and Ethernet switches. The wire diameters stated in chapter **C26x/EN CO** are mandatory.

Tighten the screws in a cross pattern (e.g. top left, then bottom right etc), take care not to exceed the torque rated for the screws.

5.1 GENERAL WIRING

Only two wires can be screwed together onto any one connector. The AC and DC analogue, digital signal, and communication wires should use separate shielded cable.

From a practical point of view the power supply of each device should have a switch (MCB, link, or fuse) to turn off the power during installation and commissioning tests.

The DS Agile C26x description sheet describes the type of board Installed on each slot (C, D etc.) It is very important to use it to correctly plug the connectors.

Connection diagrams of the C26x are given in the Connection chapter of the C264 use manual. Wires should be connected with the connector unplugged. Each wired signal has to be tested before plugging and fixing the connectors. The connectors have to be fixed on the C26x case with the screws available at each extremity of the connector.

For connection of the protective (earth) conductor see chapter *Earthing*, in the Connection chapter of the C264 use manual.

5.2 POWER SUPPLY WIRING

The BIU connector wiring is vital as it provides the power supply. Power voltage should be tested and checked to BIU reference defined in chapter **C26x/EN HW** to ensure that supply is compliant to BIU voltage. Switch off the power before plugging in the connector.

5.3 I/O BOARD WIRING

Several DIU, CCU, BIU board voltages are available for Digital Inputs. Check that the DIU voltage as stated on the delivery form matches with the nominal signal input before plugging connector to the C26x.

DOU and CCU, the boards generate Digital Output with a defined inductive characteristic. On the other side of the wire the inductance should be compliant. To avoid damage to the DO board connected to inductive circuits it may be necessary to use an anti-surge diode.

5.4 NETWORK WIRING

Wiring to the network(s) can be through fibre optic or RJ45 copper cables.

Copper Ethernet networks are contained within a cubicle. Optic fibre has to be used between cubicles.

By default, 2 connectors of the same type can be ordered with the C26x.

- 2 SFP Modules - Transceiver RJ45 10/100/1000Mbps or
- 2 SFP Modules - Transceiver Optical 100Mbps Multimode or
- 2 SFP Modules - Transceiver Optical 1Gbps Multimode or

- 2 SFP Modules - Transceiver Optical 100Mbps Single-mode SR (2 km) or
- 2 SFP Modules - Transceiver Optical 100Mbps Single-mode IR-1 (15 km)
- 2 SFP Modules - Transceiver Optical 1Gbps Single-mode up to 10km or

If more are needed, they should be ordered separately. Empty SFP cages are protected by plugs.

There are specific rules governing the installation of fibre optics (refer to the *Connection* chapter *C26x/EN CO*). Specific care should be taken with the bend radius of the fibres, and the use of optical shunts is not recommended as these can damage the transmission path over time.

Copper networks should follow class recommendation and shielding.

Warning about Laser Rays



Caution:
NEVER look into the end of a fibre optic as there is a risk of causing serious damage to the eyes. Always use optical power meters to determine operation or signal level.

Non–observance of this rule could possibly result in personal injury.

6 INSTALLING THE COMPUTER MAINTENANCE TOOL

6.1 REQUIREMENTS FOR THE PC

In this chapter, “computer” refers to the DS Agile C26x and “(host) PC” to the PC that hosts the tools.

Note:
If CMT application is needed on aView server PC, Install first aView (with required certificates) and then install CMT application.

6.1.1 SECURITY

The CMT shall be installed on a properly secured PC.

Before installing CMT, Ensure GE’s hardening tool is available on the PC. If not, Install GE’s hardening tool as described in the Installation chapter of the DS Agile System Secure Deployment Guide (SDG_enM_Xxx), section 9.5.3 OS Hardening.

It is beyond the scope of this document to describe how to secure an engineering workstation.

6.1.2 HARDWARE

- At least 700 MHz
- Windows 10 LTSC 2019 for Enterprise 64-bits edition
- At least 100 MB free space on hard disk
- A serial port (or a USB-serial adaptor)
- An Ethernet port
- Computer must have at least 3 GB of RAM

6.2 INSTALLATION ON THE PC

It is recommended to use default installation parameters. This installs the various applications and sets the C26x application in a directory accessible by the C26x. Several different versions may be installed. Each of them will be installed in a specific directory (e.g build05 version will be installed in a /Build05 directory by default).

6.2.1 INSTALLATION OF MULTIPLE CMT VERSIONS ON THE SAME PC

*Note: Good practice: If there is already a previous version of the CMT installed, uninstall it first using the tool provided in the relevant section of the Start menu (click the icon **Uninstall DS AGILE COMPUTER**).*
Exception: If the PC must manage DS Agile C26x units with different CPU boards (both CPU270 and CPU4) and if it is used to prepare new boards.

If the PC is to be used to manage both CPU270 (CPU3) and CPU4 boards, it will be necessary to install the corresponding versions of the CMT tool:

- one or two CPU3-compatible version(s) of the Computer Maintenance Tool (refer to relevant manuals for their installation procedure)
- one CPU4-compatible version of the CMT.

In that case, make sure that you install both versions in discrete folders and that you create different, easily identifiable shortcuts for each. You can for instance use these paths for the CPU4 board:

- `C:\Program Files (x86)\DSAgile\C264\NewCPU4\Computer`

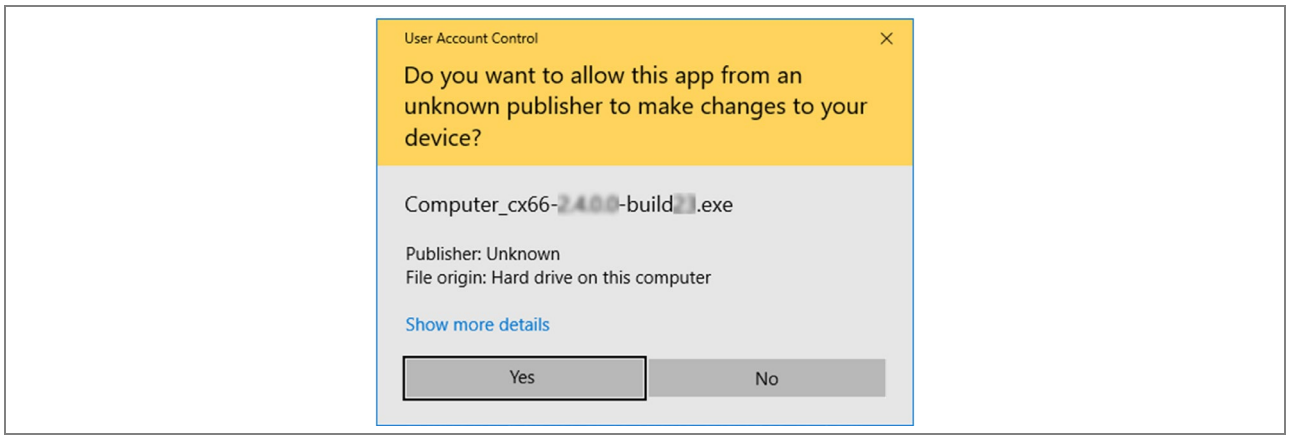
Caution:
Installing several versions of the CMT tool on the same computer may cause unforeseeable problems. It should be done only by experts.

6.2.2 INSTALLING CMT

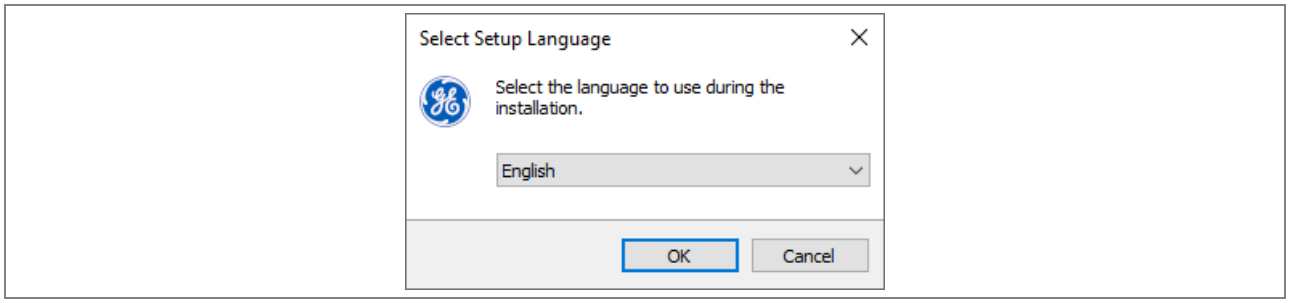
1 Unzip the system delivery file **dsagile-va.b.c.d-base.zip** (a.b.c.d is the system version).

The controller's software is in the `cx6x-a.b.c.d` folder.

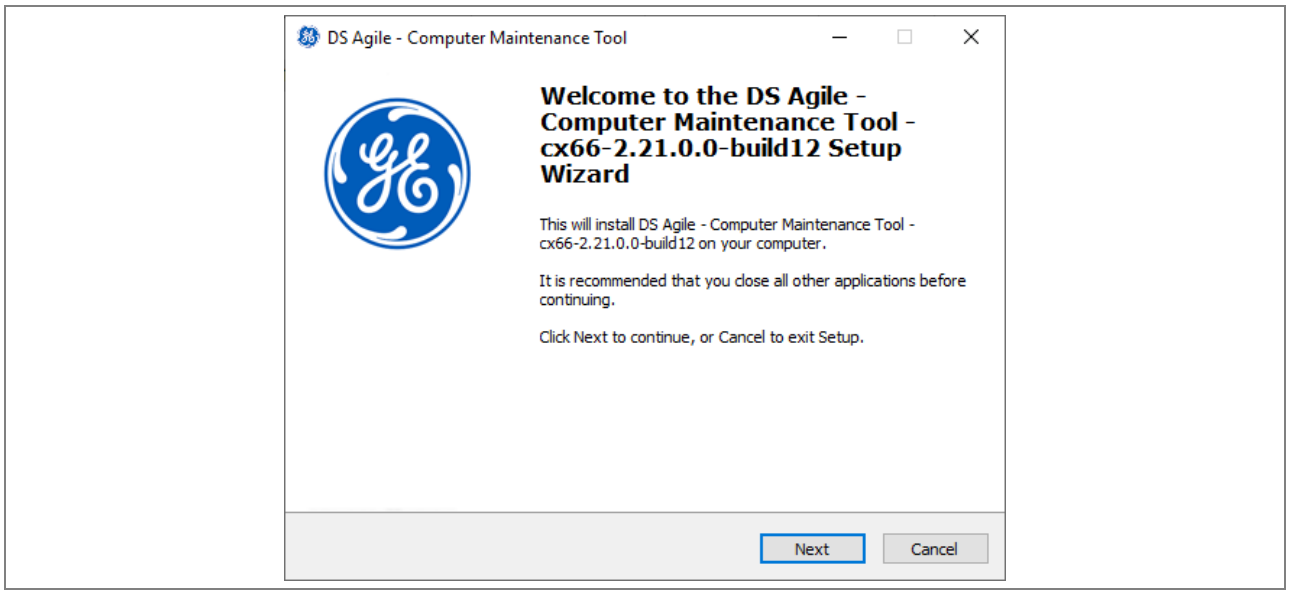
2 Launch the **Computer_cx6x-*.*.*.*-build****.exe file and click **Yes** when prompted:



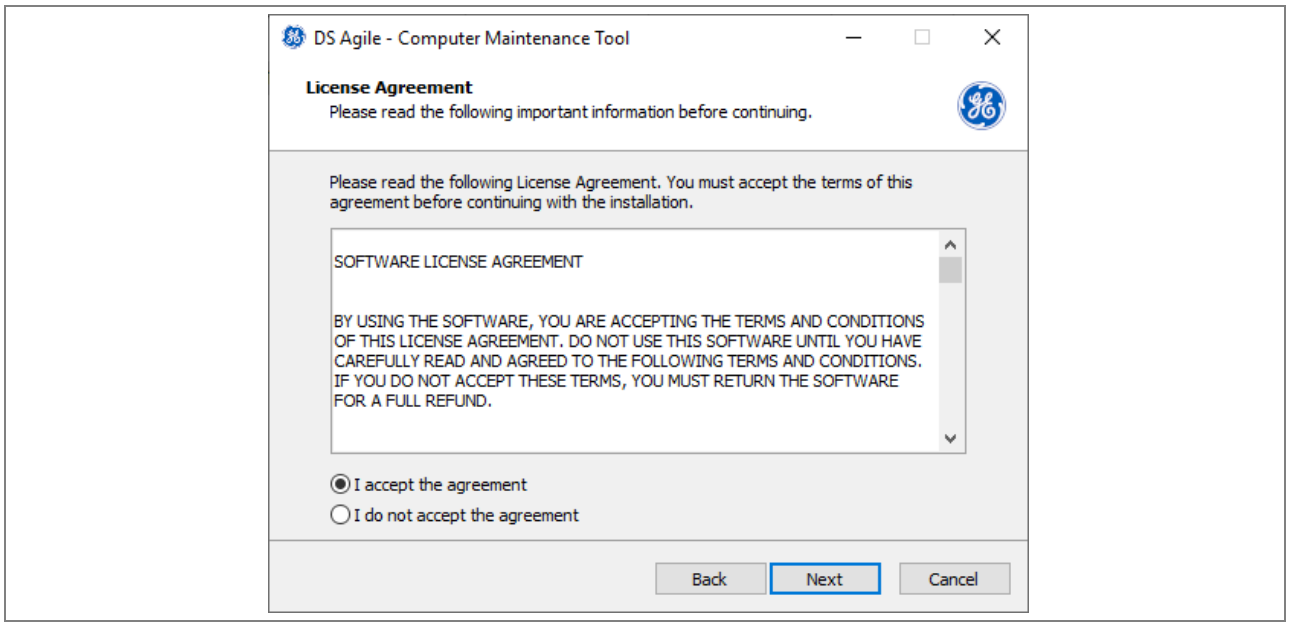
3 Select the parameters as detailed below, starting with the language to use in the installer and the CMT application (default setting, it can be changed after installation):



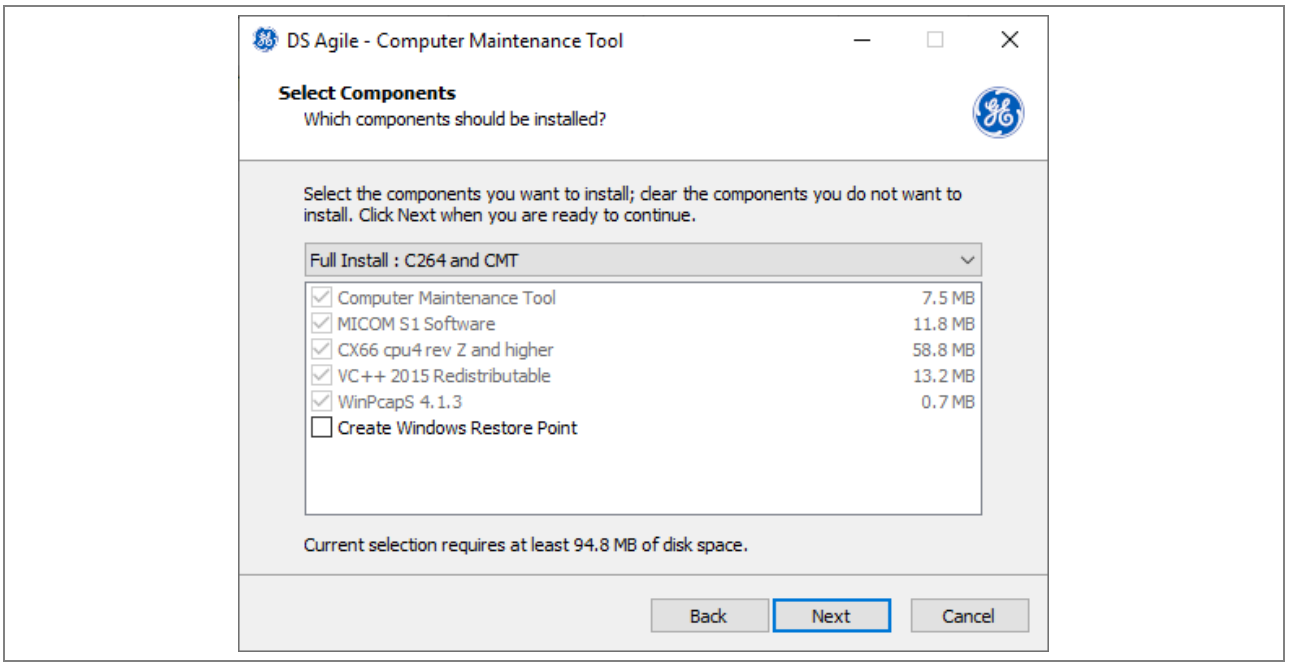
4 Cycle through the screens and click **Next >**.



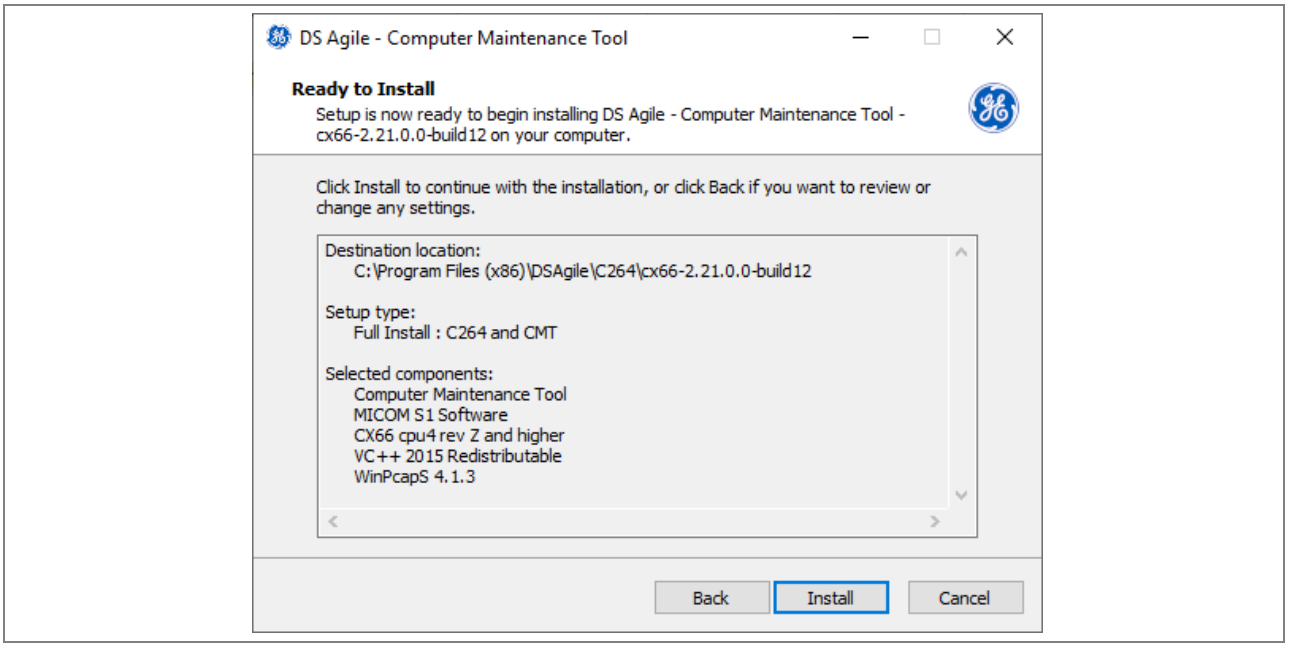
5 Accept the License Agreement, and then click **Next**



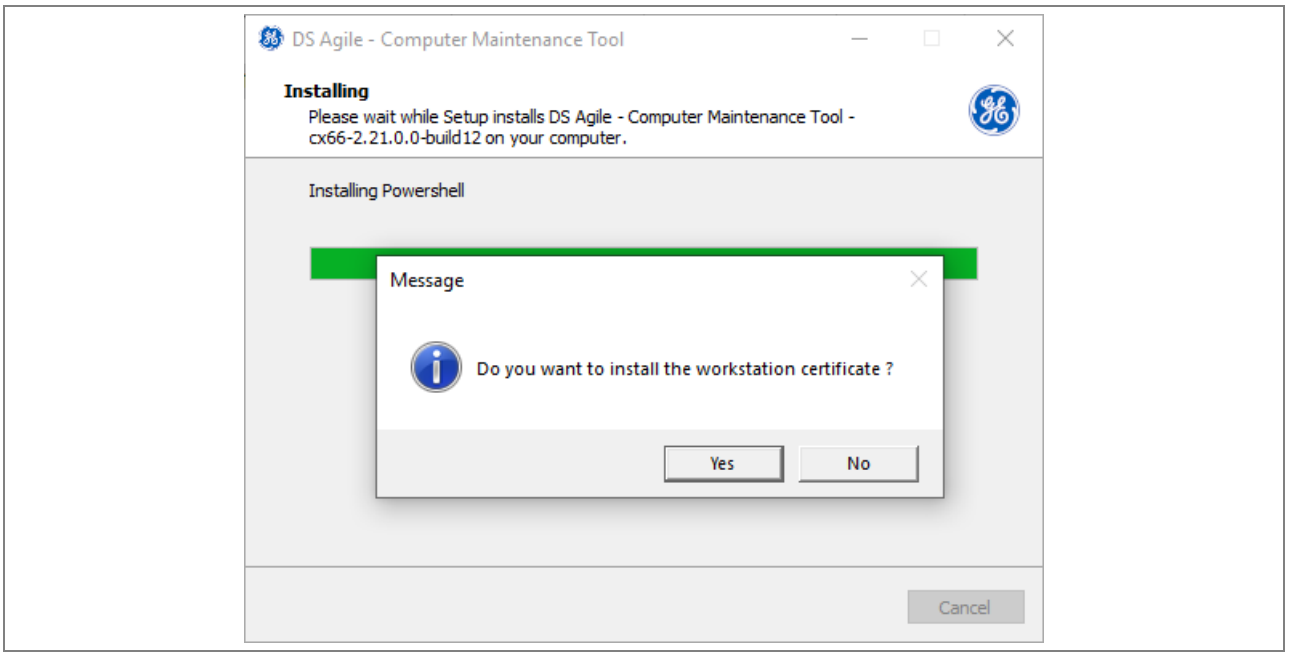
6 Select the components to install and click **Next**


DS Agile - Computer Maintenance Tool
Select Components
Which components should be installed?
Select the components you want to install; clear the components you do not want to install. Click Next when you are ready to continue.
Full Install : C264 and CMT
Computer Maintenance Tool 7.5 MB
MICOM S1 Software 11.8 MB
CX66 cpu4 rev Z and higher 58.8 MB
VC++ 2015 Redistributable 13.2 MB
WinPcapS 4.1.3 0.7 MB
Create Windows Restore Point
Current selection requires at least 94.8 MB of disk space.
Back
Next
Cancel

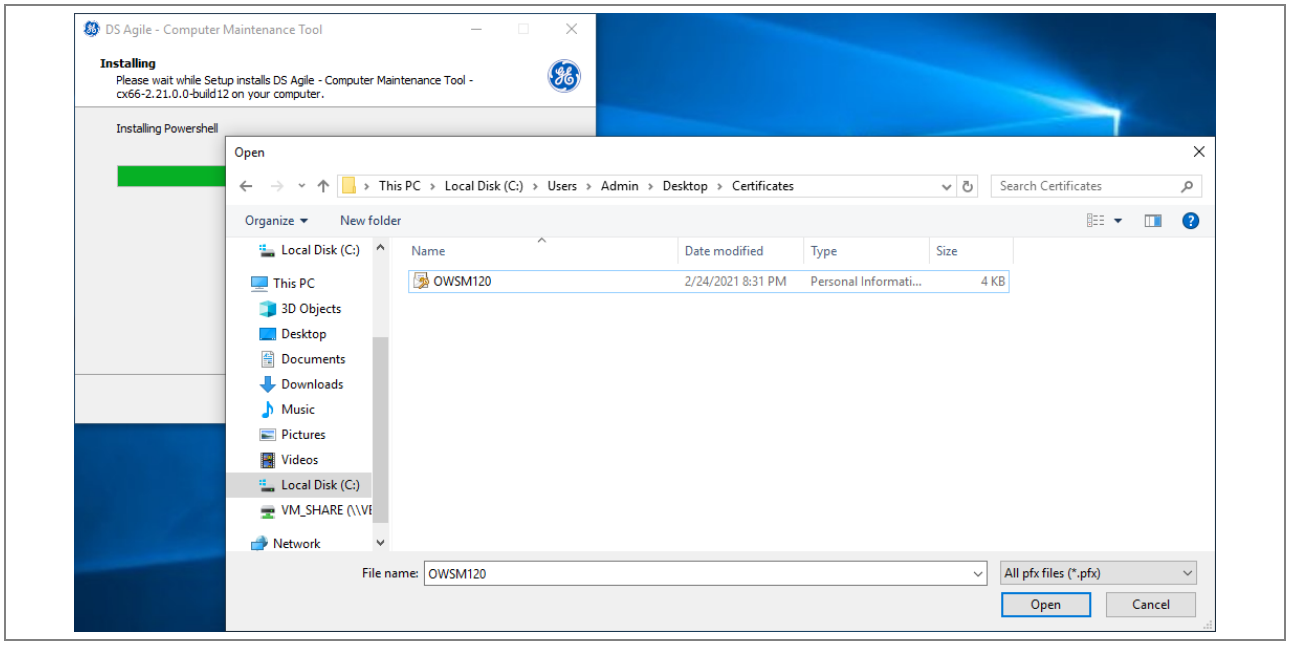
7 Check the summary (click **Back** if you need to make changes) and click **Install:**



8 During the installation process, a popup asks to install or not the certificates. Click Yes to install certificate.



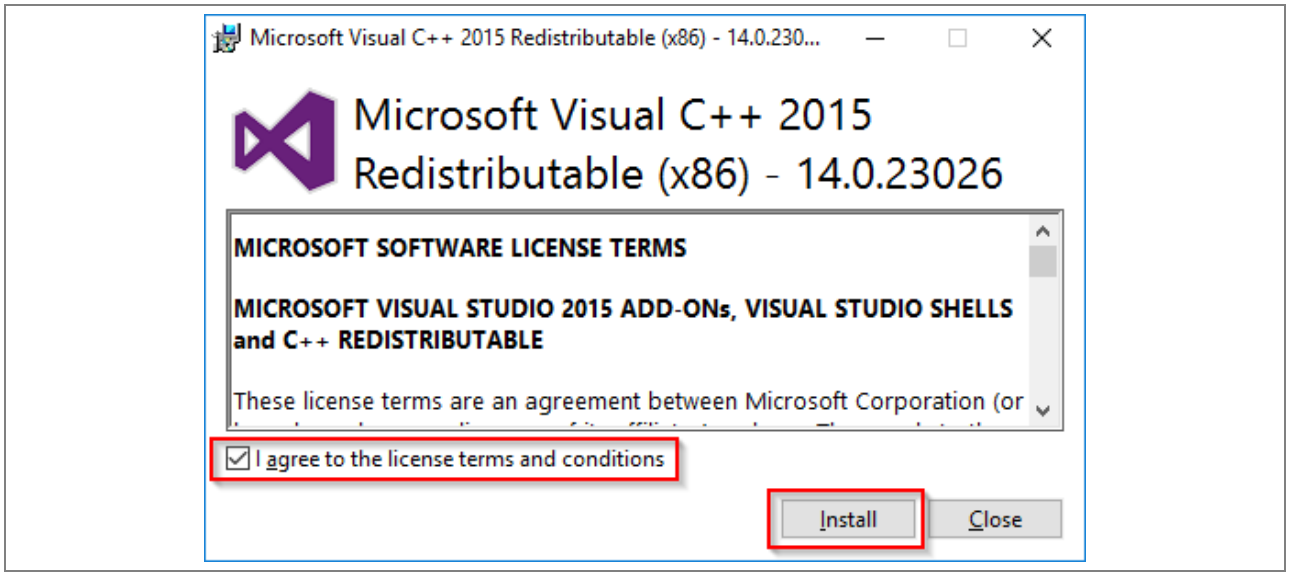
9 Select the .pfx certificate to import and click Open



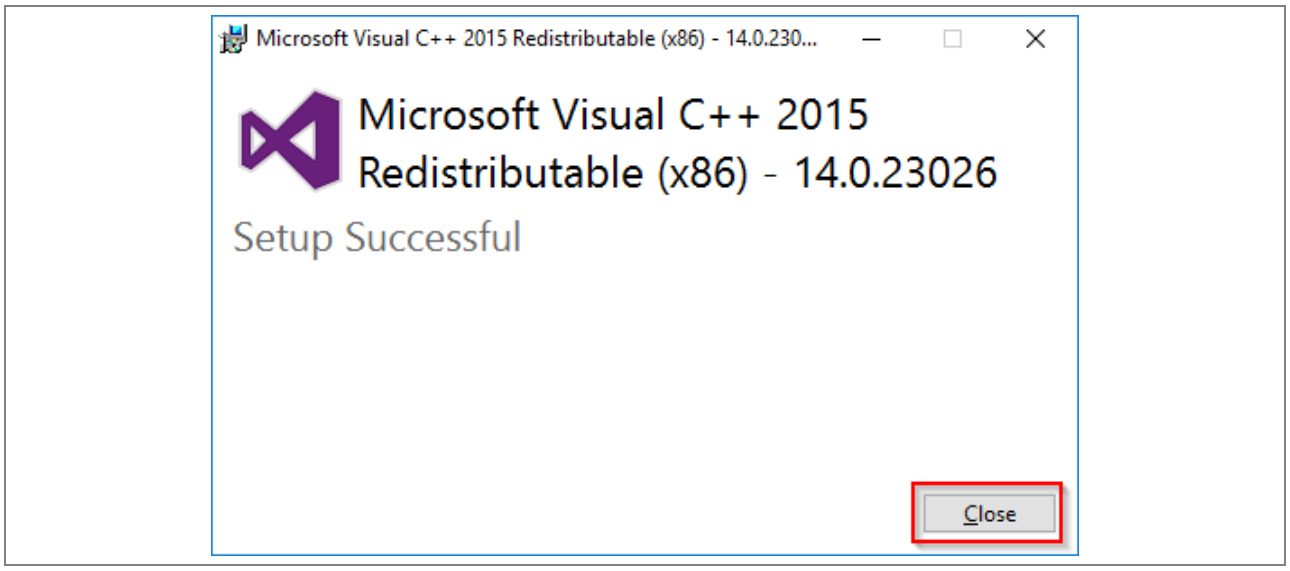
10 If Visual C++ is not installed, you will be prompted to install it

11 Accept the License agreement

12 Click **Install**



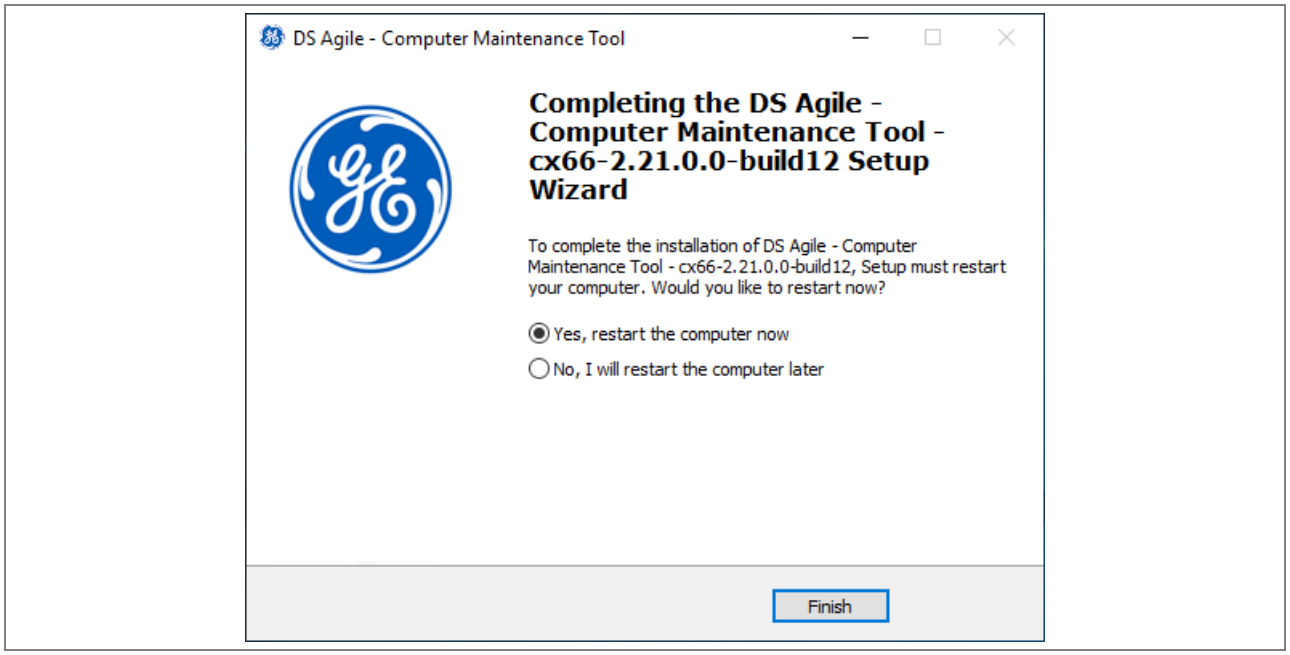
13 Click **Close**



14 Once all files have been copied, tick Install WinPCap 4.1 if it is not yet installed (older versions should be removed before installation).

Note:
The WinPcap tick-box is not visible if WinPcap is already present on the PC.

15 Thick the option to restart the computer now or the option to restart later and then click **Finish**



6.2.3 MCAFEE EMBEDDED CONTROL CONFIGURATION

It is recommended to install McAfee Embedded Control as an anti-malware solution on the PC.

The following McAfee Embedded Control feature shall be disabled:

- Memory protection for these executable files:
  - CMT.exe
  - MicomS1.exe
- Folder write protection for these executable files:
  - CMT.exe
  - MicomS1.exe

6.2.4 INSTALLING THE CA ROOT CERTIFICATE

The TLS communications between the PC and the C26x are signed by a digital certificate in order to protect the C26x against data tampering.

It is necessary to pre-install the Certificate Authority (CA) root certificate on the PC before connection.

To find out how to create the CA root public certificate, refer to the **Installation** chapter of the D**S Agile System Secure Deployment guide** (SDG_enM_Xxx.pdf) section "**9.6 Certificates**".

In our example, the CA Root public certificate is CA_DSAgile.pem.

Note: If the PC is part of a Domain, the CA Root certificate may already be installed by the Active Directory. Please check your installation.

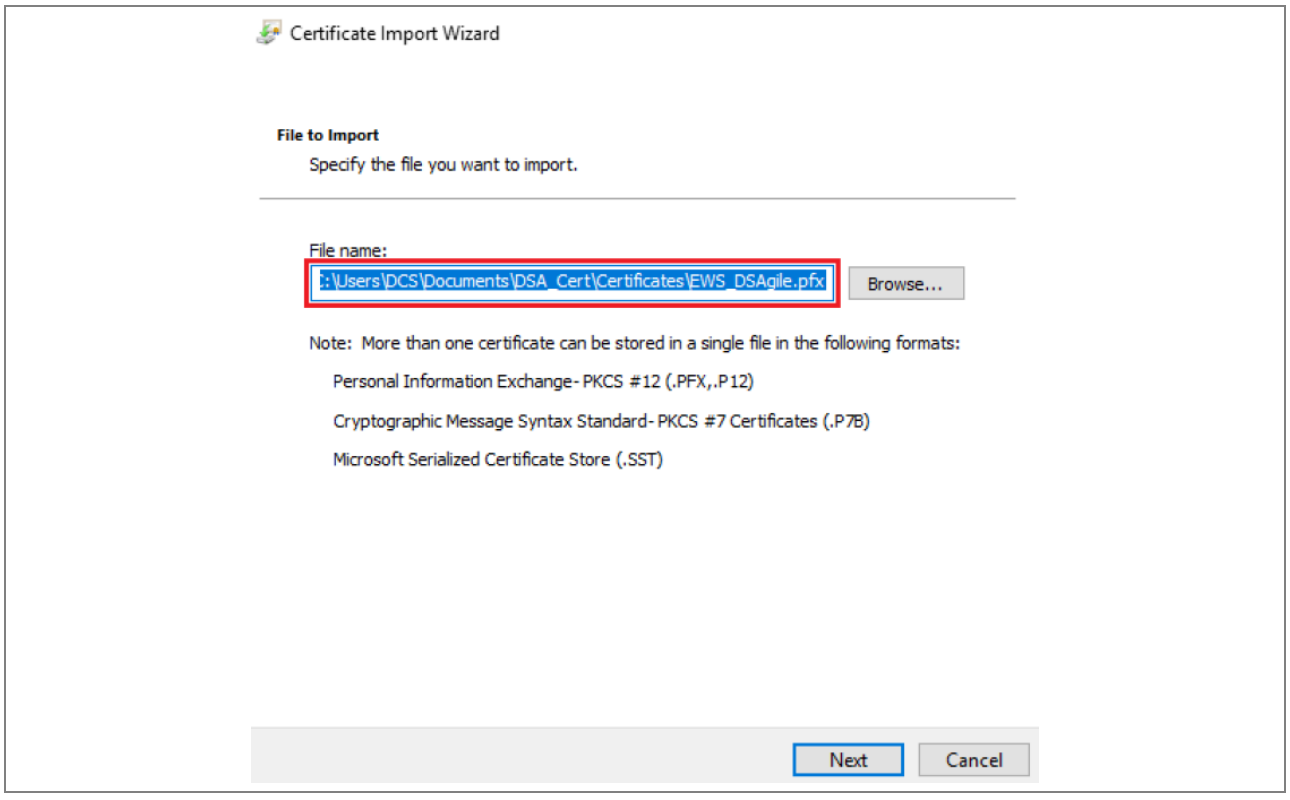
To import the CA Root certificate in "**Local Machine Certificate Store**":

1 Double click on **CA_DSAgile.pfx** file.

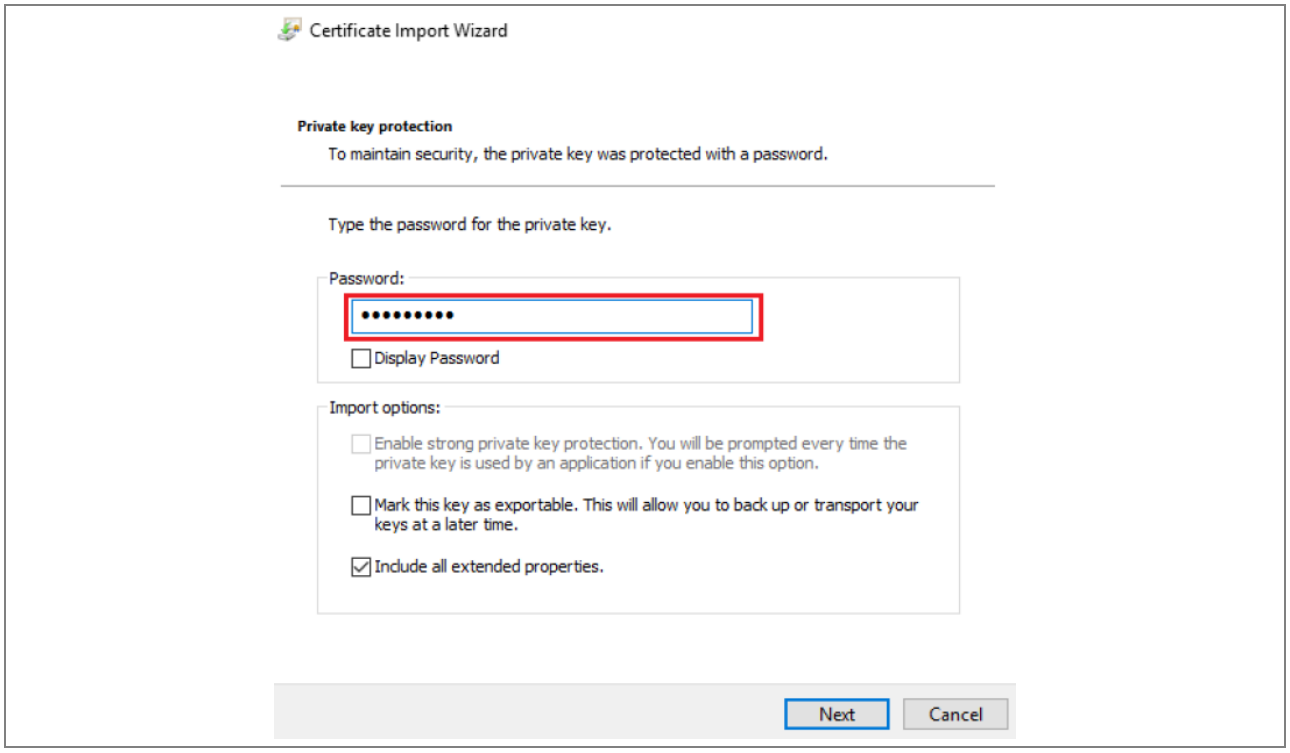
2 Select "**Local Machine**" and click "**Next**".

3 In the UAC Window, click **Yes**.

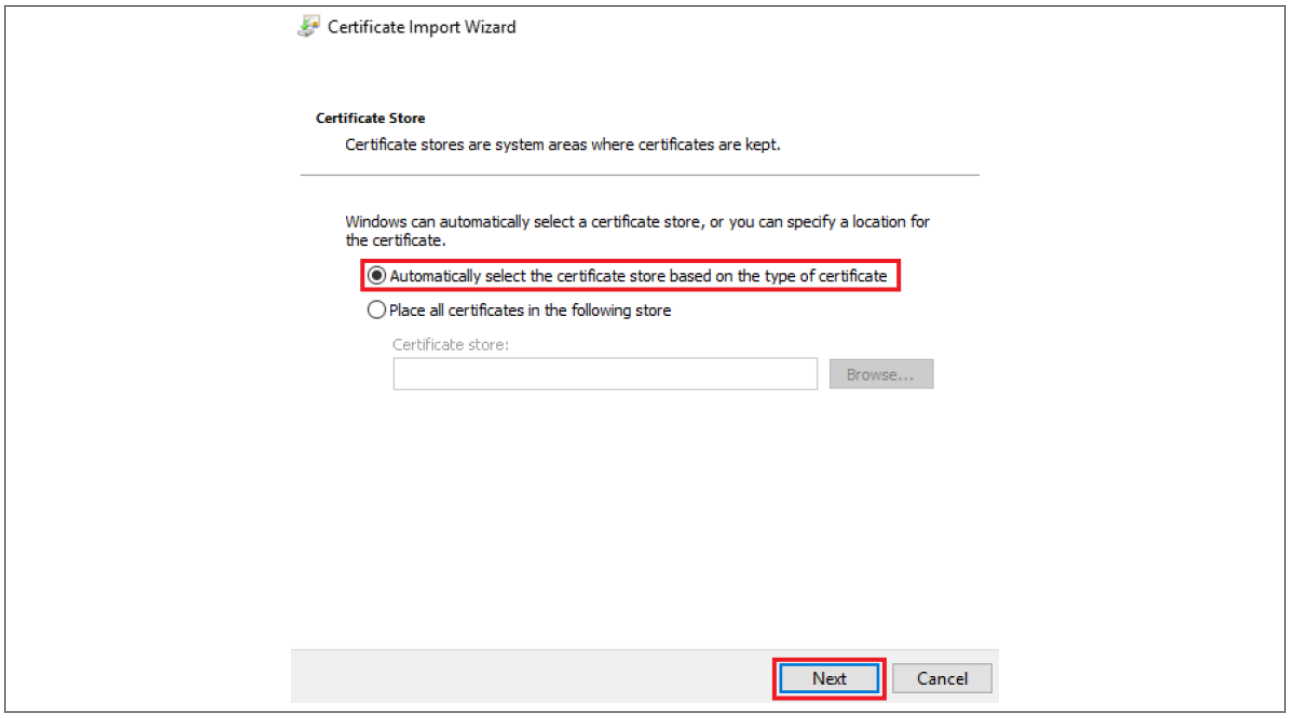
4 Verify the certificate you want to import then click "**Next**":



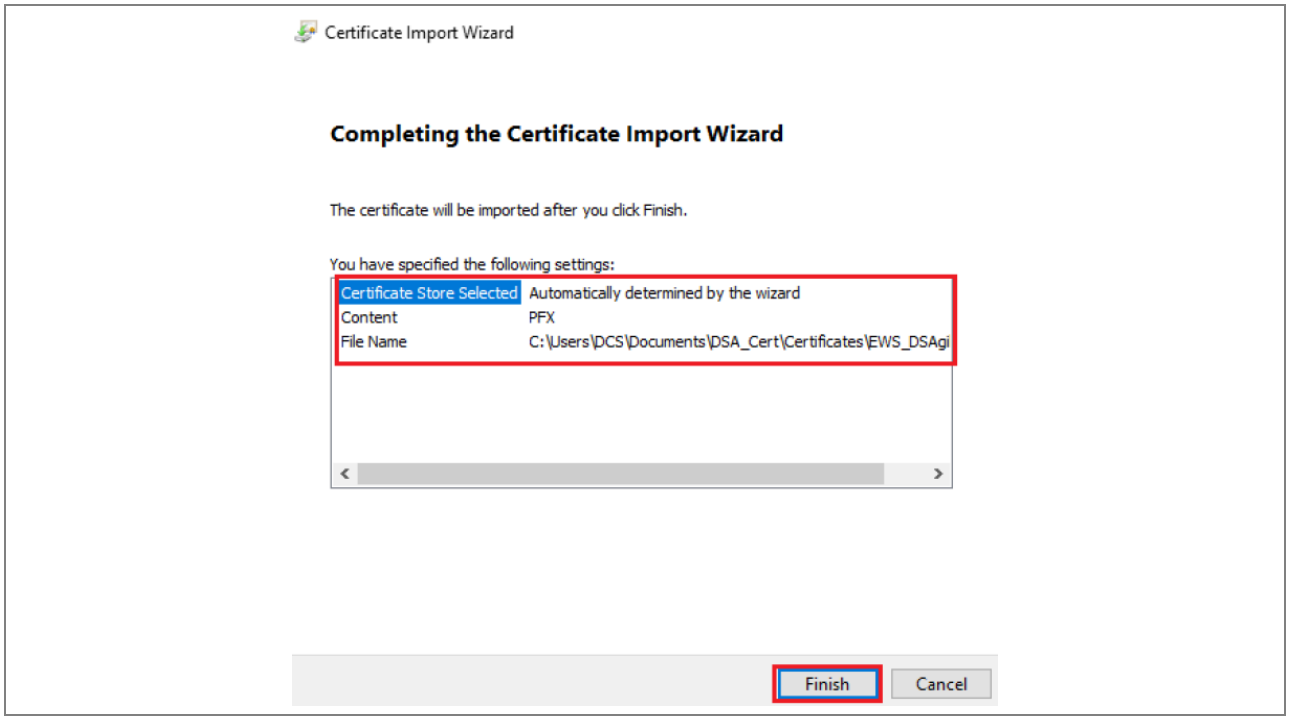
5 Enter the certificate password if needed then click “**Next**” (By default, no password is required):



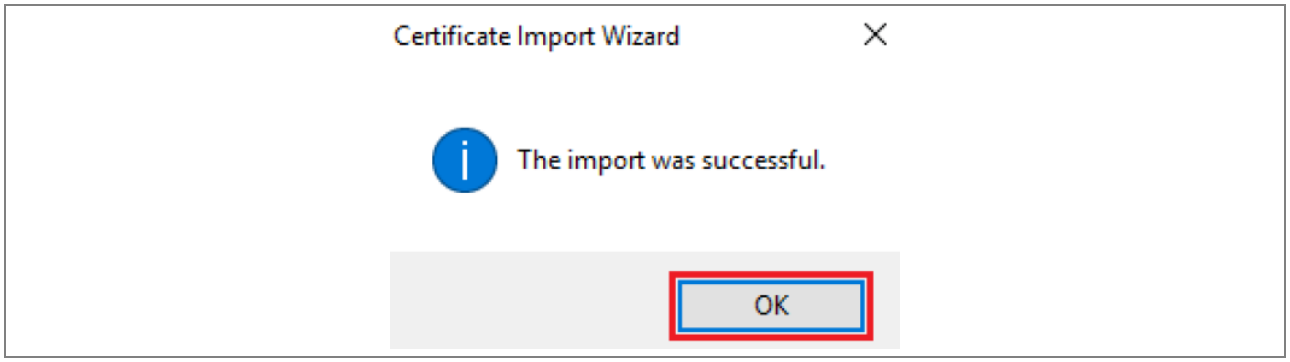
6 Select “**Automatically select the certificate store…**” then click “**Next**”:



7 Verify the certificate import information then click “**Finish**”:



8 When the import is finished, click “**Ok**”:



7 C264X FIRST POWER UP

Out of factory, the DS Agile C26x has the following default configuration:

- Bootrom start-up software,
- Factory start-up settings

The first step to operations is to upload the target firmware version to the C26x.

Caution:
Before powering up the device all the DI/DO board connectors should be disconnected to avoid unwanted incoming/outgoing signaling.

See the Commissioning Chapter (C26x/EN CM) for tests on how to check that the DS Agile C26x has not been damaged during transport, using its factory settings.

7.1 PREQUISITES

7.1.1 ETHERNET CONNECTIONS

The C26x shall be connected to the network using Ethernet Port #3 for the first power up. Refer to Connection chapter of the C264 user manual

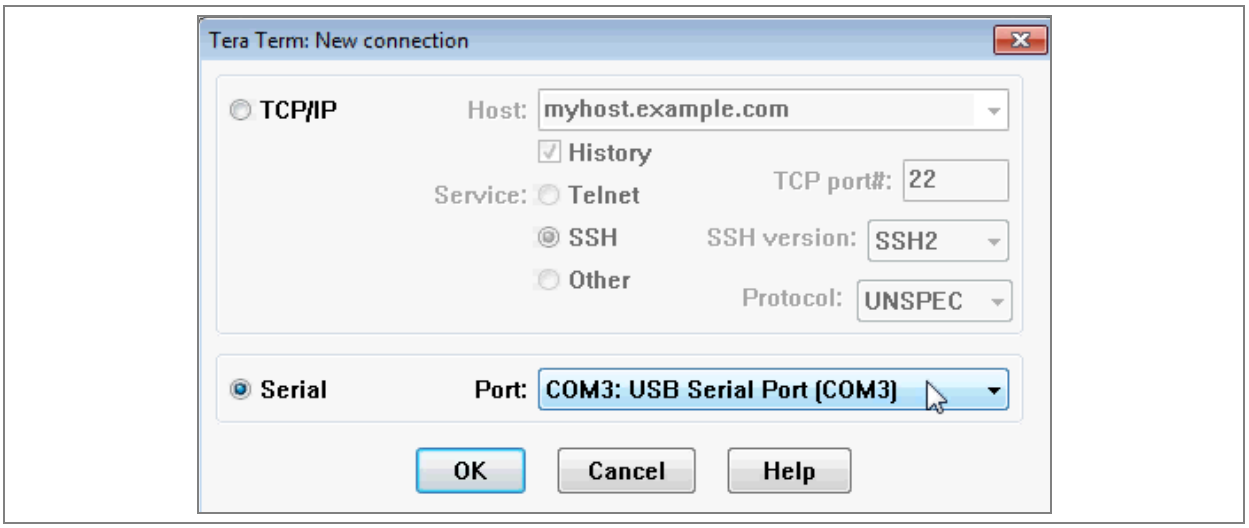
7.1.2 SERIAL PORT CONNECTIONS

The serial port can be used as a read-only console but is not necessary for the first power up.

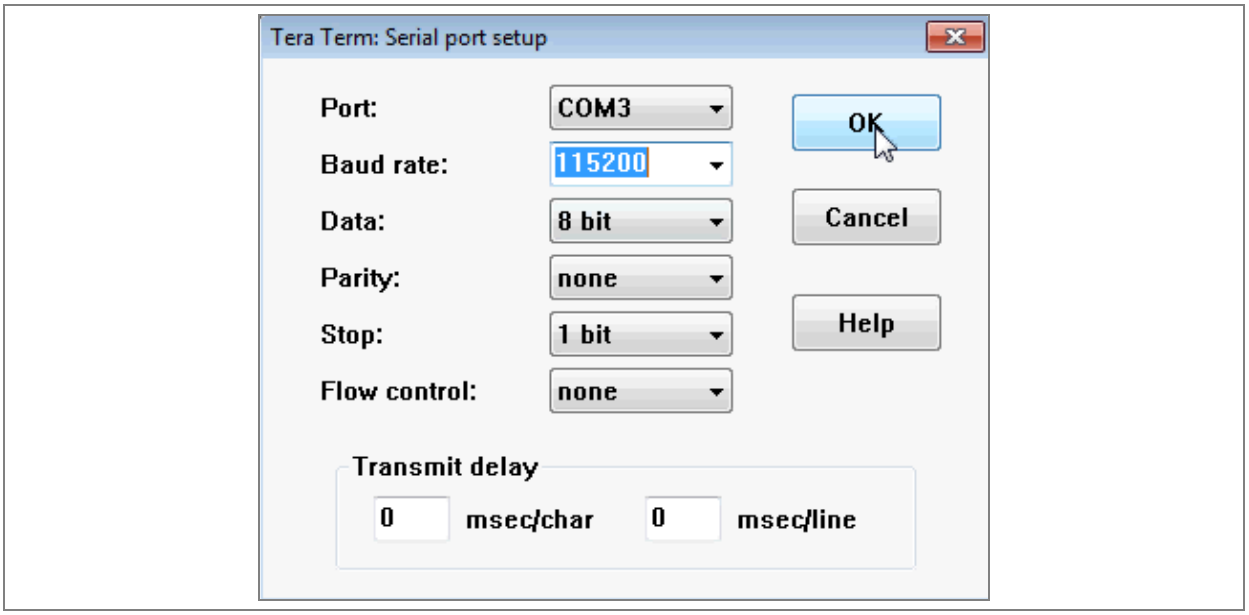
1. Connect the serial port on the front panel of the C26x to the PC, using an RS232 serial cable (see *Connexion* chapter for details).



2. On the PC, launch the terminal emulator program and establish a serial communication session with the board:
    a. Select the relevant serial COM port connected to the DS Agile C26x front panel:



    b. Click **OK**.
3. In the **Serial port setup** popup, set the communication as follows:
    - Baud rate: *115 200 bits/s*
    - Data: *8 bit*
    - Parity: *none*
    - Stop: *1 bit*



4. Click **OK**.

The terminal emulator communication is established, and the boot sequence is started.

```
U-Boot SPL 2013.01.01 (Oct 05 2016 - 18:00:28)
BOARD : Altera SOCFPGA Cyclone V Board
CLOCK: EOSC1 clock 25000 KHz
CLOCK: EOSC2 clock 25000 KHz
CLOCK: F2S_SDR_REF clock 0 KHz
CLOCK: F2S_PER_REF clock 0 KHz
CLOCK: MPU clock 800 MHz
CLOCK: DDR clock 400 MHz
CLOCK: UART clock 100000 KHz
CLOCK: MMC clock 50000 KHz
CLOCK: QSPI clock 400000 KHz
RESET: COLD
INFO : Watchdog enabled
SDRAM: Initializing MMR registers
SDRAM: Calibrating PHY
SEQ.C: Preparing to start memory calibration
SEQ.C: CALIBRATION PASSED
SDRAM: 1024 MiB
SDRAM: Scrubbing 0x01000000 - 0x02000000
SDRAM: Scrubbing success with 24 ms
SDRAM: ECC Enabled
SF: Read data capture delay calibrated to 4 (1 - 7)
SF: Detected MX66L1G45G with page size 65536, total: 134217728
ERROR: ipcom_drv_eth_init:!!!!!!!! drvname:SE, drvunit: 1

                            VxWorks System Boot

Copyright 1984-2016  Wind River Systems, Inc.
```

7.1.3 ENGINEERING WORKSTATION

A PC with the CMT installed is required (see 7 Installing the Computer Maintenance Tool).

The PC must be configured with IP address 192.168.254.1 and able to access the C26x through the network.

The CA Root public certificate must be loaded in the PC certificate store.

The C26x and the host PC must be in the same subnet.

The first connection is not possible when the PC and C26x are in different LANs separated by a router as the router IP address and network address in C26x cannot be configured before the firmware is updated and a configuration database is loaded as described in chapter C26x/EN AP.

7.1.4 TLS CERTIFICATES

The TLS communications between the PC and the C26x are signed by a digital certificate in order to protect the C26x against data tampering.

A private key and corresponding public key certificate must be created to be loaded on the C26x.

To create the necessary certificates, see section Creating Certificates available in the Network and System Security guide chapter of the DS Agile user manual.

The result is 3 C264 certificates (ca.crt, ia.crt, tmp_ia.key), which include the C264 target IP address (not the factory default).

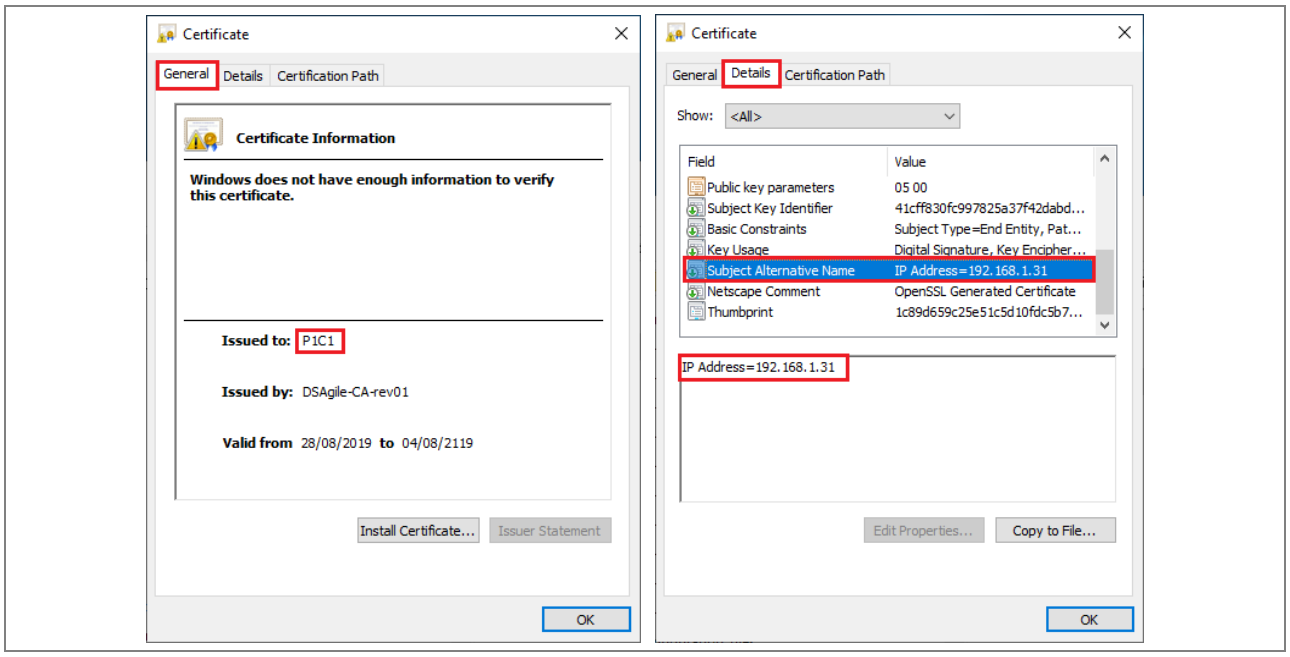
1 Connect to CMT PC and run command `sadmin bu` to get in whitlisting update mode.

2 Copy the Cx66 certificate folders (with their name matching with the BCU name and each folder containing corresponding BCU's certificate files ca.crt, ia.crt, tmp_ia.key) to the path `C:\ProgramData\DSAgile\C264\Certificates`

Make sure that the parameters of the certificates copied in the CMT folder match the target C264.

3 In the CMT folder, double click on "**ia.crt**" and check that the target network name and the IP address of the C264 are the same as defined in the certificate:

- In the "**General**" tab "**Issued to**:" = `C264 network name`
- In the "**Details**" tab "**Subject Alternative Name**" = `C264 IP addresses`



If network name or IP address have not the expected values, remove the 3 certificate files (ca.crt, ia.crt, tmp_ia.key) and replace them with the required ones.

If the C264 is updated with a wrong certificate, it won't be possible to connect to the CMT and you will have to do a factory reset to retrieve it.

4 Run command `sadmin eu` to disable whitelisting mode.

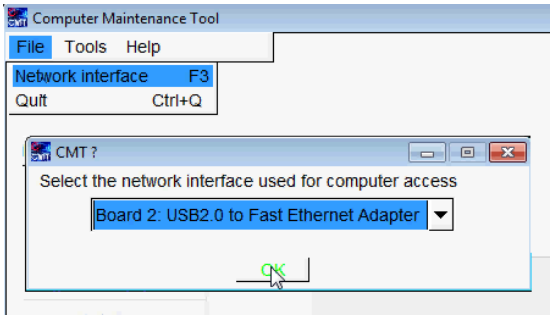
5 In CMT, click on **Bootinstall** and click **Stop computer** and **update certificate**. This action matches the BCU network name with the c264 certificate folder name, and copies that c264 certificate folder contents (Corresponding BCU's ca, ia, tmpkey) to the BCU.

7.2 LOADING THE C26X FIRMWARE

7.2.1 FIRST CONNECTION TO C26X

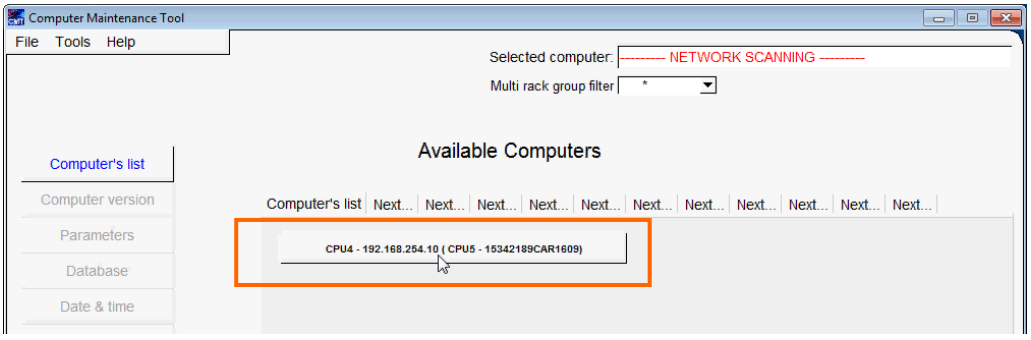
1 Launch the CMT application.

2 If managing several boards, in the **File** menu, click on **Network Interface** and select the network interface:



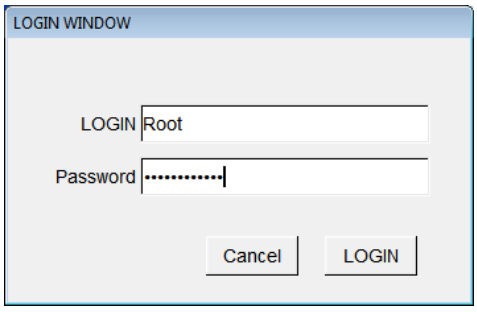
3 In the **Available Computers** list, click **Search computers** and wait during the device discovery.

4 Then, select the relevant CPU4 board from the list:



5 Double click on the computer displayed in the list and login with the default credentials:

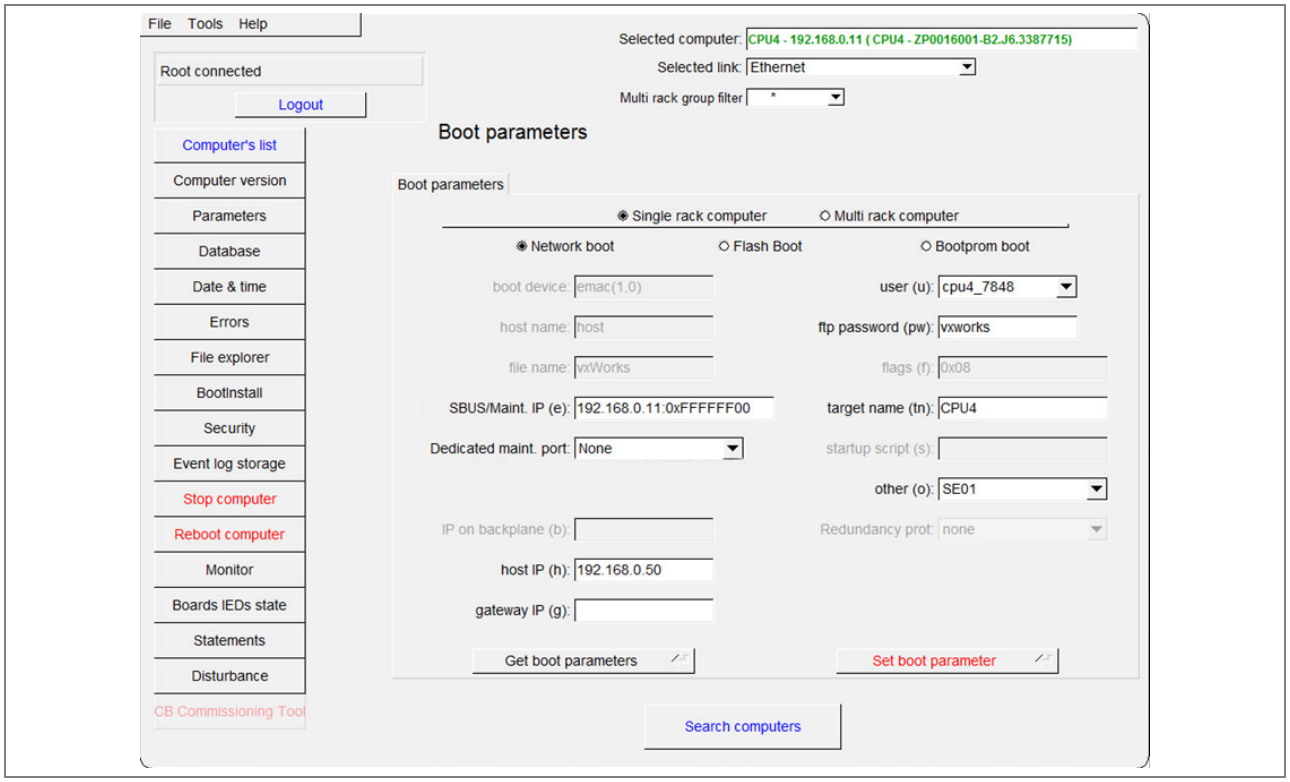
- Login: *Root*
- Password: *Root1234#*



6 Click on the **Parameters** button on the left and set the SBUS/Maint IP (and subnet mask) and target name to the target C26x values.

Ip address and target name must match those present in the certificate (see 8.1.4 TLS Certificates) other wise the C264 will be unreachable after reboot.

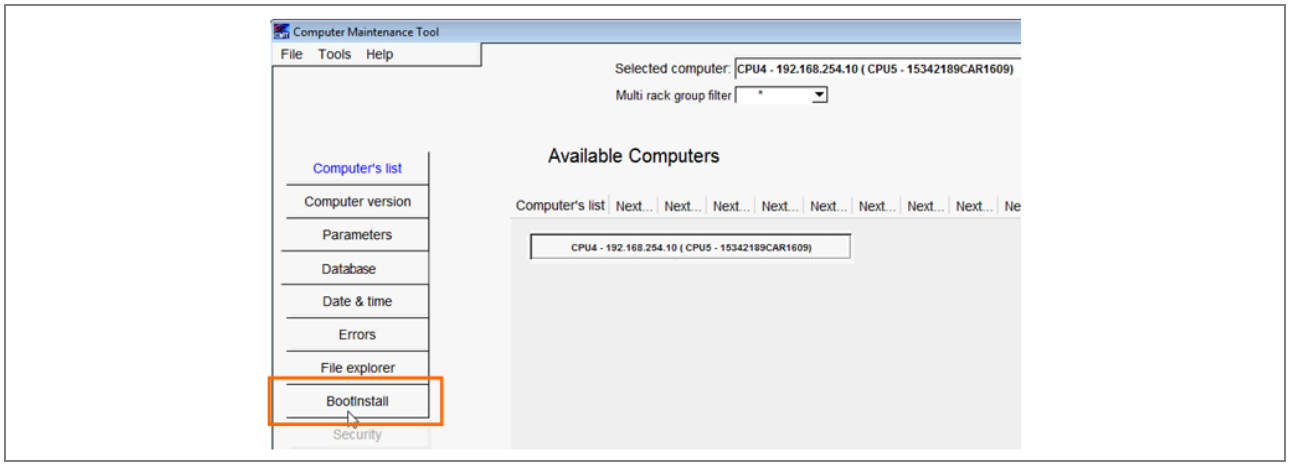
7 Save with a click on **Set boot parameters**.



7.2.2 BOOTINSTALL UPDATE

Always use the CMT version delivered with the Bootinstall files for compatibility reasons.

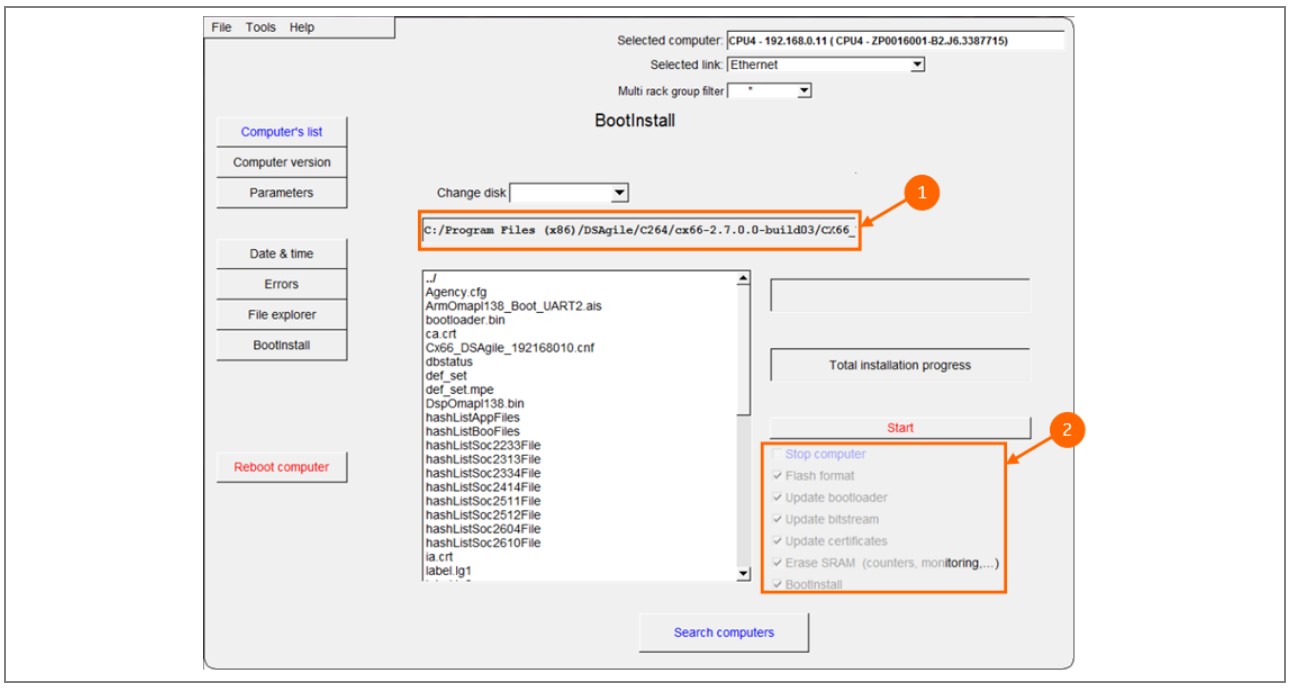
1 Click on the **Bootinstall** button on the left:



2 Make sure that the path goes to the **<Cx66 common name>** folder 1

3 On the right side of the screen, select the following actions 2 (*recommended when the selected CPU4 is a factory board that needs to be configured from scratch*):

- **Update bootloader**: to install/update loader files,
- **Update bitstream**: to select the appropriate use case depending on your application,
- **BootInstall**: to download the set of files essential to the C26x.



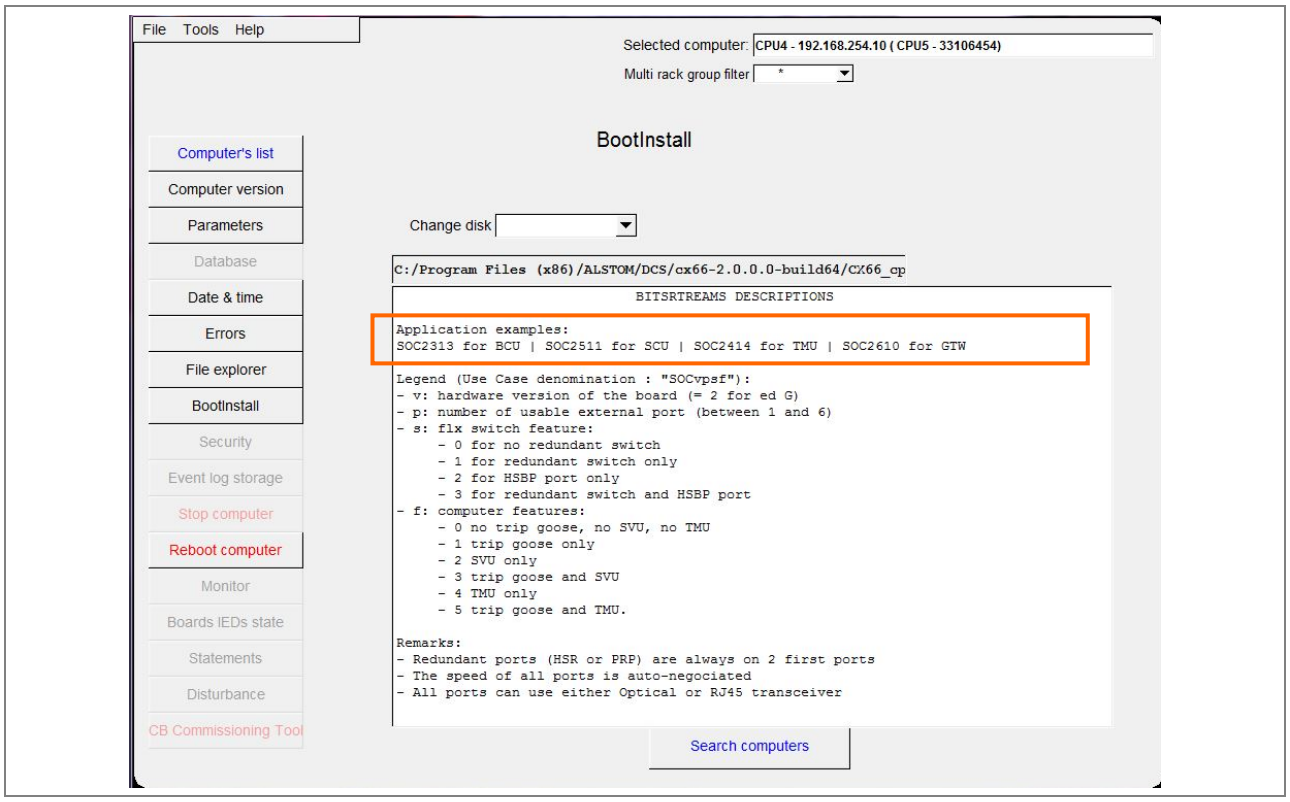
Depending on the selected C26x and the buttons you have clicked in this view, the following options may be disabled or not:

- **Stop computer**: this option is selected by default (*the box is checked*). If it is not, you will be prompted to check that box to stop the unit. When the C26x is stopped, the option is greyed out (blue font) and cleared.
- **Format Flash**: this box is forced by default if the selected C26x is not formatted.

Note: If you wish to update an existing C26x (not from scratch), you may select the actions that are appropriate to your application by checking the relevant boxes.

4 Click **Start** to start the installation process.

5 The CMT window shows the list of available bitstreams:



6 Select the bitstream source file depending on your application. For correspondence between bitstreams and port connection, refer to the table below.

Correspondence between bitstreams and port connection

Depending on the bitstream it operates on, the CPU4 has various communications configurations.

If optical redundancy is configured for ports 1 and 2 (for configuration details, refer to the *Application* chapter of the C264 user manual), the CPU4 can communicate on either a PRP (Parallel Redundancy Protocol) or an HSR (High-availability Seamless Redundancy Protocol) network.

RJ45 ports can be used to connect the C26x to a wired network or to allow it to serve as a Redbox for singly attached devices.

The following table shows which cable or fibre should be connected to what port depending on the case.

Use Case	Port 1 *	Port 2	Port 3	Port 4	Port 5	Port 6
Bitstream 2604 (BCU)	SAN RJ45	SAN RJ45	SAN RJ45	SAN RJ45	SAN RJ45	SAN RJ45
Bitstream 2511 *Reserved for future version.*	RED Opt Port	RED Opt Port	SAN RJ45	SAN RJ45	SAN RJ45	
Bitstream 2313 BCU & Redundancy (PRP/HSR)	RED Opt Port	RED Opt Port	SAN RJ45			
Bitstream 2233 BCU & SRPV2	RED Opt Port	RED Opt Port				
Bitstream 2414 BCU & Redundancy (PRP/HSR)	RED Opt Port	RED Opt Port	SAN RJ45	SAN RJ45		
Bitstream 2610 C26x GTW & Redundancy (PRP/HSR)	RED Opt Port	RED Opt Port	SAN RJ45	SAN RJ45	SAN RJ45	SAN RJ45

***Note**: Port 1 is the first port starting from the LEDs on the top.

Note: a RED port can be configured as SAN port, but a SAN port cannot be configured as a RED port.

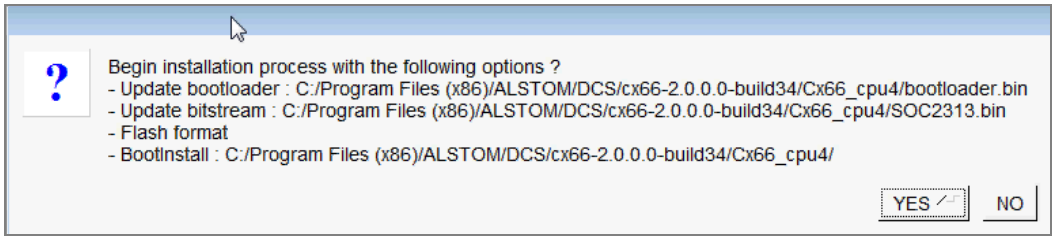
For further details on bitstream, refer to use case definition in the table below.

Bitstream ID definition:

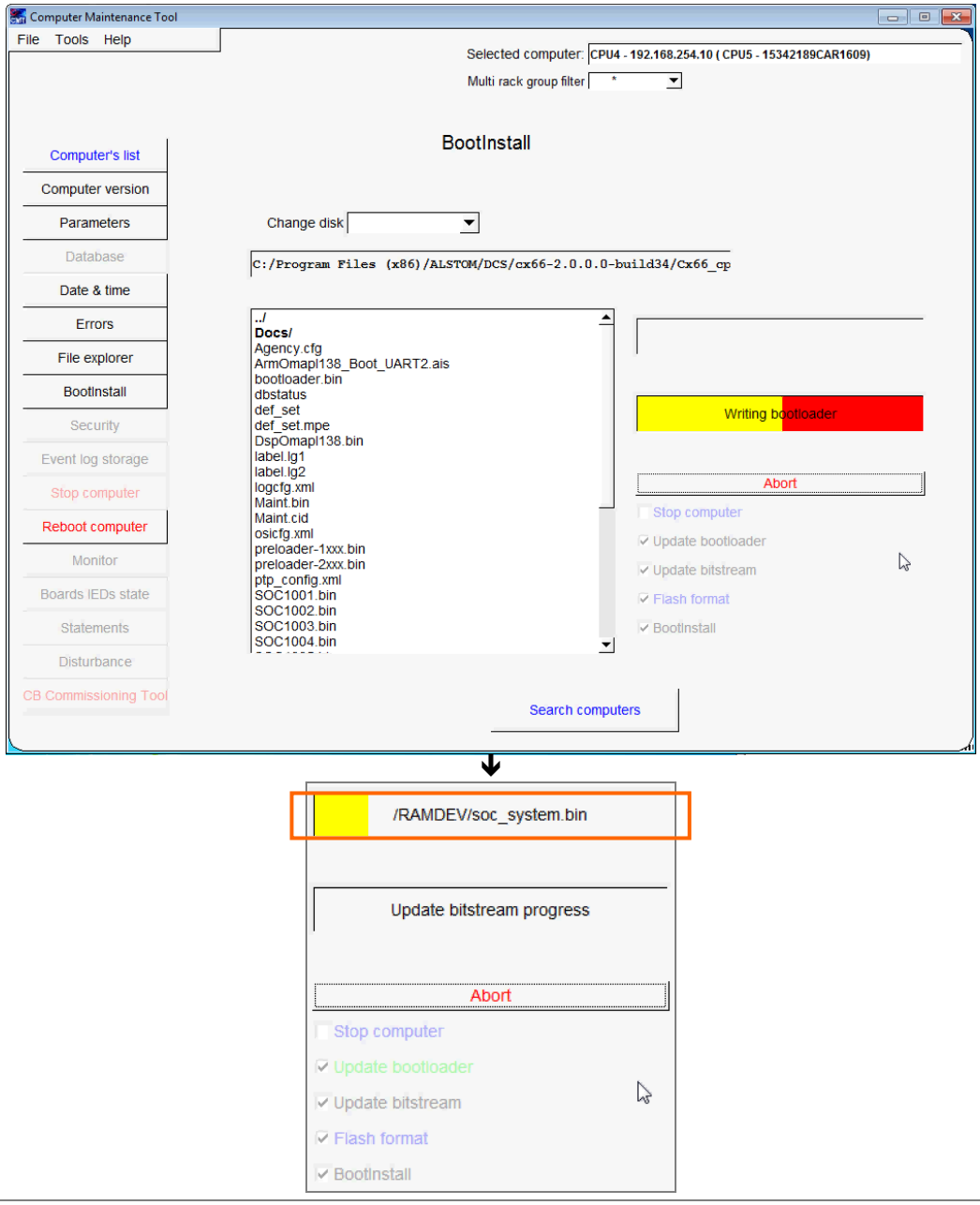
Digit #	Description
1	Hardware version of the CPU board = 2 for ed "G"
2	Number of CPU external ports configured in bitstream (from 1 to 6)
3	Redundant Switch features: **0**: No redundant switch **1**: Redundant switch (always on the first 2 external CPU ports) **2**: HSBP port, and no redundant switch **3**: Redundant switch (always on the first 2 external CPU ports) and HSBP port
4	C26x features: **0**: No trip GOOSE, no Sample Value, no TMU **1**: Trip GOOSE only **2**: SVU only **3**: Trip GOOSE and SVU **4**: TMU only **5**: Trip GOOSE and TMU

7 Click **OK** once you have selected the appropriate bitstream.

8 A confirmation pop-up is displayed, click **YES**:

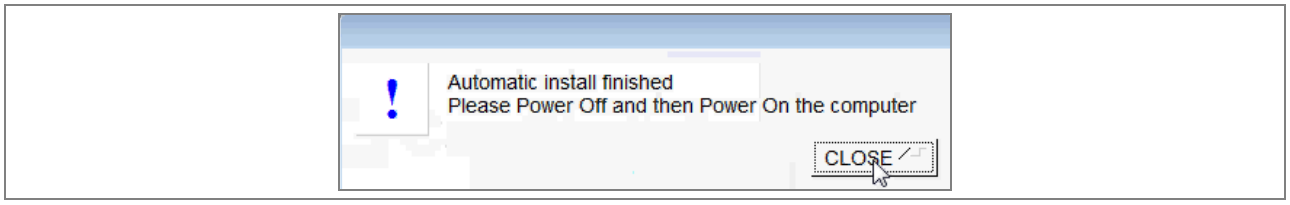


9 Wait for the process to complete (the process may take several minutes):





10 Once the automatic install is complete, a confirmation pop-up is displayed:



11 Click **Close**.

12 Reboot the C26x.

13 The display returns to the **Available Computers** list.

14 In the **Available Computers** list, click **Search computers**, and then select the relevant CPU4.

7.2.3 CHECKING C26X SETTINGS

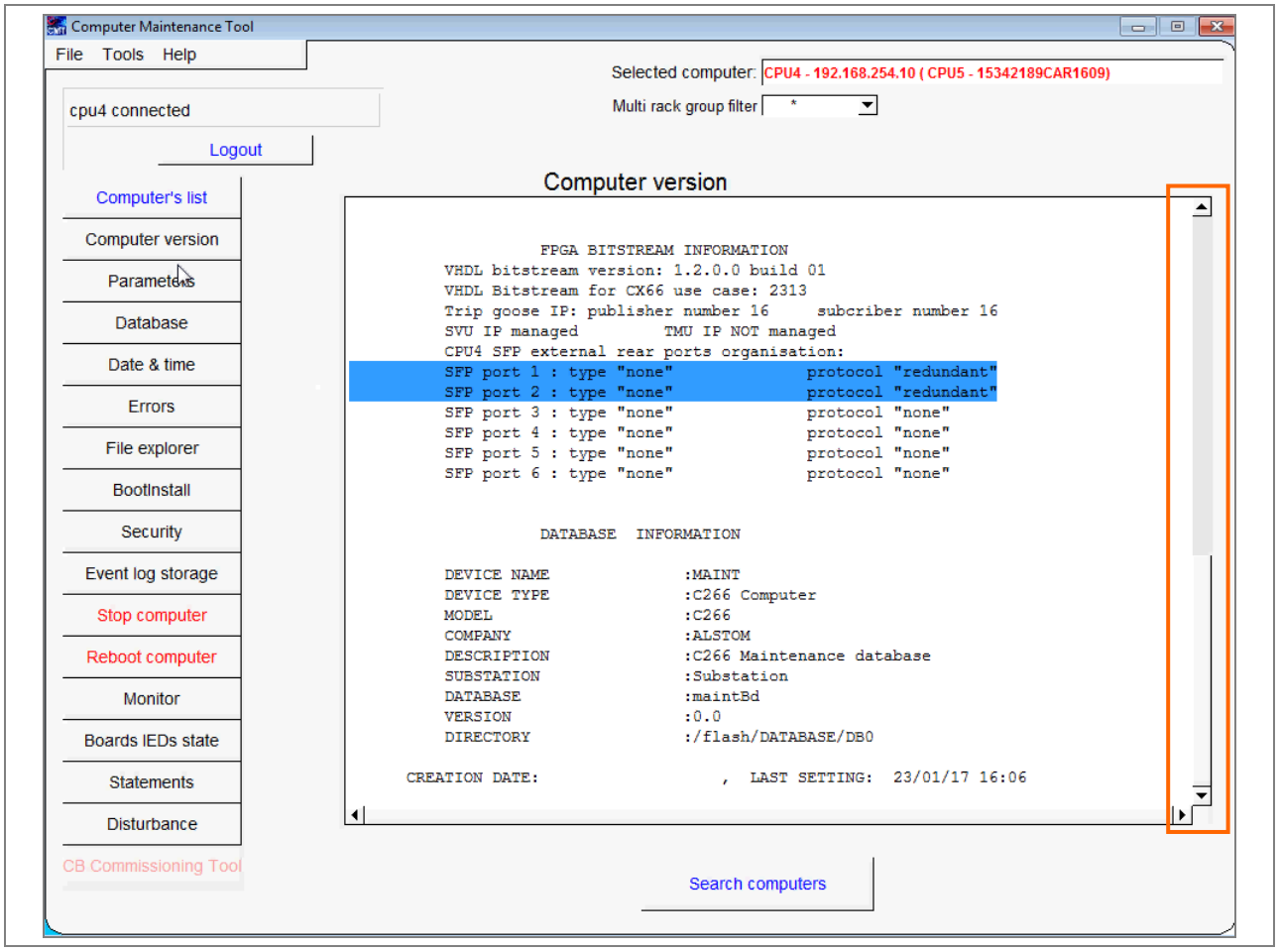
1 Log to the relevant C26x.

- User name: *Root*
- Password: *Root1234#*

Note:
If you cannot log in, turn the auxiliary power off, and then on again in order to cause a "hard reboot". Try to log in again.

2 Once logged in, you will be prompted to change the default password in compliance with security policy.

3 Click on the **Computer version** button on the left and check the CPU rear port organization. You may use the scroll bar on the right of the window to browse the contents:



Then, click on the buttons on the left panel to check that all the settings are correct or to update them.

Note: The second IP address (IP 2 on Ethernet) must be on a different subnetwork from the first IP address (IP on Ethernet (e)).

7.3 RE-USED ("PROJECT") BOARD REBOOT AND SET-UP

1 Launch the CMT application.

2 In the **Available Computers** list, click **Search computers**, and then select the relevant CPU4.

3 Log in:

- User name: *Root*
- Password: *Root1234#*

Note: if the C26x was previously configured, the password may not be the default password.

Note:
If you cannot log in, turn the auxiliary power off, and then on again in order to cause a "hard reboot". Try to log in again.

7.3.1 DATABASE REMOVAL

Both databases, if present, must be removed from the DS Agile C26x CPU4 memory:

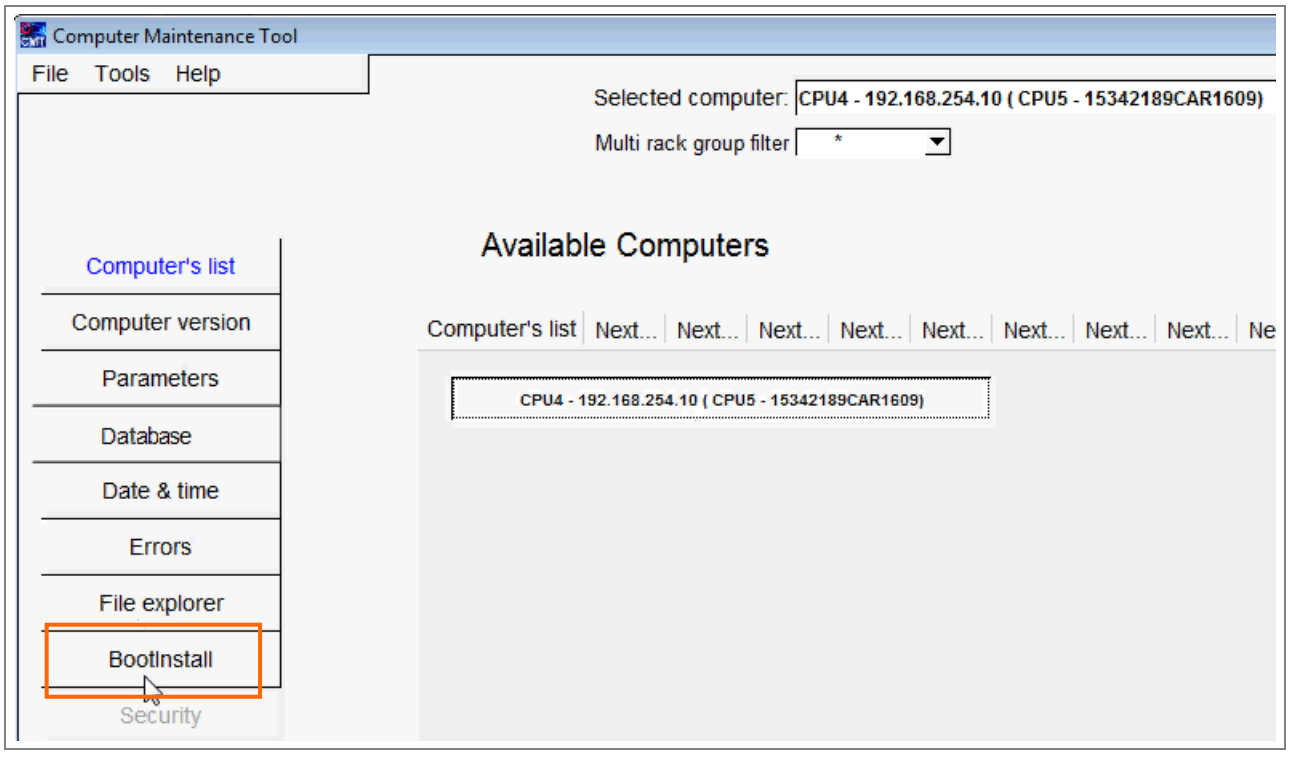
1 Click the **Database** menu button

2 Click **Clean All DB**.

3 A confirmation pop-up is displayed: **? Clean all DB**

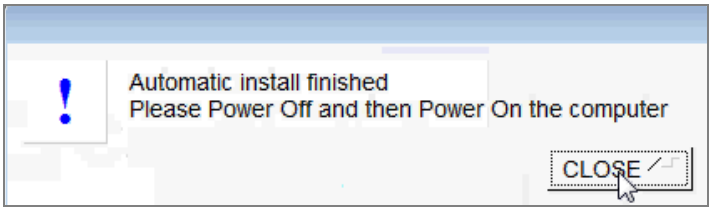
4 Click **YES** and wait for the process to complete: The unit reboots automatically, and the display returns to **Computer's list**.

5 Click on the **Bootinstall** button on the left-hand side:



The process may take several minutes.

BootInstall is complete when the confirmation popup is displayed:



6 Click **Close**. The display returns to the **Available Computers** list.

7 Turn the auxiliary power of the DS Agile C26x off, and then on again in order to cause a “hard reboot”.

8 Click the **Parameters** menu button

9 Set the following fields as described below:

- Boot type: **Flash boot**
- **other (o)**: select *SE01*.
- **IP on Ethernet (e)**: address of the Ethernet interface. Enter the 1st IP address you have chosen for the C26x, followed by “**:**” and then the **optional subnetwork mask** . Note that the Internet addresses (IP) are specified with "dot" notation (for instance: *192.168.1.1*).

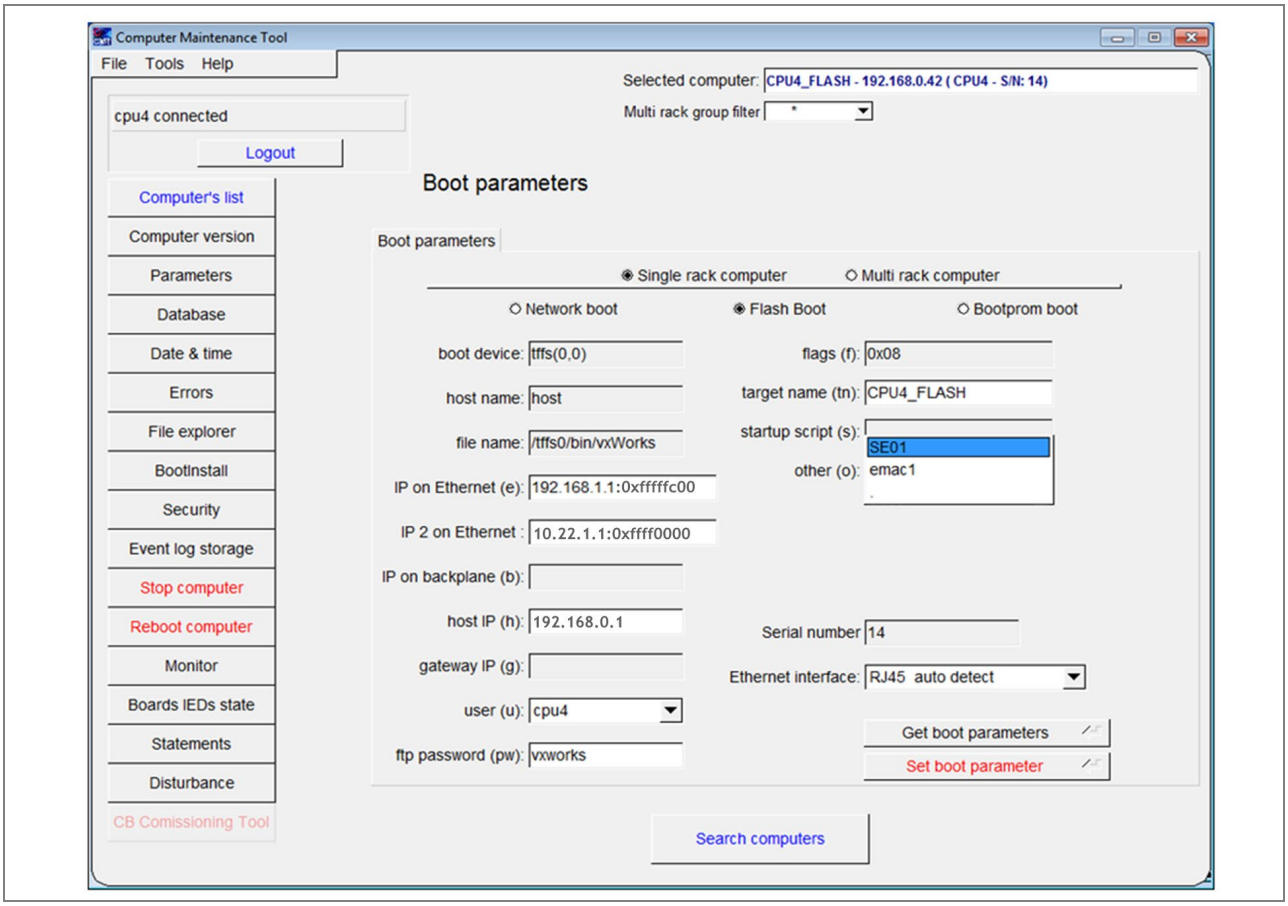
  The default subnet mask value is: 0xffffff00 = 255.255.255.

  - Example with subnet mask 0xffff0000 = 255.255.0.0

    IP on Ethernet (e): 10.22.1.1:0xffff0000
  - Example with subnet mask 0xff000000 = 255.0.0.0

    IP on Ethernet (e): 10.22.92.52:0xff000000
  - In the screenshot below, the subnetwork mask is 0xffffc00 = 255.255.252.0

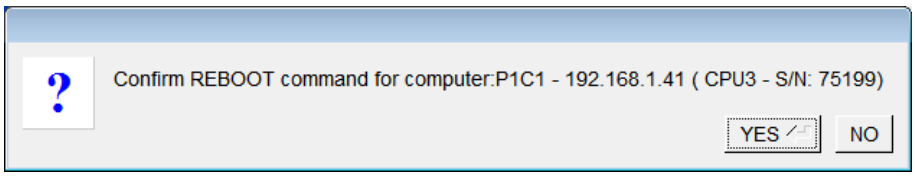
    IP on Ethernet (e): ***192.168.1.1:0xffffc00***
- **IP 2 on Ethernet**: enter the second IP address, which must be on a subnetwork different from the first IP address (**IP on Ethernet (e))**. In the screenshot below, the subnetwork mask is 255.255.0.0: *10.22.1.1:**0xffff0000***.
- **host IP (h)**: enter the Ethernet address of the PC that hosts the ftp server that hosts the firmware for netboot. It must be in the same subnetwork as the **IP on Ethernet (e)**.
- **target name (tn)**: enter a name for the DS Agile C26x (Recommended: provide the C264 short name as defined in its DB).



Note:
Do not use IP addresses with 254 as the last number.

10 Click the button **Set Boot Parameters** in order to send the new parameters to the C26x.

11 Select **Reboot Computer** to restart the C26x.



12 Click **Yes** to confirm.

The label becomes red for a while. The C26x restarts with the software installed on the PC. In the event of a failure, **experts** may type `reboot` in the SSH interface and then press any key to prevent the C26x from stopping.

7.3.2 CHANGE THE HOST IP ADDRESS

If MiCOM S1 is used, change to Host IP (h) address to the address of the PC hosting MiCOM S1.

7.4 SECURE THE MAINTENANCE PORT

The bottom flap cover of the front panel must be secured using a numbered, tamper-evident, security seal in order to indicate any unauthorised attempt to access the maintenance serial port located behind it.



Caution:
Some security seals may contain hazardous materials such as soft lead.
Strictly follow the manufacturer's safety instructions when handling them.

8 SETTINGS

This section provides the network configuration of the DS Agile C26x.

8.1 VLAN & MAC ADDRESS FILTERING

DS Agile C26x is a VLAN-enabled equipment which allows the use of traffic segregation (VLAN) in compliance with the IEEE 802.1Q standard.

DS Agile C26x also supports MAC address filtering to improve bandwidth utilization and security over the network.

VLAN Filtering

For IEC 61850 network applications, DS Agile C26x is able to perform traffic isolation of sampled values, GOOSE messages, PTP synchronizing protocol and other messages using virtual LANs (VLANs).

A VLAN gathers a group of devices that may be located anywhere on a network, but which communicate as if they were on the same physical network.

With VLAN information, you can create logical networks based on its usage instead of its physical installation, thus enabling much more flexibility on it.

Traffic segregation through Virtual LAN (VLAN) is standardized by the IEEE 802.1Q standard.

All traffic is treated in a VLAN concept. Traffic is routed between VLANs based on information (*logical LAN which the host or message belongs to*) contained in the Ethernet frame.

DS Agile C26x receives incoming VLAN packets which are then forwarded based on the filtering rules (VLAN membership) applied to the device port (interface), on the CPU4 board (see next page for port distribution).

On receiving a tagged frame, the VLAN tag of that frame is compared to the VLAN configuration of the destination port:

- Tagged VLAN will be redirected to the VLAN it belongs, based on the ports that are member of this VLAN. If the VLAN of the frame does not belong to the VLAN, the frame will be discarded.
- Untagged packets will be mapped to the default VLAN port.

MAC address filtering

MAC address filtering refers to the process of allowing or denying the forwarding of unicast and multicast packets addressed to specific MAC addresses.

DS Agile C26x supports adding MAC addresses manually to restrict or filter traffic automatically.

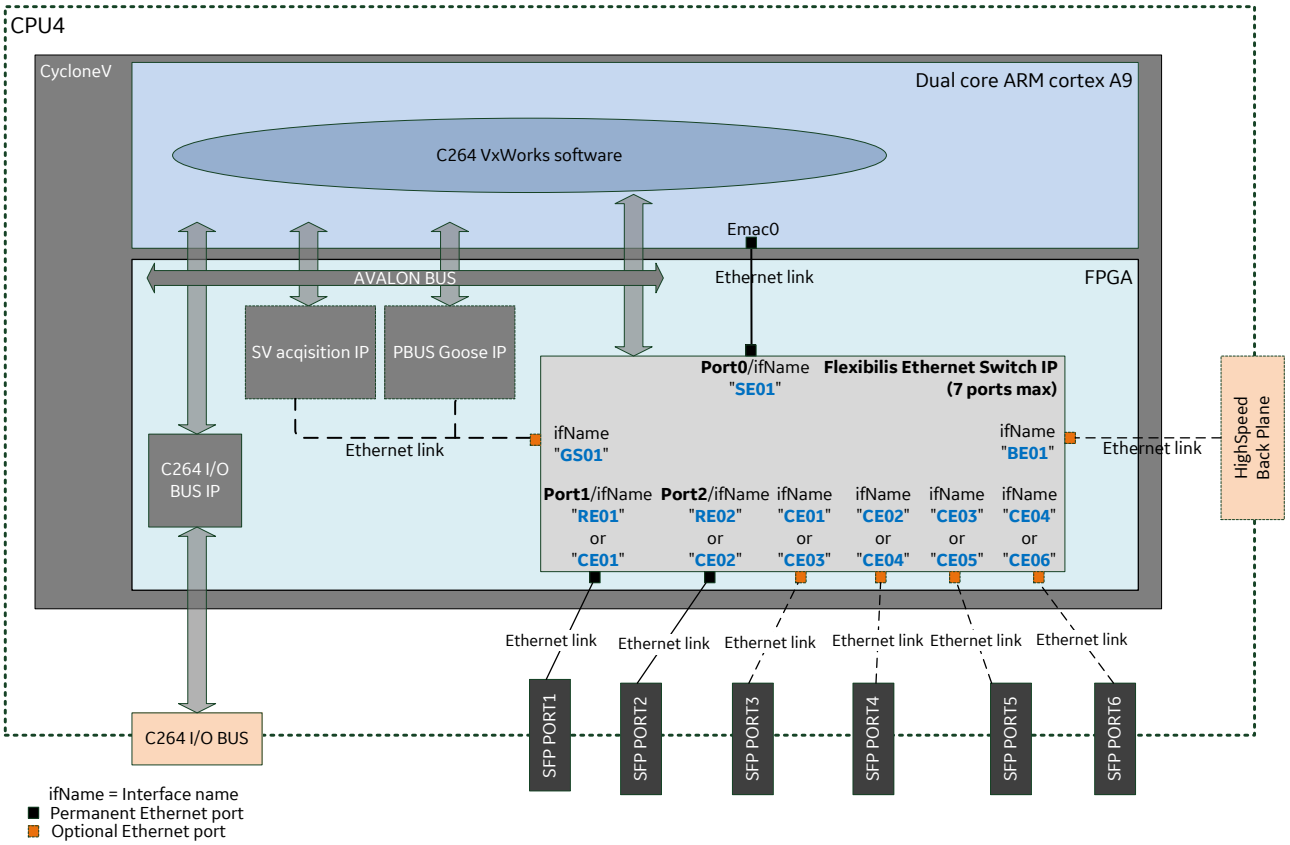
The filter relies on a range of MAC addresses applied to one or more device ports (interfaces) on the CPU4 board (see next page for port distribution).

For each interface, you can add up to 10 MAC addresses.

For each MAC address, you can combine the following rules and specify:

- whether incoming frame filtering is applied to source or destination MAC address;
- the number of bytes of the MAC address to be compared;
- the list of ports to which the incoming frame must be forwarded

8.1.1 CPU4 ARCHITECTURE & PORT DISTRIBUTION



8.1.2 CONFIGURING VLAN & MAC ADDRESS FILTERING

MAC address filtering and VLANs are implemented through the `vlan_config.xml` file installed in the `C:\Program Files (x86)\DSAgile\C264\cx66-X.X.X.X-buildXX\CX66_cpu4` folder of your maintenance PC tool.

In this file, the default VLAN configuration is set to:

- Default VLAN: **4095**
- PCP (Priority Code Point): **0**
- Tag mode: **Tagged**
- **No MAC filtering**

The installation of DS Agile C26x also contains a sample file named `"vlan_config-exemple.xml"` that can be found in `C:\Program Files (x86)\DSAgile\C264\cx66-X.X.X.X-buildXX\CX66_cpu4.`

This sample file contains a complete configuration of VLANs and MAC filtering you can start off with and edit.

We suggest saving a copy of the `vlan_config-exemple.xml` file locally in which you will configure VLANs and MAC address filters according to your needs.

To configure VLANs and MAC addresses, follow these instructions:

1 On your desktop, save a copy of the vlan_config-exemple.xml file stored in C:\Program Files (x86)\DSAgile\C264\cx66-X.X.X.X-buildXX\CX66_cpu4,

2 Open the `vlan_config-exemple.xml` file using any xml editor and make changes to one or more settings as explained below.

8.1.3 STRUCTURE OF THE SAMPLE CONFIGURATION FILE

The `vlan_config-exemple.xml` file has two main sections:

- `<VLAN_config>` in which you can configure VLANs **(1)** :
  - `<global_vlan_def>` defines the general configuration of the C26x.
  - `<interface>` defines a specific port configuration.
- `<MAC_config>` in which you can configure MAC address filtering **(2)**. This section is optional. If not present, all frames will be sent to all ports.

```
<?xml version="1.0" encoding="UTF-8"?>
<IPO_config xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:noNamespaceSchemaLocation="vlan_config.xsd">
    <config_ver>2.0</config_ver>
    <VLAN_config>
        <global_vlan_def>
            <default_vlan_id>4</default_vlan_id>
            <default_priority_code_point>0</default_priority_code_point>
            <default_tag_mode>tagged</default_tag_mode>
        </global_vlan_def>
        <interface name="SE01">...
        </Interface>
        <!-- next bloc configure CE01 interface to accept all VLAN tag eccept VLAN 10 and 4090 -->
        <interface name="CE01">...
        </interface>
        <!-- next bloc configure CE02 interface to accept only VLAN tag 2, 20 and 18 -->
        <!-- be careful : add default vlan avoid to block all non taged frames -->
        <interface name="CE02">
            <port_vlan_def>
                <default_vlan_id>2</default_vlan_id>
                <default_priority_code_point>1</default_priority_code_point>
                <default_tag_mode>untagged</default_tag_mode>
            </port_vlan_def>
            <port_vlan_profile>access</port_vlan_profile>
            <added_or_removed_vlan_id>2</added_or_removed_vlan_id>
            <added_or_removed_vlan_id>20</added_or_removed_vlan_id>
            <added_or_removed_vlan_id>18</added_or_removed_vlan_id>
        </interface>
    </VLAN_config>
    <MAC_config>
        <mac_filter interface_name="CE01">
            <filter_param mac_address="80:B3:2A:22:44:92">
                <side>source</side>
                <compared_length>48</compared_length>
                <allowed_port>SE01</allowed_port>
            </filter_param>
        </mac_filter>
        <mac_filter interface_name="RE01">...
        </mac_filter>
        <mac_filter interface_name="RE02">...
        </mac_filter>
    </MAC_config>
</IPO_config>
```

VLAN Filtering configuration

1 In the <global_vlan_def> section, set the following attributes:

- <default_vlan_id>: default VLAN ID (from 1 to 4095) for untagged devices that connect to that port (VLAN IDs 4095 is usually reserved for default vlan).
- <default_priority_code_point>: enter the default Priority Code Point of the interface (from 0 to 7). PCP is used to set a priority between the VLAN frames. The default PCP will be applied to untagged frames.
- <default_tag_mode>: incoming frames can either be configured in tagged or untagged mode:
  - **Tagged mode**: the default VLAN ID is added to the frame before it is forwarded. Tagged VLAN will be redirected to the VLAN it belongs
  - **Untagged mode**: No VLAN information is added to the frame before it is forwarded. If untagged frames shall always be rejected, set the default port VLAN to the value of a VLAN which does not belong to the VLAN configuration of the port.

2 In the <interface name> section, set the following attributes:

- <port_vlan_def>: define the specific port configuration (like global_vlan_def above) with default VLAN ID, PCP and Tag mode.
- <port_vlan_profile>: DS Agile C26x interfaces can be configured either as access ports or trunk ports:
  - **Access**: by default, an “access” port does not accept any VLAN ID but it is possible to add a list of VLAN IDs allowed at this port. When incoming frames have VLAN information, the frame will be directed to the specified VLAN.
  - **Trunk**: by default, trunk ports accept all VLAN IDs but it is possible to configure which VLAN IDs the trunk port will discard. Incoming data from a not allowed VLAN will then be discarded.
- <added_or_removed_vlan_id>: port number (from 1 to 4095) to be added (***access*** profile) or to be removed (***trunk*** profile) depending on the <port_vlan_profile> parameter.

8.1.3.1 MAC ADDRESS FILTERING CONFIGURATION

1 In the <MAC_config> section, set the following attributes:

- <mac_filter>: use the interface_name attribute to specify the port on which any incoming frame must be filtered (see port distribution on the CPU4 architecture). Example: <mac_filter interface_name="CE01">.
  Up to 7 <mac_filter> subsections can be added.

  Note: the list of ports depends on the selected bitstream. Moreover, two ports on the CPU4 are reserved; one for PBUS Gooses and one for any other frames.
  Here is the list:

  a. CE0x for SAN port
  b. RE0x for Redundant port
  c. GS01 for PBUS Gooses port connected to internal SV acquisition block and PBUS gooses transmission/reception block
  d. SE01 for internal CPU port

- <filter_param>: use the mac_address attribute to specify the MAC address to be filtered on the port. Example: <filter_param mac_address="80:B3:2A:22:44:92">.
  Up to 10 <filter_param> subsections can be configured in the <mac_filter> section.

  Note: The C26x can handle up to 16 rules. However, depending on the port interface to configure, the number of possible rules vary since internal rules are automatically set by the software based on the selected C26x feature.

  For example, for:

  a. RE0x port with PTP enabled, 9 rules are set automatically so, 7 custom rules are possible,
  b. Non-redundant port (CE0x), 7 rules are set automatically, so 9 custom rules are possible,
  c. GS01 port, 5 rules are set automatically, so 11 custom rules are possible,
  d. SE0x port, 1 rule is set automatically, so 15 custom rules are possible.

- <side>: specify whether the destination or the source address of the frame shall be filtered. Only one <side> subsection is allowed in the <filter_param> section.
- <compared_length>: enter the number of bytes (0 to 48) to be compared in the MAC address (from left to right). Example:

  48 for the whole address

  1 to only compare the « unicast/multicast » byte

  0 to filter all incoming frames, regardless of the MAC address

  24 to compare the first 3 bytes (for instance 80:B3:2A:xx:xx:xx).

  Only one <compared_length> subsection is allowed in the <filter_param> section
- < allowed_port>: specify the port to which the incoming frame will be forwarded (refer to the table above). Up to 7 ports can be allowed per <filter_param> section.

Here is an example of MAC address filtering configuration:

```
<MAC_config>
      <mac_filter interface_name="CE01">
            <filter_param mac_address="80:B3:2A:22:44:92">
                  <side>source</side>
                  <compared_length>48</compared_length>
                  <allowed_port>SE01</allowed_port>
            </filter_param>
      </mac_filter>
</MAC_config>
```

In this configuration, the filter:

- applies to incoming frames received on port ***CE01***
- applies to all bytes in the ***source*** MAC address **80:B3:2A:22:44:92**
- will **forward** those frames to the ***SE01*** port only

Once you have completed changes to the `vlan_config-exemple.xml` file save your modifications and rename the file to `vlan_config.xml` to upload it to the C26x as explained in the following section.

8.1.4 UPLOADING VLAN CONFIGURATION TO THE C26X

Once you have completed changes to the `vlan_config-exemple.xml` file and renamed the file to **`vlan_config.xml`**, follow these instructions to upload the VLAN configuration to your C26x:

2 Start the CMT.
The CMT is usually found in `C:\Program Files (x86)\DSAgile\C264\cx66-X.X.X.X-buildXX\Cmt`, or by clicking **Start | DSAgile | CMT**

3 In the **Available Computers** list, click **Search** computers and select the relevant CPU4.

4 Log into the CPU4 (*User name: Root*; *Password: Root1234#*)

5 Click on the **File explorer** button,

6 Use the **Change root** drop-down list to point to the **`C26x /flash/maint/`** folder,

7 On the PC-side, browse your PC structure and select the **vlan_config.xml** file you have just modified (just click on it once),

8 Then, click on  to upload the file selected on the PC browser to the directory selected on the C26x. Note that the file will be overwritten if it already exists in the **`/flash/maint/`** folder of the C26x,

9 Reboot the C26x to take these changes into account.

9 APPENDIX: CMT IN-DEPTH DESCRIPTION

9.1 COMPUTER MAINTENANCE TOOL (CMT) OVERVIEW

9.1.1 GENERAL

The Computer Maintenance Tool provides a user-friendly way to maintain DS Agile C26x devices.
Typing commands in the device's shell is not required; the graphical interface does main operations.

The CMT runs on Personal Computers (PC) using Windows 10 LTSC 2019 for Enterprise 64-bits edition.

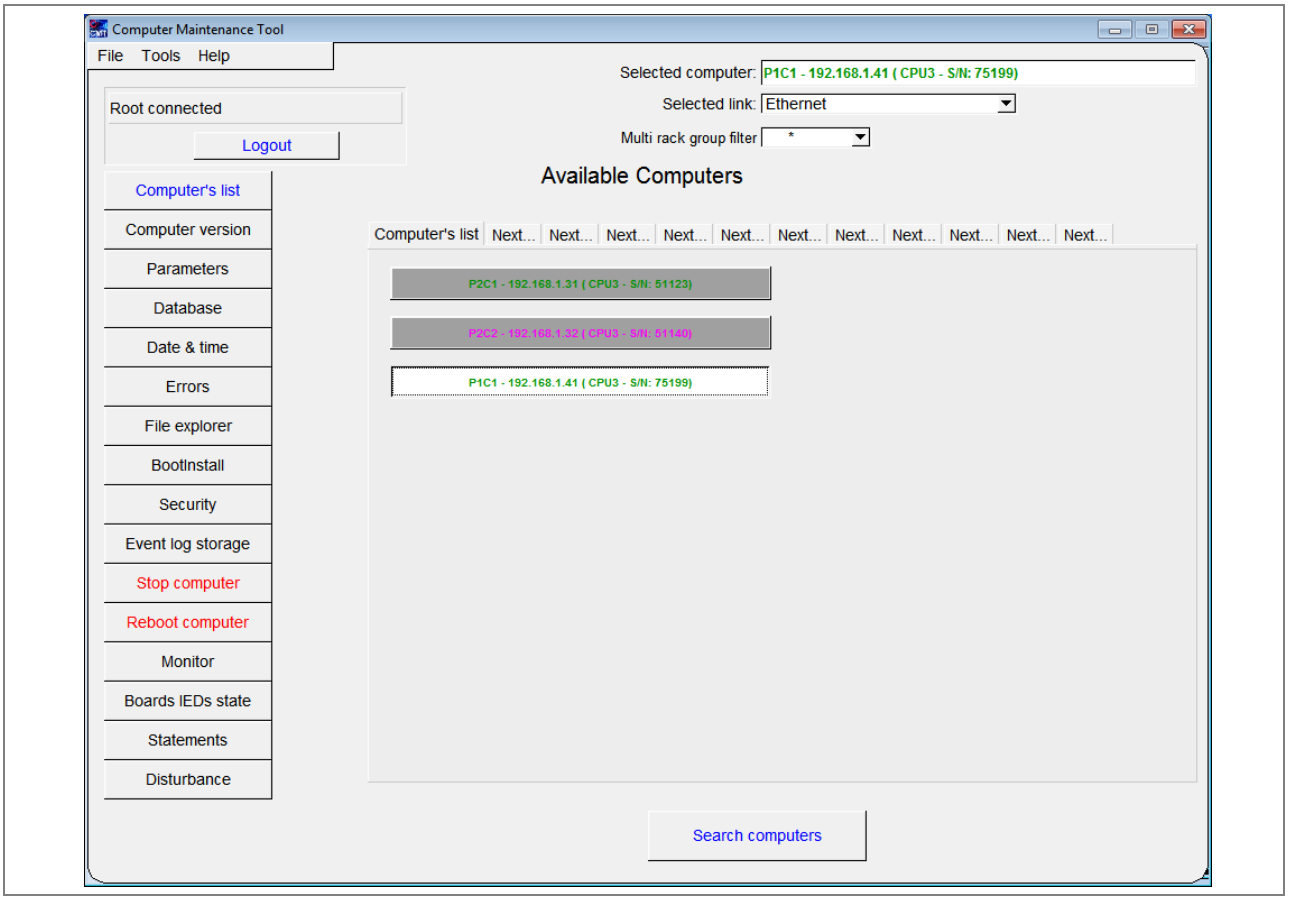
9.1.2 LAUNCHING THE SOFTWARE

CMT is installed with the default installation of the DS Agile C26x software.
The CMT is usually found in `C:\Program Files (x86)\DSAgile\C264\cx66-X.X.X.X-buildXX\Cmt`, or by by double-clicking the installed icon in the desktop.
When the software is launched, it displays a starting view for 3 seconds.



9.1.3 CMT MAIN WINDOW

The window includes various sections, accessible by clicking the buttons on the left-hand side:



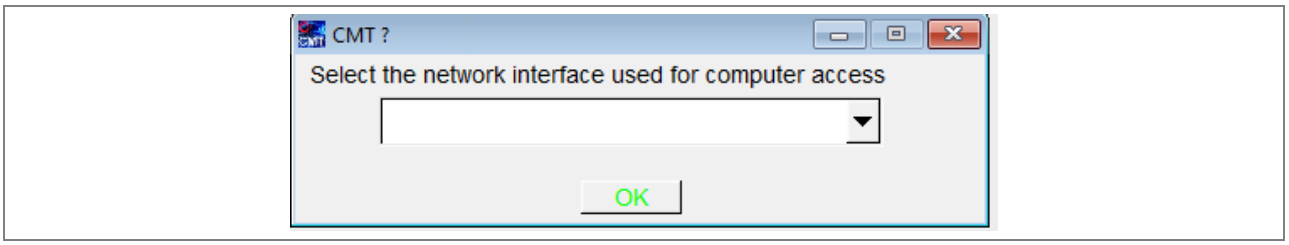
Note:
The pages available to the logged in user depend on the roles associated with the user account. See Security section for details.

9.1.3.1 MENU BAR

9.1.3.1.1 **File** menu

The **File** menu contains two submenus: **Network Interface** and **Quit**.

Network interface submenu (F2)



It is used to select the Network Interface board used by the PC to access the controller Network.

A selection popup window proposes the Network interface board already present on the PC.

Select the relevant board and click **OK**, or simply close the window if the proposed board is the correct one.

For a PC with only one Ethernet board the correct board is automatically selected.

Example:

- MS TCP Loop back interface (not useable by CMT)
- 3Com 3C90x Ethernet Adapter
- 3Com Ether Link PCI
- AT-2500 NDIS Series 4.0 driver
- NdisWan Adapter: (not useable by CMT)

The selection is saved in the Windows Registry.

Quit submenu (CTRL + q)

It is used to exit the software.

9.1.3.1.2 Tools item

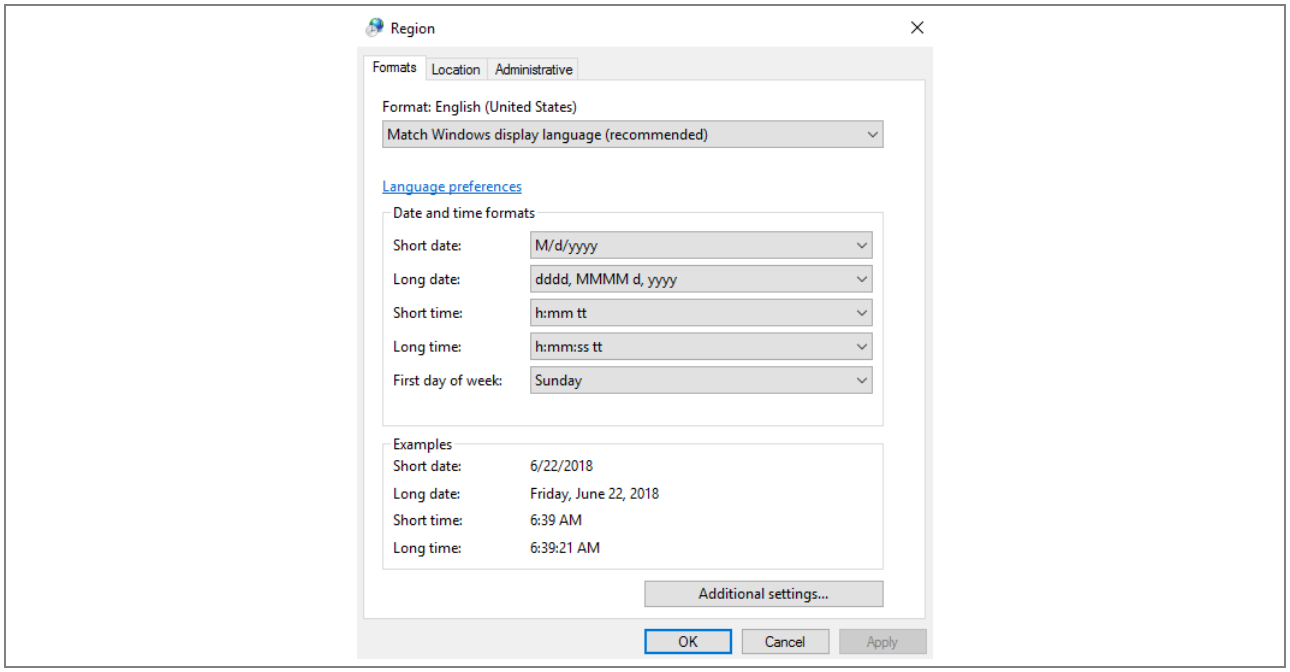
Language submenu

This menu lets you choose the language of the CMT application interface. The default language is English. The following languages can be selected: English (F5), French (F6), German (F7), Spanish (F8), Russian (F9), Simplified Chinese (F10) or Polish (F11).

The selected language is saved in the **Windows Registry**.

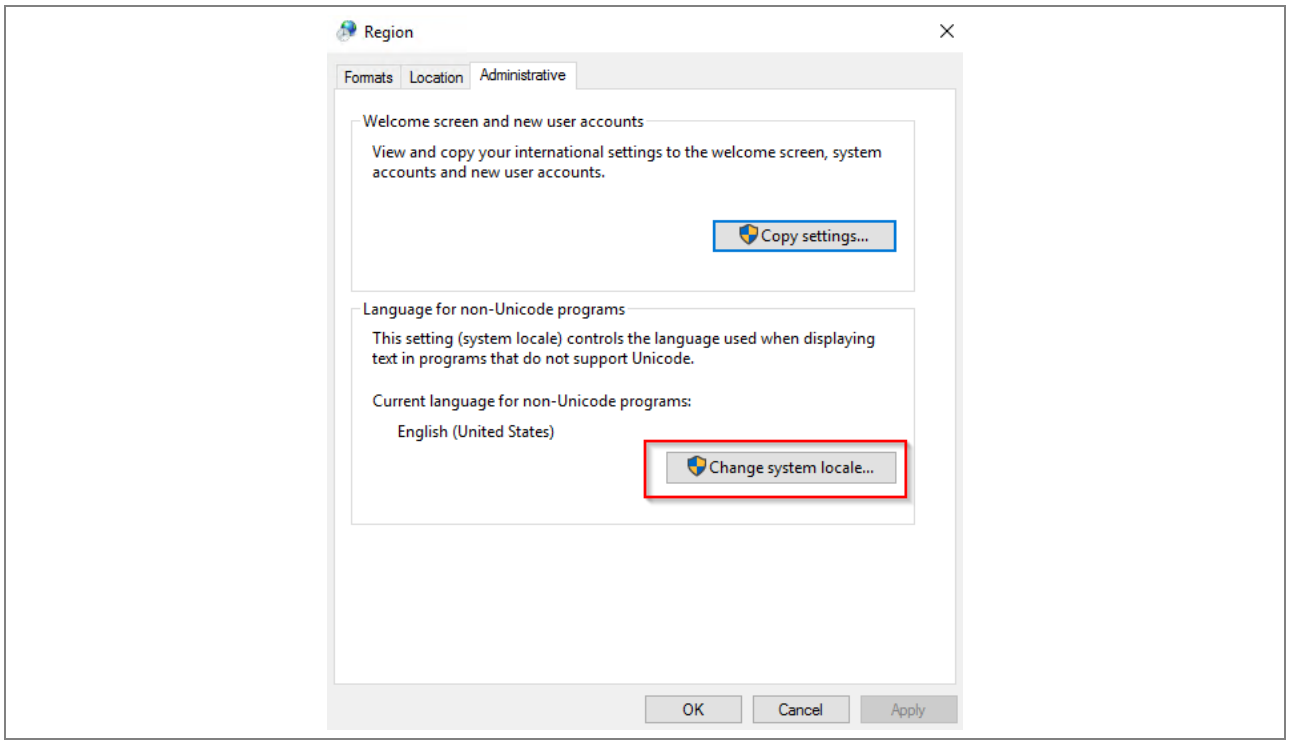
FOR NON WESTERN LANGUAGES (Russian (Cyrillic) or Chinese or Polish), the PC operating system (MS Windows) has to be configured to support Cyrillic or Simplified Chinese or Polish fonts.

From the menu **Start | Control Panel | Region and Language**:

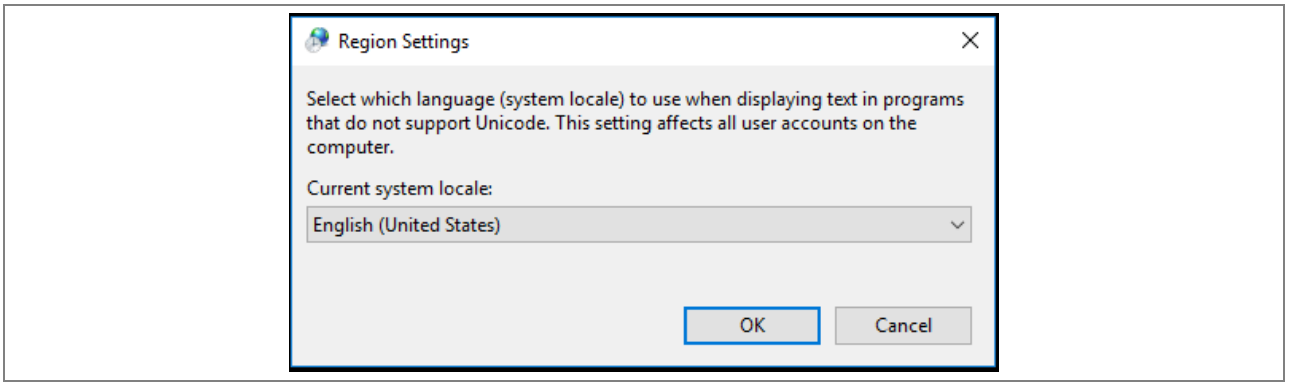


1 Click the **Administrative** tab, and then, under **Language for non-Unicode** programs, click **Change system locale...**.

Note: If you're prompted for an administrator password or confirmation, type the password or provide confirmation.



2 Select the language, and then click **OK**.

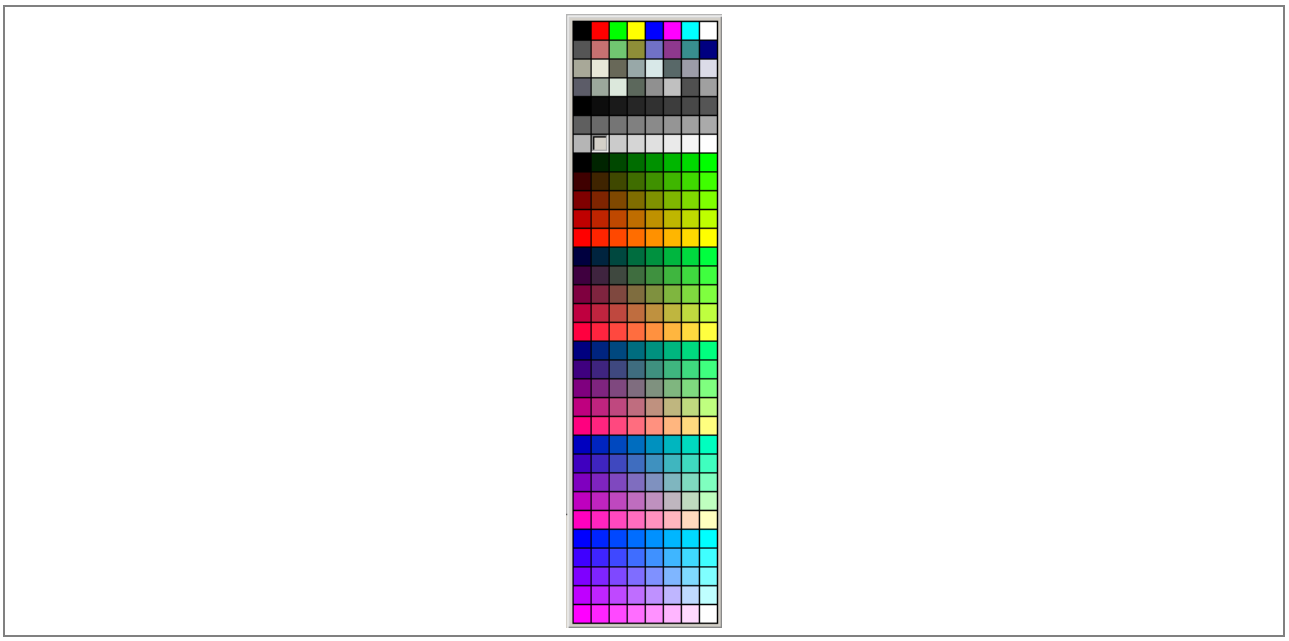


3 Restart the PC for it to take the changes into account. The top part of ASCII table (128 to 256) now points to specific characters of Cyrillic or simplified Chinese alphabet.

Background colour sub-menu

It is used to choose the background colour of the CMT application interface. The default colour is grey.

A 256-colour panel is displayed. Click one the coloured squares. This colour will now be the new background colour. It is recommended to choose a shade in the middle of a line as these will allow the best display of texts with different colours.



The selected colour is saved in the Windows Registr

9.1.3.1.3 Help menu

File menu contains two submenus: Index and About.

About submenu (F5)

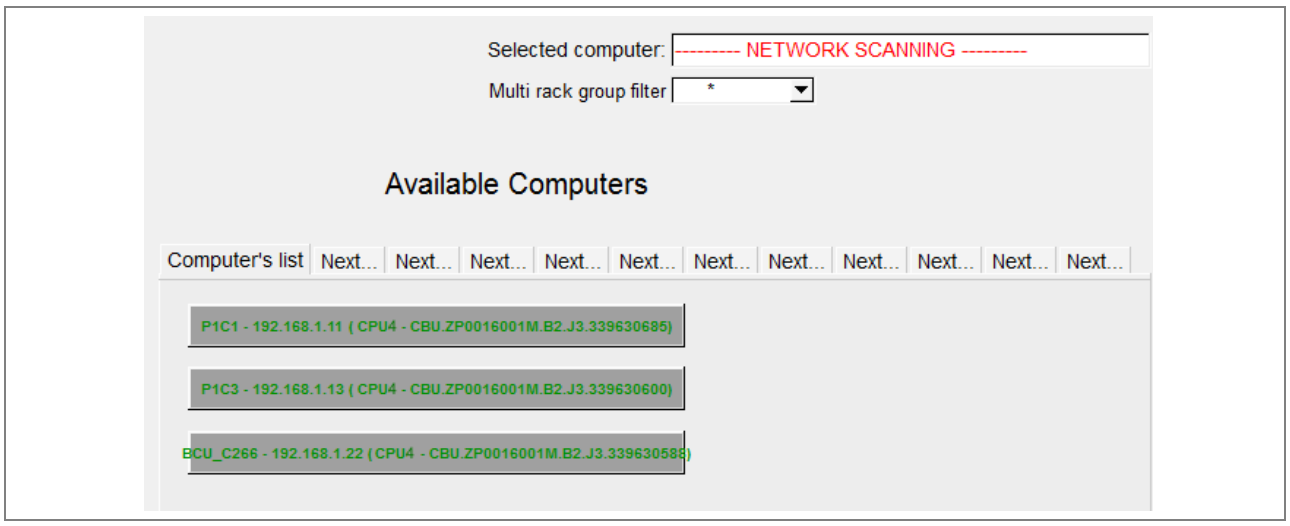
Displays an "about" box: CMT's version and copyrights. Identical to the splash screen.

9.1.3.2 SEARCH COMPUTERS BUTTON

It is used to search for computers, i.e. C26x control units, connected to the current Local Area Network (LAN). Once it is pressed, the application starts the search, and awaits answers for 4 seconds.

The search process status is indicated in the **Selected computer** field by the message:

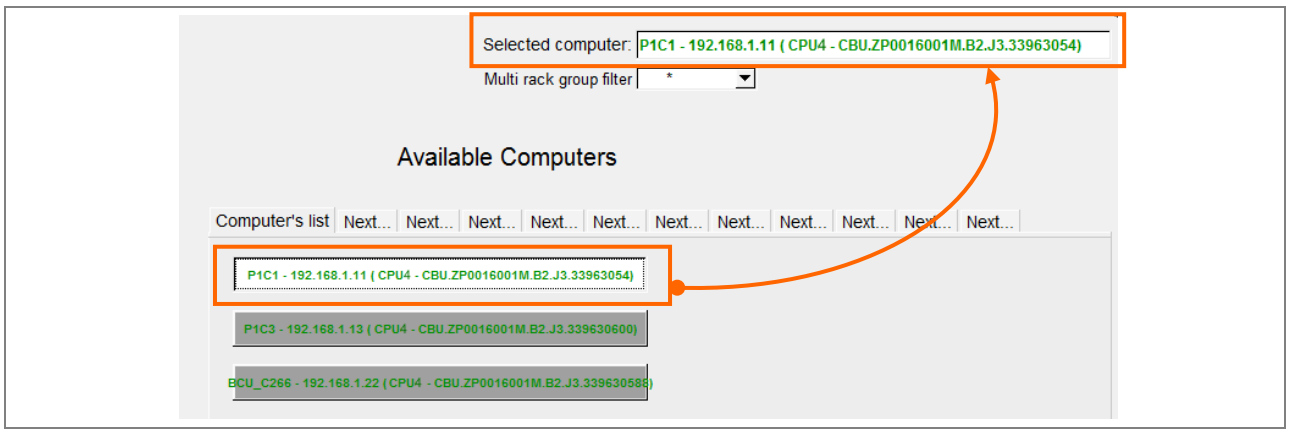
"------- NETWORK SCANNING --------"



Three situations are possible:

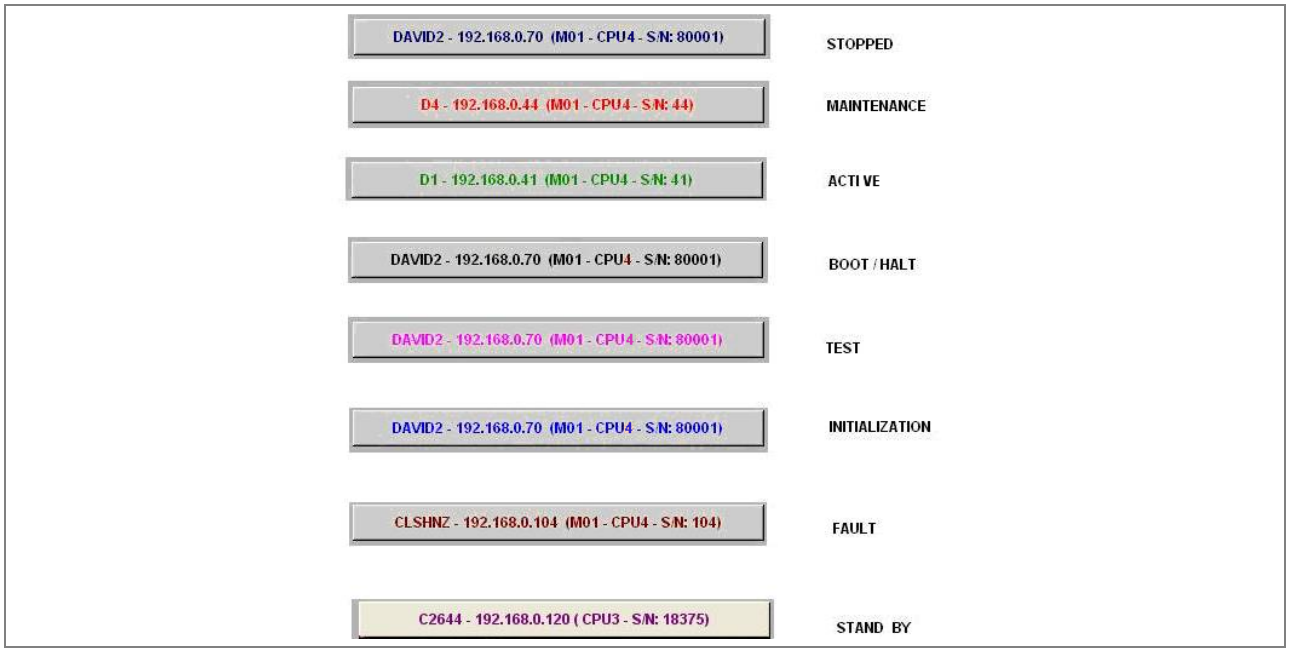
- Waiting until the timer expires; then a list of all the "responding" C26x units displays their *name*, *IP address*, *CPU board type* and *serial number*. The list is sorted according to increasing serial numbers. Scanning goes on repetitively on a 4-second time base.
- Clicking **Search computers** again stops the scanning operation. No C26x is selected.
- Clicking one the units already found stops the scanning and selects the corresponding C26x:

  The selected unit's *name*, *IP address*, *Type* and *serial number* is shown in the top right text area **Selected computer**:



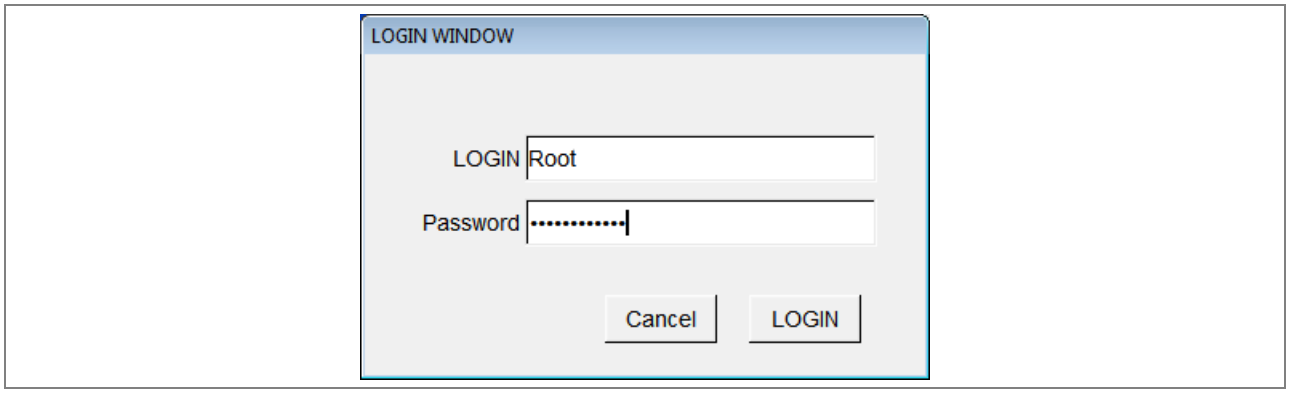
Note: Multi rack feature is not available and reserved for future DS Agile version.

Each button text colour represents a specific operating state or mode:

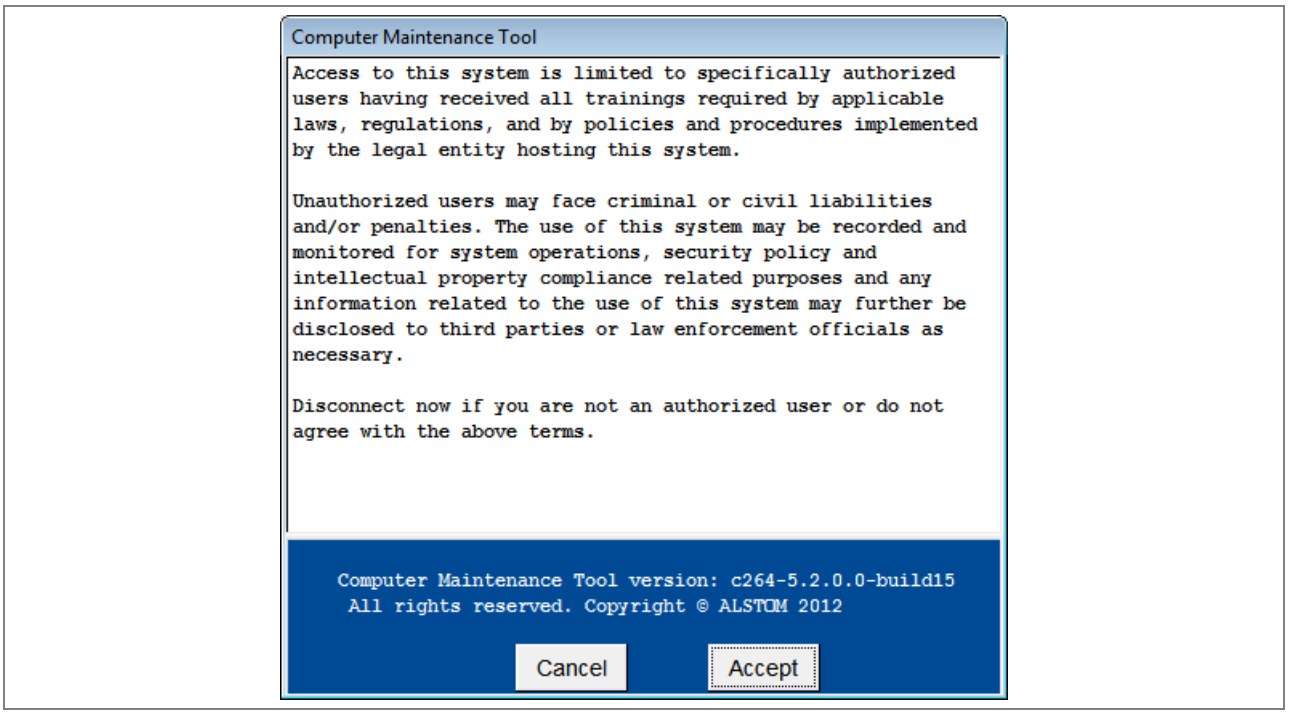


Each tab-pane can contain up to 20 buttons. Therefore, a maximum of one hundred computers can be displayed.

Upon selecting a unit, a security popup window is displayed: Enter a valid account LOGIN name and Password and click **LOGIN** in order to continue and access the memory of the selected DS Agile C26x unit. Click **Cancel** to abort.

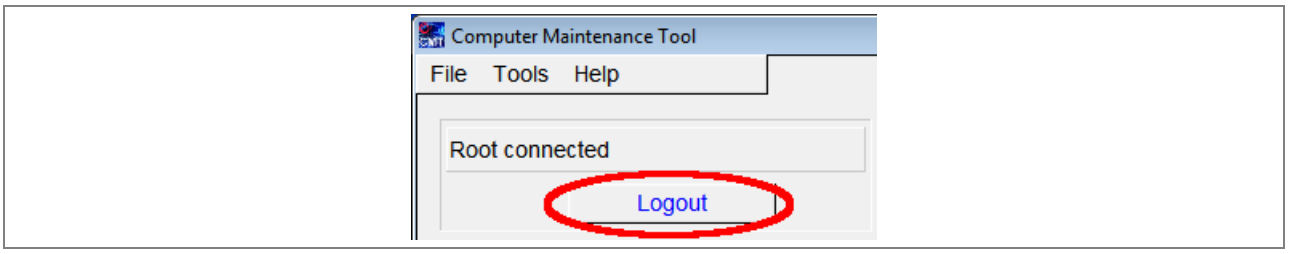


After logging in, an information/disclaimer popup is displayed. Depending on whether a configuration database is present or not, it will contain a text defined in that database, or the default text below.



Click **Accept** to log in or **Cancel** to abort.

To log in to another unit, it is necessary to enter the password again. The login name cannot be changed during a CMT session. In order to use another login name it is necessary to log out first, by clicking the **Logout** button under the current user's login name (top-left of the CMT window):



Note:
*Clicking **Logout** will terminate all the current connections.*

Good practice

Although it is not compulsory, it is highly recommended that a given login name be assigned the same password and privileges for all the C26x units it is defined in.

9.1.3.3 COMPUTER'S LIST BUTTON

The list of all the "responding" units is displayed, with their *name*, *IP address*, *Type* and *serial number*, without launching a network search.

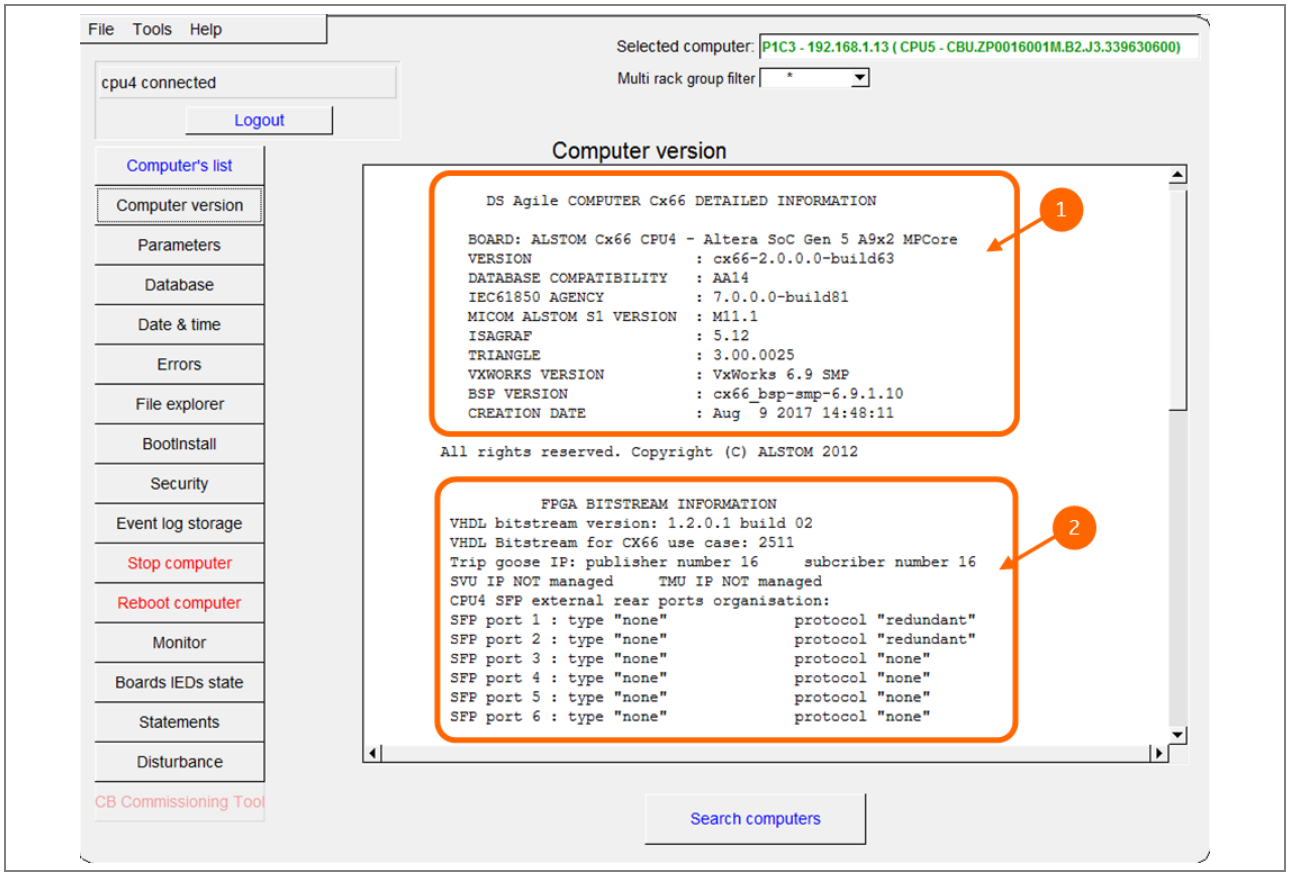
9.1.3.4 LEFT BAR

The button bar on the left-hand side of the application window contains all the operations that can be performed on the selected C26x:

- Simply click a button to launch the desired task.
- These operations are described later in this chapter.

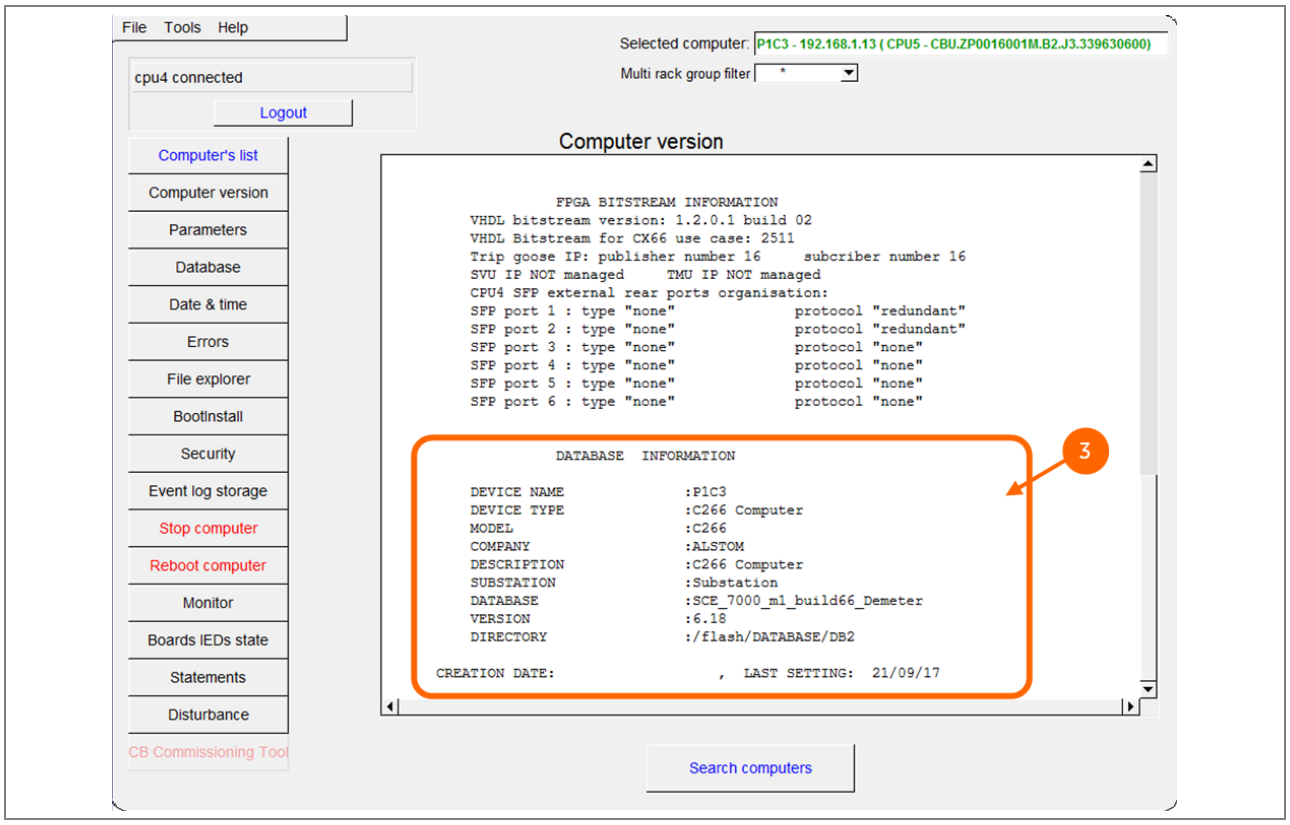
9.1.4 OPERATIONS PERFORMED BY THE BUTTONS IN THE LEFT BAR

9.1.4.1 COMPUTER VERSION



The DS Agile CMT reads the C26x memory and displays four blocks of information:

- Firmware block 1
  - Version
  - Database compatibility
  - IEC 61850-8-1 SBUS Agency version
  - ISaGRAF software version
  - Triangle software version
  - Creation date of the application software
- Bitstream Information block 2
  - Bitstream version
  - Bitstream use case
  - Process Bus information
  - Rear ports organisation



- Database block (if a database is running ...) 3
  - device name
  - device type
  - model
  - company
  - description
  - substation
  - database name
  - version
  - path of the database
  - database creation date and last setting date
- Information on the C26x state: ACTIVE / MAINTENANCE / INITIALIZATION / SIMULATION / STANDBY / FAULTY / HALTED / STOPPED / TEST

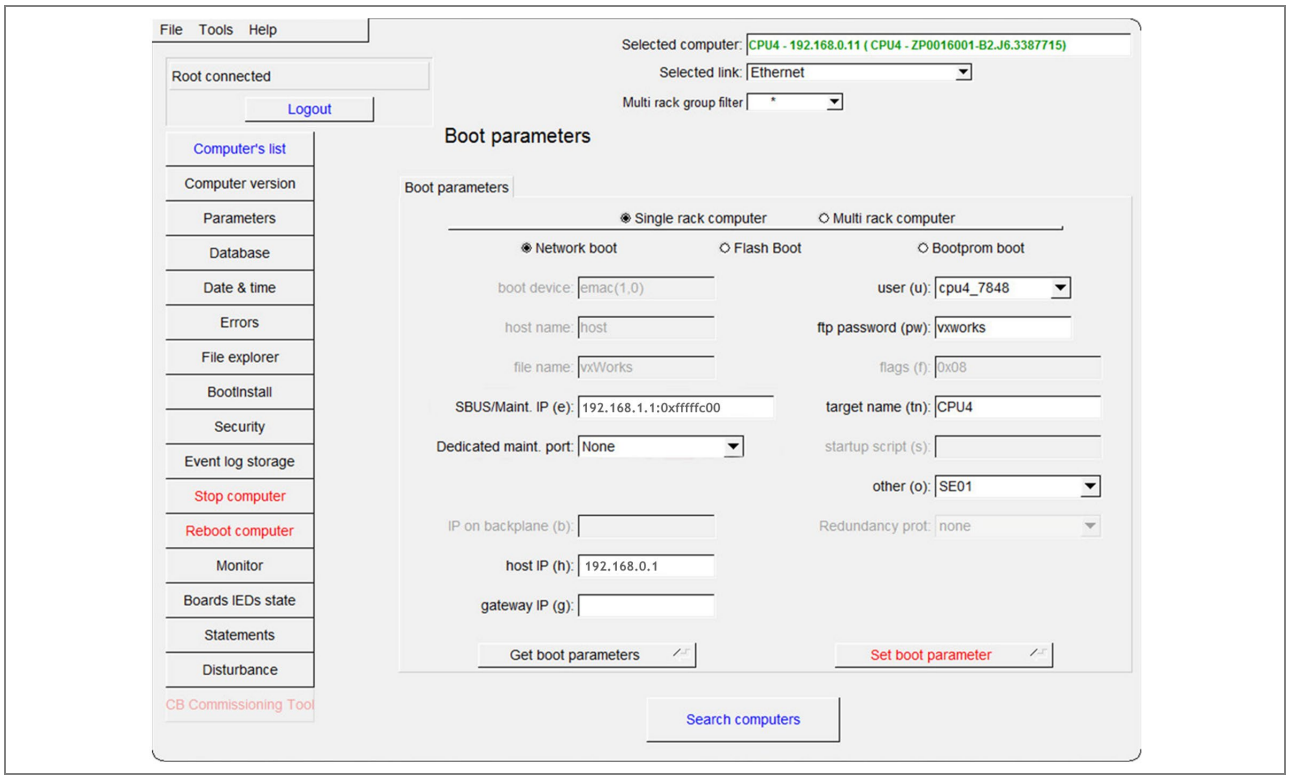
The two information blocks serve as headers in other pages.

9.1.4.2 BOOT PARAMETERS

The **Boot Parameters** button shows the selected unit's boot parameters. They define how to boot (network or flash disk) and set the internet address of the C26x.

Modifications of the values can be done for all the fields displayed in white text areas ("IP on Ethernet", "host IP" and "target name").

When a C26x boots up for the first time, a number of parameters can be defined; such as network addresses, boot device, host, and start-up file.



This information is encoded into a single structure known as the boot parameters. Boot parameters are placed at a known address in flash memory so that the booting system can find the parameters that were used to boot the system. Boot parameters are the only information blocks exchanged from the boot ROMs to the booted system.

The boot parameters are as follows:

- **boot device** (required): type of device to boot from. This must be one of the drivers included in the boot ROMs: emac(1,0) for network boot or usrld0(0,0) flash boot. Due to limited space in the boot ROMs, only few drivers can be included.
  - 1st digit: unit number of the boot device (0..n)
  - 2nd digit: processor number on a multi-rack system (0..n); this identifier, defined for the target, is unique per C26x and can be used to distinguish the C26x type in a multi-rack architecture:
    - Main C26x: 0 (zero) / 1 (1 is used only for main backup rack in case of RTU redundancy. This feature is not supported in DS Agile version 7.x)
    - Extension C26x: 2 (two) to 17
    - For a Bay controller, single rack application, the processor number is always 0.

Note: multi-rack is not supported in DS Agile version 7.0.4

- **host name:** name of the host PC to boot from. This is the name by which the host is known to VxWorks; it need not be the name used by the host itself.
- **file name**: full pathname of the VxWorks object module to be booted. This pathname is also reported to the host when you start a target server, so that it can locate the host-resident image of VxWorks.
- For Ethernet boot: vxWorks, for Flash disk boot: "/flash/bin/vxworks"
- **SBUS/Maint IP (e)**: address of the Ethernet interface. Enter the 1st IP address you have chosen for the C26x, followed by ":" and then the subnetwork mask. The Internet addresses (IP) are specified with "dot" notation (for instance: *192.168.1.1*).

  Then, enter the **optional subnetwork mask**:
  - Example with default value subnet mask: **0xffffff00** = 255.255.255.0

    SBUS/Maint IP (e): ***192.168.1.1:0xffffff00***
  - Example with subnet mask **0xffff0000** = 255.255.0.0

    SBUS/Maint IP (e): ***10.22.1.1:0xffff0000***
  - Example with subnet mask **0xff000000** = 255.0.0.0

    SBUS/Maint IP (e): ***10.22.92.52:0xff000000***
  - Example provided in image above with subnet mask 0xfffffc00 = 255.255.252.0

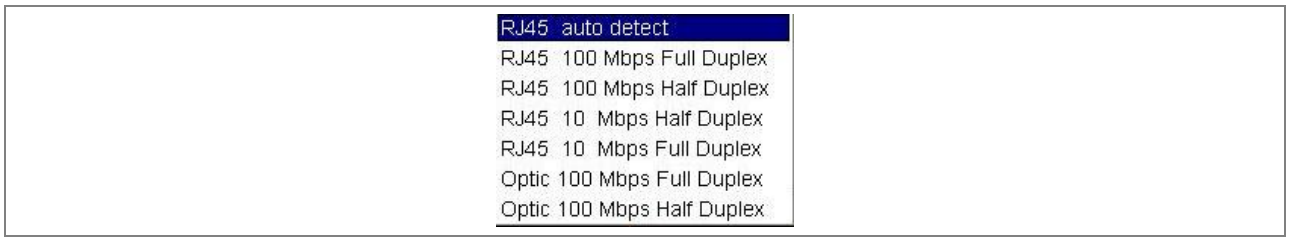
    SBUS/Maint IP (e): ***192.168.1.1:0xfffffc00***
- **Dedicated maint. Port**: Choose to use the Port 3 as a maintenance port.
- **SBUS IP (If port 3 is selected):** Enter the IP address for the SBUS.
- **IP on backplane**: address of the backplane interface (not used for a C26x). It can have an optional subnet mask and/or lease timing information as "e".
- **host IP**: enter the Ethernet address of the boot host. It must be in the same subnetwork as IP on Ethernet (e). In the image above: ***192.168.1.0***.
- **gateway IP**: address of the router to the boot host. Leave this parameter blank if the host is on same network.
- **user** and **ftp password**: credentials on the boot host.
- **flags**: system-dependent configuration flags.
  - 0x04 Do not start autoboot sequence => stop before application software loading
  - 0x08 Immediate autoboot (no countdown) => load and start application software
- **target name**: name of the C264 being booted (Recommended: provide the C264 short name as defined in its DB)
- **start-up script**: name of a file to be executed as a start-up script (not used)
- **other**: "other" string for use by the application, *SE01* for CPU4
- **serial number**: serial number of the processor board, used to set the Ethernet (Mac) address of the board
- **Redundancy port**: select the redundancy mode to be used when the C264 is with maintenance DB (none/HSR/PRP).

- **Network boot**, **Flash boot** and **Bootprom boot**. These three radio buttons define the device the C26x boots on (ftp for Network, flash memory for Flash). Bootprom boot stops the C26x after boot (with Network boot, you have to press **Reboot computer** afterwards).



  - The mode for current operations is Flash boot

- **Ethernet interface**: medium and bitrate. Available values:



  - Default mode: RJ45 auto detect (auto negotiation between the C26x and the switch).

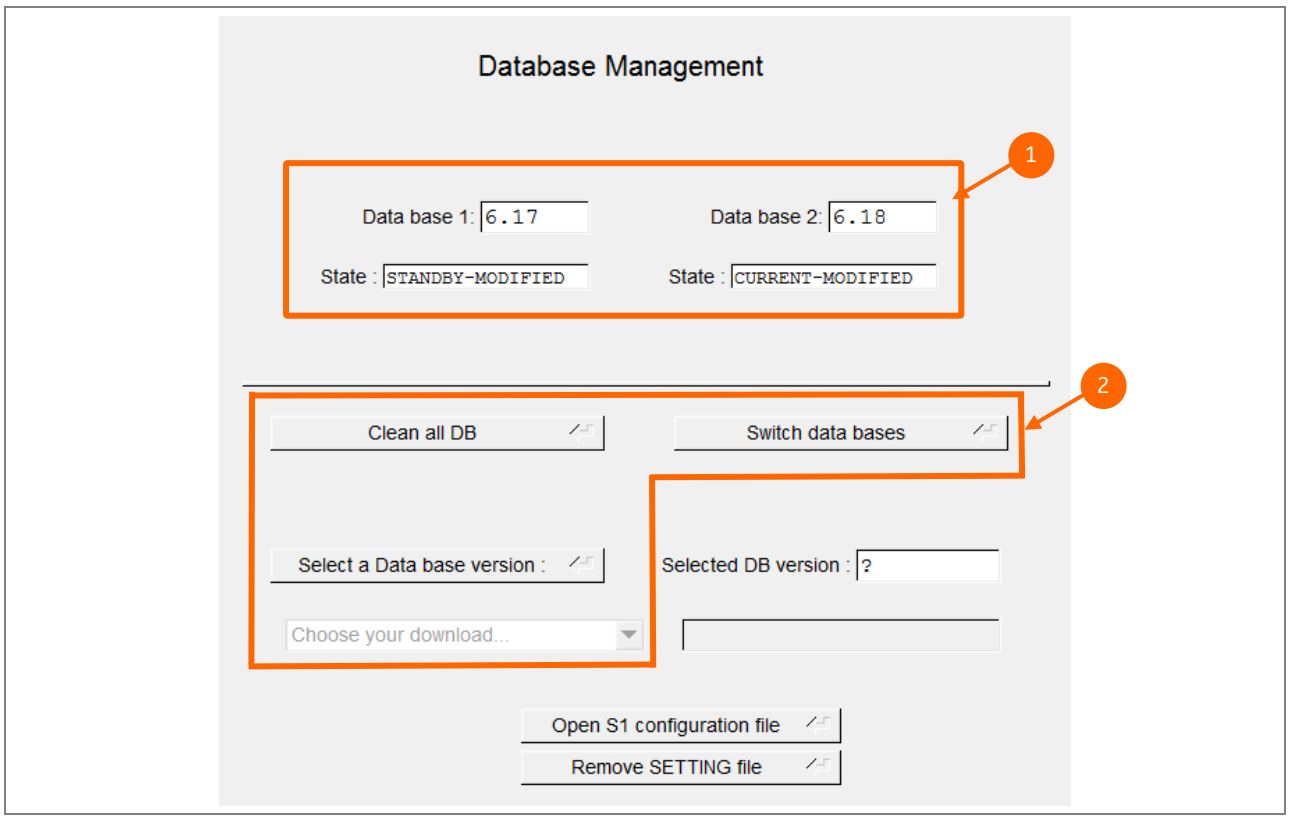
- **Get Boot parameters** button gets information by reading the C26x flash memory.

Once the modifications are complete, press the **Set boot Parameters** button to apply the changes onto the C26x (if CMT has been installed in Normal mode).

Modifications are saved in the flash memory of the C26x and **will be applied only after the next reboot.**

9.1.4.3 DATA BASE MANAGEMENT

The pane features two areas:



Information 1

Data base 1 shows the first data base version revision and its state CURRENT / STANDBY

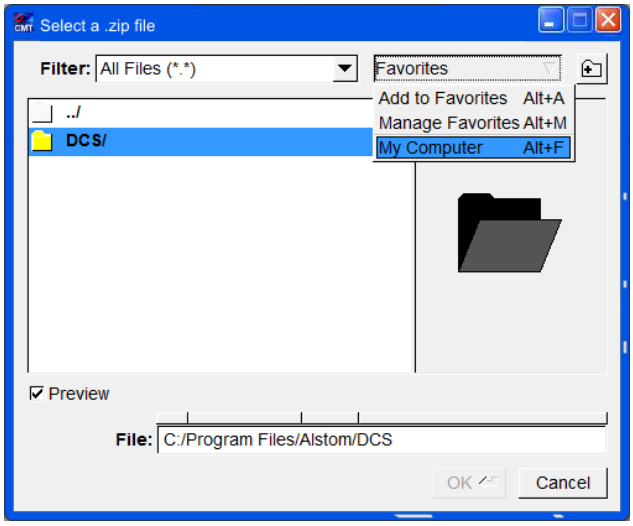
Data base 2 shows the 2nd data base version revision and its state CURRENT / STANDBY

Actions 2

Clean all DB removes the first and the second data bases. As a result, a reboot occurs (since B5.24). To be used ONLY for C26x software update.

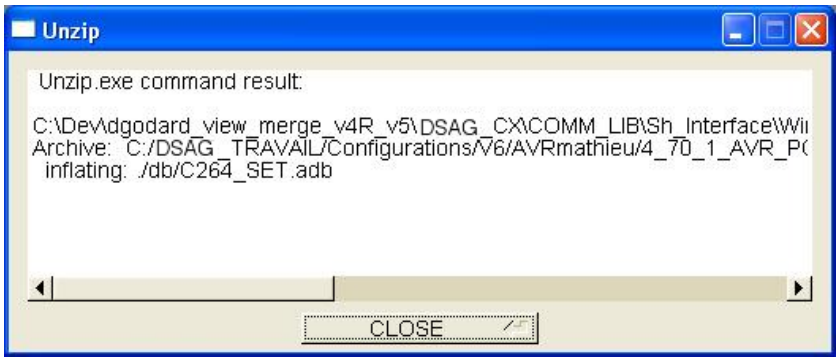
Switch data bases switches the two data bases. As a result, CURRENT becomes STANDBY and STANDBY becomes CURRENT, and a C26x search starts.

Select a Data base version to select a versioned system data base right from SCE; this opens a file chooser that shows all the available zip archives.



Navigate to the archive to load with the buttons **My Computer**, **../** and **./**.

Double click it; this displays the version revision x.yy is saved in the text area **Selected DB version** for the future downloads and extracts the .adb files. The .adb files are saved in <installation folder>/Computer/Cmt/db and displayed in a window:

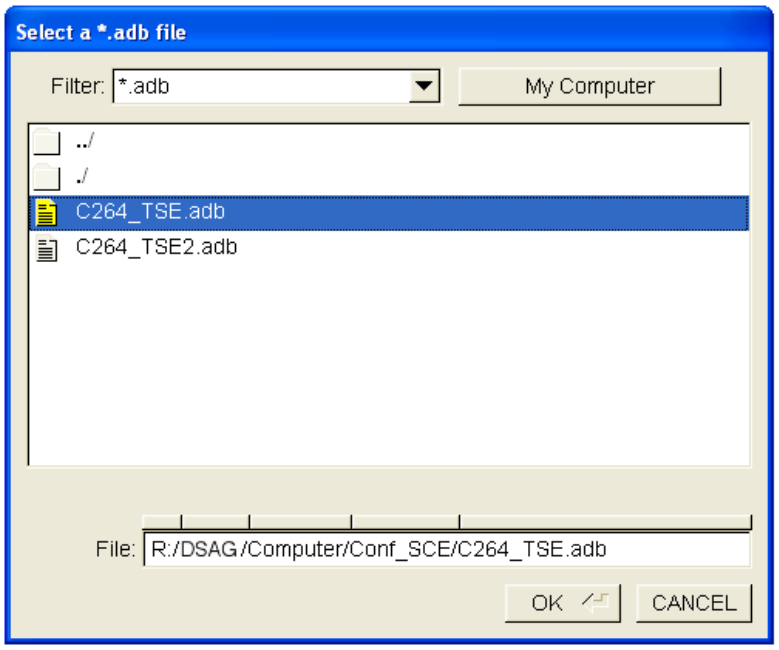


The absence of "inflating: ./db/xxxxx.adb" line indicates that unzip cannot find any *.adb files. Error origin is frequently the use of "space" in file or directory name.

Click Close.

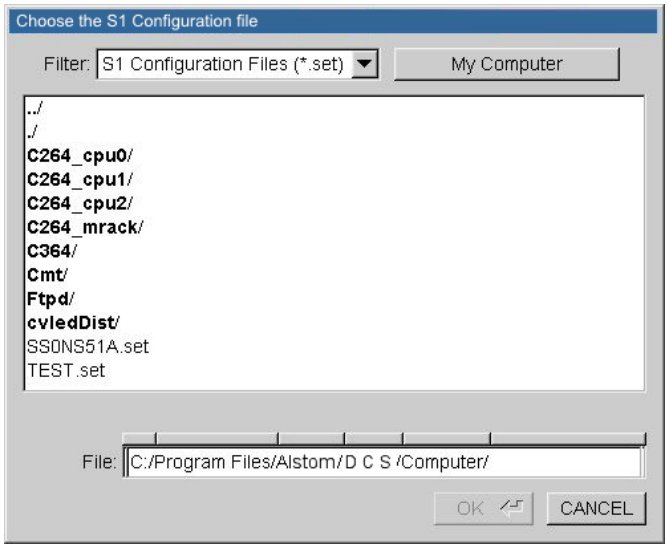
To download the *.adb file into the C26x, click in the list box **Choose your download…**.and select **Database only**.

A file chooser lists all the .adb files extracted from the archive; there are as many files as C26x units configured in SCE:



Click **OK** to start downloading database to the previously selected C26x.

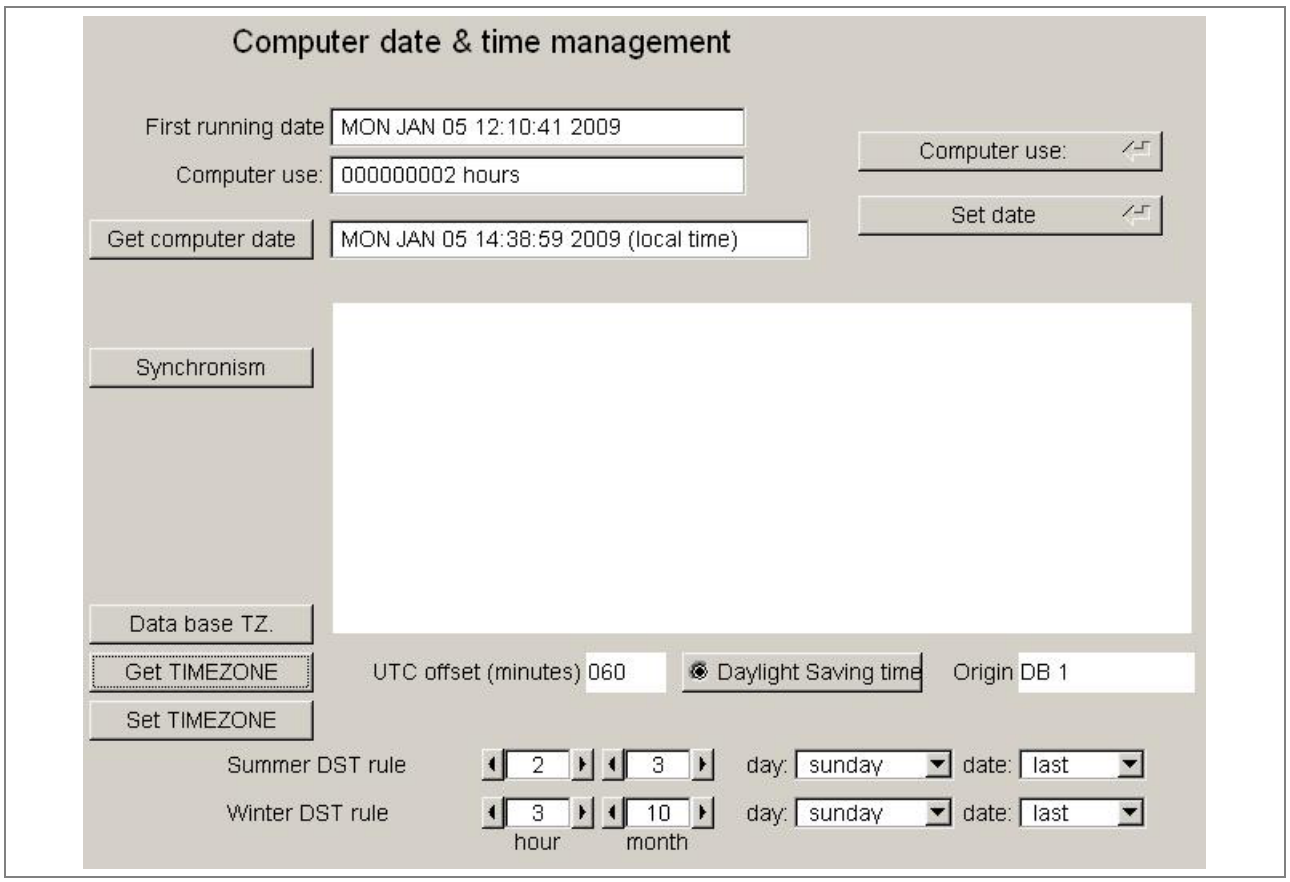
Open S1 configuration file opens a .set file in DS Agile S1 (checkout the Filter list):



For details on DS Agile S1, refer to chapter C26x/EN ST.

9.1.4.4 DATE AND TIME

This section is used to read or change date and time information.



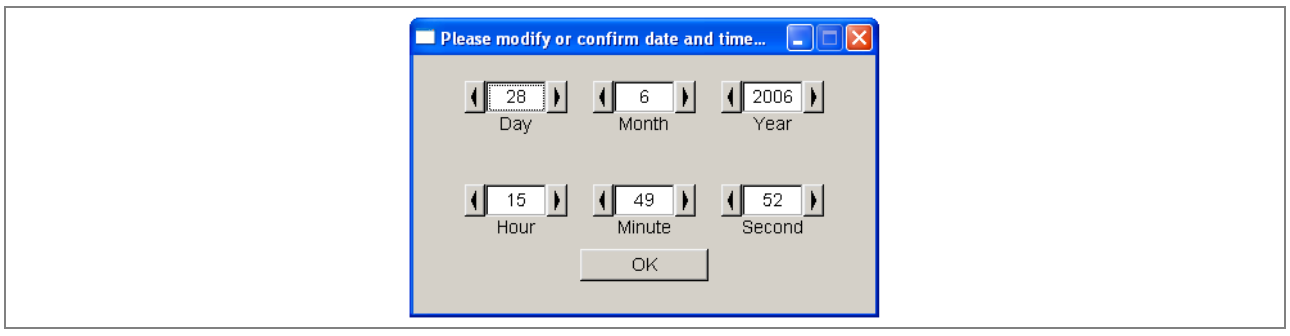
9.1.4.4.1 Main buttons

First running date of the C26x; the value stored in "/flash/MAINT/firstrd" is directly displayed here.

Computer use: number of hours the C26x has been running. This value is read in "/flash/MAINT/ophours".

Get computer date: used to read time on the C26x (local time).

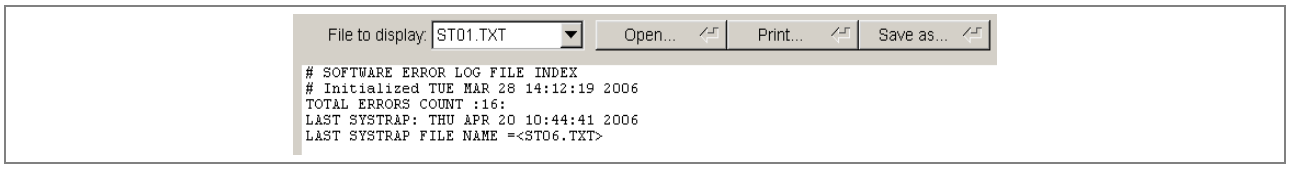
Set date: used to modify the C26x date and time. Windows on the operator PC provides the current date and time. They can be changed if needed.



Click OK to confirm the changes and send time to controller.

9.1.4.5 ERRORS

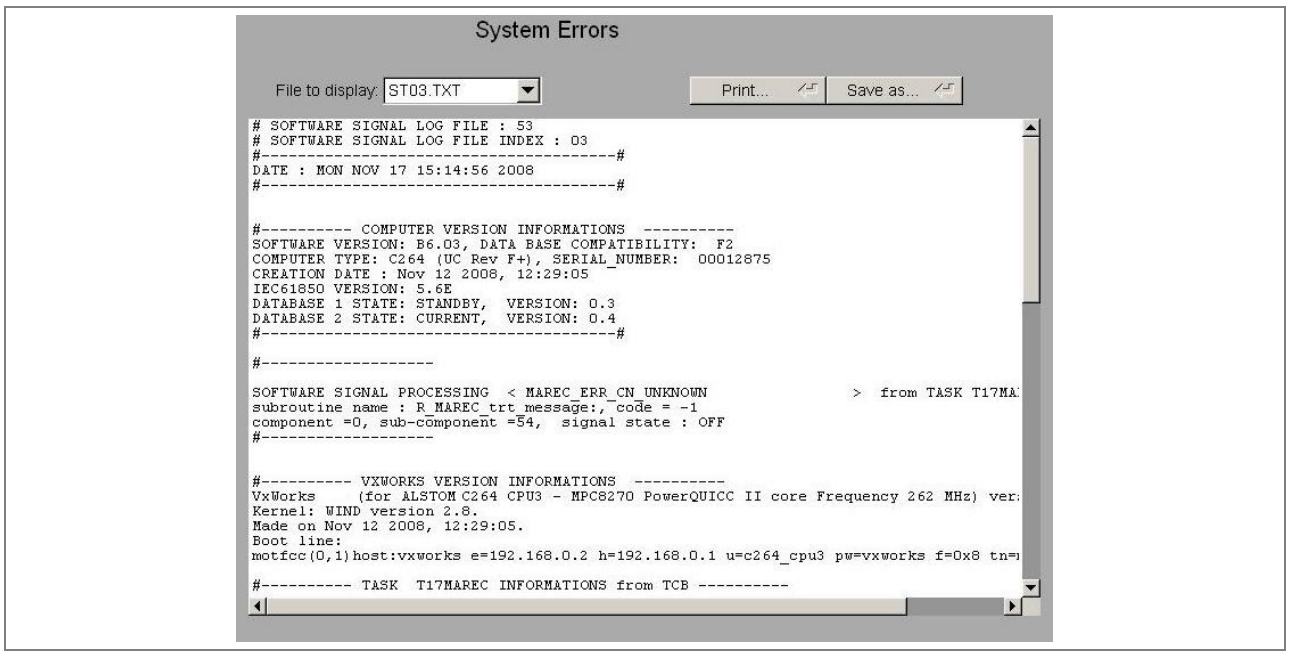
The content of "/flash/systrap/index.txt" is displayed. It shows the number of errors since the initialization of the index, the date and time of the last error and the name of the file containing information on this error.



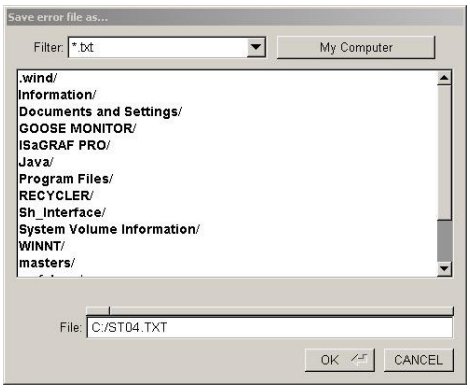
This file (with the latest systrap) is pre-selected in the **File to display** drop-down list.

On a C26x the latest ten error files are archived, select one of these files using the drop-down list.

Click a file to view it:



- **Save as...** is used to save the file on the PC disk. It opens a file chooser window:

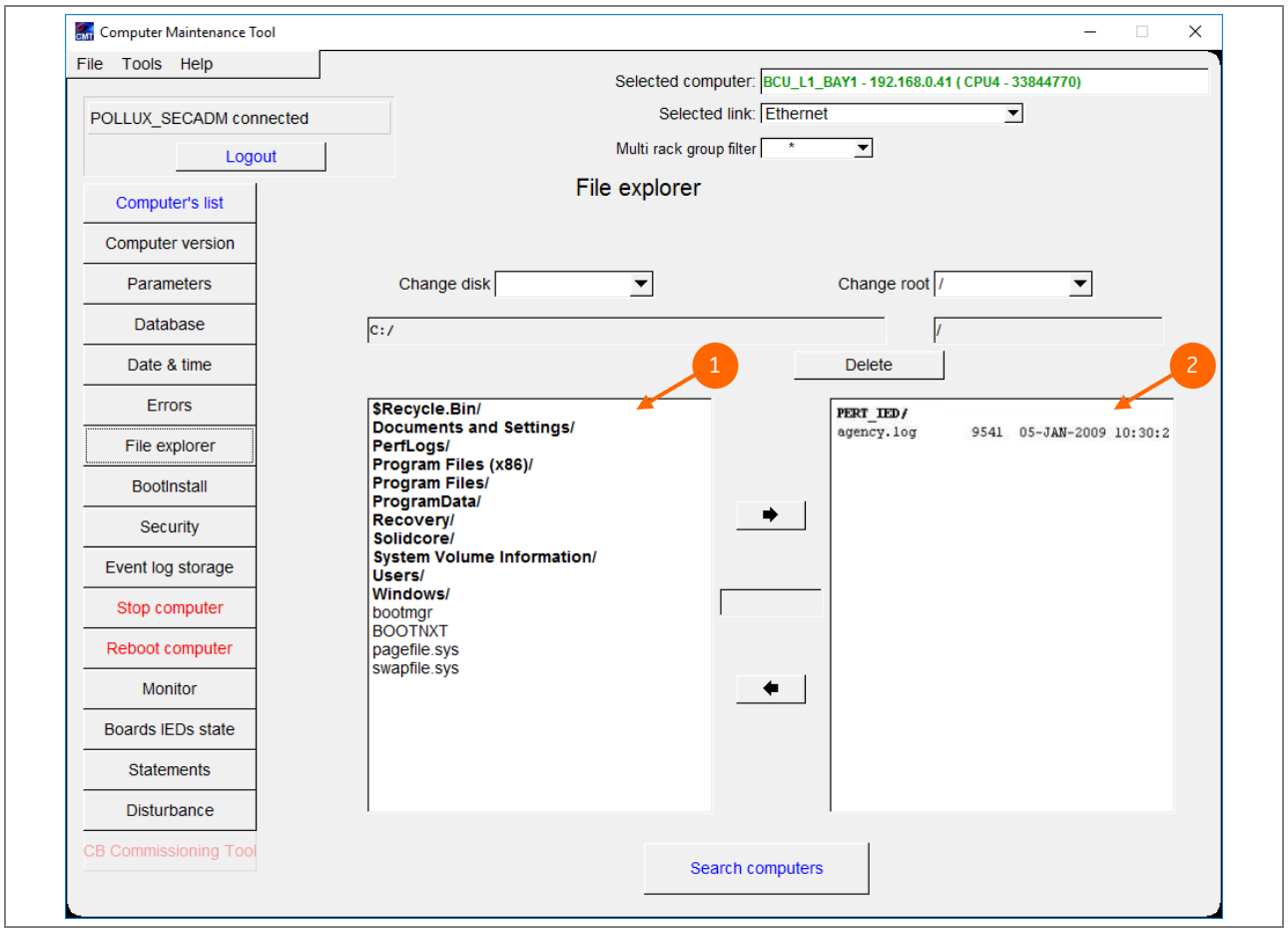


Note that the file *filename* refers to the file "/flash/SYSTRAP/*STxx.TXT*" on the C26x.

9.1.4.6 FILE EXPLORER

This section is designed like many FTP clients or file explorers.

The left part is an image of the local PC file system, the right one an image of the C26x files system.



9.1.4.6.1 Local PC side (left)

On the PC-side (1), the default current directory is the latest selected directory (value saved in the Registry).

Directories are displayed with a bold font. They can be browsed by **clicking them once**. The content of the browser is automatically updated to reflect the new directory files or subdirectories.

Files show with a normal font. To select a file, just **click** on it once (the dark blue background indicates the selection).

The drop-down list **Change disk** lists all the drives of the PC used as root for the browser.

A grey box shows the current path or selected file (bold).

9.1.4.6.2 Remote C26x side (right)

On the right side (2), select the root of the C26x file system in the **Change root** list. /RAMDEV (ramdisk) and /flash (flash memory) are available.

One click on a directory shows its content and **one click** on a file selects it (the dark blue background indicates the selection).

For each file, its size and modification date are also displayed.

The Delete button is used to delete the selected file on the C26x file system. A confirmation window opens showing the full path of the file to be deleted and user can confirm or cancel.

The **Format** button is used to erase and reformat the C26x file system, **all files are deleted**. This button is only useable while the C26x is stopped or on boot mode. A confirmation window opens and allows the user has to confirm or cancel his click.

9.1.4.6.3 Download (left to right arrow)

To begin a transfer, use the two arrows between the two browsers:

Select ➔ to download the file selected on the PC browser in the directory selected on the C26x.

The name is not changed, only files with a DOS name (8 . 3-character format) can be copied. The file is automatically overwritten if it already exists on the C26x.

The progress bar shows the progression of the transfer in yellow, the write time in flash memory is represented by a fully red progress bar.

9.1.4.6.4 Upload (right to left arrow)

Select ➔ to upload a file. The file selected on the C26x is uploaded on the PC, in the current directory.

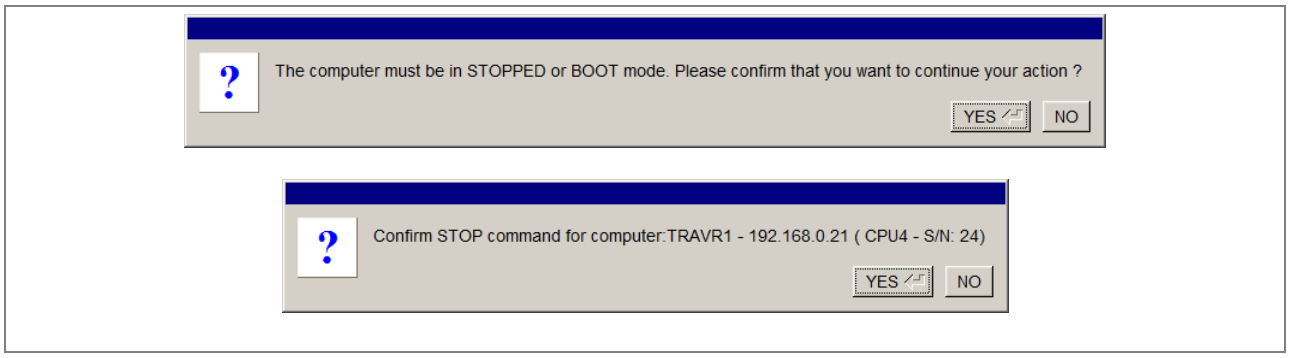
The name is not changed. The file is automatically overwritten if it already exists on the C26x.

The progress bar shows the progression of the transfer in yellow.

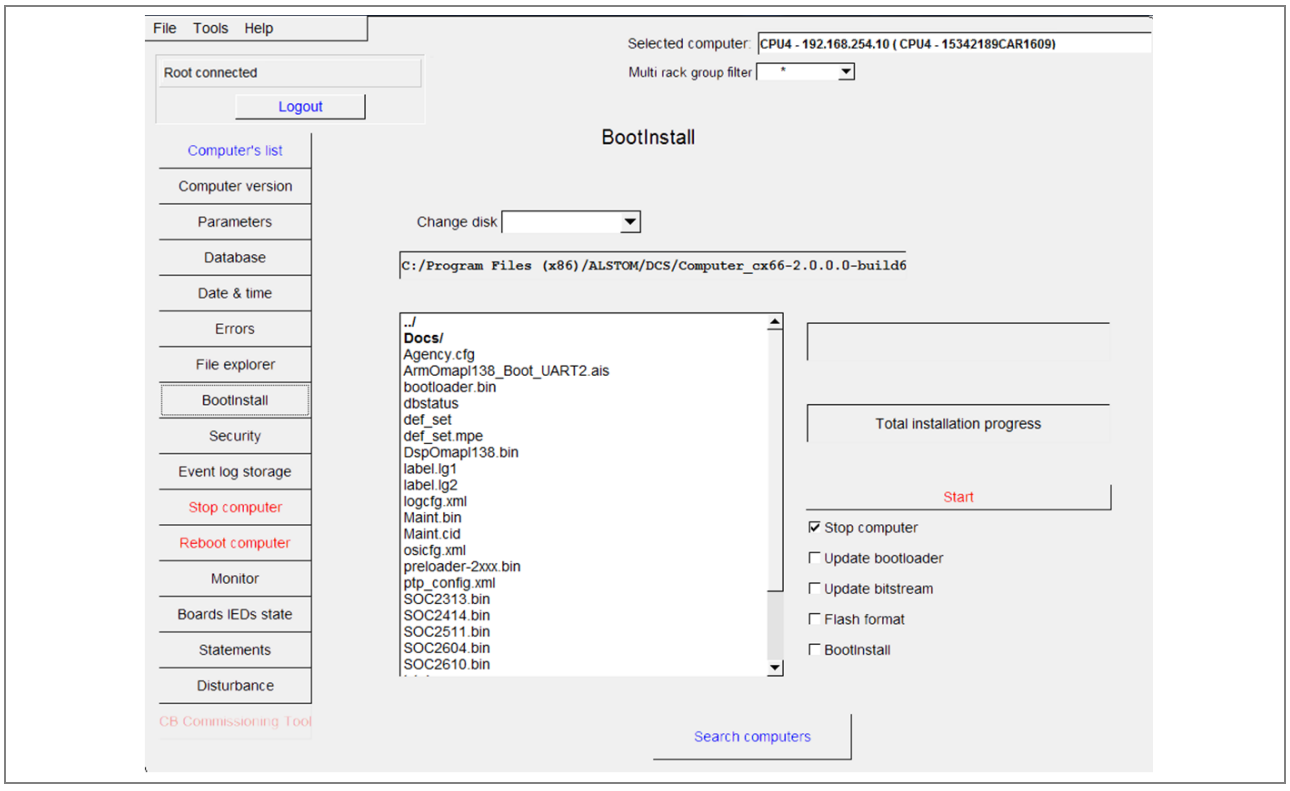
9.1.4.7 BOOTINSTALL

This function is equivalent to the *BootInstall* command, launched from a shell. It downloads automatically a set of files essential to a C26x application.

The unit must first be stopped in order to access this panel.



The directory is selected by the operator. The set of files is automatically selected and must match the type of CPU Board fitted in the C26x.



On the PC-side (left), the default current directory is the latest selected directory (value saved in Registry).

Directories are displayed in bold font. They can be browsed by **clicking them once**. The content of the browser is automatically updated to reflect the new directory files or subdirectories.

Files are shown with a normal font. To select a file, just **click** it once (a dark blue background indicates that it is selected).

The top box "Change disk" lists all the drives of the PC used as root for the browser.

A grey box shows the current path (in bold characters). If a file is selected, only the path is used, the filename is ignored.

- **Start**

  The C26x must be in the STOPPED or BOOT mode. After a confirmation window, the BootInstall begins. The top progress bar shows the progression file by file (yellow for transfer, red for write).

  The bottom progress bar shows the progression of the global process (yellow).
  the **Start BootInstall** button is deleted after each use, you have to click **BootInstall** again and select another directory.

- **Abort**

  The **Abort** button can stop the file transfer process. The click is saved and stop the download after a full file transfer, it cannot stop while a file is being transferred. No confirmation is needed.

- **Update bootloader**

- **Update bitstream**

  If the box *"Update bitstream"* is checked, the *Bitstream selection* window appears. Some *"pre-checks"* are performed (depending on what is selected: validity of the *Bitstream*, presence of the *bootloader.bin* file, presence of the *vxWorks* file and generation of the *vxWorks.bin* file). After the pre-checks, a summary of the selected components is displayed for confirmation

- **Flash format**

  If the selected CPU4 is not formatted, the **Format Flash** check box is enabled. In this case, the text *Format Flash* is displayed in **blue**.

- **Bootinstall**

  Downloads the set of files required for the C26x application.

9.1.4.8 SECURITY

The **Security** button on the left, opens the **Account Tab**, which is used to:

- Define connexion options for external applications (**My Account** sub-tab):
  - Enable/disable serial connexion to the C26x using an SSH terminal and launch it
  - Launch the parameter setting software MiCOM S1
- Disable/Enable LHMI authentication
- Manage access to the C26x (**Administration** sub-tab):
  - Create and manage user accounts
  - Enable and configure the security policy
- Monitor a log of all security-related operations, such as logging attempts (**Security log** sub-tab).

All these operations apply to a single C26x unit to which the Security Administrator must have logged in beforehand. They apply to all the user accounts defined in that C26x.

By default, DS Agile C26x units are delivered with the following Root account (use exactly the same case):

- LOGIN = *Root*
- Password = *Root1234#*

For security reasons, the Root password must be changed immediately. The user will be prompted to do so upon the first login.

The Root account is granted all administration and access rights.

9.1.4.8.1 Root account management

When a Root account is first used to log in to a C26x unit, the user is immediately prompted to change the account's password. Follow the onscreen prompts:

1 First select the **My Account** tab-pane.

1 Enter the old password (*Root1234#* by default).

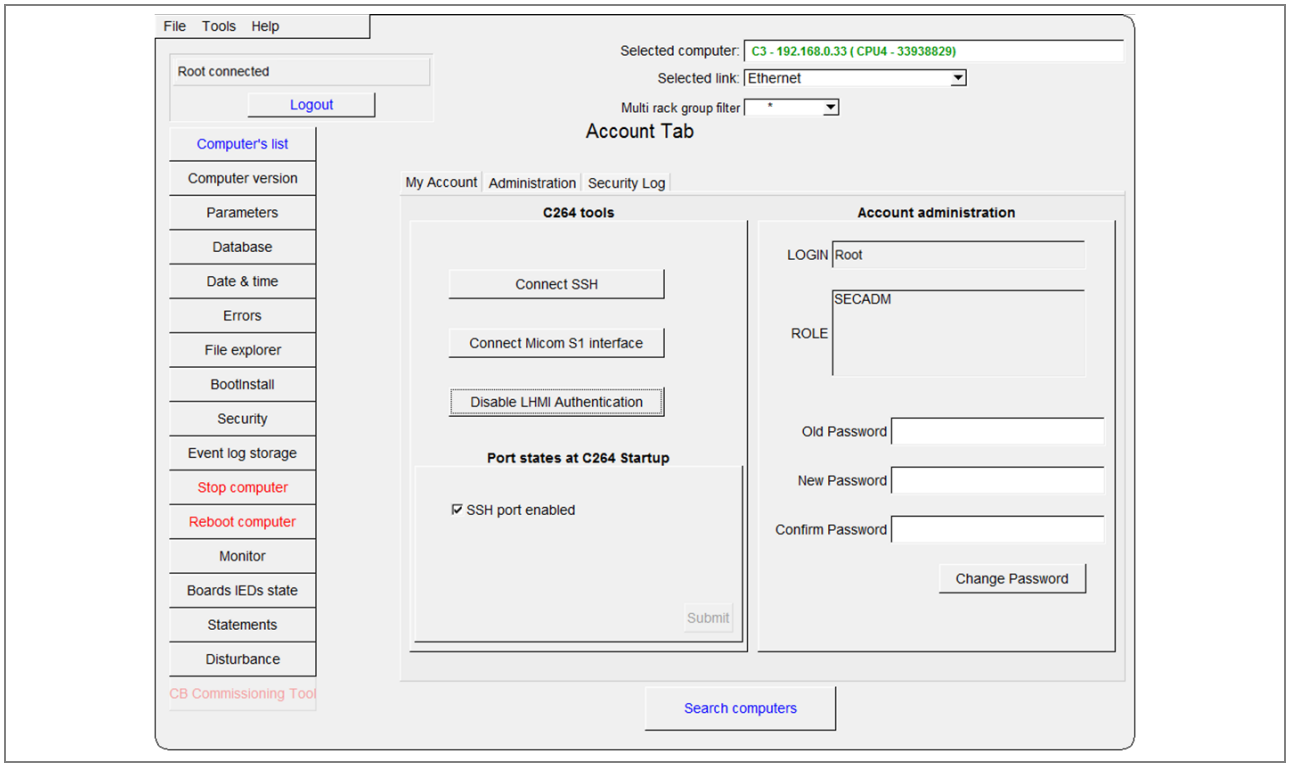
2 Enter the new password.

3 Confirm the new password by entering it again.

4 Then click **Change Password**.

Note:
The password must have at least 9 characters.

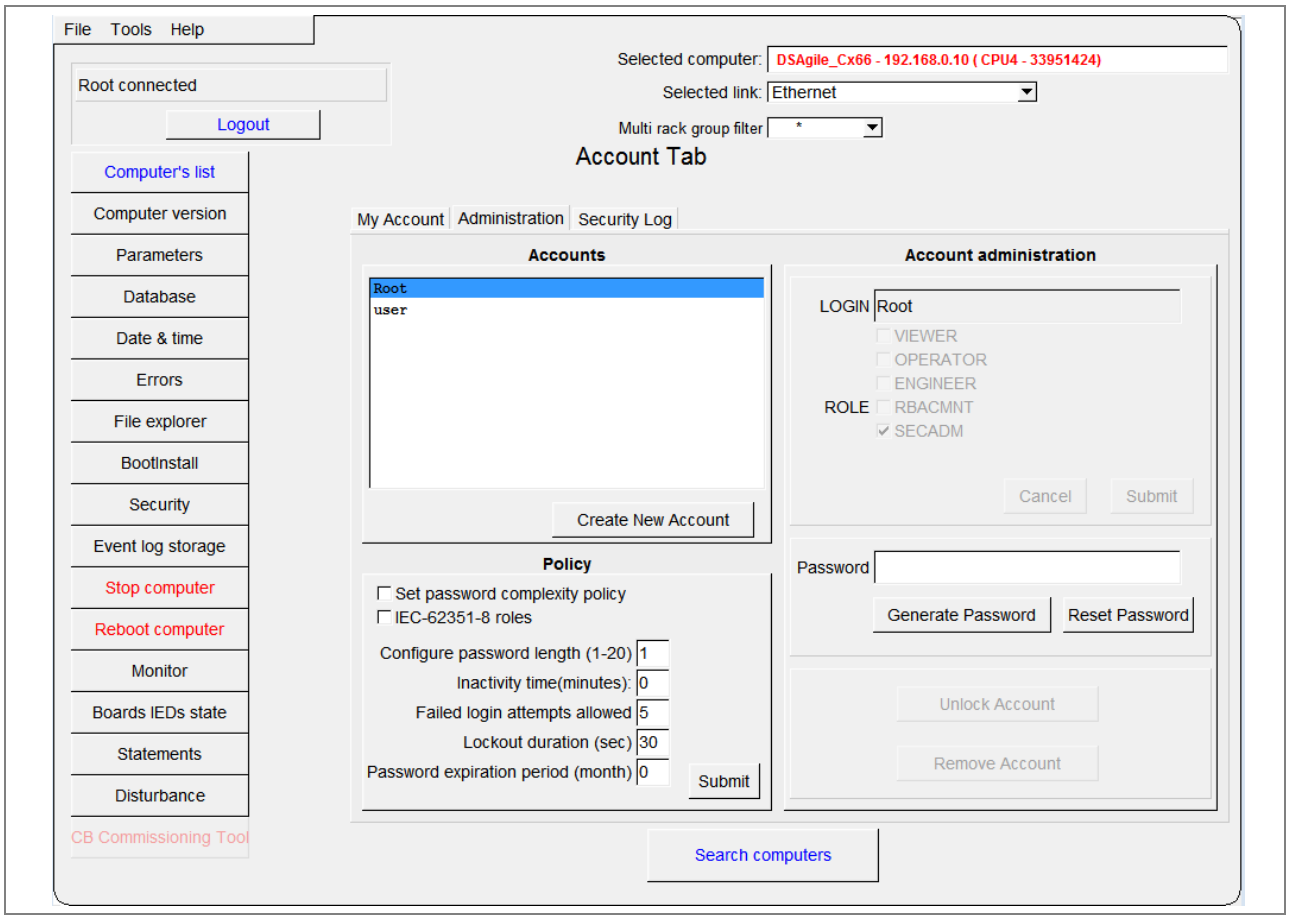
Then enable the remote access ports by ticking the corresponding box in the **Port states at C264 Startup** pane (**My account** sub-tab):



Click **Submit** to update the unit's settings.

9.1.4.8.2 Password, Security and Account management

Select the **Administration** tab:



In the **Policy** panel, enable and configure each required policy.

Password policy

To impose a minimum, tick the box ***Set password complexity policy*** and set the password parameters:

The password must contain at least 3 different types of characters among the following:

- upper case letters
- lower case letters
- digits
- blank space
- special characters/punctuation marks:

!	"	#	$	%	&	'	(	)	*	+	,	-	.	`	~
/	:	;	<	=	>	?	@	[	\	]	^	_	{	}	|

- and password length:

  Enter the minimum number of characters (1 to 20, default setting: 9). When no password policy is enabled (***Set password complexity policy*** option unchecked), the password length is between 1 and 20 characters.

IEC-62351-8 roles

Access rights for each user account are defined with functional RBAC "roles", each of them grants a set of rights related to a specific type of activity (data viewing, engineering, system configuration, account administration).

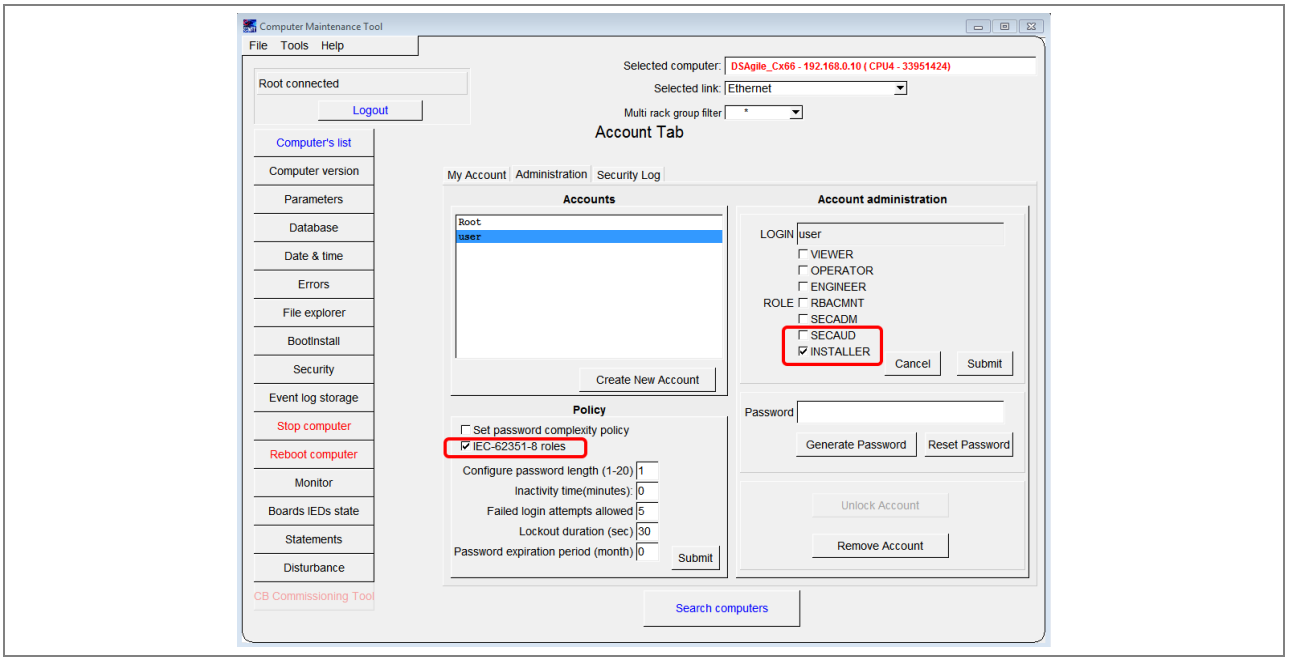
The C264 manages two lists of RBAC roles:

- **Default role list**:
  - VIEWER
  - OPERATOR
  - ENGINEER
  - RBACMNT
  - SECADM
- **IEC 62351-8 roles** list:
  - VIEWER,
  - OPERATOR,
  - ENGINEER,
  - RBACMNT
  - SECADM
  - SECAUD
  - INSTALLER

Both lists of roles and permissions are detailed in the **Functional Description** chapter of the C264 user manual.

To be compliant with the IEC 62351-8 standard on cybersecurity, check the **IEC 62351-8 roles** box and click **Submit**. After clicking on **Submit**, the user will be automatically disconnected and will need to reconnect to the C264 via the CMT to recover the new role rights of the C264.

Note: only accounts with the Security Administrator Role (SECADM) are authorized to select the table of users to be used from CMT, and to download it to the C264.



The selected role table remains active even after a reboot of the C264 or a database change.

Inactivity time(minutes)

To initiate automatic log out at the end of an inactivity timer, enter that duration as a number of minutes.

Failed login attempts allowed:

Enter the number of allowed failed attempts: the account will be locked if there is one more failed attempt than permitted. The number of consecutive login attempts can be set between 0 to 10. The default value is 3 for the “Root” account.

Note that the attempts are cumulative for the front panel LHMI and the DS Agile CMT, i.e., if the number of allowed failed attempts is 3, the account will be locked after 2 attempts on the LHMI and 2 attempts via the CMT, for instance.

Lockout duration (sec):

Enter the duration of the account lockout in seconds. The account locking period is configurable from **0** to **999 minutes**. A value of **0** specifies that the user account will be locked out until an administrator explicitly unlocks it (*not applicable to “Root” account*). By default, the account lockout duration is set to 30 seconds.

Caution:
We highly recommend that you at least set the lockout duration to less than 30 seconds to prevent any brute-force security attack. A value higher than 1 minute increases the risk of:
- A legal user locked outside a critical system after three wrong login/password attempts;
- Access to the entire substation could be blocked by a malicious attacker entering several failed login/password attempts to all the user accounts.

Note that this lockout time is counted on the unit and that if its internal clock time is changed in the meantime, that change will affect the duration of the lockout, either by lengthening it or shortening it by the time difference implemented in the time change.

Password expiration period (month)

Enter *0* if the password should never expire or set the **password expiration time** in months (*1* to *24).*

Default setting: *0*.

Account creation

The **Root** account, as well as any other account with the *Security Administrator* role, can create a user account:

- Select the **Administration** tab.
- Click **Create New Account**.
- In the **New Account** panel, enter the LOGIN name and select the associated role(s).
- Click **Generate Password**.
- Keep or change the suggested password and click **Submit** (or **Cancel** to abort).
- Send the LOGIN/Password combination to the relevant user through a secure medium.

Note:
LOGIN and Password are case-sensitive, i.e. "A" is considered a different character from "a".

Good practice:

When creating a security administrator account, add at least the VIEWER role in addition to the RBACMNT role so that the user can display general information and connect to the device's front panel HMI.

Account management

Once a user account has been created, its LOGIN name cannot be changed.

The **Root** account, as well as any other account with the *Security Administrator* role, can **reset a password**:

- Select the **Administration** tab.
- In the **Accounts** panel, select the relevant account name.
- Click **Generate Password**.
- Send the LOGIN/Password combination to the relevant user through a secure medium.

The **Root** account as well as any other account with the *Security Administrator* role can prematurely **unlock a locked-out account** before the end of the lockout period:

- Select the **Administration** tab.
- In the **Accounts** panel, select the relevant account name.
- In the **Account administration** panel, click **Unlock Account**.

The **Root** account, as well as any other account with the *Security Administrator* role, can delete any other account, except the Root account:

- Select the **Administration** tab.
- In the **Accounts** panel, select the relevant account name.
- In the **Account administration** panel, click **Remove Account**.

Password change

Upon their first connexion to a C26x unit, all users are directed to change their password.

No changes can be made to a LOGIN name once the account is created.

All users can change their own password:

- Select the **My Account** tab.
- Enter the current password in the **Old Password** box.
- Enter the new password in the **New Password** box and in the **Confirm Password** box.
- Click **Change Password**.

9.1.4.8.3 C264 tools

Enable/Disable LHMI Authentication

By default, the C264 is configured in **Secure** mode with the disclaimer banner set to TRUE in the SCE database properties. In **Secure** mode, any key that is pressed on the C264 local HMI requires authentication (the Login panel is displayed).

When the CMT is connected to the C264, users with administrator rights (SECADM) can disable or enable the **secure** mode by clicking on the **Disable/Enable LHMI Authentication** button in the **Security\My account** tab. This **Disable/Enable LHMI Authentication** button is greyed out to other users or when no disclaimer banner is configured.

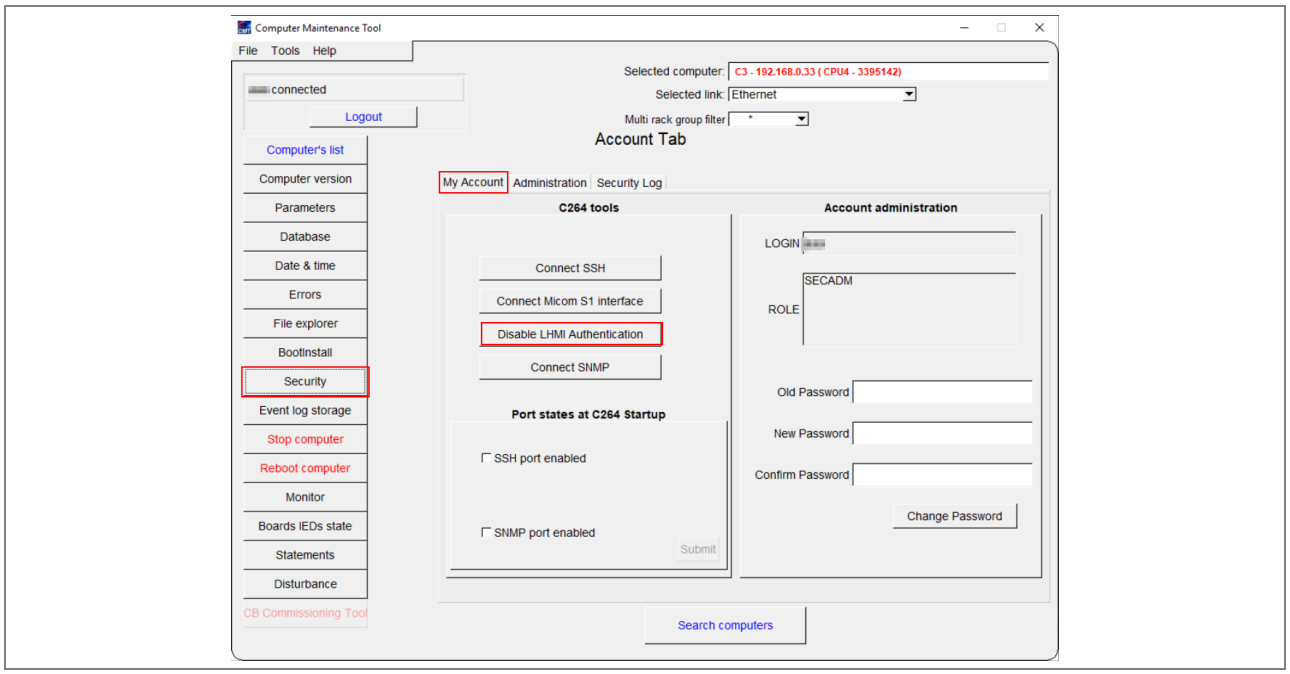


Figure 1: Disable LHMI Authentication when Secure mode is configured

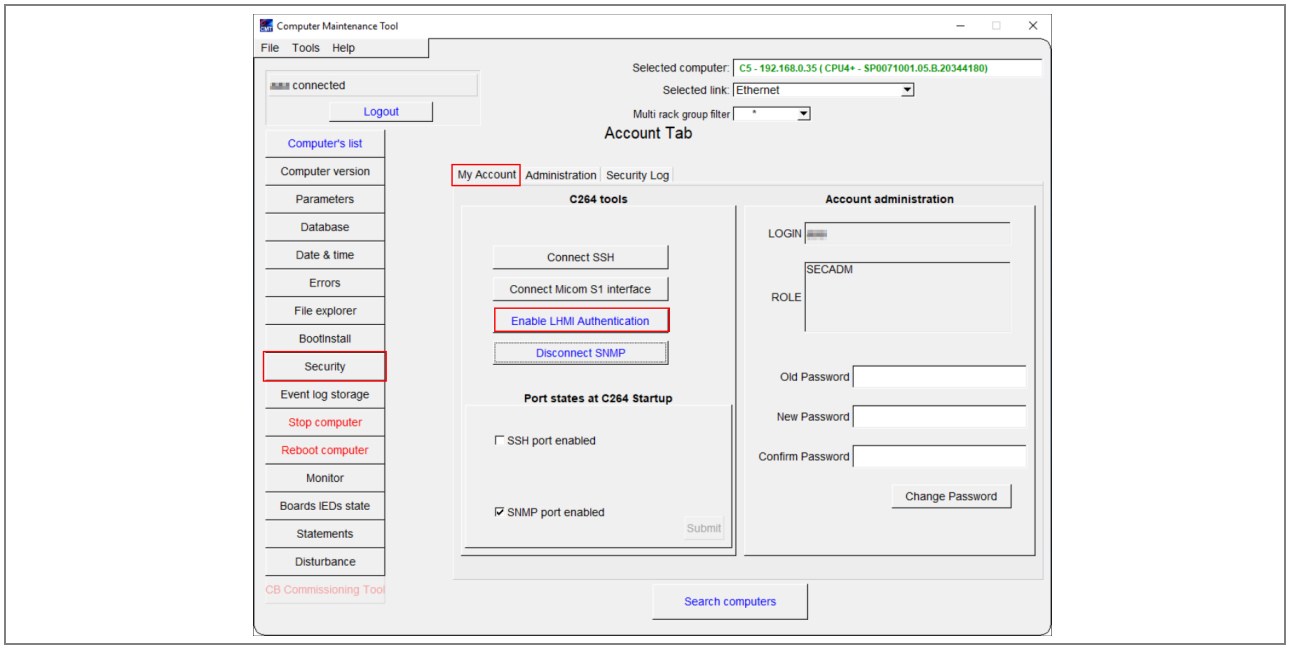


Figure 2: Enable LHMI Authentication when Secure mode is not configured

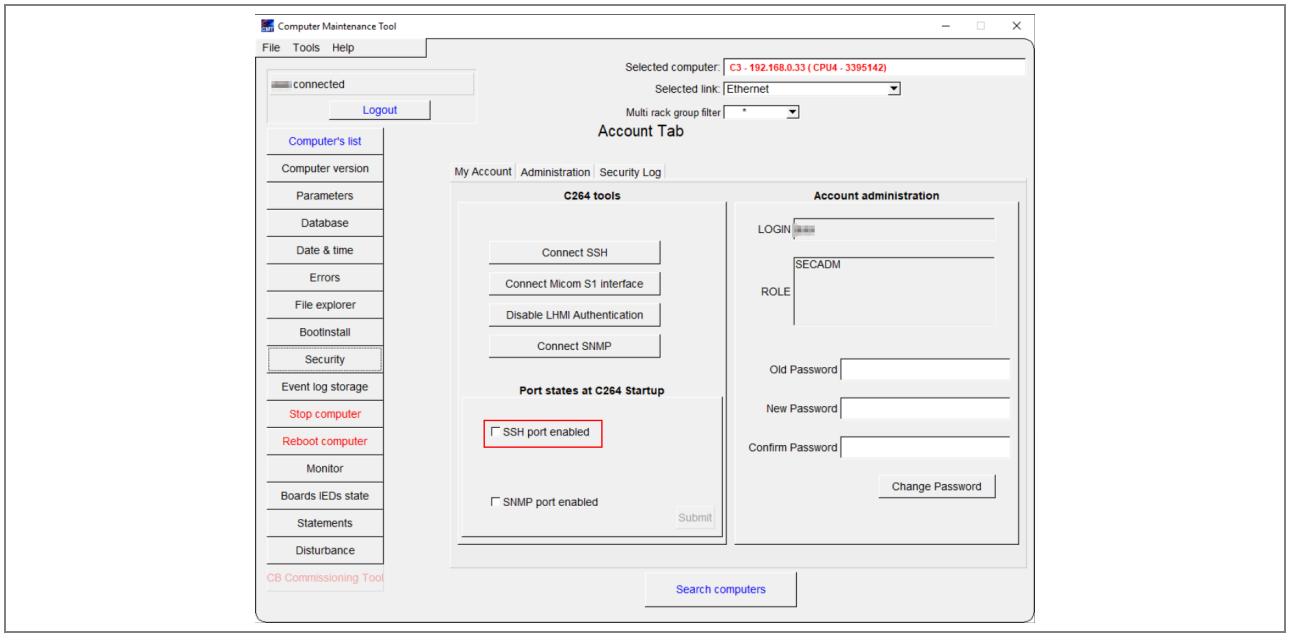
*Note: when the mode is changed through the **Disable/Enable LHMI Authentication** button, the parameter value is saved and restored upon the C264 reboot or DB switch.*

Enable the SSH port

It is possible to manage the C26x from an SSH command line interface. Only an operator logged in with the **root** account can connect to the unit using SSH.

To enable the SSH port:

- Open the **My Account** tab-pane.
- Tick the **SSH port enabled** box in the **Port states at C264 Startup** panel to authorize SSH connection you must be logged to the unit with the Root account),
- Click **Submit** to update the unit's settings.
- The console can then either be launched independently or by clicking the button Connect SSH in the **C264 tools** panel. It can be used even after the CMT has been closed.



SSH terminal

Only an operator logged in with the Root account can connect to the unit using an SSH terminal. The **Connect SSH** button is hidden to other users.

- Open the **My Account** tab-pane.
- Click **Connect SSH** in the **C264 tools** panel.

This launches the default SSH client on the operator's PC. SSH is connected to the selected C26x.

Note:
You can use any SSH client to establish a connection with the C26x's SSH server.

It can be used to easily get a shell on the C26x, in order to perform tasks that CMT cannot handle.

- Login: **Root**
- Password: C264Root account's password, by default **Root1234#**
  (changing the **Root**'s password in DS Agile CMT also changes it for the SSH access)

The "logout" command or the Windows closure can be used to terminate the session.

As SSH sessions are launched independently of the CMT, multi-sessions on two or more C26x units are possible. It is not, however, possible to connect to both the Ethernet ports of a C26x simultaneously.

It is possible to start a session directly from the SSH terminal, without using the CMT. In that case, select port 22 to connect to the C26x.

In all cases, access will be denied if the SSH port has not been enabled beforehand.

SSH uses a TCP/IP stack and the C26x has to be accessible from the PC in that mode.

Commands:

- Type i to display the list of available commands
- Type lkup <command name> to get help on a command
- Type S_DBTEST_print_bay to list the C26x's datapoints

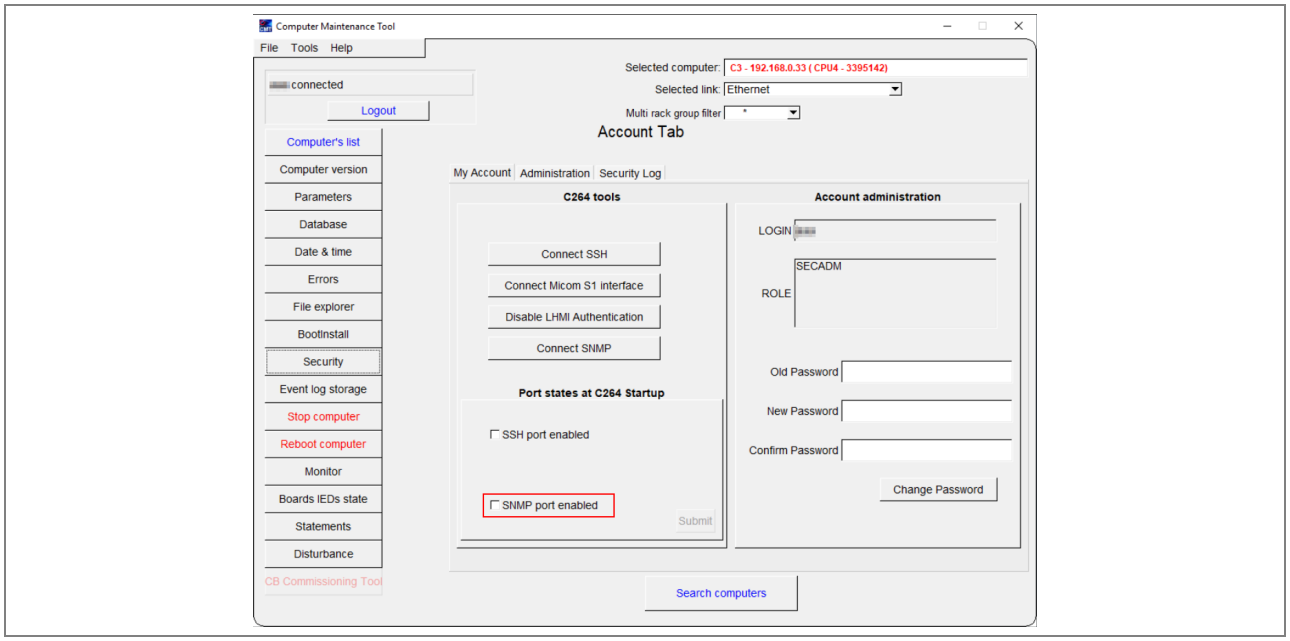
The SSH session times out after 10 minutes of inactivity (no command sent). This setting is configurable.

Enable the SNMP port

It is possible to manage the C26x from an SNMP command line interface. Only an user with SECADM role can perform following actions.

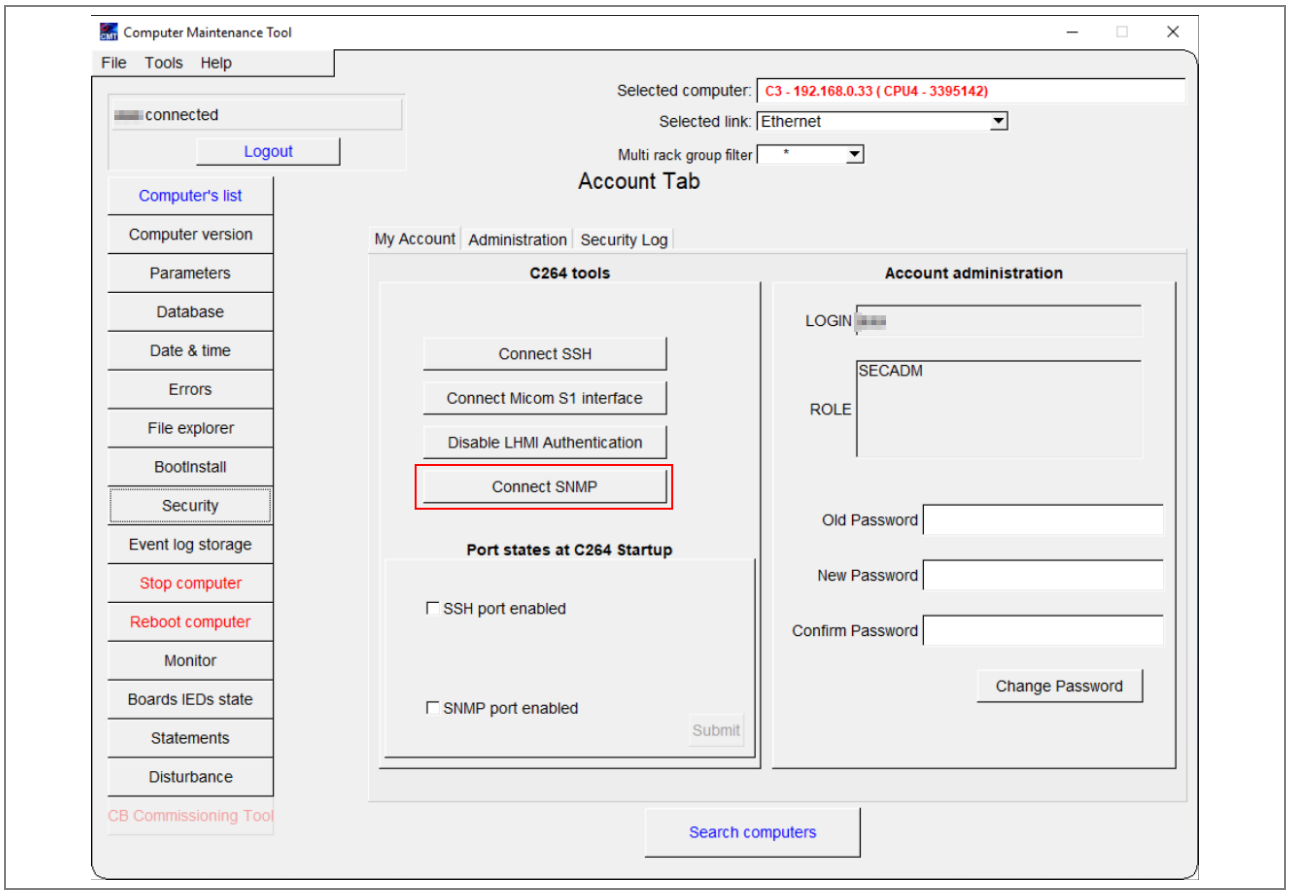
To enable the SNMP port:

- Open the **My Account** tab-pane.
- Tick the **SNMP port enabled** box in the **Port states at C264 Startup** panel,
- Click **Submit** to update the unit's settings.



- Click Connect SNMP to connect the CMT to a C26x computer through SNMP server.

Note:
Only user with SECADM privilege can use this functionality.

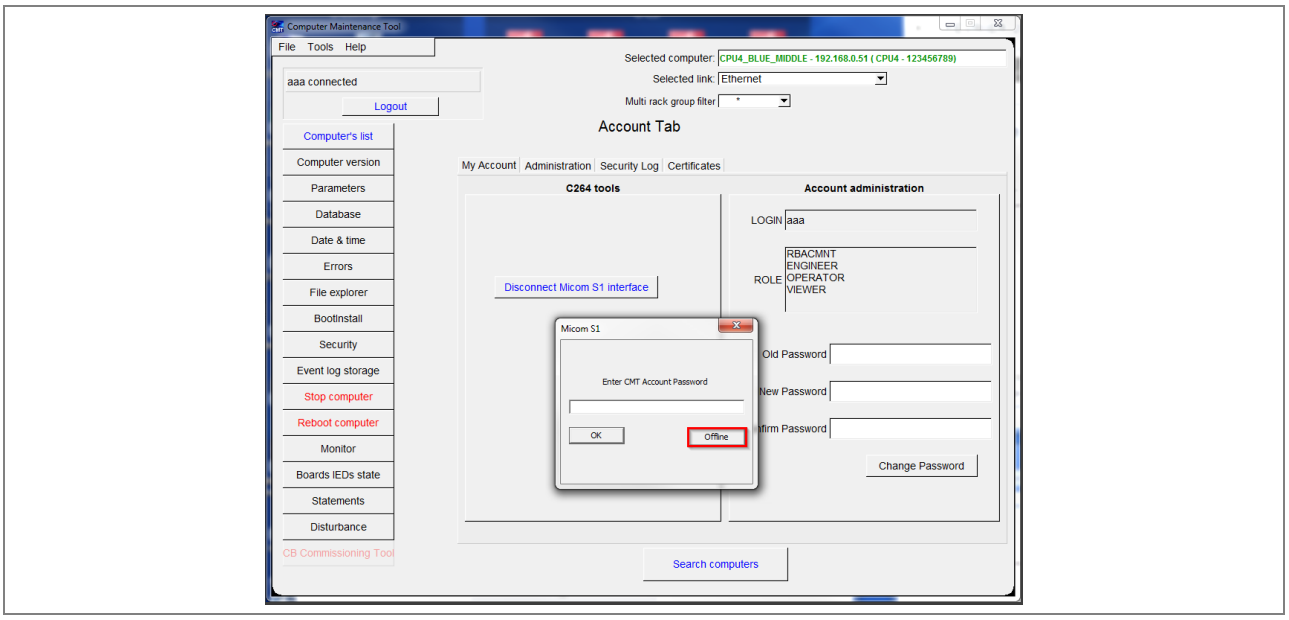

Computer Maintenance Tool
File Tools Help
connected
Logout
Selected computer: C3 - 192.168.0.33 (CPU4 - 3395142)
Selected link: Ethernet
Multi rack group filter *
Account Tab
Computer's list
Computer version
Parameters
Database
Date & time
Errors
File explorer
BootInstall
Security
Event log storage
Stop computer
Reboot computer
Monitor
Boards IEDs state
Statements
Disturbance
CB Commissioning Tool
My Account
Administration
Security Log
C264 tools
Connect SSH
Connect Micom S1 interface
Disable LHMI Authentication
Connect SNMP
Port states at C264 Startup
SSH port enabled
SNMP port enabled
Submit
Account administration
LOGIN
ROLE
SECADM
Old Password
New Password
Confirm Password
Change Password
Search computers

Connect MiCOM S1 interface

The setting software can only be connected to a C26x unit only via the CMT if the corresponding port is enabled on that unit (see above).

To launch the S1 application, open the **My Account** tab-pane and click **Connect Micom S1 interface** in the **C264 tools** panel. Enter the CMT user account password and click OK.

It is possible to open MiCOM S1 in “offline” mode by clicking the **Offline** button in the popup.



In this mode, the user cannot connect to any CX66 but prepare the setting files.

For more information see the Settings chapter of the C264 user manual.

Note:

- Closing MiCOM S1 affects neither the CMT connection nor the SSH communications.
- Closing the SSH terminal affects neither the CMT connection nor the MiCOM S1 connection.
- Logging out from a C26x unit in the CMT (or closing the CMT) terminates the MiCOM S1 connection and make it impossible to upload/download settings. It also closes the S1 application if it was launched from the CMT.
- Logging out from a C26x unit in the CMT (or closing the CMT) does not affect the SSH communications.

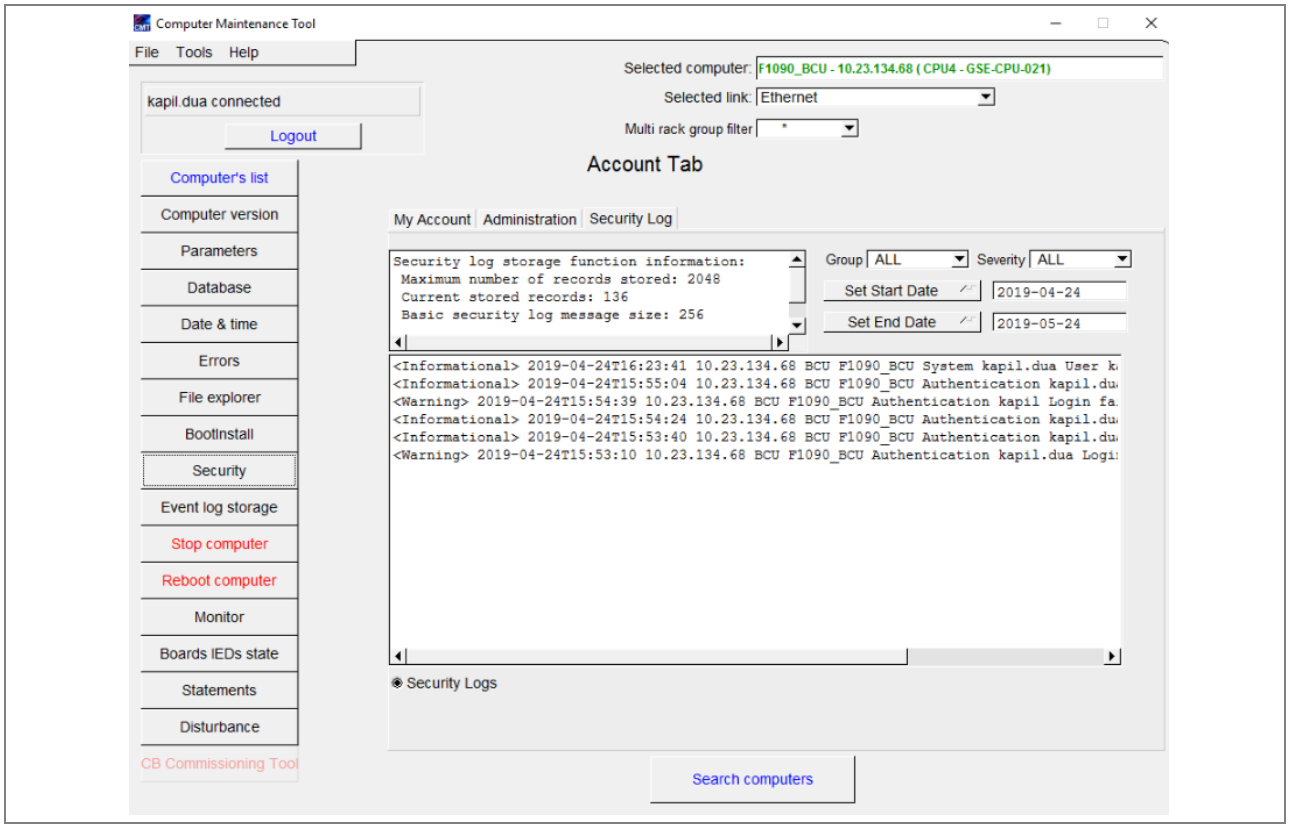
9.1.4.8.4 Security Log

The C26x logs all security-related user activity, such as login attempts and user operations.

The **Security Log** tab-pane displays the C26x local log messages and a summary panel shows:

- The number of currently stored messages
- The maximum number of messages
- The basic security log message size

The CMT returns the log status from the previous month. The beginning and the end of the log is shown in the **Start Date** and **End Date** fields. The user may change this period using the calendar and filter the search results by “Severity” and “Group”.



Any security event generates an entry in the security log file in the following format:

```
[Severity Level] [Timestamp] [HostName] [Facility] [Subsystem Name] [Group] [User Name] [Message]
```

Where:

- **Severity Level** depends on the security event:
  - Informational
  - Notice
  - Warning
  - Error

- **Timestamp** is the local time of the device when the message was generated. Its format is **YYYY-MM-DDTHH:MM:SS**
- **HostName** is the IP Address of the device from which the message was generated
- **Facility** is the subsystem type (BCU…)
- **Subsystem Name** is the device network name
- **Group** is the message category:
  - Authentication
  - Security
  - System
- **User Name** is the user or the system initiating the message
- **Message** is the security event description

The security log is circular: when it is full, the latest event replaces the oldest. It can contain up to 2048 events.

Standard System log messages

- Start/Stop/Reboot of the C264 device
- Login attempts (successful or failed)
  - Password error: `BAD PASSWORD`
  - Expired password: `EXPIRED PWD`
  - Account locked after x attempts: `LOGIN LOCKED`
  - Non-existing account: `LOGIN NO ACCOUNT`
  - Another user is already logged in: `LOGIN IN USE`
- Logout: `LOGOUT SUCCESS`
- Logout after timeout: `SESSION TIMEOUT`
- Override logged user: `STEAL SESSION`
- User account changes:
  - New account: `CREATE NEW USER X With ROLE:` |a|b|c| (ex: |OB|SyE|SyA|SeA)
  - Password reset: `RESET PASSWORD FOR X`
  - Password change: `CHANGE PASSWORD FOR X`
  - Change of role: `ROLE CHANGE FOR X NEW ROLE is:` |a|b|c| (ex: |OB|SyE|SyA|SeA)y
  - Unlock: `ACCOUNT UNLOCK FOR X`

- Remove a user account
- Lock a user account
- Database switch: `SWITCH DB`
- Firmware update
- Syslog server down
- AD server down
- Certificate expiration

Specific C264 log messages

- Bootloader update: `UPDATE BOOTROM`
- VxWorks application update: `UPDATE vxWorks file`
- SSH port enabled: `ENABLE SSH`
- SSH port disabled: `DISABLE SSH`
- User access through SSH: `User @login successful login with ssh`
- BCU fails switching the Database because user's privileges are insufficient: `Database switch failure > @dbVersion to @newDbVersion > (optional) @FailureExplanation`
- BCU fails updating the Firmware because firmware's file integrity is incorrect: `Firmware update failure > @firmVersion to @newFirmVersion > (optional) @FailureExplanation`
- Date & time modified: `Date & time modified`
- Syslog message lost (buffer is full)
- MiCOM S1 Settings updated

The following operations are NOT logged:

- Device shutdown
- Sensitive information such as passwords

Note: The security log is saved in the flash memory and is preserved when the C26x is rebooted. It is not possible to modify or delete the security log except by erasing the flash memory.

The security log can be sent to a central repository (Syslog server) if it is defined in the configuration database. When a Syslog server is **enabled**, the C264 sends its log messages on the configured server as soon as they are generated.

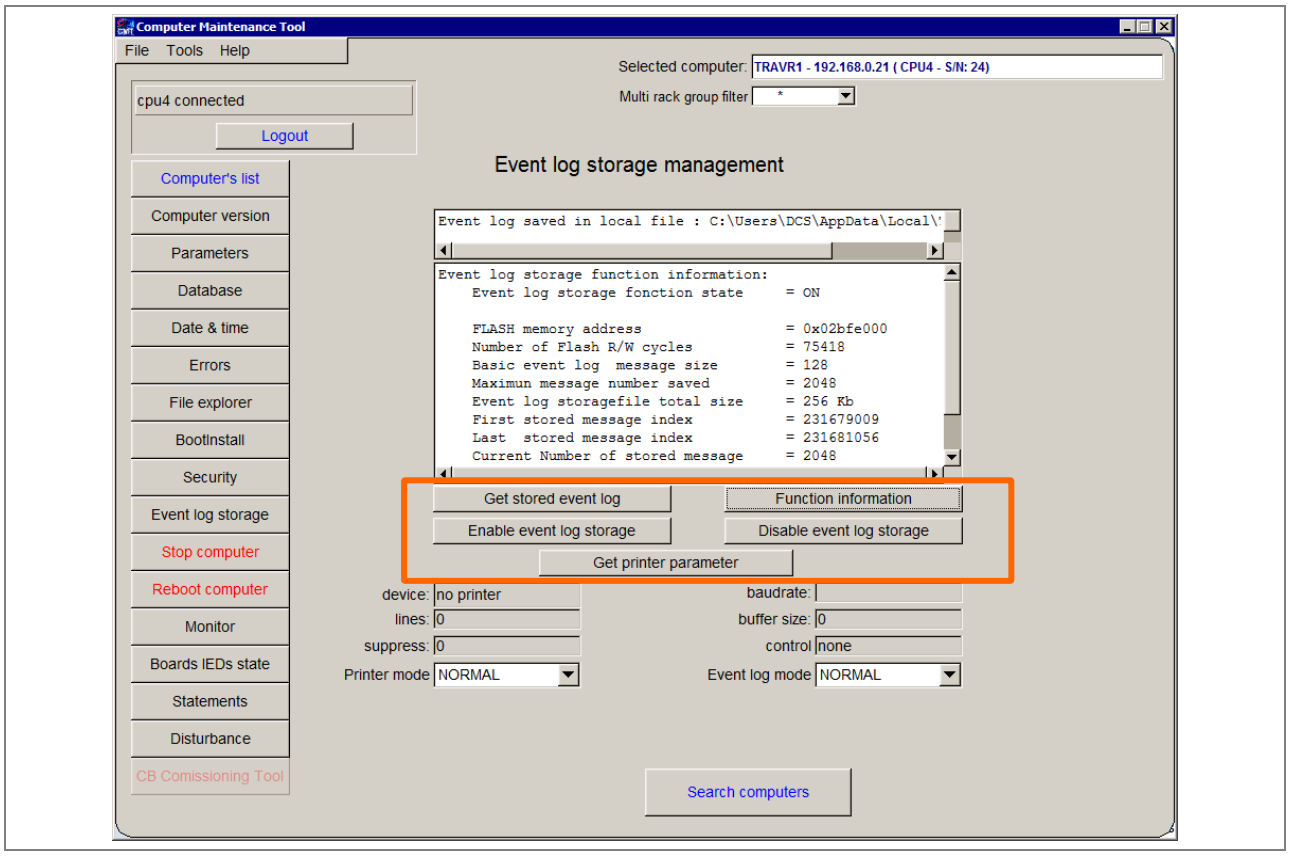
Note: The C264 always logs messages locally, regardless of the presence of a Syslog server.

Whether logs occurring during a communication loss are received, the process depends on the communications protocol. If the communication protocol is **different from UDP**, the C264 is informed of the communication loss. It stores its date and time and transmits the intervening logs when the communication is restored.

9.1.4.9 EVENT LOG STORAGE

This section reads or changes event log storage from or to the C26x.

9.1.4.9.1 Event log storage management



Function Information

"Function information" gives information about event log storage mechanism.

Enable/Disable event log storage

"Disable event log storage" (default state) disables event log storage mechanism. The state is updated in function information window.

```
Event log storage function information:
    Event log storage fonction state     = OFF
```

"Enable event log storage" (default state) enables event log storage mechanism. The state is updated in function information window.

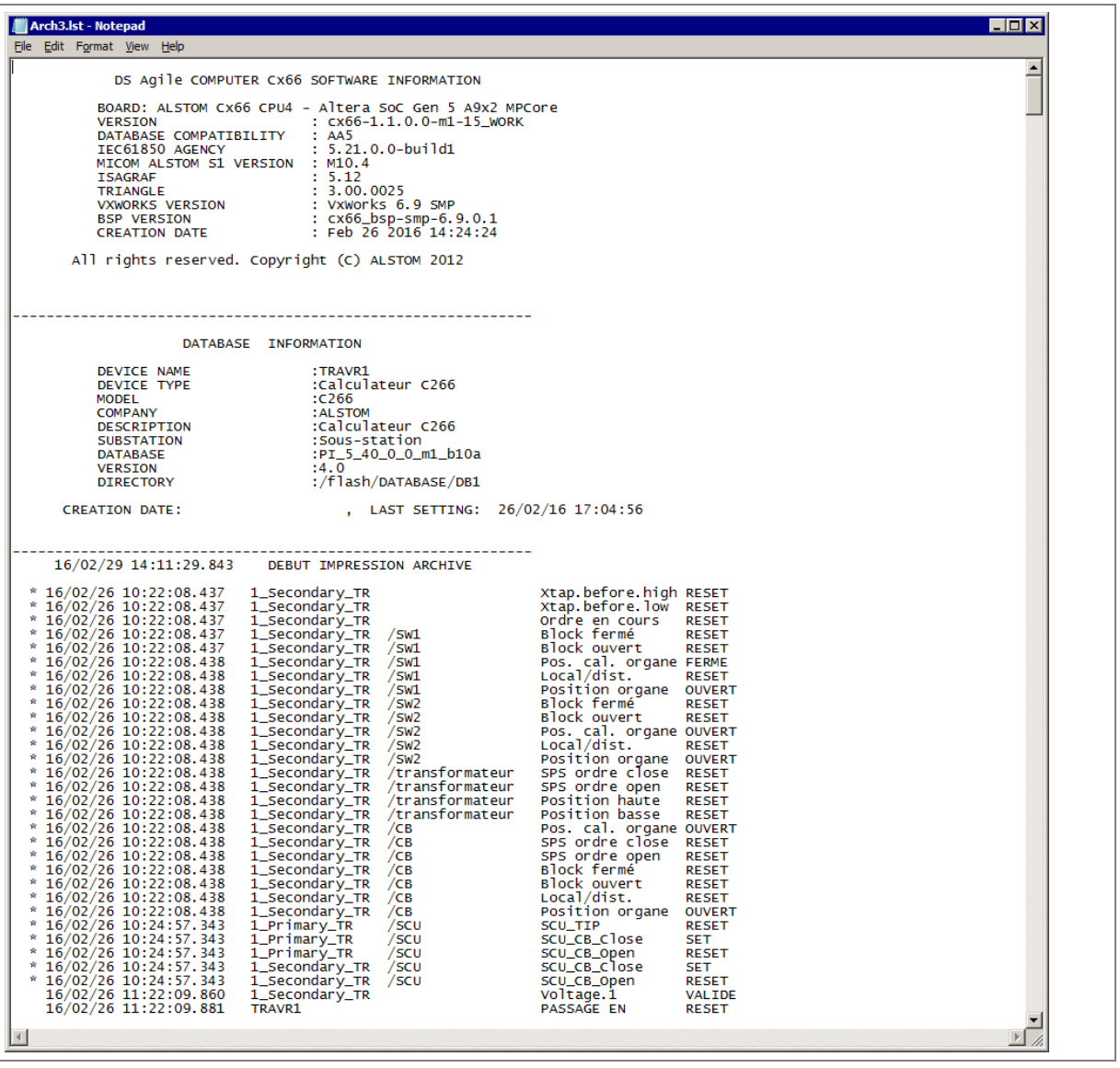
```
Event log storage function information:
    Event log storage fonction state     = ON
```

Get stored event log

"Get stored event log" reads event log saved in the C26x flash memory, transfers it in a "temporary" file: c:\Temp\ArchX.lst

```
Event log saved in local file :  c:\Temp\Arch2.lst
```

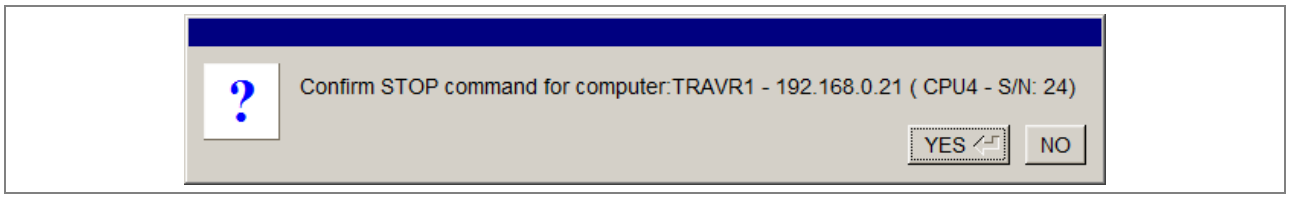
and opens a "notepad" window.



The file can be edited, printed, saved like a regular PC file.

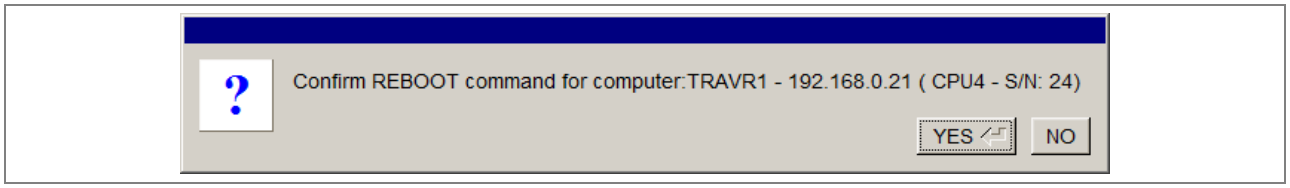
9.1.4.10 STOP COMPUTER

This operation stops the selected C26x application software. It suspends all tasks except "SYNCHRO" and "SUPERV". A confirmation is needed.



9.1.4.11 REBOOT COMPUTER

This operation reboots the selected C26x. A confirmation is needed.



Notes

The output of a PSL automation can be altered by such a reboot; in this case, it is preferable to reboot through the shell.

9.1.4.12 MONITOR

This panel displays, for each board, with or without automatically refreshing:

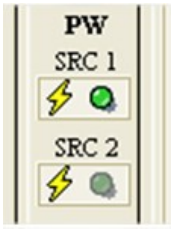
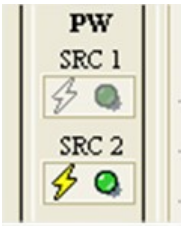
- the board status:
  - Green label for *PRESENT* and *CONFIGURED*
  - Blue label for *MISSING*
  - Grey label for *NOT CONFIGURED*
- the states of the inputs (green virtual LEDs) and outputs (red virtual LEDs):
  - "Lit" for *ON* / *CLOSED*
  - "Extinguished" for *OFF* / *OPEN*
  - None for *NOT CONFIGURED*
- the channel statuses: *VALID* / *INVALID* / *CONFIGURED* / *NOT CONFIGURED*

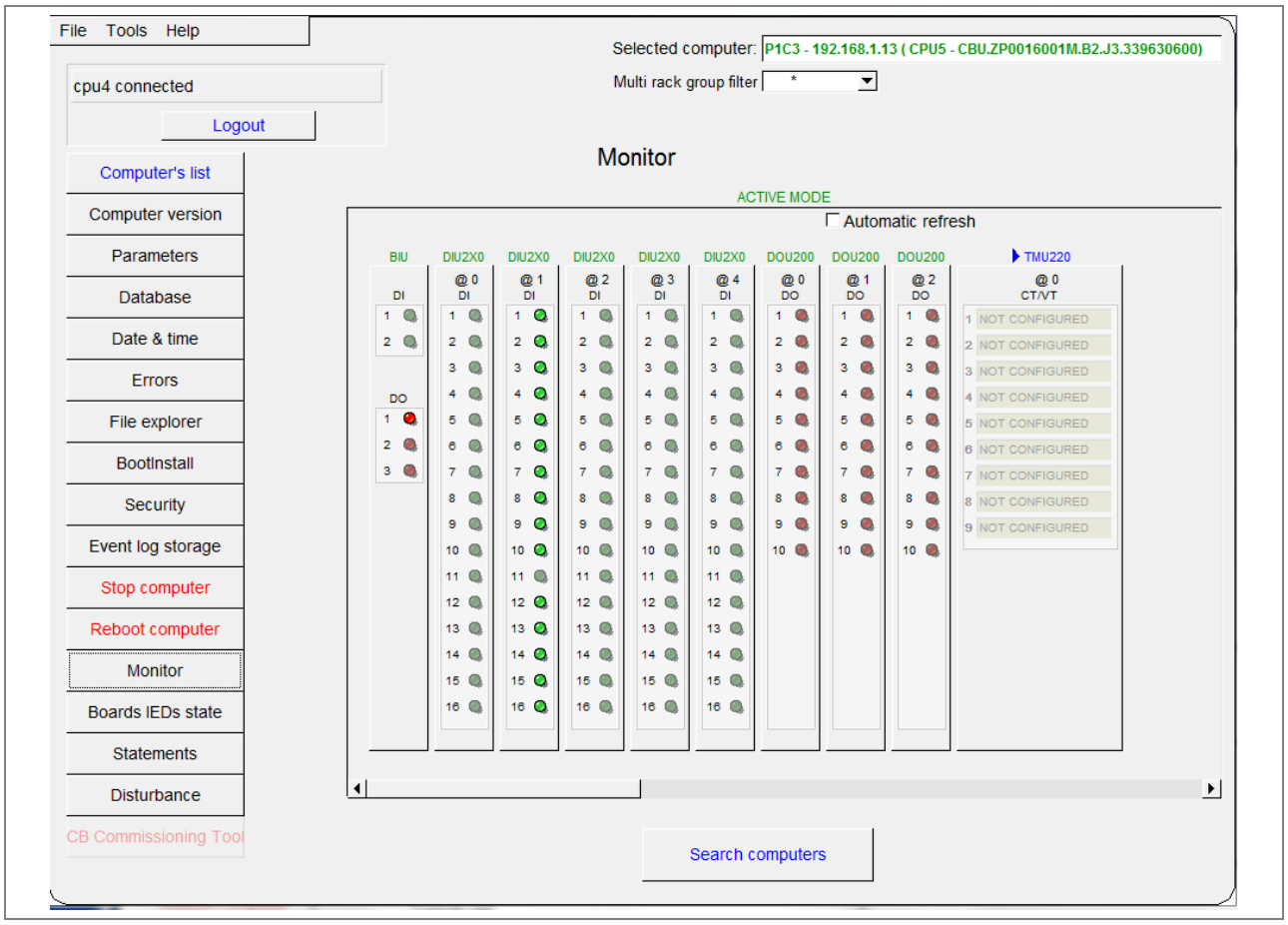
Particular case: BIU261D

If a dual input power supply board (BIU261D) is present, the state of each power supply input is shown in the BIU column, under the state of the board's DOs, in the form of a virtual "LED" with a lightning bolt symbol to the left:

Symbol	Meaning
	The power supply source is not available
	The power supply source is available
	The power supply input is not in use
	The power supply input is in use

Examples:

	
Power supply source 1 is available Power supply source 2 is available ➔ Power supply input **1** is used	Power supply source 1 is not available Power supply source 2 is available ➔ Power supply input **2** is used


File Tools Help
Selected computer: P1C3 - 192.168.1.13 (CPU5 - CBU.ZP0016001M.B2.J3.339630600)
Multi rack group filter *
cpu4 connected
Logout
Monitor
Computer's list
Computer version
Parameters
Database
Date & time
Errors
File explorer
BootInstall
Security
Event log storage
Stop computer
Reboot computer
Monitor
Boards IEDs state
Statements
Disturbance
CB Commissioning Tool
ACTIVE MODE
Automatic refresh
BIU
DIU2X0
DOU200
TMU220
DI
DO
CT/VT
NOT CONFIGURED
Search computers

9.1.4.13 BOARDS AND IEDS STATE

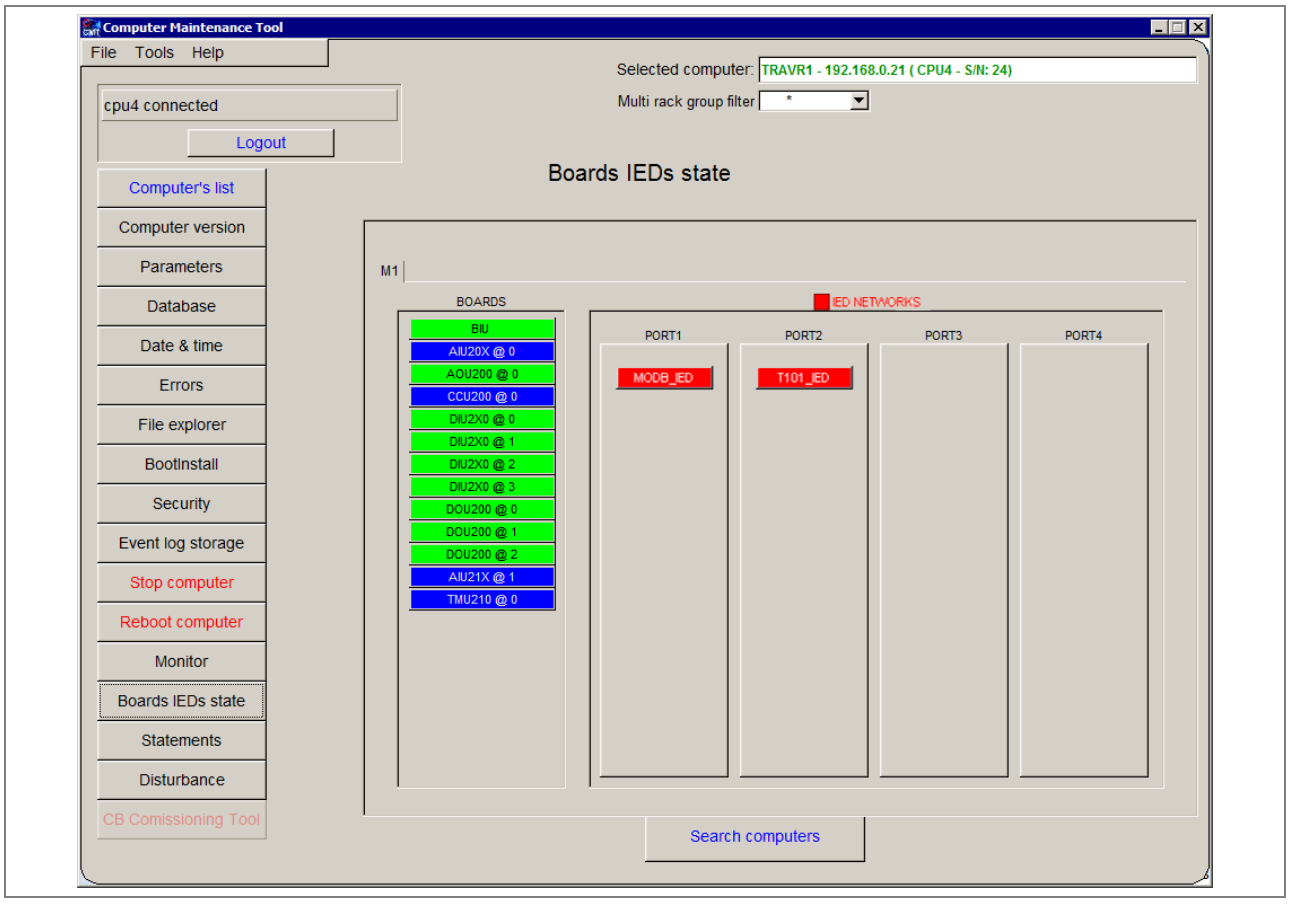
This panel displays:

- the state of the boards
- the main racks and their extensions (if applicable)
- the data from max 1 main and 32 extensions
- the configured boards' states:
  - Green for *OK*,
  - Blue for *MISSING/FAILURE*,
  - Red for *BOARD FAILURE*)

  and SCE index (@0, @1, etc)

Note:
If two or more boards of the same type have the same address, e.g. "@0", they will be displayed in BLUE, not red.

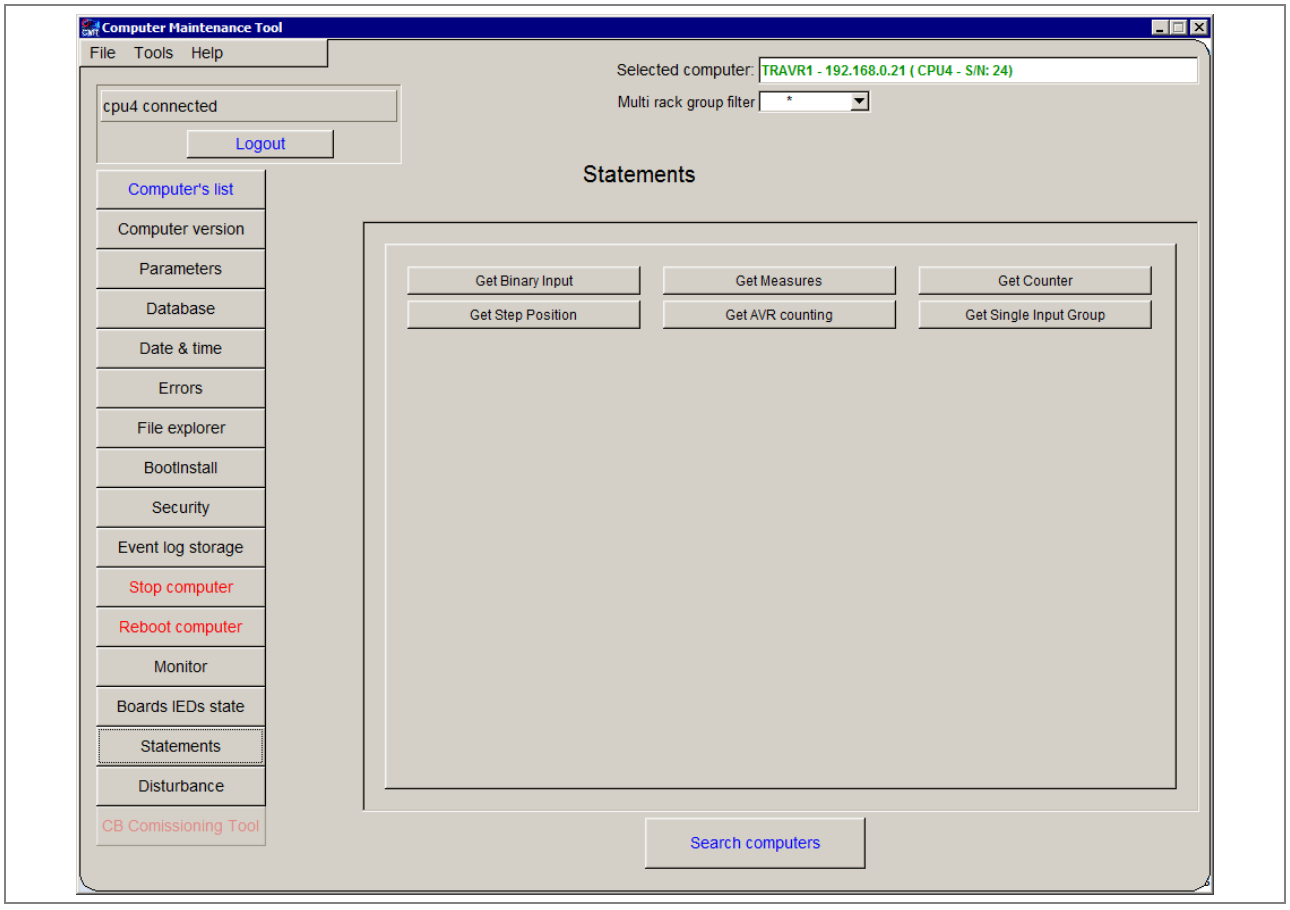
- the communication state of the configured IEDs in the rack / on a serial port (max 16 IEDs x 4 ports):
  - Green for *IED CONNECTED*
  - Red for *IED DISCONNECTED !* and for *IED HAS AN UNKNOWN STATUS*



9.1.4.14 STATEMENTS

This panel displays datapoints current status / values in a Notepad viewer:

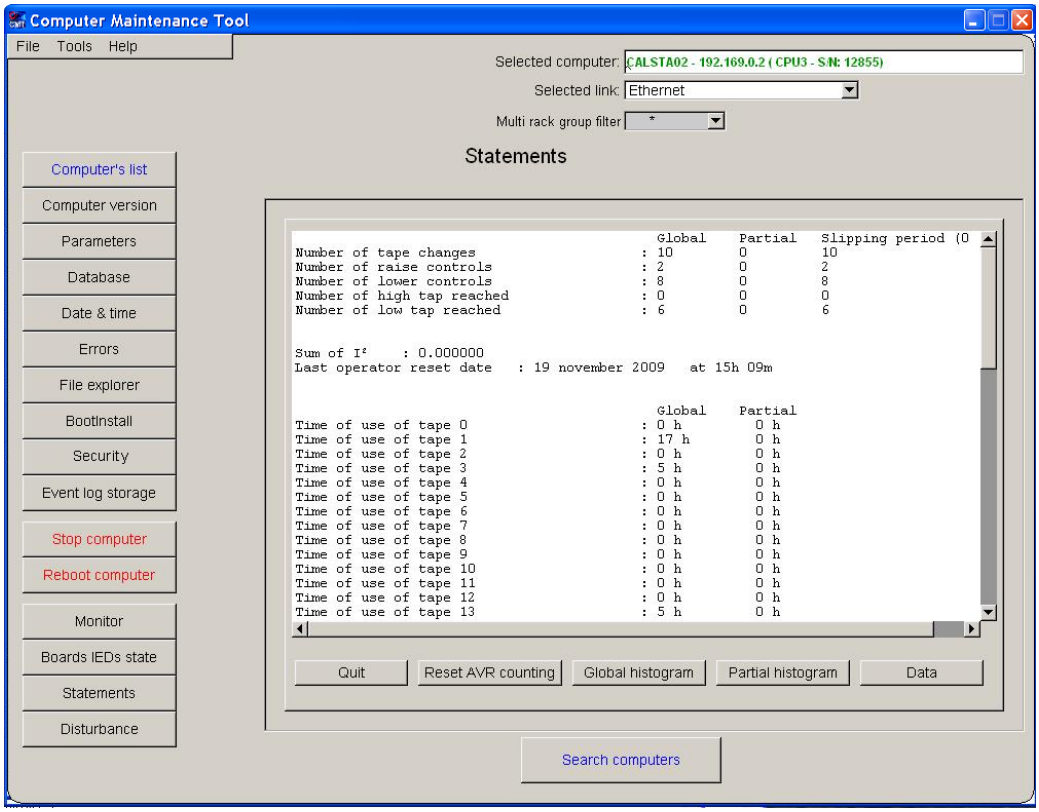
- Binary Inputs
- Measurements
- Counters
- TPI (Step Position Information)

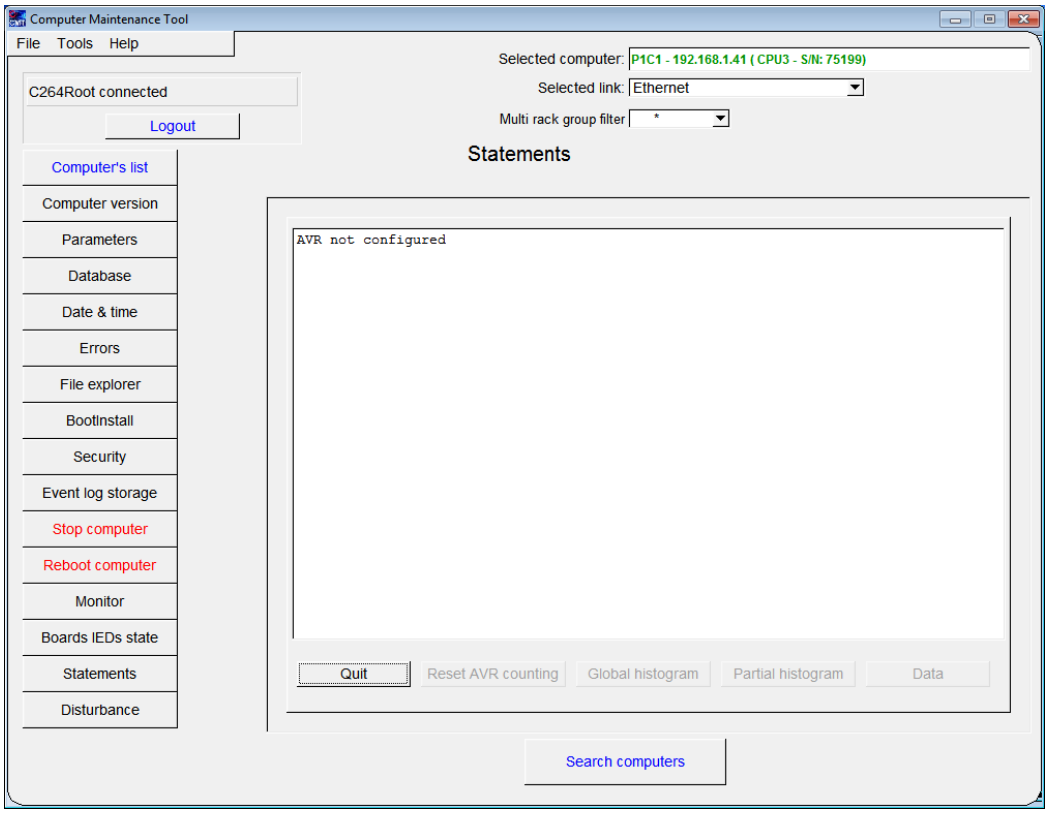


Example: TPI in conjunction with the AVR function

The AVR function (refer to the chapter C26x/EN FT) includes counting the number of tap changes and times of use of tape changers. CMT enables the operator to view them

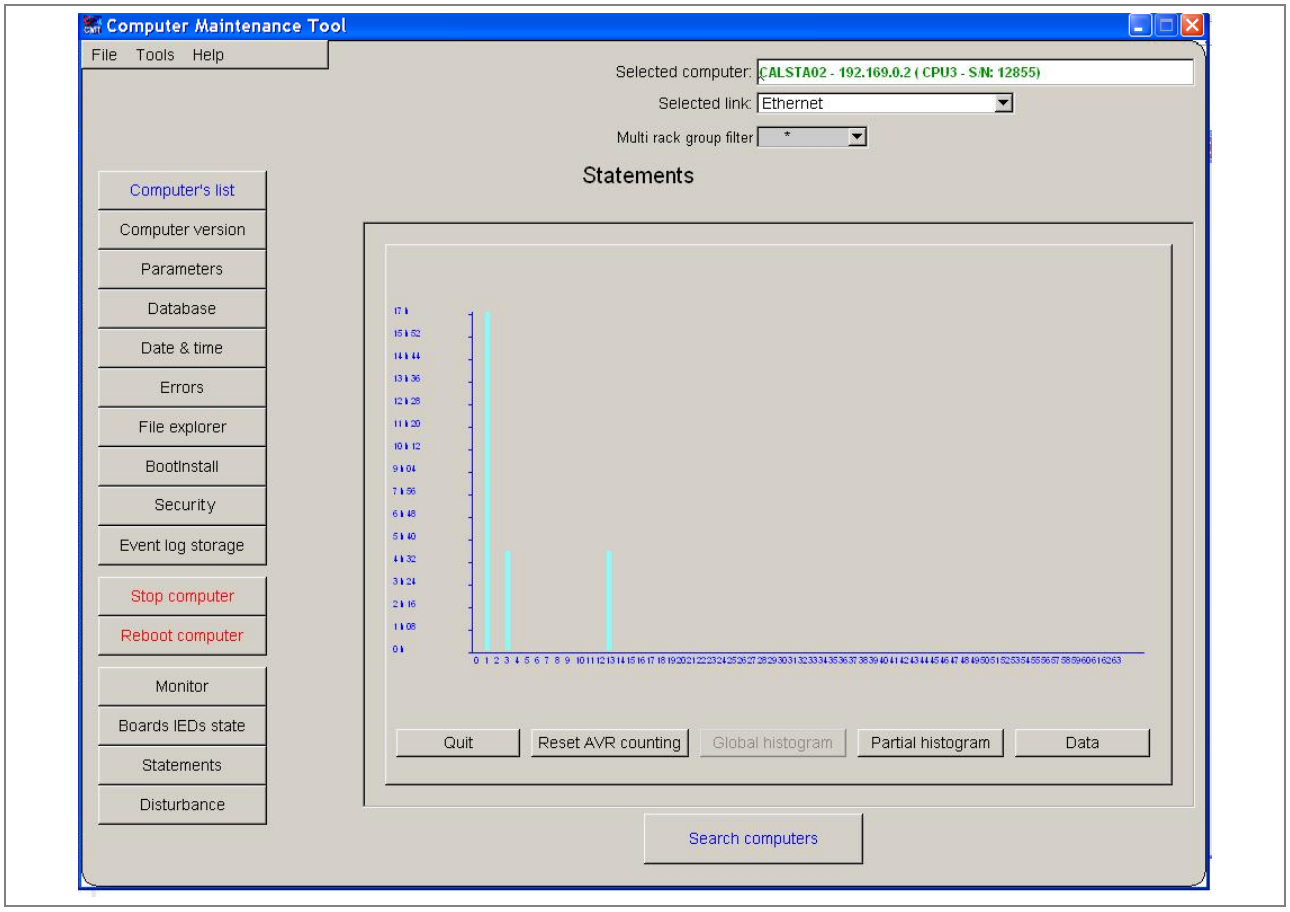
- since the C26x init (Global)
- since the latest reset time (Partial)
- permanently on a slipping period set in DS Agile S1 (refer to chapter C26x/EN ST):





Press the button **Reset AVR counting**; this refreshes the page and sums the I² and times of use of each tape (0 to 63).

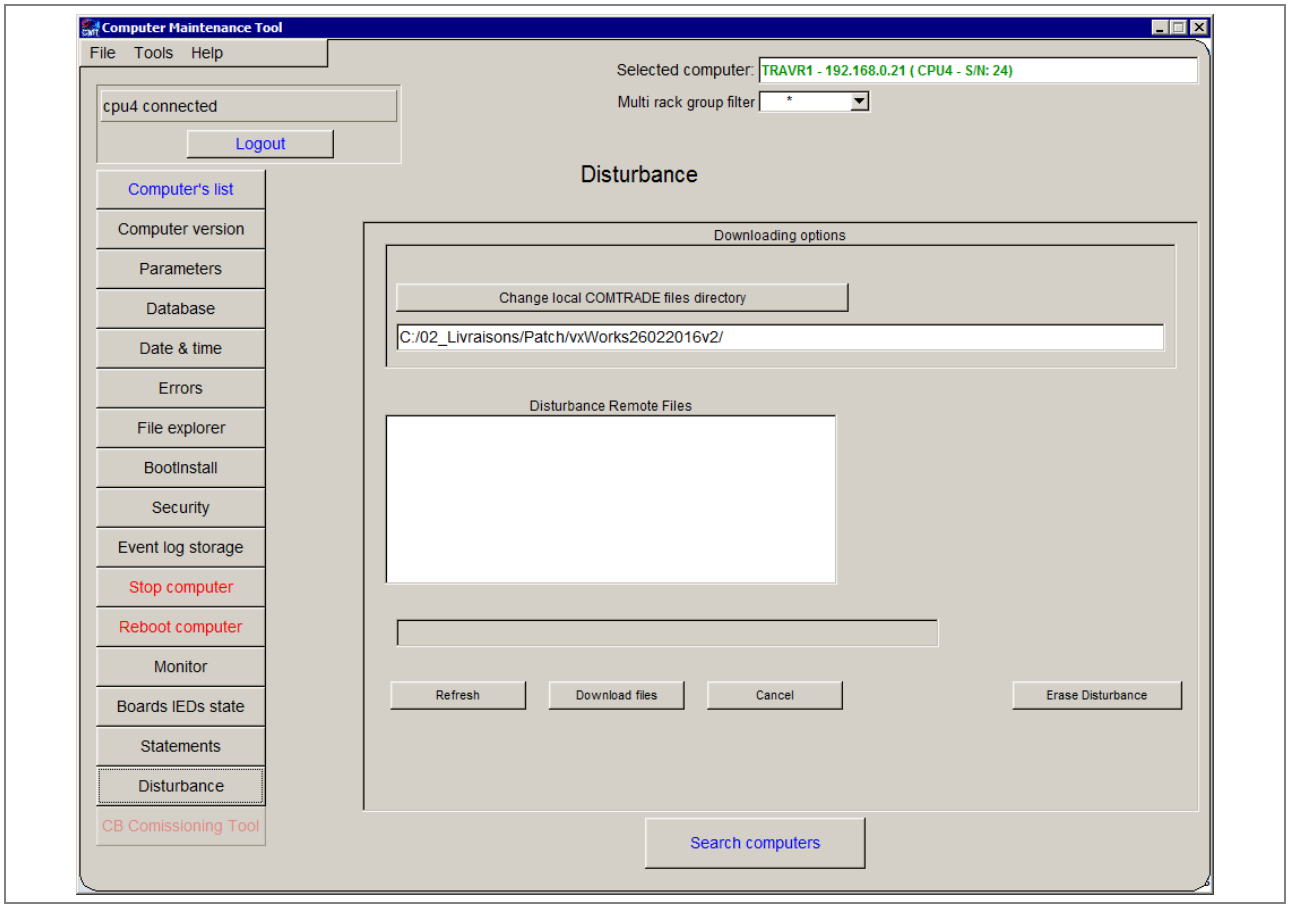
Press either **histogram** button to view the Pareto charts:



9.1.4.15 DISTURBANCE

This allows to:

- display the list of slow and fast waveforms
- download from the C26x to the CMT the slow and fast waveform files
- convert automatically these files to COMTRADE 2001
- optionally delete file(s) after successful transfer



The list of disturbance files is displayed in the central text area.

To refresh it, press **Refresh**.

The button **Erase Disturbance** is used to erase the Fast WaveForm files from the C26x's memory.

APPLICATION

C26X/EN AP/E72E

Contents

1	**SCOPE OF THE DOCUMENT**	**5**
2	**CONFIGURATION SCOPE FOR THE C26X**	**6**
2.1	**General DS Agile system configuration**	**6**
2.2	**DS Agile C26x Configuration**	**6**
2.3	**Spare object**	**7**
2.4	**Smart tables**	**8**
3	**DEFINING A C26X CONFIGURATION IN THE SYSTEM HIERARCHY**	**9**
3.1	**Setting the system parameters relevant to C26x units**	**9**
3.1.1	General parameters	9
3.1.2	Labels	10
3.1.3	Alarm	12
3.1.4	Computer routing	12
3.1.5	Cyber security	13
3.1.6	IEC 61850 attributes	13
3.1.1	Scs Time Synchronisation	14
3.2	**Adding and configuring a C26x in the system's architecture**	**16**
3.2.1	Setting the general attributes of a C26x	18
3.2.2	Configuring binary input (BI) filtering	19
3.2.3	Configuring measurement acquisition and transmission	21
3.2.4	Configuring counter acquisition	22
3.2.5	Miscellaneous attributes	22
3.2.6	IEC61850 Capabilities attributes	23
3.2.7	C264 Time Synchronization	24
3.2.8	Locating a C26x in a substation (mandatory)	26
3.2.9	Defining a C26x redundancy (optional)	27
3.3	**Adding C26x hardware components**	**28**
3.3.1	Adding boards	28
3.3.2	Setting the common attributes of C26x boards	30
3.3.3	Setting the specific attributes of each C26x board	30
3.3.4	Configuring a communication channel	43
3.3.5	Configuring the CPU4 board	44
3.3.6	Configuring an AI channel	48
3.3.7	Configuring an AO channel	49
3.4	**C26x IP address and routing table definition**	**50**
3.4.1	C26x as a gateway connected to a router and a remote IEC104 SCADA	50
3.5	**Networking a C26x on the station-bus network**	**55**
3.5.1	Connecting a C26x to other station-bus sub-systems	55
3.5.2	Defining the address map of a station-bus network	70
3.5.3	Addressing a datapoint on the SBus or PBus network	92
3.6	**Networking IEDs on a C26x's legacy network**	**93**
3.6.1	Creating a legacy network of IEDs	93
3.6.2	Defining the address map of a legacy IED	102
3.6.3	Addressing a datapoint on an IED legacy network	127
3.7	**Networking a SCADA on a C26x SCADA network**	**128**
3.7.1	Creating a SCADA network	128

3.7.2	Defining the address map of a SCADA network	137
3.7.3	Addressing a datapoint on a SCADA legacy network	151
3.8	**Defining the management of waveform records**	**152**
3.8.1	Defining the management of IED disturbance records	152
3.8.2	Defining T103 IED extra information for disturbance records	152
3.8.3	Defining the management of waveform records acquired via the C26x's CT/VT board	155
3.9	**Defining a C26x klaxon**	**165**
3.10	**Setting system information for C26x components**	**165**
3.10.1	Setting general system information of a C26x	166
3.10.2	Setting system information of board	170
3.10.3	etting system information of a SCADA network	172
4	**DEFINING A DATAPOINT**	**173**
4.1	**Topology**	**173**
4.1.1	Electrical and system datapoints	173
4.1.2	Input and Output datapoints	173
4.2	**Creating a datapoint profile**	**174**
4.2.1	Overview	174
4.2.2	Using the Profiles table	175
4.2.3	Forbidden characters	175
4.2.4	Defining an xPS profile	176
4.2.5	Defining an MV profile	178
4.2.6	Defining a Counter profile	182
4.2.7	Defining an xPC profile	184
4.2.8	Defining a SetPoint profile	188
4.2.9	List of Predefined profiles	190
4.3	**Creating a datapoint**	**191**
4.3.1	Using an SPS datapoint	191
4.3.2	Using a DPS datapoint	194
4.3.3	Using an MPS datapoint	205
4.3.4	Using an MV datapoint	207
4.3.5	Using a TPI datapoint	213
4.3.6	Using a Counter datapoint	217
4.3.7	Using an SPC datapoint	219
4.3.8	Using a DPC datapoint	222
4.3.9	Using an MPC datapoint	225
4.3.10	Using a SetPoint datapoint	228
4.4	**Defining local archiving of datapoint events and alarms by the C26x**	**232**
4.5	**Defining the acquisition source for input datapoints**	**233**
4.5.1	Overview	233
4.5.2	Smart tables	233
4.5.3	Smart tables for TMU boards	234
4.5.4	Acquiring input datapoints via input channels	236
4.5.5	Acquiring an input datapoint via a non-DS Agile IEC61850-communicating IED	240
4.5.6	Producing an input datapoint	241
4.6	**Defining the control source for output datapoints**	**244**
4.6.1	Overview	244
4.6.2	Smart tables	244
4.6.3	Controlling an output datapoint via output channels	244
4.6.4	Controlling an output datapoint via a non-DS Agile IEC 61850-communicating IED	247

4.6.5	Producing an output datapoint	248
4.6.6	Acknowledgement definition in case of simultaneous orders	249
4.7	**Defining a datapoint association**	**250**
4.7.1	Adding a target datapoint	250
4.7.2	Linking the target datapoint to the original datapoint	251
4.7.3	Defining the states associations	252
5	**DEFINING A C26X CONFIGURATION IN THE ELECTRICAL HIERARCHY**	**253**
5.1	**Defining an electrical topology**	**253**
5.1.1	Defining a Site	255
5.1.2	Defining a Substation	255
5.1.3	Defining a Voltage level	264
5.1.4	Defining a Bay	266
5.1.5	Defining a Module	273
5.2	**Defining Condition monitoring functions**	**286**
5.2.1	Configuring the Circuit Breaker monitoring function	286
5.2.2	Configuring a Switchgear monitoring function	293
5.2.3	Configuring an OLTC monitoring function	296
5.2.4	Configuring the Motor Monitoring function	304
5.2.5	Configuring the Residual Life time function	308
5.3	**Defining a Synchrocheck function**	**312**
5.3.1	Circuit-breaker definition for synchrocheck	312
5.3.2	Creating a synchrocheck function	317
5.3.3	Internal synchrocheck automation	318
5.3.4	External synchrocheck	328
5.3.5	Synchrocheck pop-up in aView	330
5.3.6	Adding a Synchrocheck Type 5 Function	331
5.4	**Defining an Auto-recloser built-in function**	**343**
5.4.1	Auto-recloser behaviour	343
5.4.2	Creating an auto-recloser function	343
5.4.3	Adding an auto-recoloser function	344
5.4.4	AR Type 1	345
5.4.5	AR Type 3	353
5.5	**Defining a Tap changer built-in function**	**358**
5.5.1	Tap changer behaviour	358
5.5.2	Creating a tap changer built-in function	359
5.5.3	Setting the TPI parameters	361
5.6	**Defining an automatic voltage regulation – AVR – built-in function**	**365**
5.6.1	Creating an AVR function	365
5.6.2	Graphic section (example of operator workstation listing out the datapoints)	369
5.6.3	AVR behaviour	370
5.7	**Defining an electrical regulation by user function**	**383**
5.7.1	Datapoint Grouping	384
5.7.2	Controlling an xPC using an xPS state change	388
5.7.3	Producing a DPS from 2 SPSs	389
5.7.4	Defining an interlock	389
5.7.5	Defining an automatic/manual dependency	391
5.8	**Dynamic line rating (DLR)**	**391**
5.9	**Defining a Fresnel function**	**394**
5.9.1	Configuration	395

6	**PROCESS BUS NETWORK**	**403**
6.1	**System Configuration**	**403**
6.2	**Sample value Configuration (BCU)**	**409**
6.3	**Digital Input Configuration**	**417**
6.4	**Digital Output Configuration**	**419**
6.4.1	SPC/DPC without feedback	419
6.4.2	SPC with feedback	421
6.4.3	DPC with feedback	423
7	**DEFINING A C26X INTERFACE**	**425**
7.1	**Security disclaimer messages**	**425**
7.1.1	Description and Limits	425
7.1.2	Configuration	425
7.2	**Local HMI definition**	**428**
7.2.1	Defining a bitmap table	428
7.2.2	Defining a C26x workspace	430
7.2.3	Defining a C26x Bay mimic	431
7.2.4	Displaying a datapoint state through an LED	445
8	**DEFINING PROTECTION FUNCTIONS**	**446**
8.1	**Adding a Protection Function**	**446**
8.1.1	Common datapoints	447
8.1.2	Common Protection Function Attributes	448
8.1.3	Setting Group Management	449
8.1.4	Replicating one Protection Setting group to another	450
8.2	**[50/51/67] Phase Overcurrent protection**	**452**
8.2.1	Overcurrent Configuration	453
8.2.2	Stage Configuration	455
8.2.3	Replicate setting values of one setting group to another	461
8.3	**[50N/50G/51N/51G/67N] Earth Fault protection**	**462**
8.3.1	Earth Fault Configuration	463
8.3.2	Stage Configuration	466
8.3.3	Replicate setting values of one setting group to another	469
8.4	**[50BF] Circuit Breaker Failure protection**	**472**
8.4.1	CB Failure Configuration	473
8.4.2	Internal Initiation (optional)	475
8.4.3	External initiation	479
8.4.4	Limits	483

1 SCOPE OF THE DOCUMENT

This document describes how to configure the C26x unit.

To generate a template from an existing IEC 61850 compliant C26x, refer to the Human Interface chapter of the SCE user manual (section Tools menu).

2 CONFIGURATION SCOPE FOR THE C26X

2.1 GENERAL DS AGILE SYSTEM CONFIGURATION

To define a complete DS Agile system, three aspects must be considered:

The system topology contains de units that manage the customer's electrical process. Generally, these are supplied by GE Grid Solutions and they correspond to GE Grid Solutions' system process definition to meet the customer's needs.

The electrical topology represents the customer's electrical process definition in terms of typed electrical units (transformers, disconnectors, circuit-breakers…) that are connected to one another through busbars or lines. This information is normally provided by the customer.

The graphical topology contains the mimic diagrams and their associated animated graphics that will be displayed at the substation's control points (aView, the system HMI) and bay control points (C26x's front panel HMI).

When a new configuration is created using the SCE, these three topologies are automatically instantiated via root objects:

- A 'Site' object for the electrical topology, containing one 'Substation' object.
- A 'Scs' (acronym for Substation Control System) object for the system topology, containing one 'SBUS network' object and, optionally, one 'PBUS network' object if a process bus is used.
- A 'Graphic' object for the graphical topology.

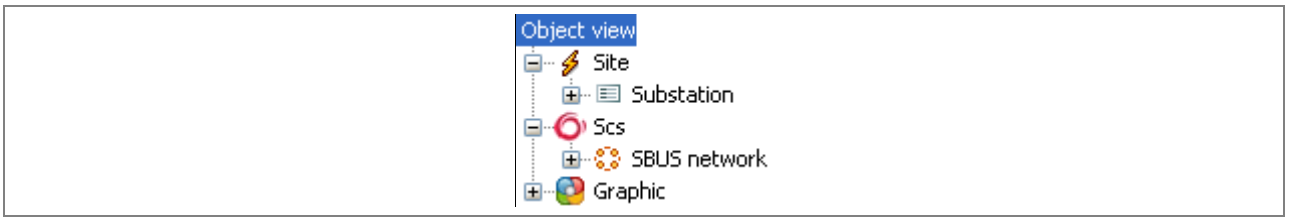


Figure 1: General architecture of a DS Agile configuration in the System Configuration Editor (SCE)

2.2 DS AGILE C26X CONFIGURATION

In the general DS Agile system configuration, the C26x is present in the three topologies:

- Electrical topology (**Site**): The C26x manages the bays and their associated modules or substation information.
- System topology (**Scs**):

  There are 2 default objects at the root of the SBUS network in the System hierarchy:

  - the **SMT** (System Configuration Tool): The **SMT** object is unique. It is automatically added when a database is created and it must be configured (see SMT/EN AP for details),
  - the **System Group**: The **System Group** contains the devices managing, monitoring and/or protecting one or more electrical bays.

    The C26x is a direct sub-component of the System Group.
  - DS Agile aView: a **System HMI** node must be added from the **Object entry** window.
- Graphical topology (**Graphic**): The C26x can be fitted with an LCD HMI to display animated graphics representing the bay's topology as well as information lists such as alarms, measurements, etc.

2.3 SPARE OBJECT

At DS Agile SCE level, a spare object is an object created for possible ulterior use or in order to disable an HMI command.

The label of a spare object is displayed in gray italic text in the Explorer window. The configuration of this object and of its spare attribute is the same as that of any other object and attribute.

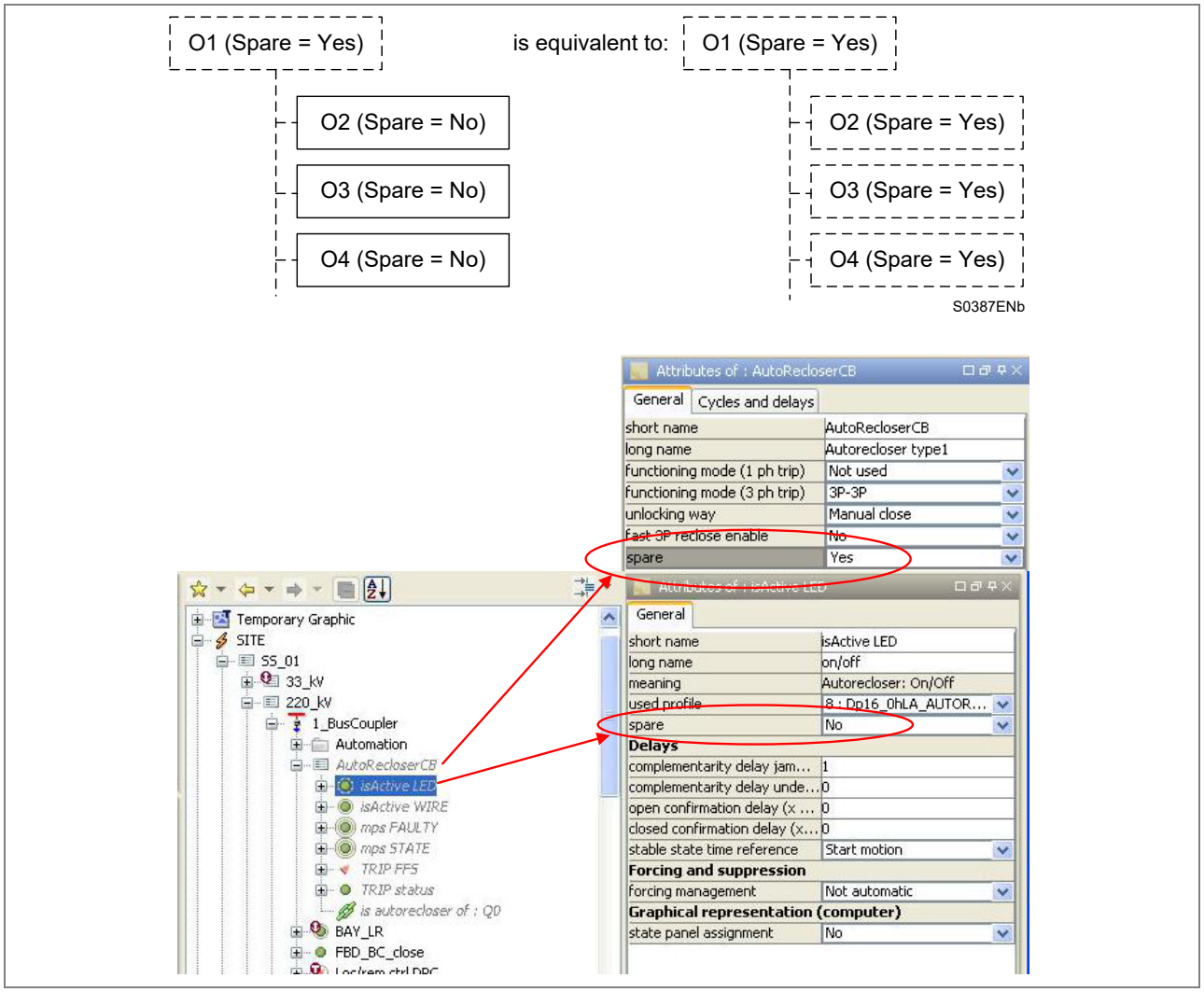
To configure an object as spare, simply set its ‘spare’ attribute to *'Yes'*.

Any object can be spared, including those used in the C26x's configuration.

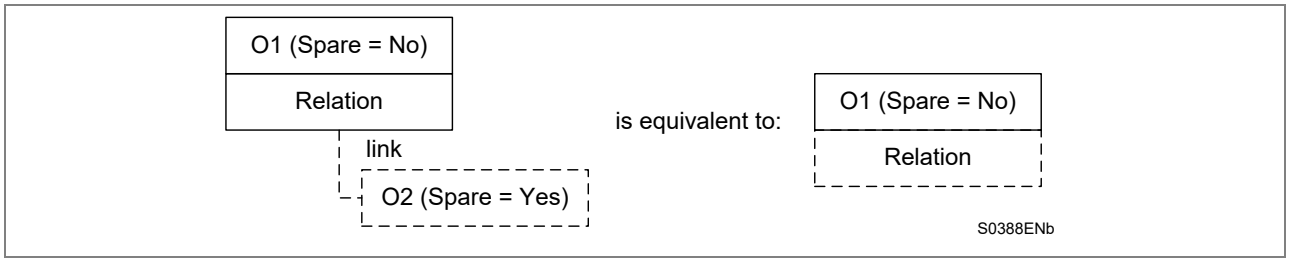
Spare objects are not passed on to the generator tools.

Object sparing follows these two rules:

- Objects O2, O3, O4, etc., not individually spared, are considered as spare objects if they are linked, directly or not, to a spare composite parent object (O1):

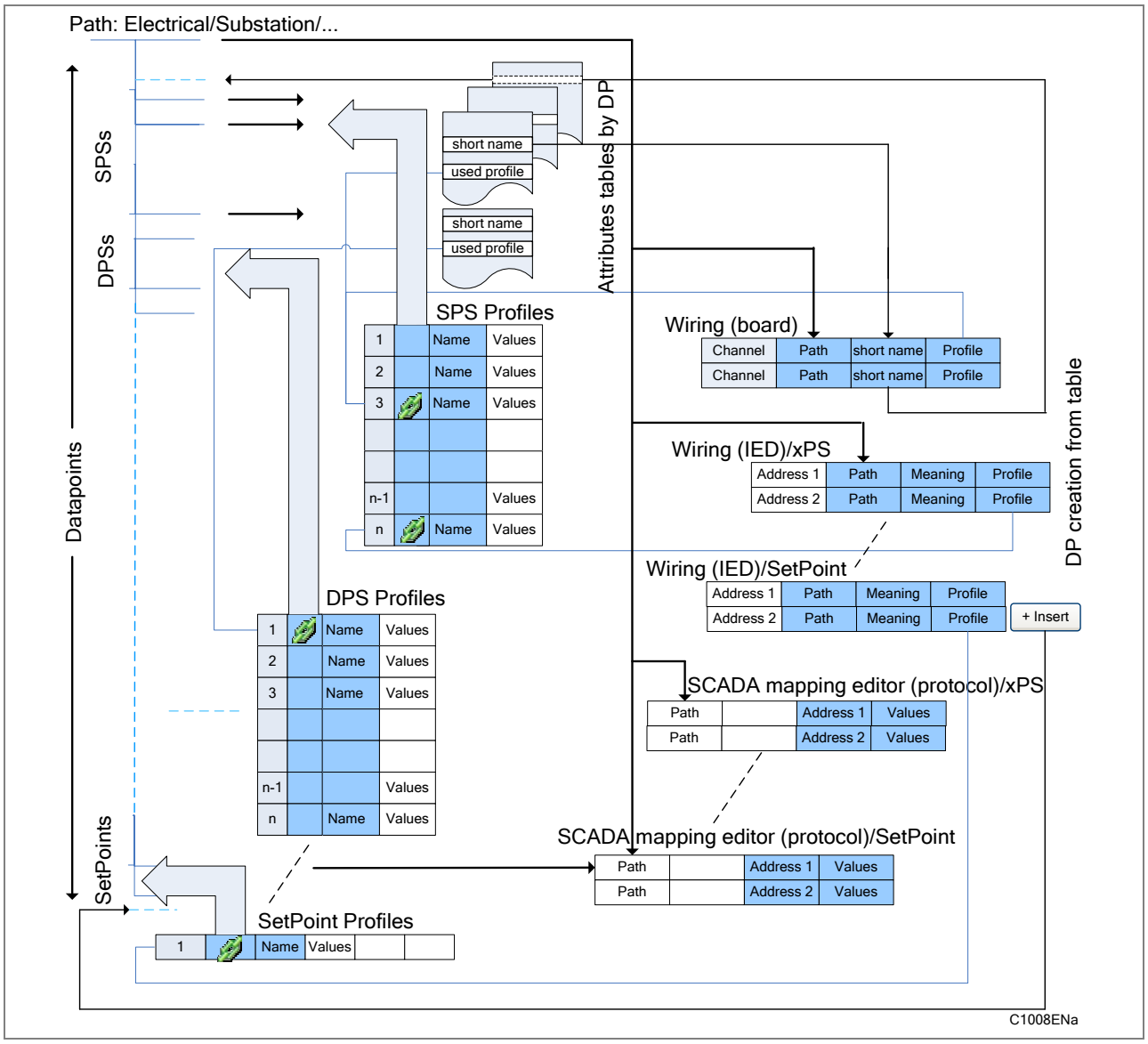


- A relation defined on an object O1, not spare, and linked to a spare object O2, is considered as a relation with no link:



2.4 SMART TABLES

Several autofill tables can be invoked to speed up input. They are detailed in the corresponding sections. The interactions between tables are sketched in this figure:



3 DEFINING A C26X CONFIGURATION IN THE SYSTEM HIERARCHY

3.1 SETTING THE SYSTEM PARAMETERS RELEVANT TO C26X UNITS

System configuration is done at the Scs root. It defines the global behaviour of DS Agile units.

It encompasses these attributes:

- Common labels used for control acknowledgement, time quality logging, alarm management logging, C26x board management.
- Alarm management characteristics (alarm processing type, sound time-delays, alarm clearing modes per level of gravity).

as well as the relations that define operators' action rights on system datapoints.

3.1.1 GENERAL PARAMETERS

Some Scs object attributes affect all the C26x units defined in the substation network:

(1) **Firewall usage**: not available with CPU4 board

(2) **Password:** These fields are no longer used. The user accounts and passwords are defined using the CMT only. See Installation chapter for information on default account/password and how to create/change accounts and passwords.

(3) **time zone**: used for timestamp information

(4) **Behaviour on DOU, CCU, HBU or AOU failure** (Control refused on faulty board / Computer goes in fault mode)

(5) **SBMC management for group** (No / Yes): management of SPS groups when some of the SPS that they contain are managed by a bay in SBMC mode:

- *No*: SPS groups will disregard the fact that some of the SPS that they contain are managed by a bay in SBMC mode and will keep taking their states into account,
- *Yes*: SPS groups will not consider any SPS managed by a bay in SBMC mode and will ignore their states.

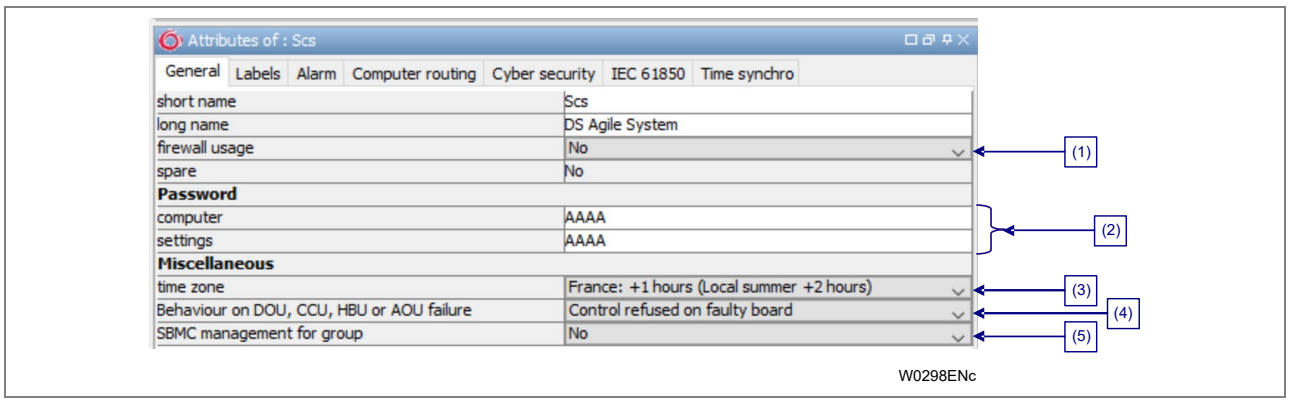


Figure 2: General attributes of Scs objects

3.1.2 LABELS

(6) **board and status Labels**

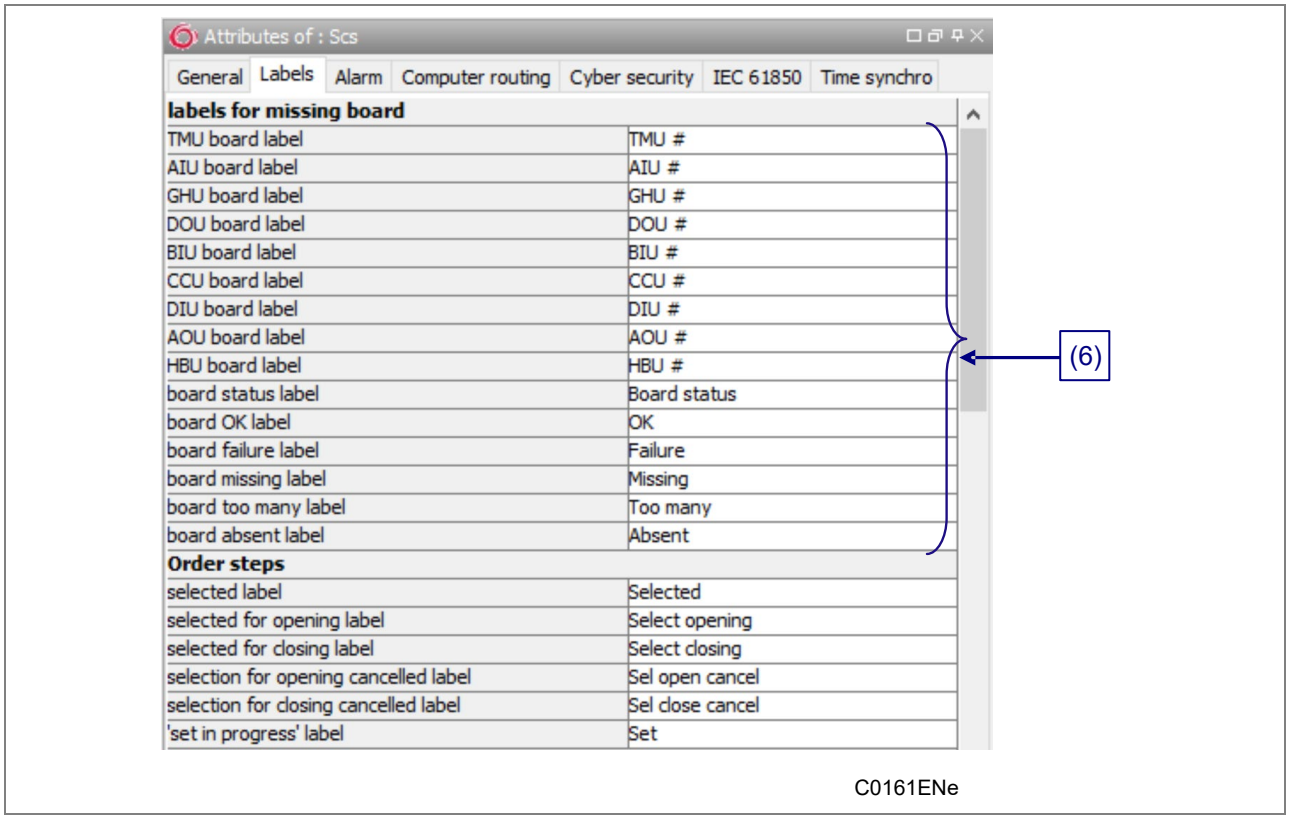


Figure 3: Labels attributes of Scs objects (1/2)

(7) Control acknowledgement Labels used for order logging

Control acknowledgement	
'OK acknowledgement' label	Ack. OK
'IncoherentRequest' label	KO- incoh. order
'ComputerNotReady' label	KO- init. comp.
'BaySubstModeFault' label	KO- bay/sub mode
'ControlModeFault' label	KO- ctrl mode
'DeviceLocked' label	KO- device lock.
'RequestInProgress' label	KO- req running
'InterlockNOK' label	KO- interlock
'DeviceAlreadyInPos' label	KO- already set
'HWFault' label	KO- DO fault
'PosInvalid' label	KO- invalid pos
'TimeOut' label	KO- timeout
'AutomationRunning' label	KO- Automatism
'DeviceAlreadySelected' label	KO- already sel.
'DeviceNotSelectable' label	KO- not selec.
'UniquenessIncoherency' label	KO- uniqueness
'NotSelected' label	KO- sel. requir.
'OperatorCancel' label	KO- cancel
'Feedback TimeOut' label	KO- feedback
'AckFailedOrder' label	KO- failed order
'BadTCIP' label	KO- timeout TCIP
'TCIPTooLong' label	KO-TCIP too long
'BadTap' label	KO- bad position
'MinTap' label	KO- min position
'MaxTap' label	KO- max position
'DeviceFailedToOperate' label	KO- absent IED
'SynchroNOK' label	KO- synchrocheck
'global ATCC off' label	KO- ATCC off
'ATCC transformer maximum' label	KO- ATCC trf max
'ATCC invalid topology' label	KO- ATCC inv top
'ATCC invalid TPI' label	KO- ATCC inv TPI
'ATCC disconnected transformer' label	KO- ATCC dis trf
'ATCC MCB trip' label	KO-ATCC MCB trip
ATCC invalid voltage transformer' label	KO-ATCC inv Vtrf
ATCC invalid voltage bus' label	KO-ATCC inv Vbus
'Param change in exec' label	KO-Param ch exec
'Select failed' label	KO-Select failed
'ICT open' label	KO-ICT open
'unknown IEC61850 name' label	Unkwn IEC name
'rejected by HMI' label	rejected by HMI
'Timeout in IOModule' label	HMI time-out
'Unknown IEC61850 Err Code' label	unkwn IEC Error
Timestamp quality labels	
'SyncTime' state label	Synchronized
'NotSyncTime' state label	Not synchronized

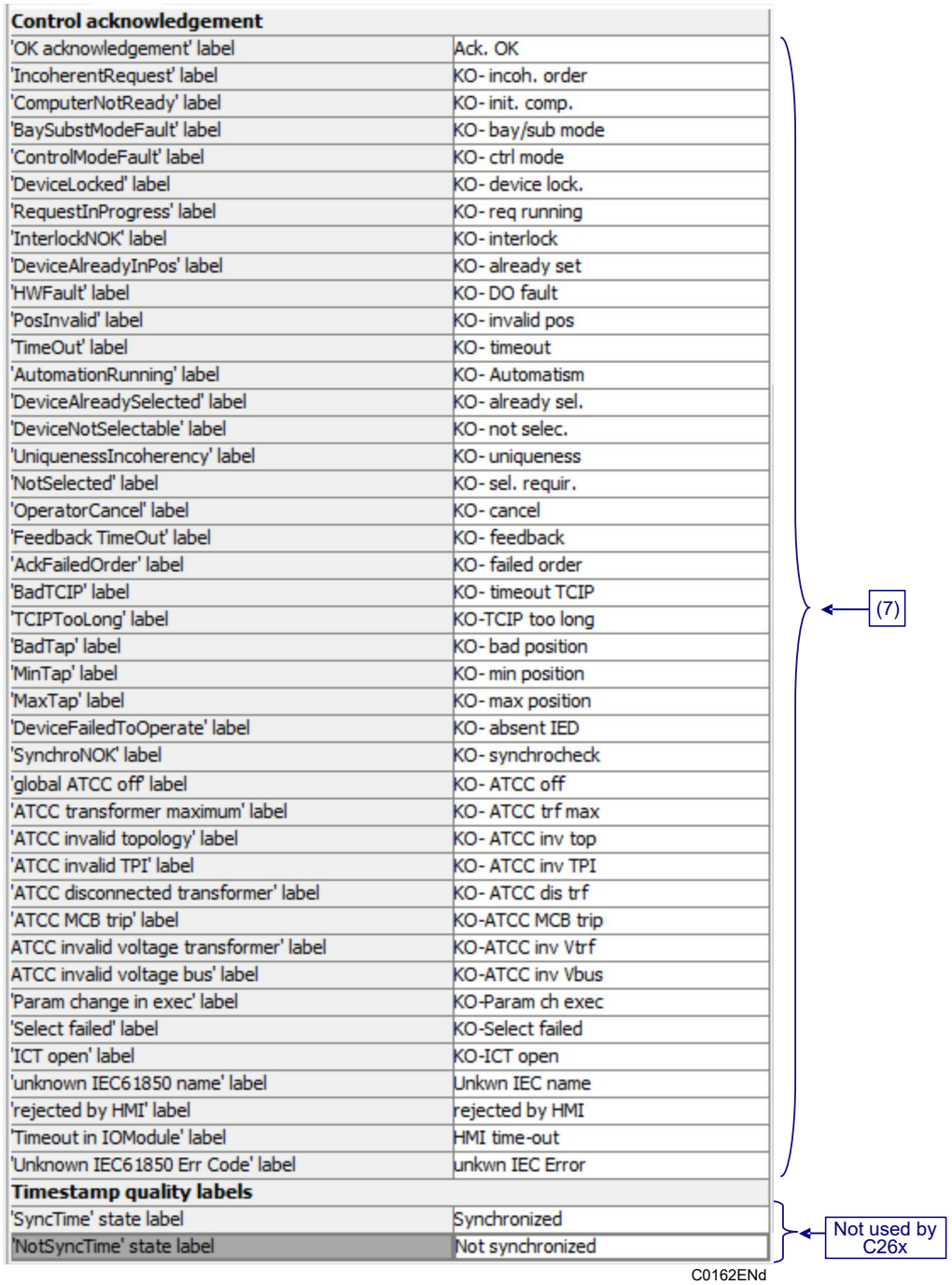


Figure 4: Labels attributes of Scs objects (2/2)

3.1.3 ALARM

(8) **Alarms managed on computer** (*No/Yes*): attribute indicating whether alarms are managed by the C26x. Client-specific, always keep the default value of *Yes*.

(9) **Gi (1≤i≤:5) default alarm clearing mode** (*Manual* / *Automatic*)

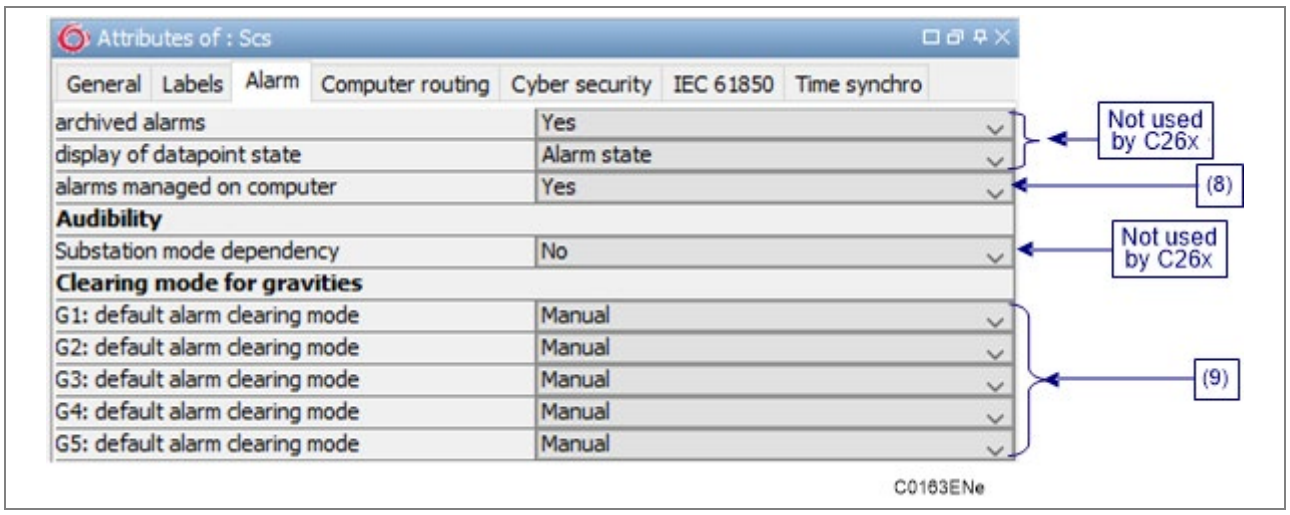


Figure 5: Alarm attributes of Scs objects

3.1.4 COMPUTER ROUTING

(10) **Computer routing attributes**

- **Gateway TCP/IP address**: IP address of the intermediate “Router” (if present)
- **Target TCP/IP address**: IP address of the authorized remote “Client” (Scada, …)

Please see section *3.4 C26x IP address and routing table definition* for further details.

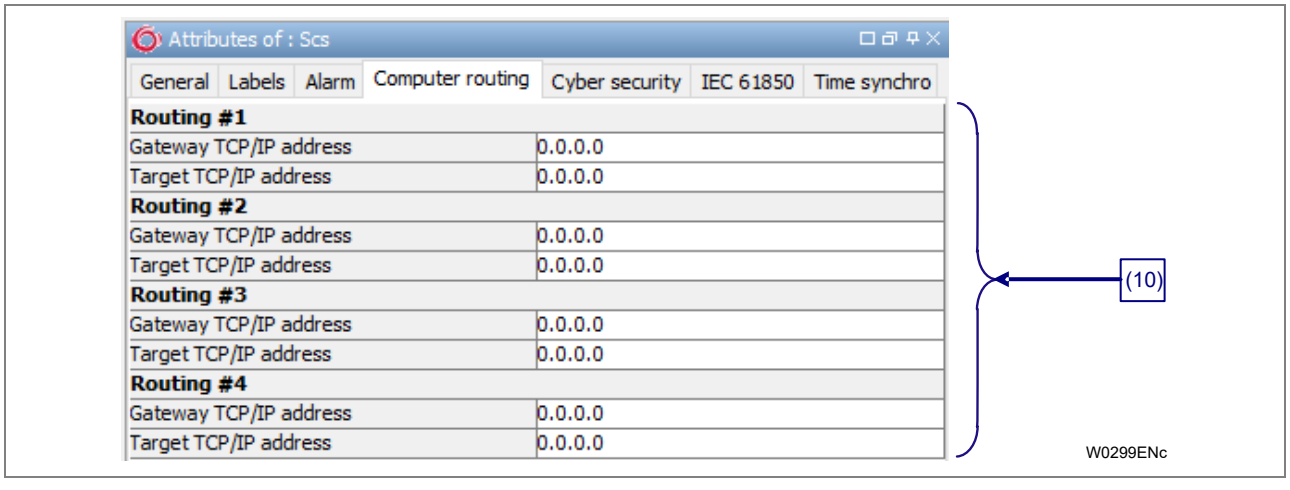


Figure 6: Computer routing attributes of Scs objects

3.1.5 CYBER SECURITY

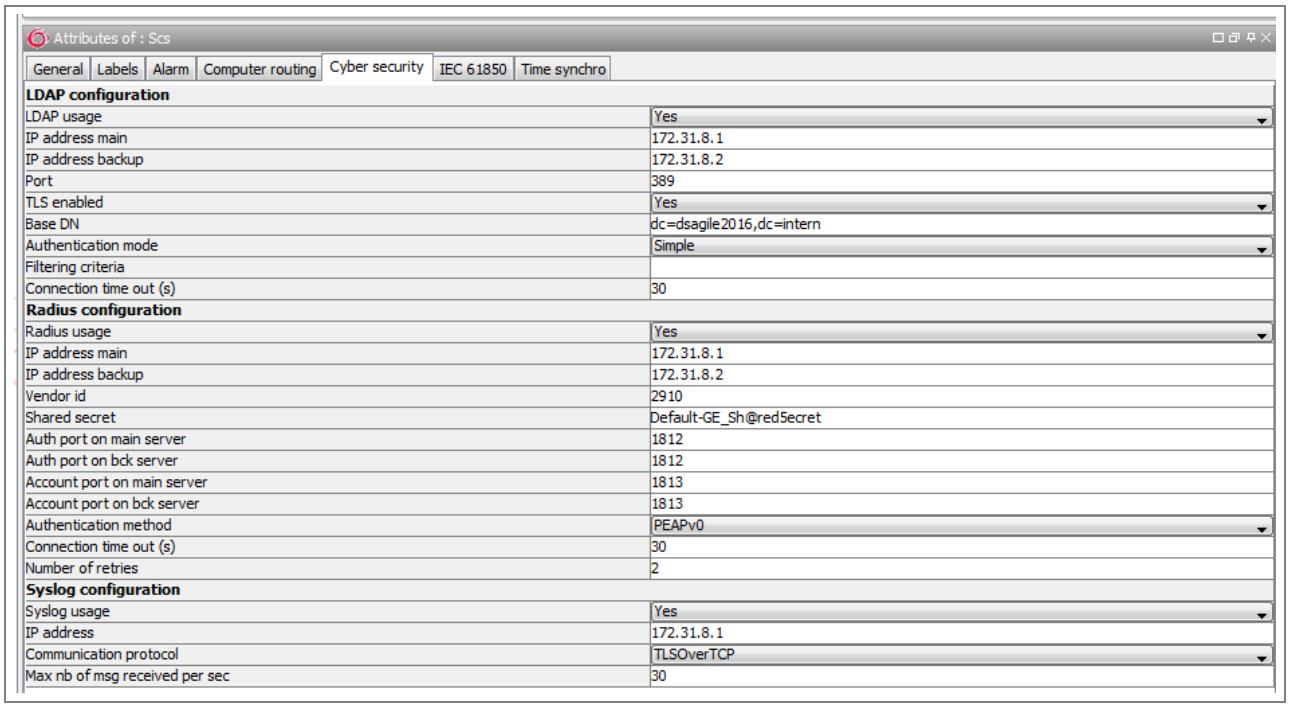


Figure 7: Cyber security attributes of Scs objects

Set **LDAP usage** to **No**, as LDAP is not supported,

Set **RADIUS usage** to **Yes** if the C26x is connected to a centralized authentication server,

Set **Syslog usage** to **Yes** if the C26x sends its log files to a central log repository.

Then set the corresponding attributes as described in the Secure Deployment Guide user manual (SDG_enM_XXX).

3.1.6 IEC 61850 ATTRIBUTES

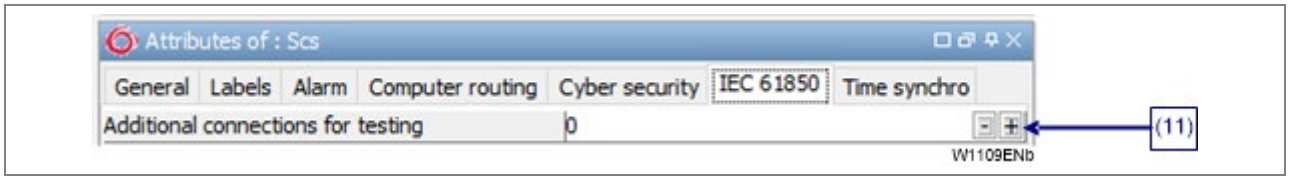


Figure 7: IEC 61850 attributes of Scs objects

(11) **Additional connections for testing ([0, 10], step 1)**: Indicates the number of testing devices that may be connectec to the network. It is used by DS Agile devices only.

3.1.1 SCS TIME SYNCHRONISATION

Time synchronization parameters can be set at Substation Control System (SCS). In that case, all C264 units connected to the station-bus network through NTP/SNTP (Simple Network Time Protocol) inherit synchronization parameters from the SCS. Depending on your application, it is possible to configure each C26x computer individually to set specific synchronization parameters as explained in section ***3.2.7 C264 Time Synchronisation***.

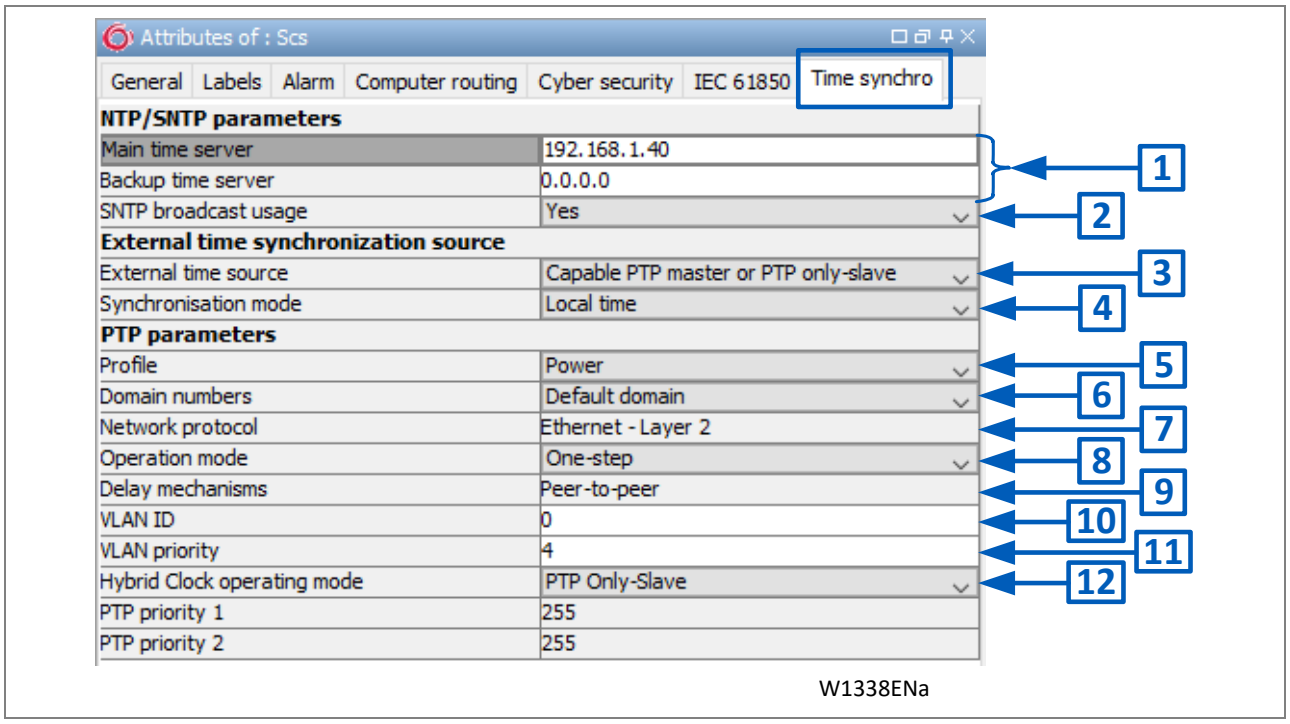


Figure 8: Time Synchronization attributes at Substation Control System (SCS)

(1) **Main time server / Backup time server:** If using NTP/SNTP time server to synchronize your system, enter the IP address of the main and backup NTP/SNTP server. Both Main & backup addresses must be within the same network as the device.

(2) **SNTP broadcast usage** *(No / Yes)*: not used.

(3) **External time source:**

- ***None***: Internal Oscillatory clock
- ***SNTP client***
- ***Capable PTP master or PTP only-slave:*** ordinary clock can be set as a PTP-master or PTP-slave only device.

(4) **Synchronization mode:**

- ***UTC***: The C264 can be synchronized using NTP protocol, which uses Greenwich Mean Time as its standard to display time information on the device whatever its location.
- ***Local time***: displays the local time corresponding to the geographical location of the device.

(5) **Profile:** A profile is a set of rules for constraining PTP for a specific application:

- ***Power***: The IEEE **Power** Profile defines specific or allowed values for PTP networks used in power substations. You may use multiple independent PTP clocking subdomains within a **Power** profile by associating PTP domains (see Domain numbers below).
- ***Custom****:* User-defined profile

(6) **Domain numbers:** This is a logical grouping of PTP devices that communicate and synchronize to each other (but that are not necessarily synchronized to clocks in another domain). Select the domain number to be used for this clock. The range is from 0 to 127. The default domain is 0.

- ***Power*** profile*:*
  - *Default domain (0)*
  - *Alternate domain 1*
  - *Alternate domain 2*
  - *Alternate domain 3*
- ***Custom*** *profile:*
  - *Enter a domain number from 4 to 127.*

(7) **Network protocol:** Ethernet – Layer 2. Default value. Messages are sent over Ethernet frames as specified in the IEEE standard.

(8) **Operation mode:** determines how SYNC messages (time-stamp) are sent to slave devices. Set the clock to the desired value depending on the compatibility mode of the switch in your system:

- ***One-step***: one-step clock.
  This operation mode minimizes network traffic (time information is provided using a single event message. Follow-up messages are not sent). May not be supported by some switches.
- ***Two-step***: two-step clock.
  Time information is provided using the combination of an event message and a subsequent general message. The follow-up message sends a precise estimate of the time the Sync message was placed on the PTP communication path. This clock type is commonly used.

(9) **Delay mechanisms:** Peer-to-peer by default

(10) **VLAND ID: For tag-based VLANs. This is the ID to look for in the PTP frame. It identifies the individual VLANs you create on your network. The VLAN ID must be specified in the range from 1 to 4094. Note that:**

- ***VLAN 0*** is not used for VLAN routing but only to carry priority information.
- ***VLAN 4095*** is not allowed by the 802.1Q standard

(11) **VLAND priority:** enter the VLAN priority for VLAN PTP frames (set to 7 by default).

(12) **Hybrid Clock operating mode:** a Hybrid clock combines two roles: Ordinary clock and Transparent clock. Ordinary clock can act either as a master or as a slave. In most of network implementation, Ordinary Clocks remain in slave state and only become Master when all of the Preferred Masters in the network are unavailable.

- ***Capable PTP Master***: The ordinary clock can be set as a PTP-master device. It means that it will postulate as PTP master during a selection campaign.
- ***PTP Only-Slave***: The ordinary clock can be set as a PTP-slave only device. It means that it will not postulate as time master during a selection campaign.

3.2 ADDING AND CONFIGURING A C26X IN THE SYSTEM'S ARCHITECTURE

To add a C26x definition select the **System Group** under the **SBUS network** in the **Object view** then in the **Objects entry** window, open `Physical device > IEC61850 physical device > IEC61850 computer`, and then double-click on a "C264" unit as shown below:

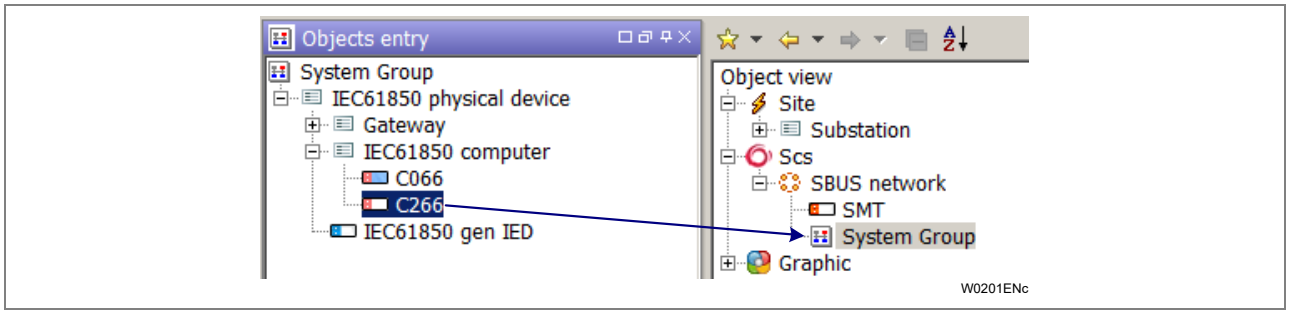


Figure 9: Adding a C26x to the system's architecture

When clicking on **Add** or double-clicking on a C26x, the user is prompted to configure a bitstream before the C26x is added to the architecture:

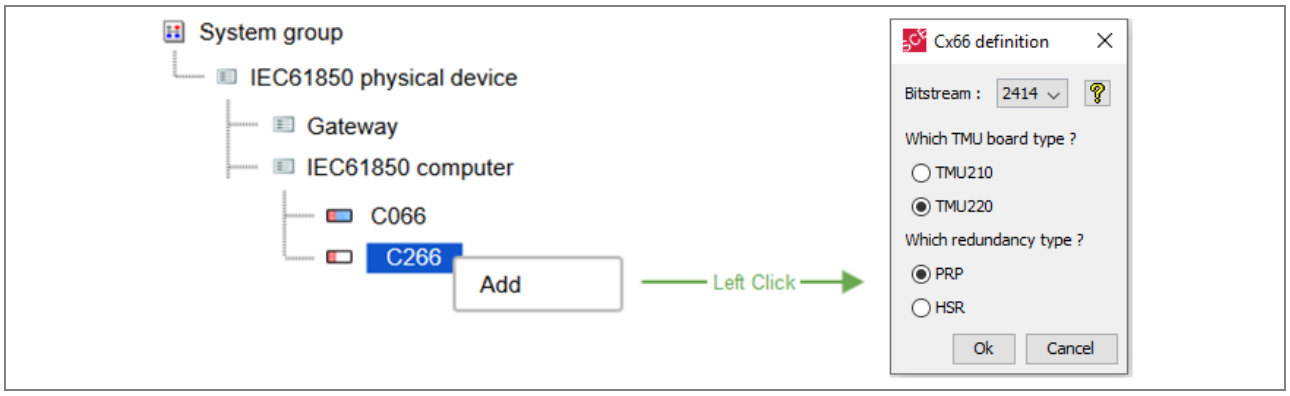
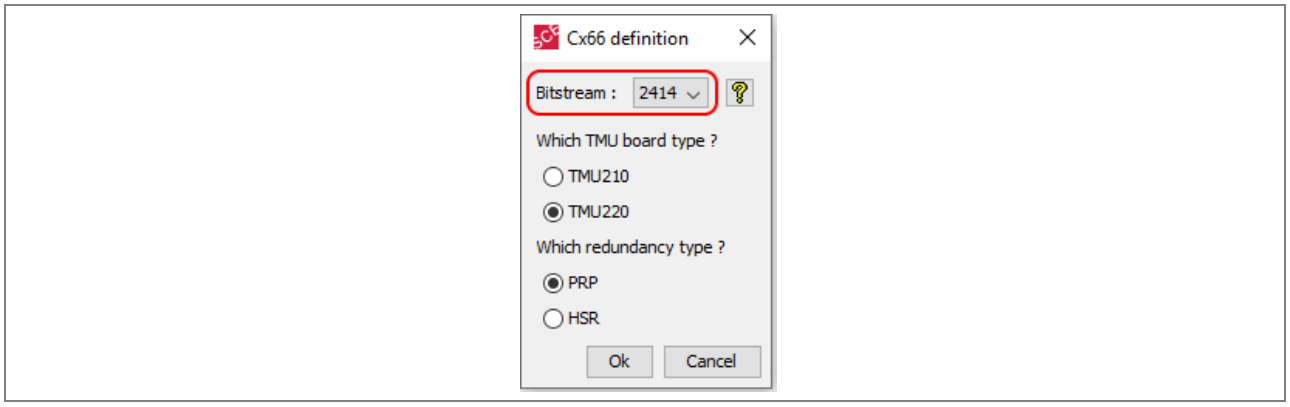


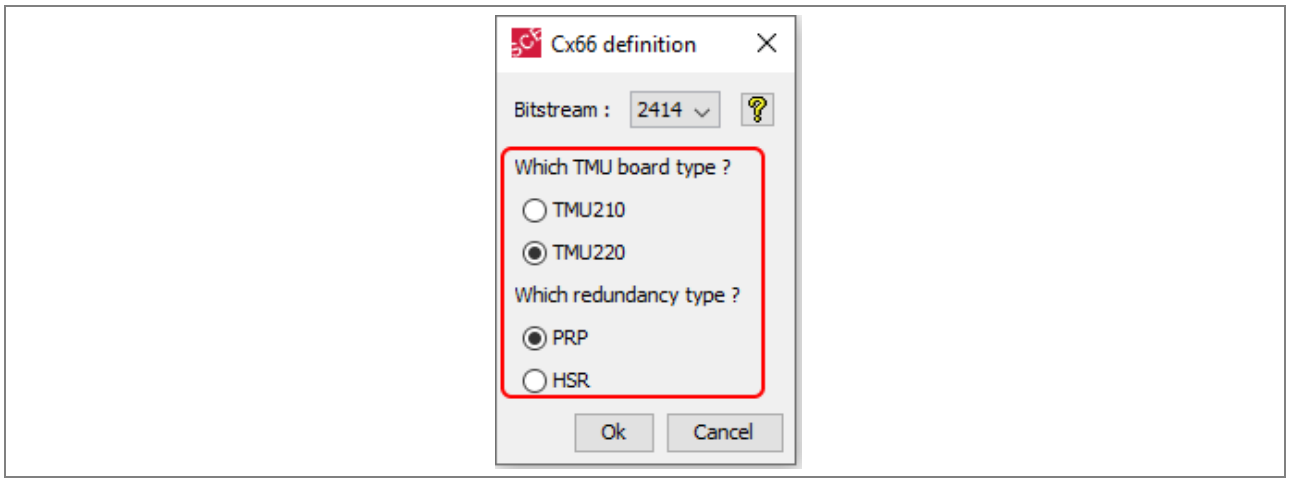
Figure 10: Defining the C26x bitstream

1 Use the **Bistream** drop-down list to select the relevant bitstream according to the different bitstream configuration use cases available in the **Network Monitoring** chatpter of the C264 user manual:



2 Depending on the selected bitstream, tick the appropriate TMU board and redundancy type.

3 Click **OK** to validate your choice and add the C26x to your system.



Components of a C26x

When you add a device from the **Objects Entry** window, for instance a C26x, the following sub-tree of the C26x definition, with default and optional components, is created:

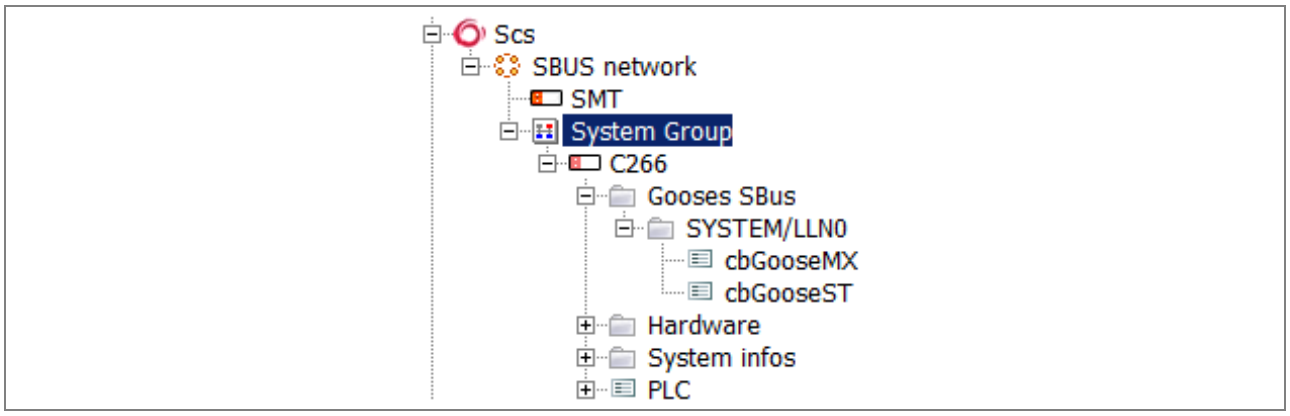


Figure 11: C26x components

- Folders ‘Gooses SBus’ and ‘C26x IEC Map’ (to be added manually): describe the station-bus network address mapping of datapoints managed by the C26x (add the second folder for datapoints without automatic addressing)
- Folder ‘Hardware’: contains all the boards defined for the C26x
- Folder ‘Hardware extension’: contains all the boards defined for the extension rack (mutirack option)
- Folder ‘System infos’: contains all the general system (i.e. not wired to boards) datapoints of the C26x
- ‘PLC’ (Programmable Logic Controller): contains the relations and ISaGRAF system information

3.2.1 SETTING THE GENERAL ATTRIBUTES OF A C26X

When adding a C26x to the System Group on the SBUS network, some of its attributes must be set and checked:

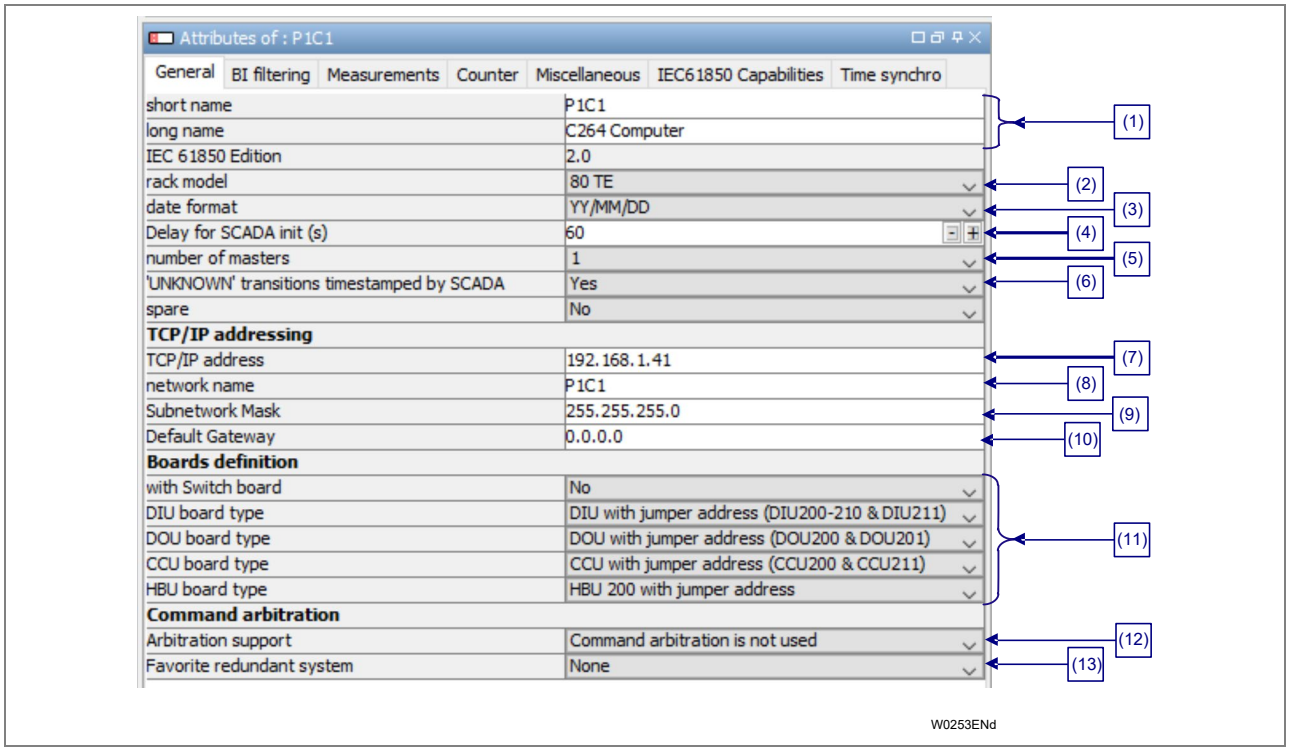


Figure 12: Setting General attributes

(1) **short name** and **long name**: used for logging, alarms, …

(2) **rack model** (80TE / 40TE): there are two C26x variants: wider case (80TE) and compact variant (40TE). The height of both C26x variants is 4U.

(3) **date format**: **defines the date format displayed on the C26x's front panel HMI (LCD)**

(4) **Delay for SCADA init (s)** (only used for a C26x-Standalone RTU, default value: 60s): elapsed time between two ASDU frames - Not applicable to system version v7.x.x

(5) **UNKNOWN transitions timestamped by SCADA** (only used for a C26x-Standalone RTU) Not applicable to system version v7.x.x

(9) **number of masters**: reserved for future use.

(10) **TCP/IP address** (limited to 15 characters) of the C26x. Default IP address: 0.0.0.0

(11) **Network name** (limited to 34 characters) of the C26x

(12) **Subnetwork Mask**: mask of the SBUS subnetwork containing the C26x (limited to 15 characters). Default value: 255.255.255.0. If this attribue is set in the SCL file, the field is updated accordingly in the configuration.

(13) **Default Gateway**: address of the gateway to which the C26x is connected (limited to 15 characters). Default value: 0.0.0.0. If this attribue is set in the SCL file, the field is updated accordingly in the configuration.

(14) **Boards definition**: types of the boards fitted on the C26x and for some of them, whether their location in the rack is defined using jumpers or in their configuration attributes ("slot affectation"). For the DIU211, selecting …with slot affectation… also allows to choose the inputs' voltage range.

(15) **Arbitration support** (only used for SCADA protocols T101 and T104 in a C26x-Standalone RTU) Not applicable to system version v7.x.x.

(16) **Favorite redundant system**: Reserved for future use.

Configuration rules and checks

- The **TCP/IP address** value of any device must be unique among all the units within an Ethernet Network (except for aView server and aView client).
- The **network name** value of any device must be unique among all the units within an Ethernet Network (except for aView server and aView client).

3.2.2 CONFIGURING BINARY INPUT (BI) FILTERING

There are two types of input signal handling:

- **Debouncing**: the start transition is signaled with the correct time, the following changes within the debouncing time are ignored. The range of the debouncing time is 0 to 20 ms (1 ms step). The event is time-stamped at the time of the first transition
- **Filtering**: the transition is only signaled if the signal is stable for at least as long as the filtering time. The range of the filtering time is from 0 to 20 ms (with a 1 ms step). Filtering is allowed only if debouncing is applied (i.e. filtering cannot be applied if there was no debouncing beforehand). The event is time-stamped at the instant of the first transition.

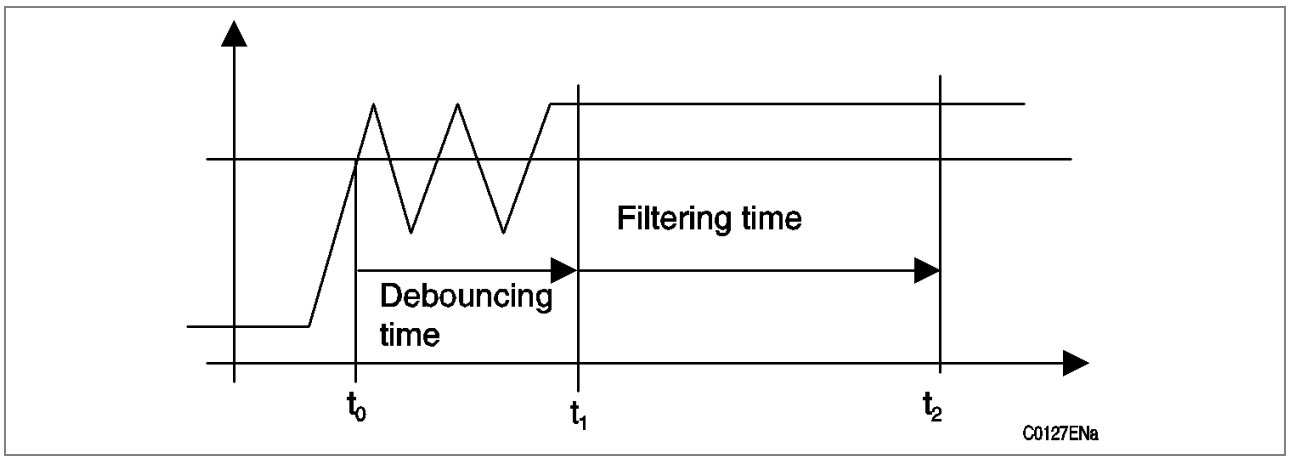


Figure 13: Debouncing and filtering

A value of 0 means that no filter is applied: a change of state is validated as soon as it is detected.

Three pairs of delays (debouncing/filtering) are defined:

- one for all Digital Inputs which will be used as Binary Inputs
- one for all Digital Inputs which will be used as Digital Measurements
- one for all Digital Inputs which will be used as counters

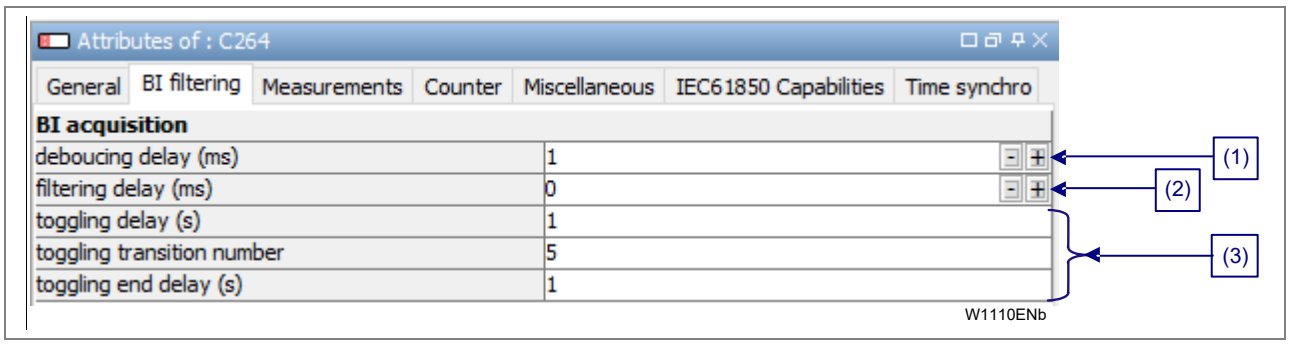


Figure 14: Setting BI acquisition attributes

(1) **debouncing delay** (range [0, 20 ms], step 1 ms)

(2) **filtering delay** (range [0, 20 ms], step 1 ms)

(3) **toggling** attributes are defined as follows:

- A digital input (DI) is said to be toggling if its state has changed more than N times within a given time period, T_1.
- A toggling DI becomes valid again if its state has not changed within another time period, T_2.
- N (**toggling transition number**), T_1 (**toggling delay**) and T_2 (**toggling end delay**) are parameters determined for each C26x during the configuration process.

Configuration rules and checks

If the attribute **debouncing delay** is set to *0*, then the attribute **filtering delay** must be set to *0* too.

3.2.3 CONFIGURING MEASUREMENT ACQUISITION AND TRANSMISSION

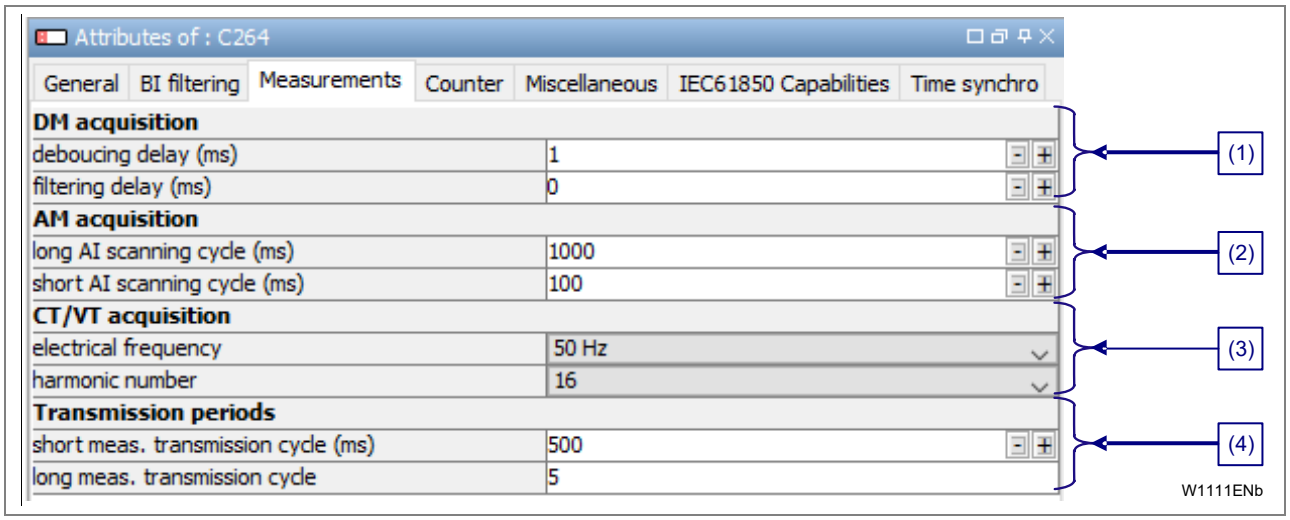


Figure 15: Measurements attributes for a C26x

(1) **Debouncing delay** and **filtering delay**: used for digital measurements

(2) **Analogue measurements** acquired on AIU boards: AM acquisition samples ranges for long scanning (range [500 ms, 10000 ms], step 500 ms) and short scanning (range [100 ms, 1000 ms], step 100 ms). For each AIU board channel, a short or long scanning period chosen (see section 3.3.6 Configuring an AI channel).

(3) **CT/VT acquisition** on the TMU board with fundamental frequency of either 50 or 60 Hz (the number of harmonics is fixed to a maximum of 16). BCU only.

(4) **short meas. transmission cycle (ms)**: Short transmission period on the station bus (range [0, 60 s], step 100 ms) and
long meas. transmission cycle: Long transmission period defined as an integer multiple of the short period ([0..600] x short transmission period)

Setting a period to *0* means periodic transmission is disabled:

- for both short and long periods if it is the short period
- for the long period only if it is the only one set to *0*

Configuration rules and checks

If the attribute **debouncing delay** is set to *0*, then the attribute **filtering delay** must be set to *0* too.

3.2.4 CONFIGURING COUNTER ACQUISITION

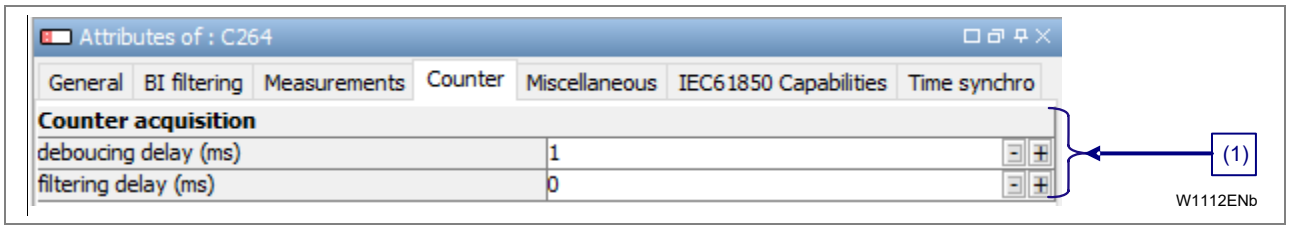


Figure 16: Counter acquisition attributes of a C26x

(1) **debouncing delay** and **filtering delay**: used for digital counters (see section ***3.2.2 Configuring binary input (BI) filtering*** for details)

Configuration rules and checks

If the attribute **debouncing delay** is set to *0*, then the attribute **filtering delay** must be set to *0.*

3.2.5 MISCELLANEOUS ATTRIBUTES

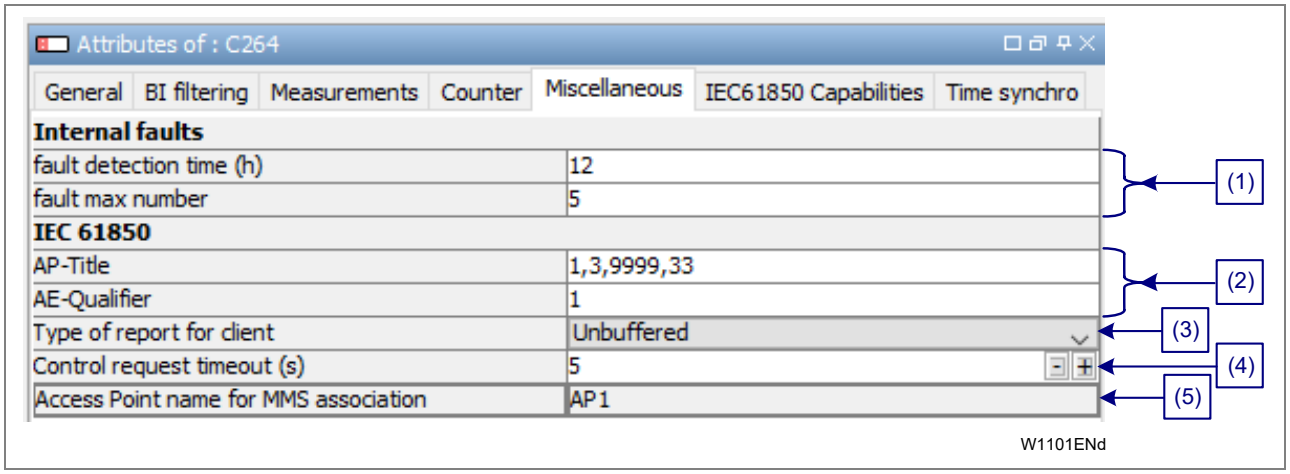


Figure 17: Miscellaneous attributes of a C26x

(1) **Internal faults**: Number of software faults allowed in a given period else the C26x remains in HALT mode. The C26x reboots automatically as long as it does not reach the **fault max number** within the **fault detection time** period. When these criteria are met, the C26x remains in HALT mode.

(2) **AP-Title: MMS parameter**. Always set at the default value.
AE-Qualifier: Extension of the IP address if several server applications are using the same agency. It will start at 1 for the first application, then 2 for the second and so on… up to a maximum of 50.

(3) **Type of report for client (**unbuffered / buffered): Preferred type of report sent to clients. BCU only.

(4) **Force trigger options** (No / Yes): This is used to manage which report trigger options the C26x uses for IED polling.

- *Yes*: The C26x first sets the minimum trigger options when activating reports: MVLU_TRGOPS_DATA and MVLU_TRGOPS_GI, before setting all the trigger options in a second step.
- *No*: The C26x directly sets all the trigger options.

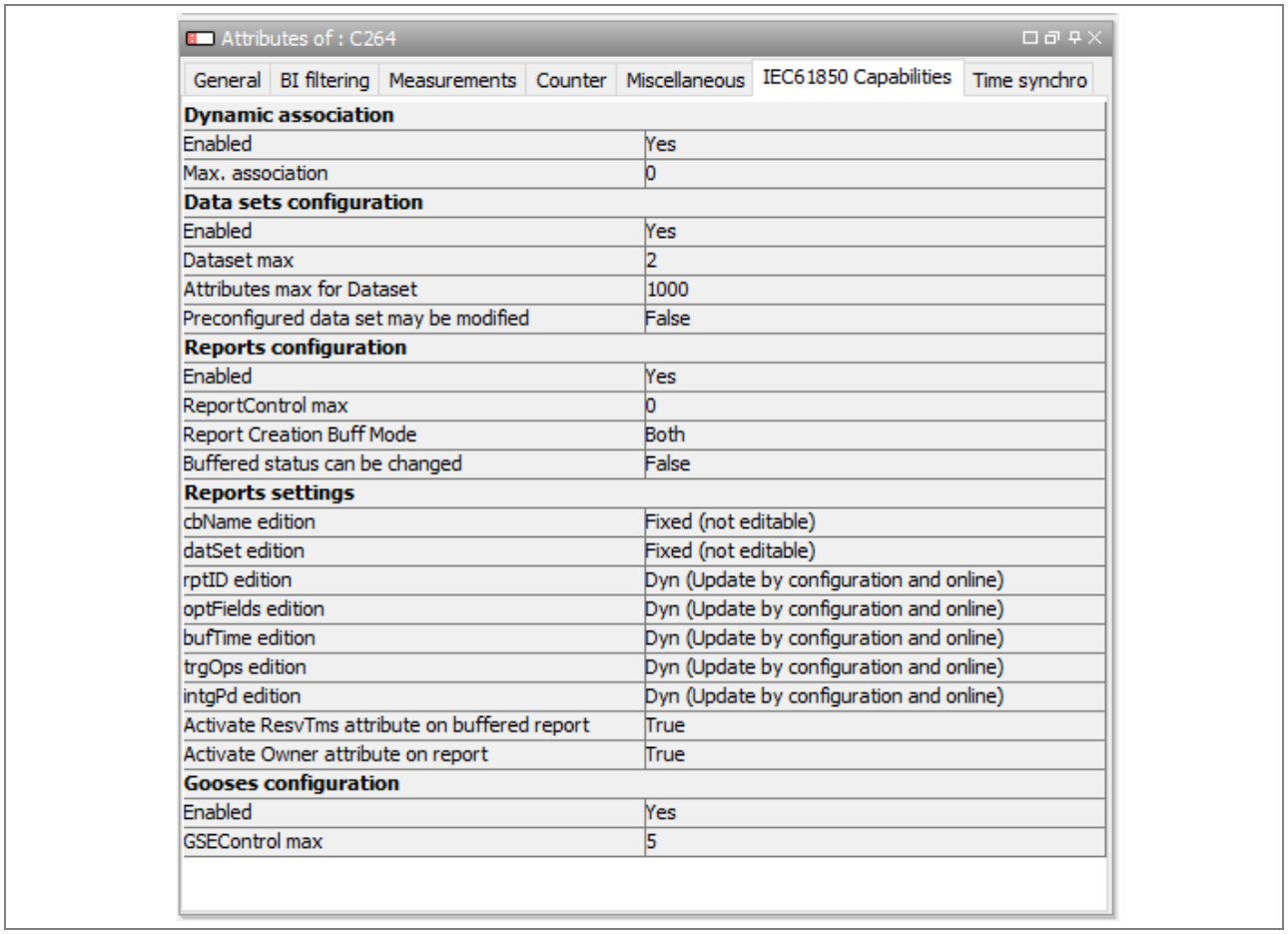
(5) **Access Point name for MMS association**: Name of the SBUS access point for this device. This information is used by the agency at the client side when associating client and server on SBUS. For DS Agile devices, the value is set to AP1. For IED generics, the value is calculated during ICD model import.

Note:
Trigger option compatibility must be maintained throughout the system, i.e. all the polled IEDs must be compatible with the selected option.

3.2.6 IEC61850 CAPABILITIES ATTRIBUTES

The IEC61850 Capabilities tab-pane sums up the station bus communications characteristics of the C26x with regard to GOOSE and REPORT messages.

The attributes displayed in this tab-pane are either fixed, dynamic or automatically computed by the SCE when automatic addressing is performed. They cannot be set here.



Dynamic association	
Enabled	Yes
Max. association	0
Data sets configuration	
Enabled	Yes
Dataset max	2
Attributes max for Dataset	1000
Preconfigured data set may be modified	False
Reports configuration	
Enabled	Yes
ReportControl max	0
Report Creation Buff Mode	Both
Buffered status can be changed	False
Reports settings	
cbName edition	Fixed (not editable)
datSet edition	Fixed (not editable)
rptID edition	Dyn (Update by configuration and online)
optFields edition	Dyn (Update by configuration and online)
bufTime edition	Dyn (Update by configuration and online)
trgOps edition	Dyn (Update by configuration and online)
intgPd edition	Dyn (Update by configuration and online)
Activate ResvTms attribute on buffered report	True
Activate Owner attribute on report	True
Gooses configuration	
Enabled	Yes
GSEControl max	5

3.2.7 C264 TIME SYNCHRONIZATION

Depending on your application, it is possible to configure each C26x computer individually to set specific synchronization parameters.

Time synchronization settings are defined in the C264 **Time Synchro** tab:

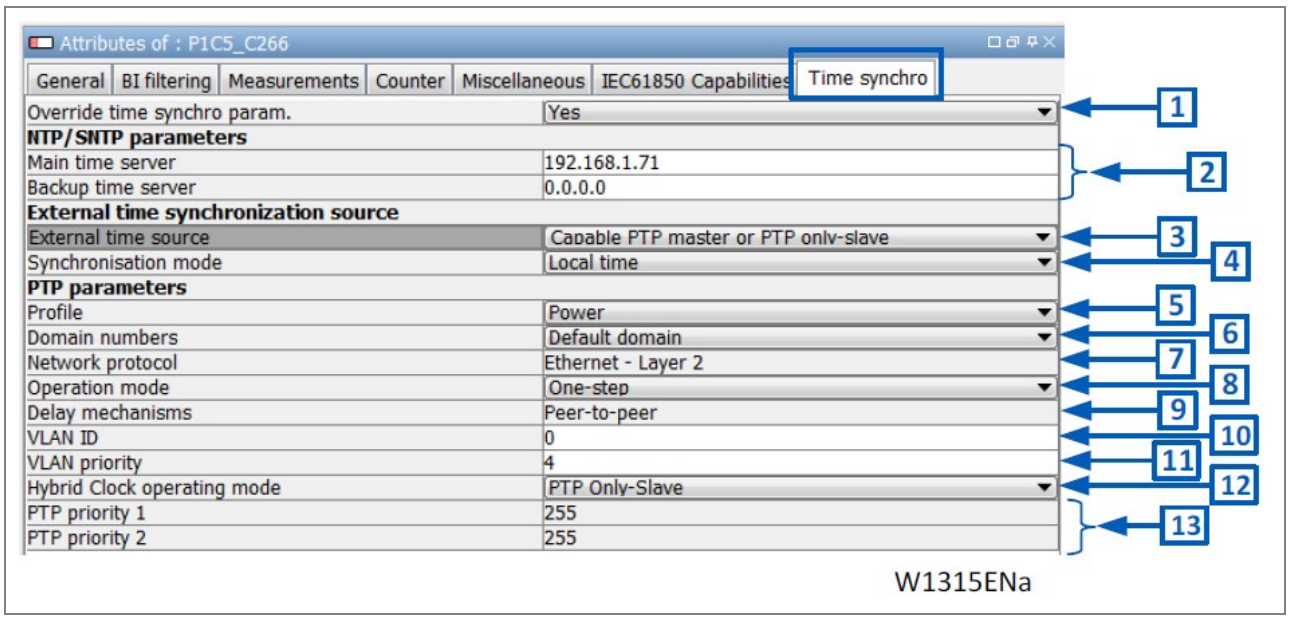


Figure 18: Time Synchronization attributes of a C26x

(1) **Override time synchro param.**:

- ***No***: as a default, the C26x inherits time synchronization parameters from the Substation Control System (SCS). Refer to section **3.1.1 Scs Time Synchronisation** for further details.
- ***Yes***: overrides the synchronization parameters inherited from the SCS to apply specific time settings for the selected C26x (for example for a C26x which will send the ptp frames when the GPS clock fails).

(2) **Main time server / Backup time server:** if using NTP/SNTP time server to synchronize your system, enter the IP address of the main synchronisation source for the system and the backup NTP/SNTP server for the system in case the main time server fails. Both Main & backup addresses must be within the same network as the device.

(3) **External time source:**

- ***None***: Internal Oscillatory clock
- ***SNTP client***
- ***Capable PTP master or PTP only-slave:*** ordinary clock can be set as a PTP-master or PTP-slave only device.

(4) **Synchronization mode:**

- ***UTC***: The C264 can be synchronized using NTP protocol, which uses Greenwich Mean Time as its standard to display time information on the device whatever its location.
- ***Local time***: displays the local time corresponding to the geographical location of the device.

(5) **Profile:** a profile is a set of rules for constraining PTP for a specific application:

- ***Power***: The IEEE **Power** Profile defines specific or allowed values for PTP networks used in power substations. You may use multiple independent PTP clocking subdomains within a **Power** profile by associating PTP domains (see Domain numbers below).
- ***Custom****:* User-defined profile

(6) **Domain numbers:** this is a logical grouping of PTP devices that communicate and synchronize to each other (but that are not necessarily synchronized to clocks in another domain). Select the domain number to be used for this clock. The range is from 0 to 127. The default domain is 0.

- ***Power*** profile*:*
  - *Default domain (0)*
  - *Alternate domain 1*
  - *Alternate domain 2*
  - *Alternate domain 3*
- ***Custom*** *profile:*
  - *Enter a domain number from 4 to 127.*

(7) **Network protocol:** Ethernet – Layer 2. Default value. Messages are sent over Ethernet frames as specified in the IEEE standard.

(8) **Operation mode:** determines how SYNC messages (time-stamp) are sent to slave devices. Set the clock to the desired value depending on the compatibility mode of the switch in your system:

- ***One-step***: one-step clock.
  This operation mode minimizes network traffic (time information is provided using a single event message. Follow-up messages are not sent). May not be supported by some switches.
- ***Two-step***: two-step clock.
  Time information is provided using the combination of an event message and a subsequent general message. The follow-up message sends a precise estimate of the time the Sync message was placed on the PTP communication path. This clock type is commonly used.

(9) **Delay mechanisms:** Peer-to-peer by default

(10) **VLAND ID**: for tag-based VLANs. This is the ID to look for in the PTP frame. It identifies the individual VLANs you create on your network. The VLAN ID must be specified in the range from 1 to 4094. Note that:

- ***VLAN 0*** is not used for VLAN routing but only to carry priority information.
- ***VLAN 4095*** is not allowed by the 802.1Q standard

(11) **VLAND priority:** enter the VLAN priority for VLAN PTP frames (set to 7 by default).

(12) **Hybrid Clock operating mode:** a Hybrid clock combines two roles: Ordinary clock and Transparent clock. Ordinary clock can act either as a master or as a slave. In most of network implementation, Ordinary Clocks remain in slave state and only become Master when all the Preferred Masters in the network are unavailable.

- ***Capable PTP Master***: the ordinary clock can be set as a PTP-master device. It means that it will postulate as PTP master during a selection campaign.
- ***PTP Only-Slave***: the ordinary clock can be set as a PTP-slave only device. It means that it will not postulate as time master during a selection campaign.

(13) **PTP priority**: specify the C264 fallback order in case of Grandmaster Clock failure. The range for both priorities is from 0 to 255. Lower value (0) indicates higher priority:

- ***PTP priority 1***: Set a value to override the default BMCA criteria i.e clock quality, clock class, etc. for best master clock selection.
- ***PTP priority 2***: Set a value to give the C26x priority over other identical C26x.

Note: If all C26x have the same Priority1 then, Priority2 will be used to select the Preferred PTP Master clock.

If all priorities are identical, the Preferred PTP Master clock will be selected based on the physical performance of the C26x ("BMCA"= Best Master Clock Algorithm). The Best Master Clock Algorithm is a software mechanism that determines which Grand Master clock with the same subnet has the best resolution. The comparison is done according to several criteria such as the priority, the clock class, the clock accuracy…

3.2.8 LOCATING A C26X IN A SUBSTATION (MANDATORY)

As indicated in section *3.1 Setting the system parameters relevant to C26x units*, each system device has to be located in a specific substation. This is done by defining the mandatory relation (1) **is located in** for each device in the system, especially the C26x units.

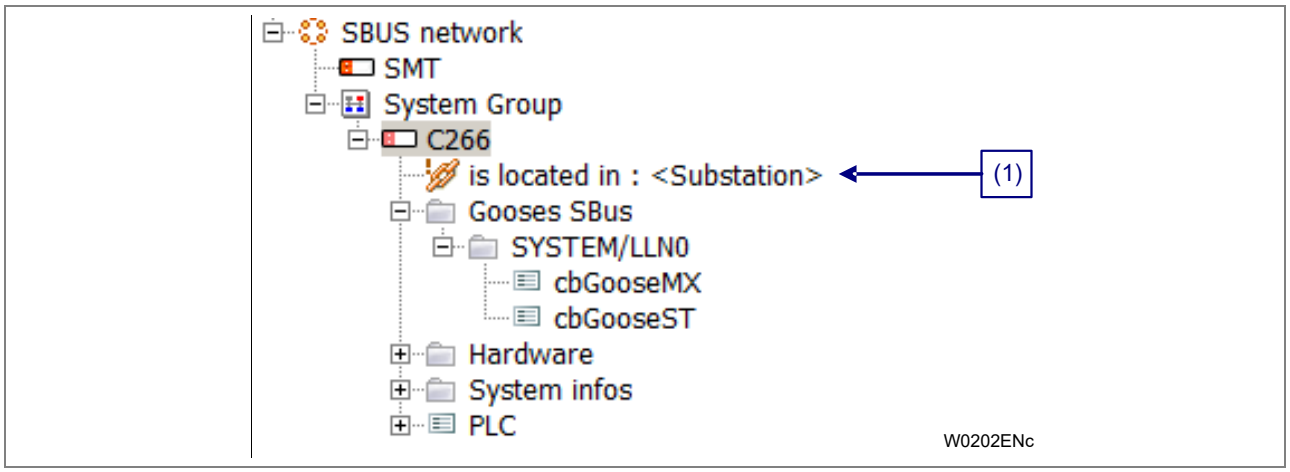


Figure 19: Locating a C26x in a substation

3.2.9 DEFINING A C26X REDUNDANCY (OPTIONAL)

To define a redundant C26x:

- Create the main C26x which will act as the master.
- Open the contextual menu of the C26x and select **Create backup** (1).

Then:

- A second C26x (which will act as slave) is automatically created with an implicit relation of backup between the two C26x units.
- A new relation **has for backup** is automatically created under the main C26x.
- When the backup C26x is created, most of its attributes and components are identical to those of the main C26x and cannot be edited. The only exceptions are its short name and long name, as well as its network identification (IP address and network name) that must be correctly updated. When an object is added to (or removed from) the main C26x, the same object is added to (or removed from) the backup C26x but its attributes can only be modified at the main C26x level and those changes will be automatically cascaded to the backup C26x level.

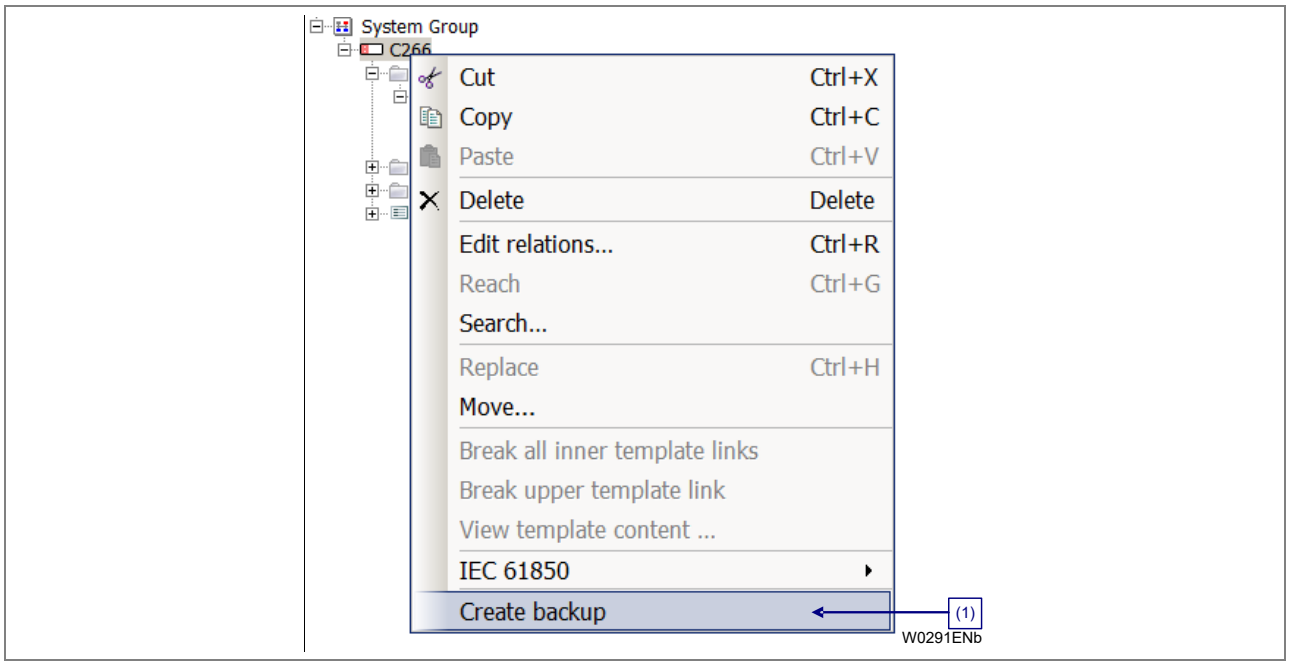


Figure 20: Creating a C26x redundancy

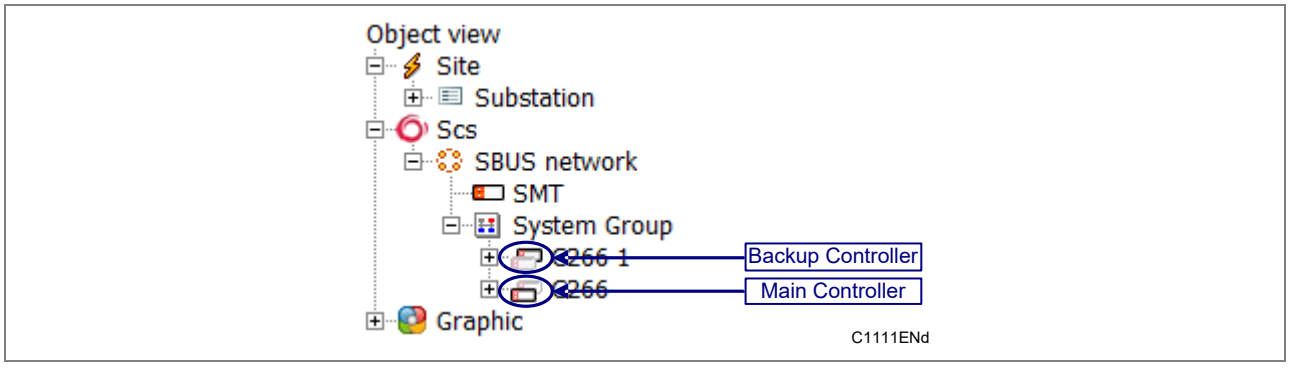


Figure 21: Defining a C26x redundancy

3.3 ADDING C26X HARDWARE COMPONENTS

3.3.1 ADDING BOARDS

The following boards, each managing specific functions, can be added to the DS Agile C26x units depending on the required functionalities:

- **DIU2xx** – Digital input boards with 16 digital input channels:
  - digital and counter acquisition
  - digital measurement acquisition
- **AIU201** – Analogue input boards with 4 analogue input channels:
  - analogue measurement acquisition
- **AIU210-211** – Analogue input boards with 8 analogue input channels:
  - analogue measurement acquisition
- **TMU210/TMU220** - CT and VT input boards with 4 CT and 4 VT input channels (5 VT inputs on TMU220):
  - CT/VT sampling acquisition,
  - MV computations based on acquired samples are performed by the CPU470 board
- **DOU2xx** – Digital output boards with 10 digital output channels:
  - execution of single or dual, transient or permanent commands
  - setting of digital setpoints
- **HBU200** – High Speed/High Break digital output boards with 10 digital output channels:
  - execution of single or dual, transient or permanent commands
- **CCU2xx** – Mixed digital boards with 8 digital input and 4 digital output channels (make sure that the DOs 4,5,6,7 are defined but not used):
  - Circuit breaker Control Unit
- **CPU470** – CPU4 Processor board with up to 6 communication channels: several configurations (“bitstreams”) are available
- **BIU2xx** – Power Supply board with communication channels (serial communication ports)
- **GHU300** – Graphical panel boards with LED channels
- **AOU200** – Analogue output board with 4 analogue output channels

The C26x hardware definition is done in SCE by adding typed boards under the C26x object. Mandatory boards (CPU270, GHU300, BIU2xx) are automatically created with the C26x. Implicitly typed channels are created with the corresponding boards.

Note:
Ethernet communications boards (SRP28x, SRP29x) are automatically recognized by the CPU4 processing board and are therefore not added in the SCE configuration.

Linking datapoints to input/output channels is called datapoint "wiring".

To add a board definition, select the C26x level and add the board from the contextual **Objects entry** window: Either double-click on the board's name or right-click on it and then select **Add** as shown below:

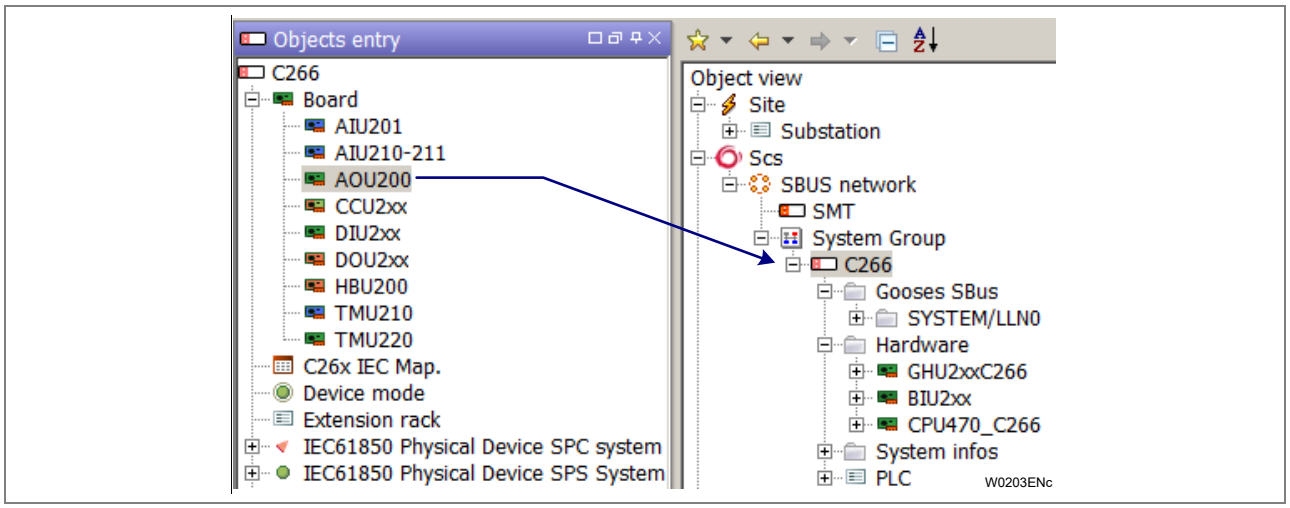


Figure 22: Adding a board to a C26x

Slots and boards in a C26x 80TE unit

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	
BIU	CPU																

- Slots from C to Q may contain a board of the following types: AIU201, AIU210-211, AOU200, CCU2xx, DIU2xx, DOU20x, HBU200
- Slot Q may contain one TMU2xx board or one board of the above types.
- If a TMU2xx board is present, then the number of boards must be ≤ **14**; if 2 TMU220 boards are present, then the number of boards must be ≤ **11**; if not the number of boards must be ≤ **15.**
- If there is an Ethernet board (SRP28x, SRP29x) it must be installed in either slot C or D.

Slots and boards in a C26x 40TE unit

A	B	C	D	E	F	G	H
BIU	CPU						

- Slots C to F may contain a board of the following types: AIU201, AIU210-211, AOU200, CCU2xx, DIU2xx, DOU20x, HBU200
- Slots G and H may either contain one TMU2xx board or two boards of the above types
- If a TMU2xx board is present, then the number of boards must be ≤ **4**; if not, the number of boards must be ≤ **6**.
- If there is an Ethernet board (SRP28x, SRP29x) it must be installed in either slot C or D.

Note:
A 40TE or 80TE C26x unit can manage up to 4 AOU boards. AOU boards cannot be used in a C26x redundancy environment

3.3.2 SETTING THE COMMON ATTRIBUTES OF C26X BOARDS

For each board fitted into the C26x the short name attribute (1) may be edited so as to ensure correct logging and alarm discrimination of the board status datapoint.

For the AIU2xx, CCU2xx, DIU2x0, DIU211, DOU200, DOU201, HBU200 and AOU200 boards the **board number** attribute (2) must be set.

For the CPU470, BIU2xx, GHU300, and TMU2x0 boards, this attribute is forced to 0 by the SCE and, except for TMU220, it does not appear in the attributes window:

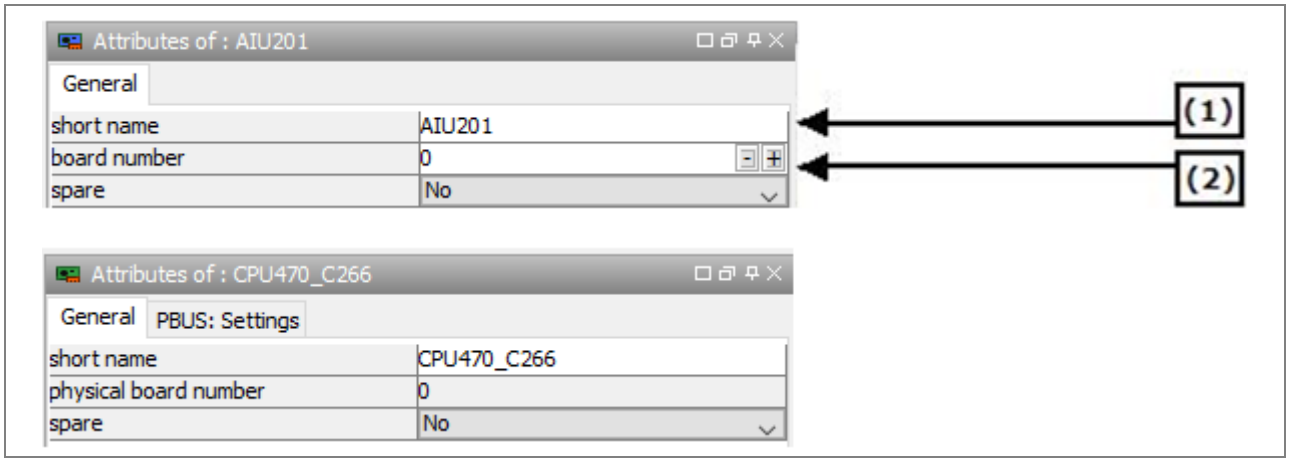


Figure 23: General attributes common to all boards

For each board type (AIU201, AIU210/AIU211, AOU200, CCU2xx, DIU2xx, DOU2xx, HBU200), the **board number** attribute values must start at 0, be unique and contiguous.

3.3.3 SETTING THE SPECIFIC ATTRIBUTES OF EACH C26X BOARD

3.3.3.1 ATTRIBUTES OF A BIU2XX BOARD

The BIU2xx power supply board can have either a single (BIU261S) or a dual (BIU261D) power supply source. For the BIU261, the type of power supply must be indicated by setting the **BIU board type** in the **General** tab-pane:

- *BIU mono source* if the board manages a single input power supply,
- *BIUR dual source* if if the board manages a dual input power supply.

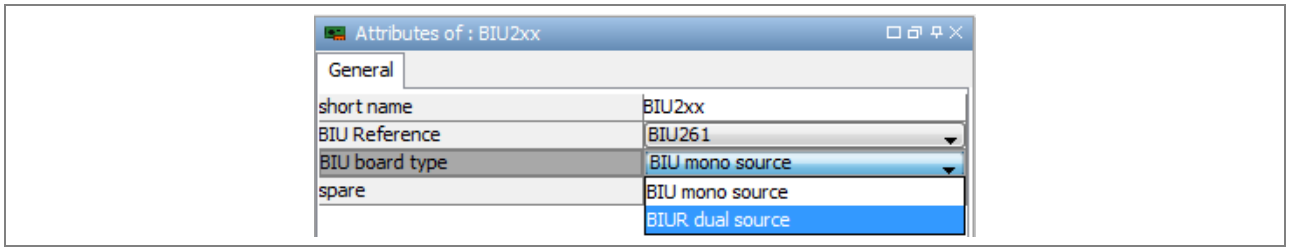


Figure 24: General attributes of BIU2xx boards

Datapoints for dual input power supply board BIU261D (*BIUR dual source* setting)

When *BIUR dual source* is selected, SPS datapoints are available to indicate the available power supply sources and which input is currently used to power the C26x. They are present but spared and non-configurable if *BIU mono source* is selected.

These SPS datapoints can be found in the **System infos** folder under the BIU2xx node:

- *Volt source used*: This datapoint is *SET* while the secondary power supply input is in use. It is *RESET* while the secondary power supply input is NOT used, i.e. the primary input is used or the C26x is not powered at all.
- *Voltage source 1*: This datapoint is *SET* when an adequate voltage is available at the primary input's terminals. It is *RESET* when there is no voltage or when the voltage level is outside the board's range.
- *Voltage source 2*: This datapoint is *SET* when an adequate voltage is available at the secondary input's terminals. It is *RESET* when there is no voltage or when the voltage level is outside the board's range.

All three can be assigned to LEDs on the C26x's front panel by adding the relation **has state displayed on : Led**. They can also be transmitted over the Station Bus network to the DS Agile aView and to a SCADA via the DS Agile Gateway.

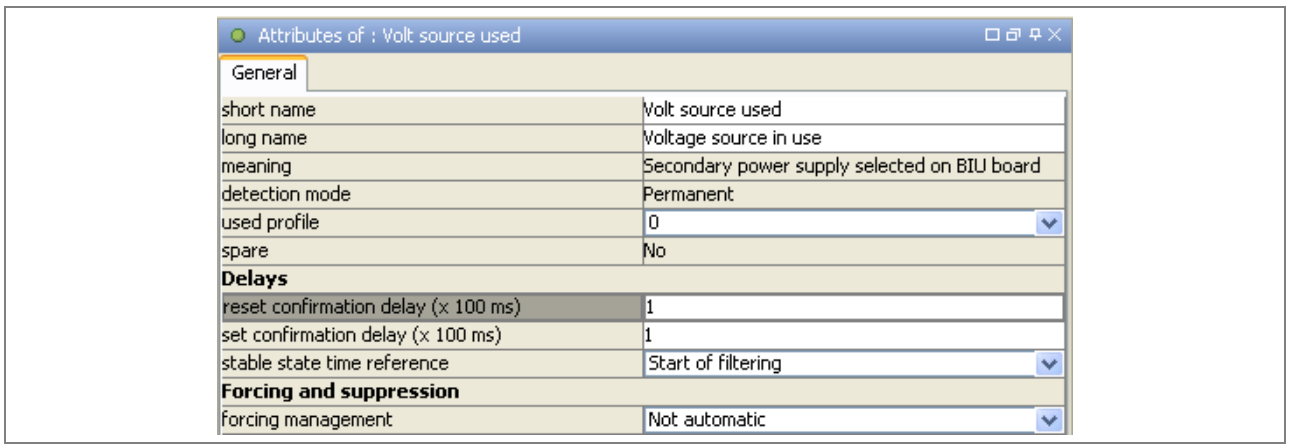


Figure 25: Attributes of a voltage source datapoint (example for *Volt source used*)

Caution:
Both delays: reset confirmation delay (x 100 ms) and set confirmation delay (x 100 ms), should be set to at least *1* (i.e. 100 ms) in order to avoid transitory state changes during the voltage source switching sequence (up to 20 ms).

Note:
These datapoints cannot be spared when BIUR dual source *is selected. A profile must be defined whether they are used or not.*

3.3.3.2 ATTRIBUTES OF A CPU470 BOARD

The attributes of the CPU470 board are relevant to its management of the process bus, with regards to communications settings.

General attributes

(1) **short name**

(2) **physical board number**: set to 0 by default. This setting is fixed and cannot be changed

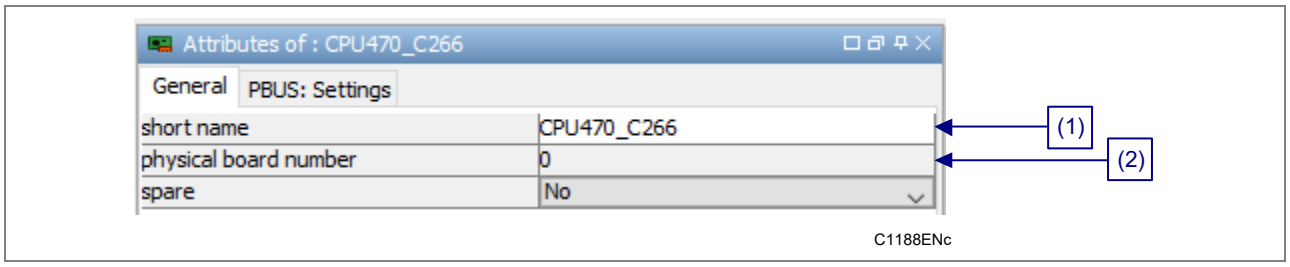


Figure 26: General attributes of a CPU470

PBUS: Settings attributes

This tab is present only for the BCU (C266) application.

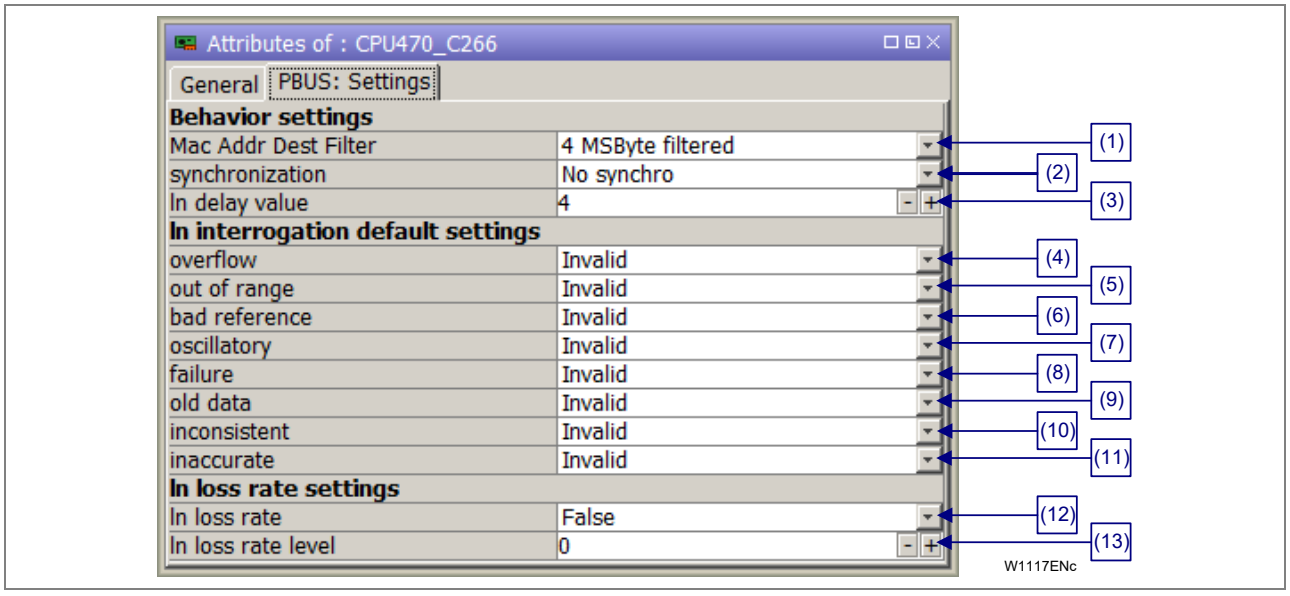


Figure 27: Process bus setting attributes of a CPU470

Behavior settings:

(1) **Mac Addr Dest Filter** (*No filter* / *4 MSByte filtered* / *All address bytes filtered*): Enables and disables filtering using the four most significant bytes of the Destination address (01-0C-CD-04-xx-xx) in the Header MAC section of the received frames.

- *No filter*: Mac address filtering is disabled.
- *4 MSByte filtered*: Filtering using the four most significant bytes of the Destination address (01-0C-CD-04-**-**) in the Header MAC section of the received frames.
- *All address bytes filtered*: Customized filtering of the Destination address (01-0C-CD-04-**-**) in the Header MAC section of the received frames.

(2) **synchronization (No synchro / Local synchro PPS / Global synchro PPS)**: Sets the time-synchronisation source of the merging units:

- ***No synchro***: The merging units do not receive any synchronisation signal.
- ***Local synchro PPS***: The merging units are synchronised using a local (not global) synchronisation source.
- ***Global synchro PPS***: The merging units are synchronised using a GPS (or equivalent) synchronisation signal.

Note: If ARS build-in function with reclosing is implemented in your system and synchronisation switches from Global to Local:

- All the features managed by the ARS remain in service except "reclosing" (REB.POSS) which is RESET.
- All measurements remain valid even if Sampled Values are tagged "Local" and the SCE setting on CPU4 board "synchronisation" is set to "Local".
- Each concerned datapoints (ARS voltage control SPS) will accept "local" or "global" synchronisation for voltage control only.

(3) **In delay value** (2 to 10, step 1): Set the maximum number of samples between the reception of the Ethernet message from the first merging unit and the reception of the Ethernet message from the last merging unit.

In interrogation default settings:

(4) **overflow** (Valid / Invalid): Sets the default response when the quality Overflow marks the validity of the frame as "invalid":

- *Valid*: the sampled analogue value is considered as valid.
- *Invalid*: the sampled analogue value is considered as invalid.

(5) **out of range** (Valid / Invalid): Sets the default response when the quality Out of Range marks the validity of the frame as "questionable":

- *Valid*: the sampled analogue value is considered as valid.
- *Invalid*: the sampled analogue value is considered as invalid.

(6) **bad reference** (Valid / Invalid): Sets the default response when the quality Bad Reference marks the validity of the frame as "questionable":

- *Valid*: the sampled analogue value is considered as valid.
- *Invalid*: the sampled analogue value is considered as invalid.

(7) **oscillatory** (Valid / Invalid): Sets the default response when the quality Oscillatory marks the validity of the frame as "questionable":

- *Valid*: the sampled analogue value is considered as valid.
- *Invalid*: the sampled analogue value is considered as invalid.

(8) **failure** (Valid / Invalid): Sets the default response when the quality Failure marks the validity of the frame as "invalid":

- *Valid*: the sampled analogue value is considered as valid.
- *Invalid*: the sampled analogue value is considered as invalid.

(9) **old data** (Valid / Invalid): Sets the default response when the quality Old Data marks the validity of the frame as "questionable":

- *Valid*: the sampled analogue value is considered as valid.
- *Invalid*: the sampled analogue value is considered as invalid.

(10) **inconsistent** (Valid / Invalid): Sets the default response when the quality Inconsistent marks the validity of the frame as "questionable":

- *Valid*: the sampled analogue value is considered as valid.
- *Invalid*: the sampled analogue value is considered as invalid.

(11) **inaccurate** (Valid / Invalid): Sets the default response when the quality Inaccurate marks the validity of the frame as "questionable":

- *Valid*: the sampled analogue value is considered as valid.
- *Invalid*: the sampled analogue value is considered as invalid.

In loss rate settings:

(12) **In loss rate** (True / False): Enables (True) or disables (False) the collection of IEC 61850-9-2LE Frame Loss Rate statistics.

(13) **In loss rate level** (0 to 100, step 1): Defines the lost rate threshold for the IEC 61850-9-2 sampled value frame per cycle (in %). If the Frame Loss Rate is higher than this setting, the sampled value is considered “Invalid”.

3.3.3.3 ATTRIBUTES OF A DIU2XX/DOU2XX/HBU200 BOARD

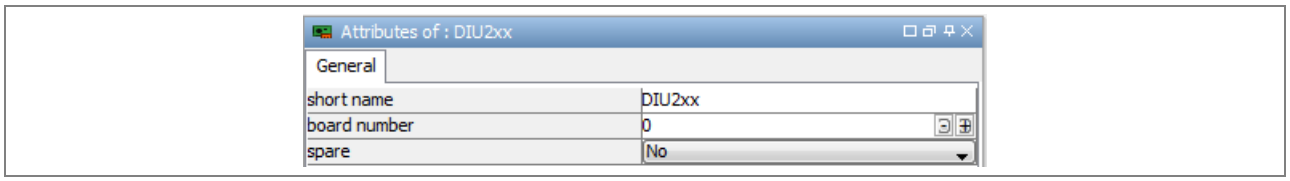


Figure 28: General attributes common to DIU/DOU/HBU boards

Board configuration

If, in the C266's attributes, compatible boards (DIU211, DOU201, CCU211 and HBU200) have been set to *…with slot affectation…*:

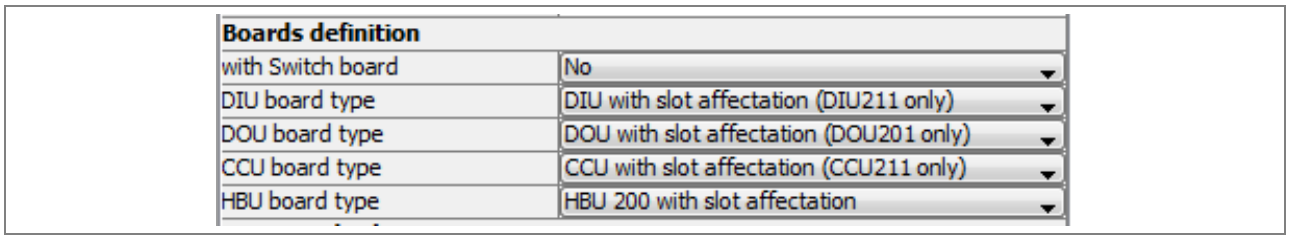


Figure 29: Board definition attributes of a C26x

then there are extra settings in the board's attribute window.

For all the compatible boards, the setting slot number is added. The letter entered in this field takes precedence over the physical jumper setting on the board.

Note:
See section 3.3.1 Adding boards *for slot number configuration rules.*

For boards fitted with digital inputs (DIU211 and CCU211), there is also a setting for the voltage range of the inputs: **input voltage**.

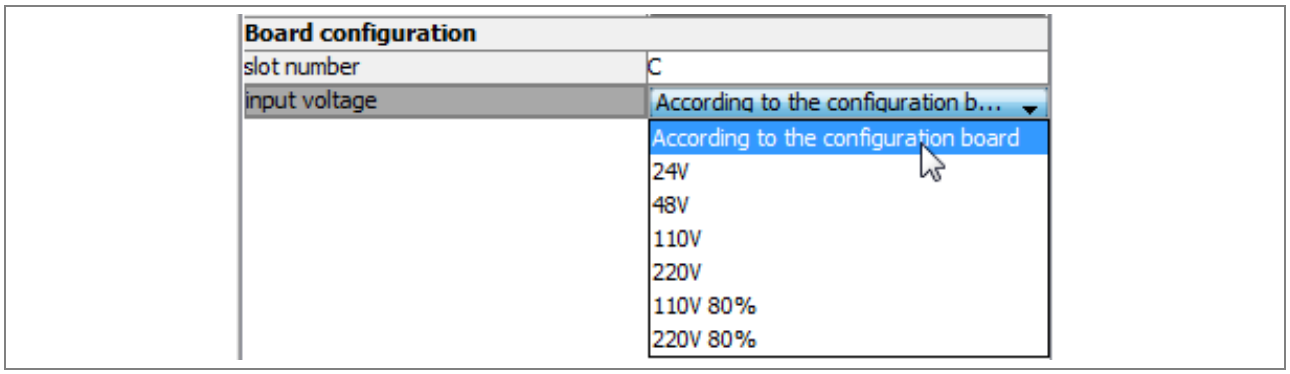


Figure 30: Board configuration attributes specific to a DIU211 board

Selecting ***According to the configuration board*** means that the range is chosen by positioning jumpers on the board (see *Hardware* chapter).

For specifics on each voltage range, see the ***Ratings*** section in the *Technical Data* chapter of the C264 user manual.

Board number attribute

- For boards set to ***…with slot affectation…***: it is not settable and is automatically calculated when an SBUS automatic addressing is performed.
- Boards that do not support the "slot affectation" feature and compatible boards set to *…with jumper address…*: This number must be set manually according to this rule: For each board type (DIU2xx, DOU2xx, HBU200), the **board number** attribute values must start at 0, be unique and contiguous.

3.3.3.4 ATTRIBUTES OF A GHU3XX BOARD

(1) **HMI type**: for GHU boards, the specific attribute must be set to:

- *Simple* if the C26x is fitted with a GHU board without LCD (GHU310/220)
- *Complete* if the C26x is fitted with a GHU board with LCD (GHU300)

(2) **Button management**: Only available if the the parameter **HMI type** is **Simple**. If the front panel is a GHU310, the L/R button can be configured to:

- *Local/Remote*: Switch the C26x bay mode between *Local* and *Remote*
- *Test Leds*: Test the proper operation of the LED indicators on the front panel

(3) **LED allocation**: Free (the LEDs on the C26x front panel can be freely assigned to datapoints) or pre-defined (factory-set configuration)

(4) The **default start panel** is the panel that will be displayed when the C264 is booted

(5) The **default inactivity panel** is the panel that will be displayed after the timeout **delay before inactivity** (6) elapses

(7) **alarm panel present**: *Yes* or *No*

(8) **setting panel present**: *Yes or No*. This option is only relevant if the C26x has protection functions, as otherwise this panel will be empty but for the header.

(9) **AVR panel present**: *Yes or No*.

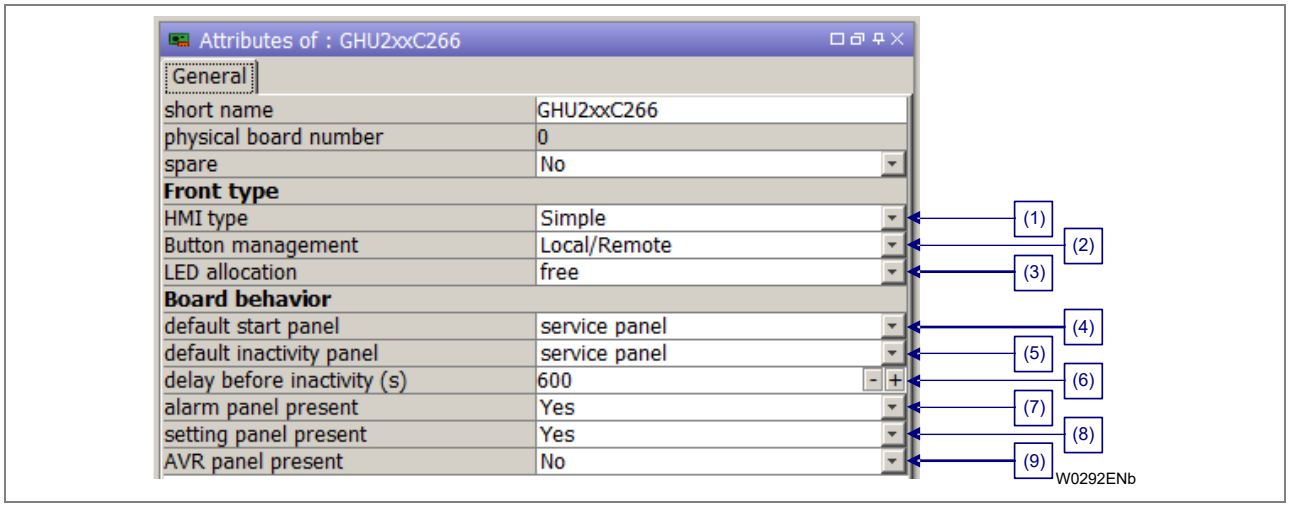


Figure 31: General attributes specific to a GHU300 board

Note:
*For a complete HMI, the extra relation **has for workspace** (1) must be filled in at board level. For details about the C26x workspace, see section 7.2.2 Defining a C26x workspace.*

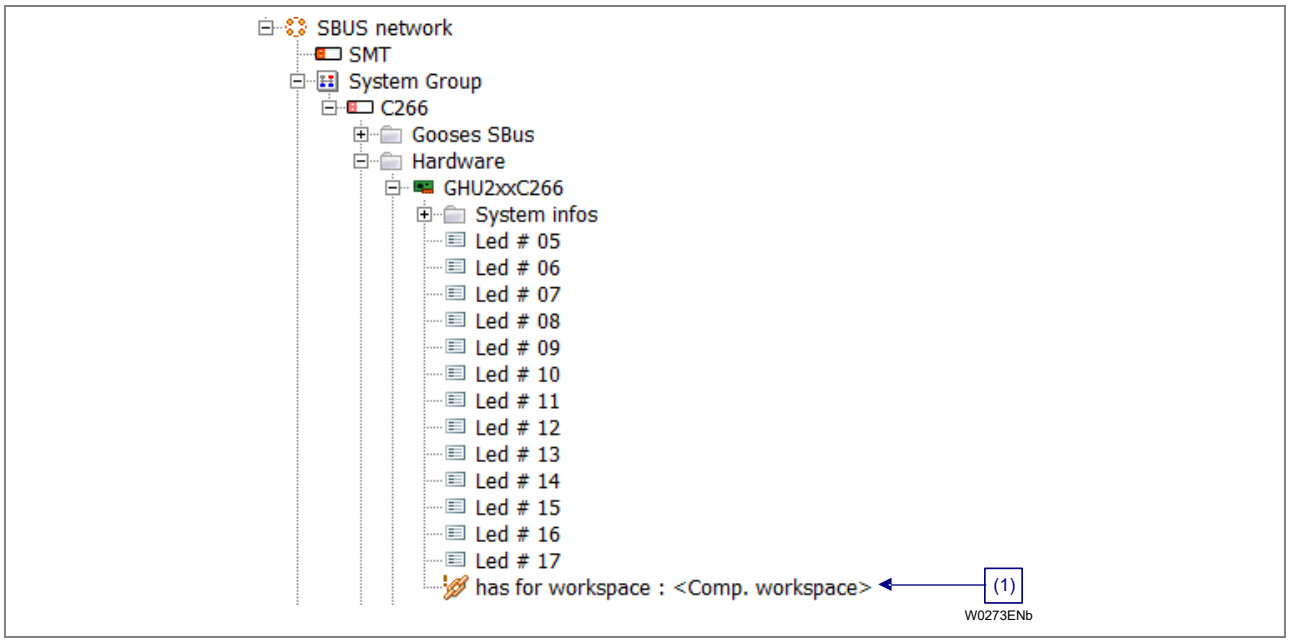


Figure 32: Defining a workspace for a complete GHU300 board

For C26x LED configuration, see section *7.2.4 Displaying a datapoint state through an LED*.

Configuration rules and checks

- If the **HMI type** attribute is set to *Simple*, then **Led#5** must not be assigned (no relation link from **Led#5** to any datapoint) as it is reserved for the Local/Remote indication on that front panel.
- If the **HMI type** attribute is not set to *Complete*, then the relation **has for workspace** must not be linked as there will be no LCD to display the workspace on the front panel.

3.3.3.5 ATTRIBUTES OF A TMU220 BOARD (BCU ONLY)

For TMU220 board, the following attributes have to be set for correct CT/VT computation of derived measurements.

General tab-pane

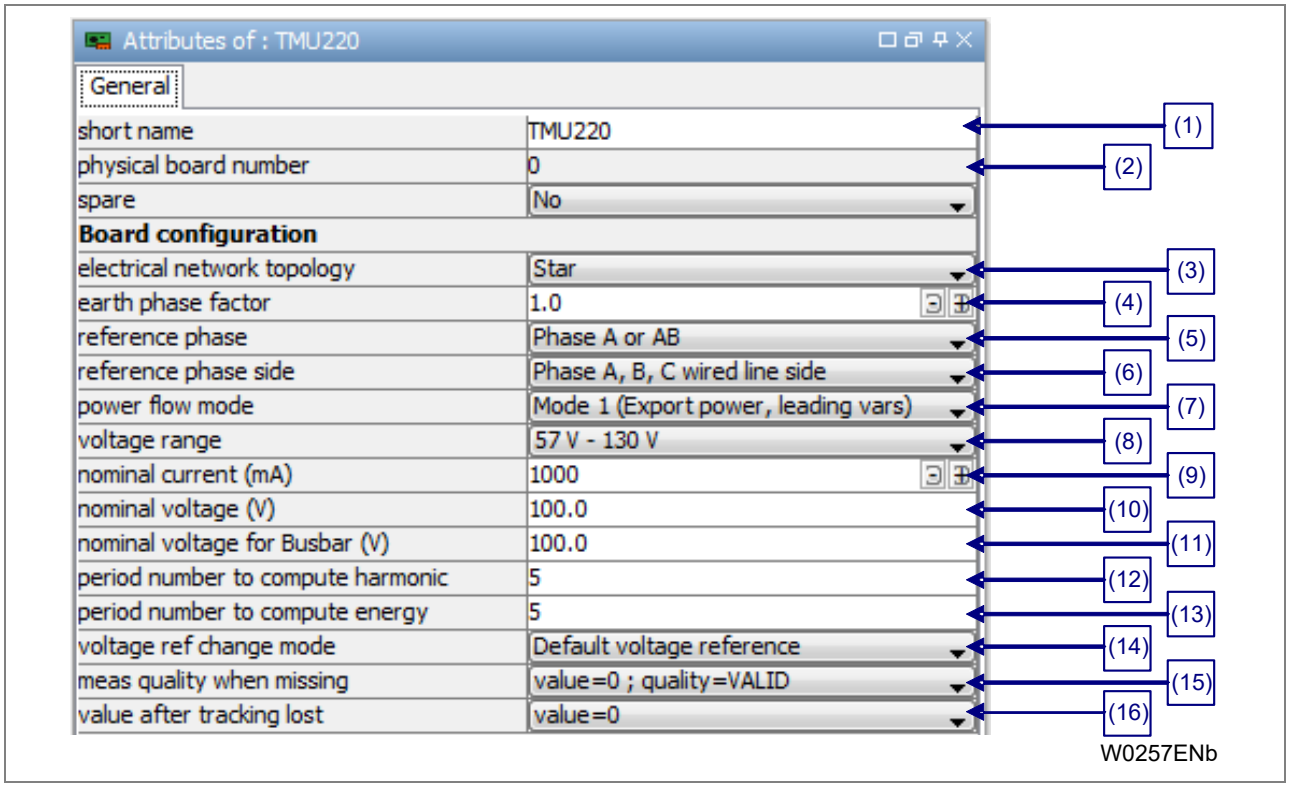


Figure 33: General attributes specific to a TMU220 board

(1) **short name**

(2) **physical board number:**

- If there is one TMU board: the physical board number is 0 (default value).
- If there are two TMU boards, one must be set to *1* and the other to *0:*
  - **0** refers to the TMU board located at the far right of the rack (from the front view);
  - **1** refers to the TMU board located at the left side of the TMU board 0.

(3) **electrical network topology** (Star / Delta): VT arrangement for the three phase or phase-phase voltages, as defined for (6) reference phase side.

(4) **earth phase factor** (range [0.0, 2.0], step 0.01): Earth factor K0 used by the Synchrocheck function to derive the phase-phase voltages from the phase-neutral voltages and vice-versa where there are different VT topologies on the line side and on the busbar side.

(5) **reference phase** (Phase A or AB / Phase B or BC / Phase C or CA): Phase or phase pair used by the Synchrocheck function to compare the line and busbar voltages.

(6) **reference phase side** (Phase A, B, C wired line side / Phase A, B, C wired busbar side).

(7) **power flow mode** (Mode 1 (Export power, leading vars) / Mode 2 (Import power, leading vars) / Mode 3 (Export power, lagging vars) / Mode 4 (Import power, lagging vars)).

(8) **voltage range** (57 V - 130 V / 220 V - 480 V): voltage range of the TMU board's voltage inputs.

(9) **nominal current** (1000 mA / 5000 mA): Rated secondary phase current.

(10) **nominal voltage** (range [1 V, 500 V], step 0.00001 V): Rated secondary three-phase voltage.

(11) **nominal voltage for busbar (V)** reserved for future use.

(12) **period number to compute harmonic** (range [1, 50], step 1): number of electrical periods between consecutive harmonics counts.

(13) **period number to compute energy** (range [1, 50], step 1): number of electrical periods between consecutive energy counts.

(14) **voltage ref change mode** (Default voltage reference / Current voltage reference):

- *Default voltage reference*: as soon as the stated reference phase is valid again, the TMU acquisition process locks onto it
- *Current voltage reference*: the TMU acquisition process remains locked onto the phase that has a valid signal

(15) **meas quality when missing** (value=0; quality=VALID / quality=FAULTY)

- *value=0; quality=VALID*: when the TMU board receives no signal, that absence is considered as a valid 0 value that the C26x transmits over the network: IEC, HMI, GTW…
- *quality=FAULTY*: when the TMU board receives no signal, that absence is considered as an invalid value and the C26x transmits the signal "self-check fault" over the network: IEC, HMI, Gateway…

During TMU frequency synchronization, set the related measurement values to 0 /self-Check fault. Do not set the related measurement values to 0 / Valid.

If the reference phase signal is absent, the values transmitted by the TMU board are set to invalid.

(16) **value after tracking lost** (value=0; hold current value): reserved for future use. display of MV values after an interruption of frequency tracking.

Refer to the Connection chapter of the C26x user manual for the description of the TMU2xx electrical CT/VT inputs and database association.

Bay association

The BCU can manage up to 2 bays, both either digitally (through merging units) or conventionally through TMU boards. Configure the relation **is used by : <Bay>** to the bay wired to each TMU board.

3.3.3.6 ATTRIBUTES OF A TMU210 BOARD

For TMU210 board, the following attributes have to be set for correct CT/VT computation of extra measurements:

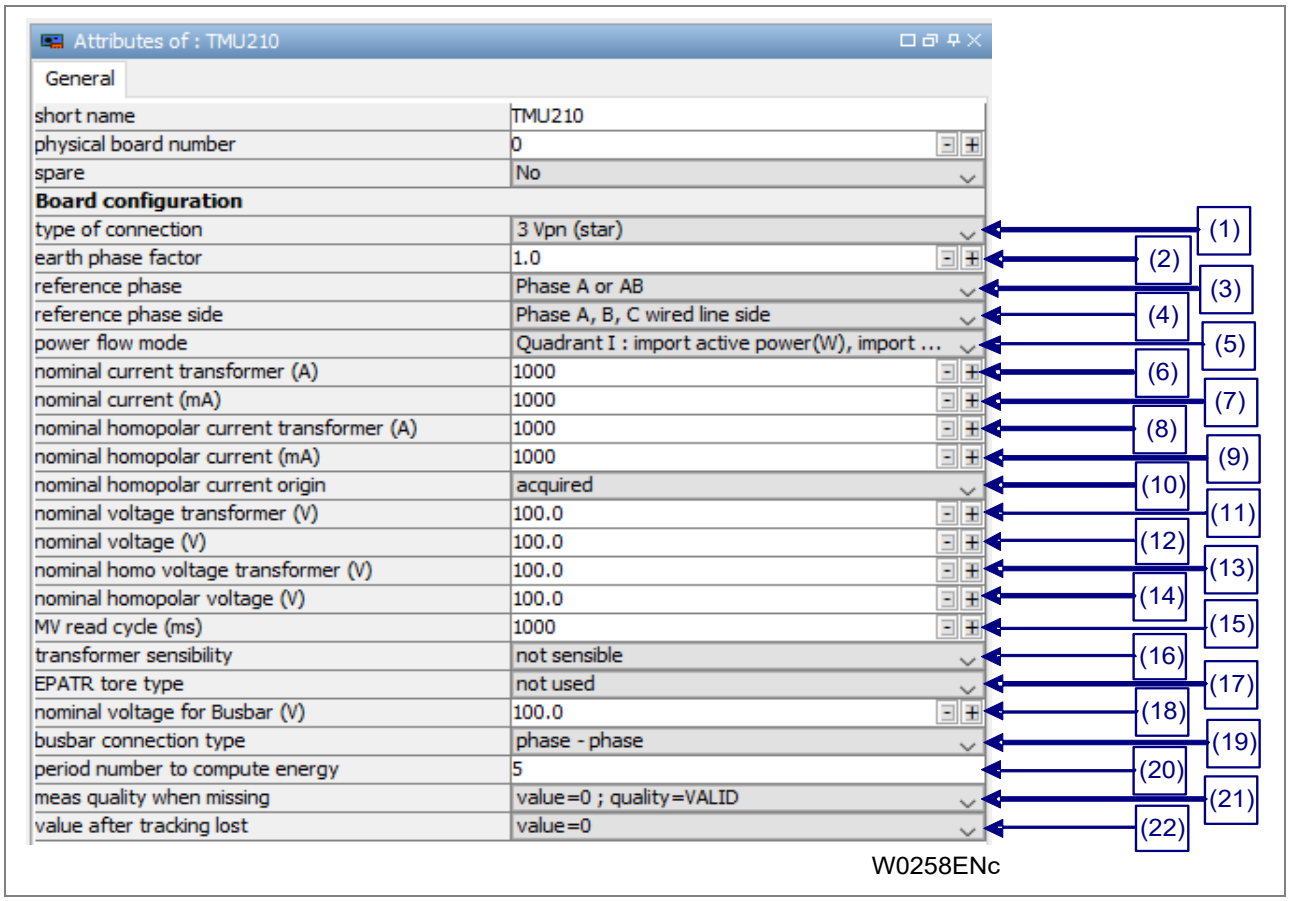


Figure 30: General attributes specific to a TMU210 board

(1) **type of connection** (3 Vpn (star) / 3 Vpn + V0 (star) / 2 Vpn + V0 (partial star) / 2 Vpp + V0 (partial delta) / 3 Vpp + V0 (delta) / 3 Vpn + Vb (star) / 3 Vpp + Vb (delta)) of the voltage transformers.

(2) **earth phase factor** (range [0.0, 2.0], step 0.01): Earth factor K0 used by the Synchrocheck function to derive the phase-phase voltages from the phase-neutral voltages and vice-versa where there are different VT topologies on the line side and on the busbar side.

(3) **reference phase** (Phase A or AB / Phase B or BC / Phase C or CA): Phase or phase pair used by the Synchrocheck function to compare the line and busbar voltages.

(4) **reference phase side** (Phase A, B, C wired line side / Phase A, B, C wired busbar side).

(5) **Power flow mode:**

- **Quadrant I: import active power (W), import reactive power (VAr)**. In quadrant I, both powers flow positively. The power factor is lagging (inductive influence)
- **Quadrant II: export active power (W), import reactive power (VAr)**. In quadrant II, reactive power is positive and active power flows negatively.
- **Quadrant III**: **export active power(W), export reactive power (VAr)**. In quadrant III, reactive and active power flow negatively.
- **Quadrant IV**: **import active power(W), export reactive power (VAr)**. In quadrant IV, reactive power flows negatively, and active power flows positively.

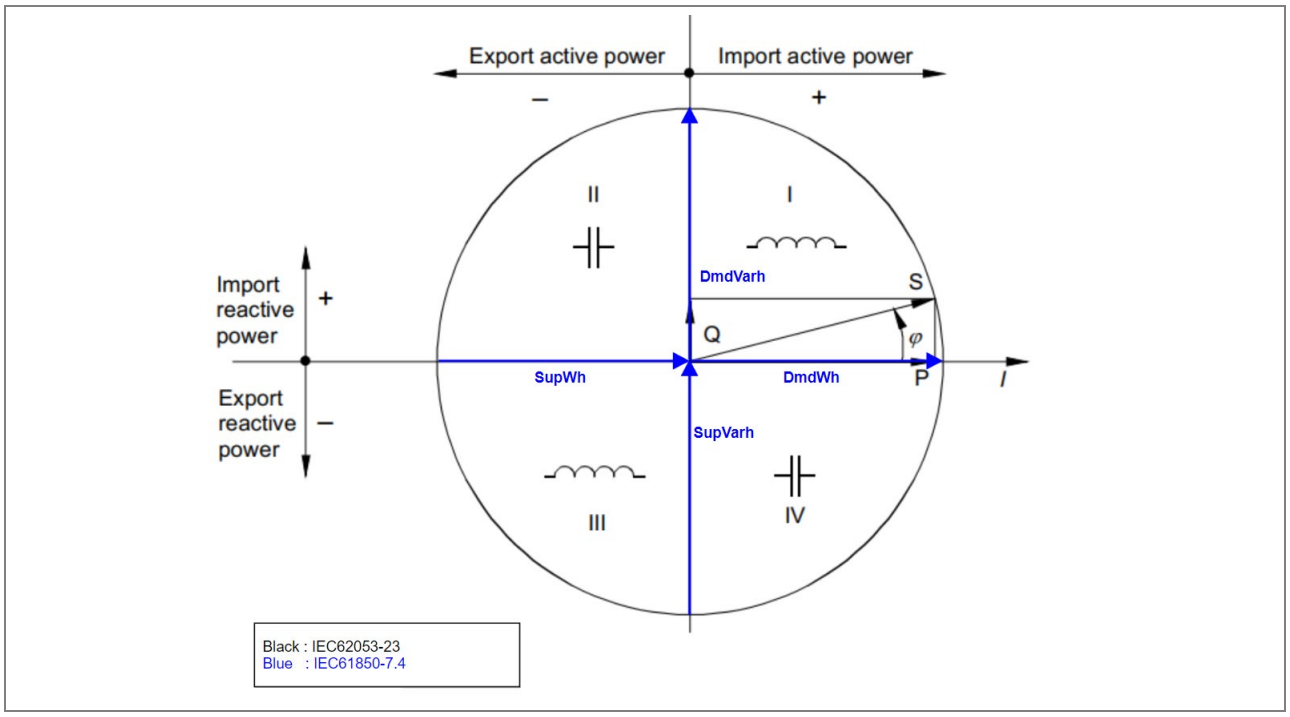


Figure 34: representation of bi-directional power flow quadrants according to IEC62053-23 & IEC61850-7.4 standards

(6) **nominal current transformer (A)**: (range [1, 9999 A], step 1 A): Rated primary phase current

(7) **nominal current (mA)**: (1000 mA / 5000 mA): Rated secondary phase current

(8) **nominal homopolar current transformer (A)**: (range [1, 9999 A], step 1 A): Rated primary neutral current

(9) **nominal homopolar current (mA)**: (1000 mA / 5000 mA): Rated secondary neutral current

(10) **nominal homopolar current origin** (acquired / computed): Defines whether the neutral current is measured from a dedicated CT or if it derived from the sum of the three phase currents

(11) **nominal voltage transformer (V)**: (range [10, 1200000 V], step 1 V): Rated primary phree-phase voltage

(12) **nominal voltage (V)**: (range [57 V – 130 V], step 1 V): Rated secondary phree-phase voltage

(13) **nominal homo voltage transformer (V)**: (range [10, 1200000 V], step 1 V): Rated primary residual voltage

(14) **nominal homopolar voltage (V)** (range [57 V – 130 V], step 1 V) : Rated secondary residual voltage

(15) **MV read cycle (ms)** (range [100, 9900 ms], step 100 ms): time interval at which measured values are refreshed on the local LCD and re-sent over the network (to SCADA etc.)

(16) **transformer sensibility** (sensitivity) (not sensible / sensible / very sensible): setting used to determine the Ien range for earth fault protection.

(17) **EPATR tore type** (400/1 / 100 / 80/1 / not used): transformer ratio for the resistive earth fault core balance CT (legacy protection function)

(18) **nominal voltage for busbar (V)** (range [57 V,130 V], step 1 V): Rated secondary busbar voltage

(19) **busbar connection type** (phase – phase / phase - neutral)

(20) **period number to compute energy**: (range [1, 50], step 1) set this attribute according to the number of frequency network cycles. The accuracy of measurement is highly dependant of this attribute.

(21) **meas quality when missing**: quality state behaviour according to missing value provided by Merging Unit (MU) (value=0; quality=VALID / quality=FAULTY)

- *value=0; quality=VALID*: when no signal is received, that absence is considered as a valid 0 value that the C26x transmits over the network: SCADA, HMI, GTW…
- *quality=FAULTY*: when no signal is received, that absence is considered as an invalid value and the C26x transmits the signal "self-check fault" over the network: SCADA, HMI, Gateway…

If the reference phase signal is absent, the values transmitted by the merging unit are set to invalid.

(22) **value after tracking lost**: default value according lost value provided by Merging Unit (valid = 0, or hold current value)

If the reference phase signal is absent, the values transmitted by the TMU210 board are considered invalid.

Please refer to the Connections Chapter of the C264 user manual for the description of the TMU210 electrical CT/VT inputs and database association.

3.3.4 CONFIGURING A COMMUNICATION CHANNEL

A communication channel is a physical port available on the BIU board upon its creation or manually added as an option.

A communication channel can be used exclusively for communications with a SCADA network

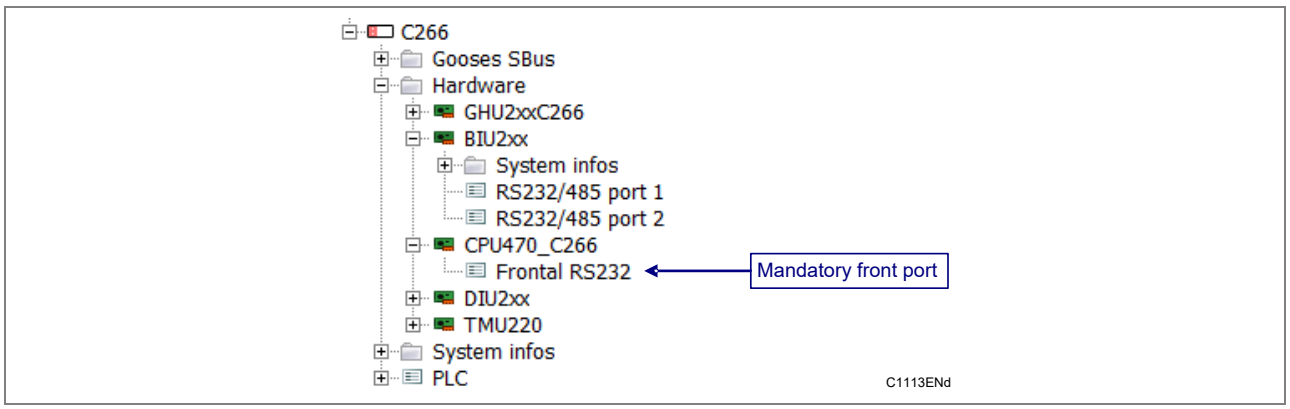


Figure 35: Use of communication channels

General attributes and Transmission attributes

The Frontal RS232 port is not configurable and is by default set with the following settings:

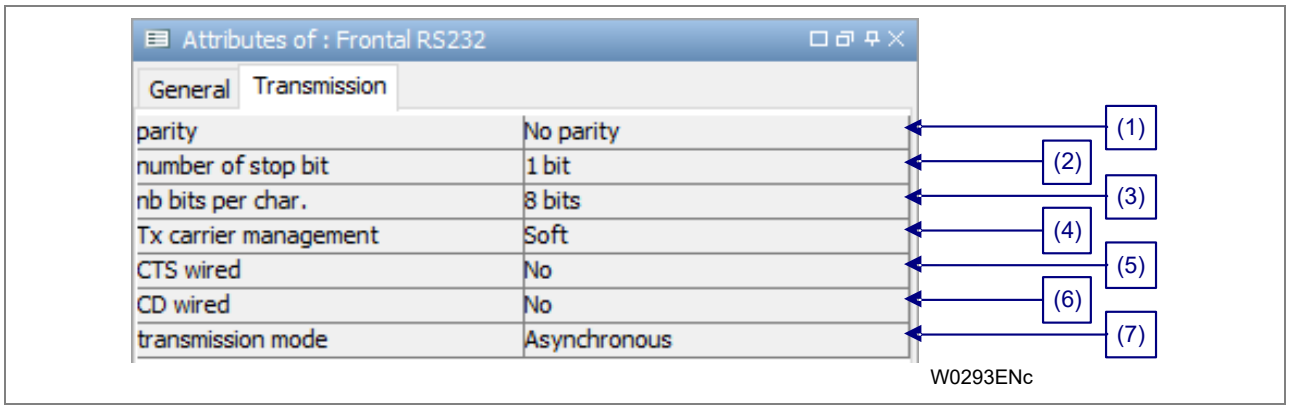


Figure 36: General attributes and Transmission attributes of a communication channel

(1) **parity:** *No parity*

(2) **number of stop bits**: *1 bit*

(3) **nb bits per char.**: *8 bits*

(4) **Tx carrier management**: Soft means that the RTS and CTS line are not managed by the C26x

(5) **CTS wired**: fixed to No

(6) **CD wired**: fixed to No

(7) **Transmission mode**: asynchronous

3.3.5 CONFIGURING THE CPU4 BOARD

3.3.5.1 SETTING THE CPU4 REDUNDANCY PROTOCOL

The CPU4 board can communicate on either a PRP (Parallel Redundancy Protocol) or an HSR (High-availability Seamless Redundancy Protocol) network.

To set the CPU4 redundancy protocol, follow these instructions:

1 In the **Object view**, click on the internal switch of your CPU4 board,

2 Then, set the attributes to the relevant redundancy protocol:

- **Protocol**: select either HSR/PRP/None for the redundant ports 1 and 2 depending on the compatible bitstream.
- **Entry forget time**: time after which the device will remove an entry from the duplicate table. When the device receives the second frame of a pair after 400 ms (default value), it will processe the frame instead of discarding it.

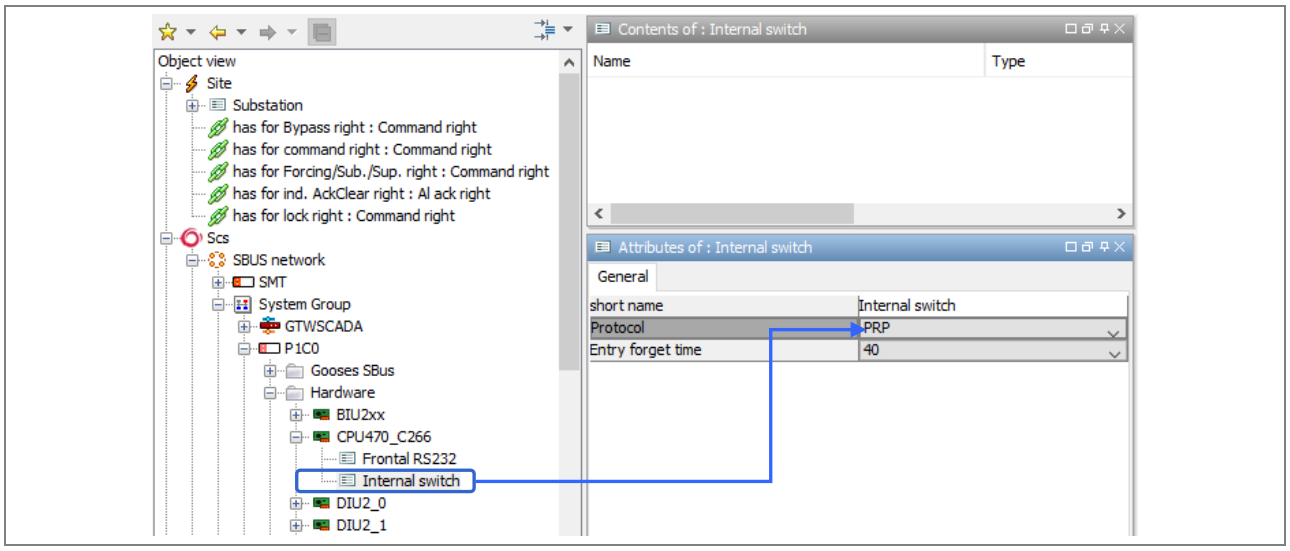


Figure 37: Setting the CPU4 redundany protocol

3.3.5.2 CPU4 ETHERNET PORT MONITORING

The CPU4 ports return specific information, such as speed and status to the system. This information is sent every 10 seconds.

According to your configuration and bitstream use case, you may want to monitor each port individually to control:

- **Port status**
- **Port speed**

Note: The CPU4 may be interfaced with an SRP28x Ethernet switch board through the High-speed bus (bitstream SOC2233). In such a case, the SRP28x ports are not monitored. Port monitoring does not apply to the link between the CPU4 and the SRP28x boards (High Speed Back Plane).

Port Status

The port status provides information on how the port is networked in term of equipment and protocol. A port may have different states depending on whether it is or not:

- Configured,
- Simple attachment
- Redundant (PRP/HSR),
- Connected through an SFP transceiver,
- With traffic. Only incoming data received from a CPU4 external port and processed by the C264 is taken into account to determine whether the port **traffic** is ON or OFF. Transmitted data (TX data) is ignored.

Port speed

The CPU4 ports are half/full duplex and auto-sense the transmission speed. When connected to an SFP transceiver, they auto-negotiate with the connected device to determine the optimal transmission speed:

- 10 Mbps,
- 100 Mbps
- 1000 Mbps

3.3.5.2.1 Configuring datapoints to monitor the CPU4 ports

To monitor a CPU4 port (for speed and/or status), follow these instructions:

1 In the **Object view** panel, click on the **Internal switch** of your CPU4 board,

2 In the **Object entry** panel on the left, add the port datapoint(s) your wish to monitor in accordance with your system architecture and the C264 bitstream configuration. Either double-click on the datapoint or right-click on it and then select **Add**.

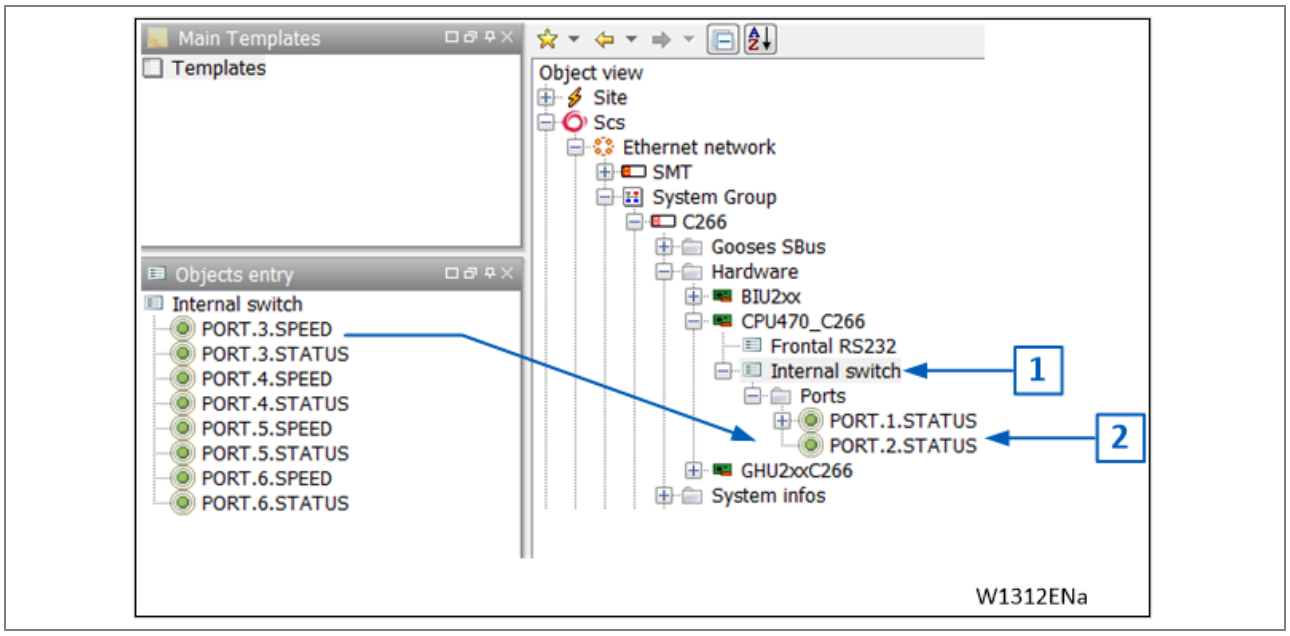


Figure 38: Selecting port datapoints to be monitored

3 Add a new MPS profile per datapoint (speed and status) and set each state as follows (*due to the maximum attribute size, state labels are deliberately truncated*):

Port status

Profile		
MPS Port Status	**States**	**Description**
0	**OFF**	Disabled per configuration
1	**SAN ON NO trafic**	Simple attachement ON without traffic
2	**SAN ON traffic**	Simple attachement ON with traffic
3	**SAN ERROR**	Transceiver not plugged or plugged but not forwarding
4	**PRP ON NO trafic**	PRP attachement ON without traffic
5	**PRP ON trafic**	PRP attachement ON with traffic
6	**PRP ERROR**	Transceiver not plugged or plugged but not forwarding
7	**HSR ON NO trafic**	HSR attachement ON without traffic
8	**HSR ON trafic**	HSR attachement ON with traffic
9	**HSR ERROR**	Transceiver not plugged or plugged but not forwarding

Port speed

Profile	
MPS Port Speed	**States**
0	10 Mbps
1	100 Mbps ffic
2	1000 Mbps (1 Gbps)
3	Unknown

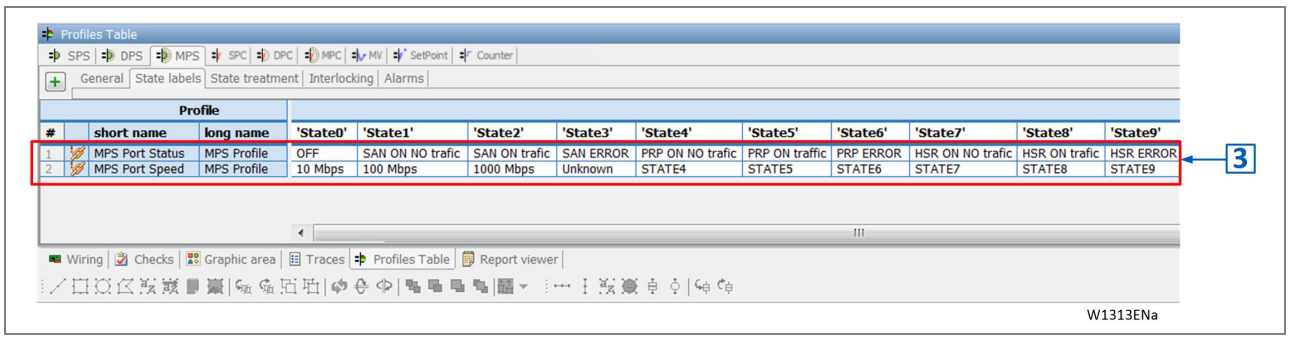


Figure 39: Status and speed MPS profiles for port monitoring

4 Then, for each port datapoint, link the appropriate MPS profile:

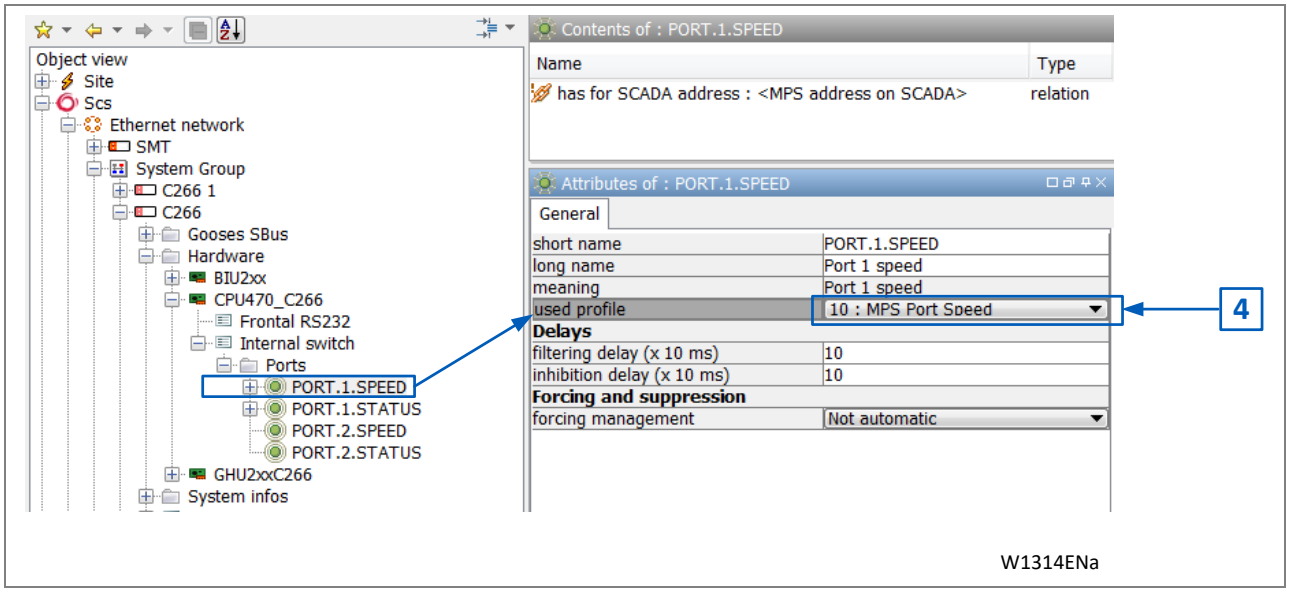


Figure 40: Linking the MPS profiles for port monitoring

3.3.6 CONFIGURING AN AI CHANNEL

An AI channel is an analogue input available on the AIU201 and AIU21x boards upon their creation. AI channels are used for analogue measurement acquisition.

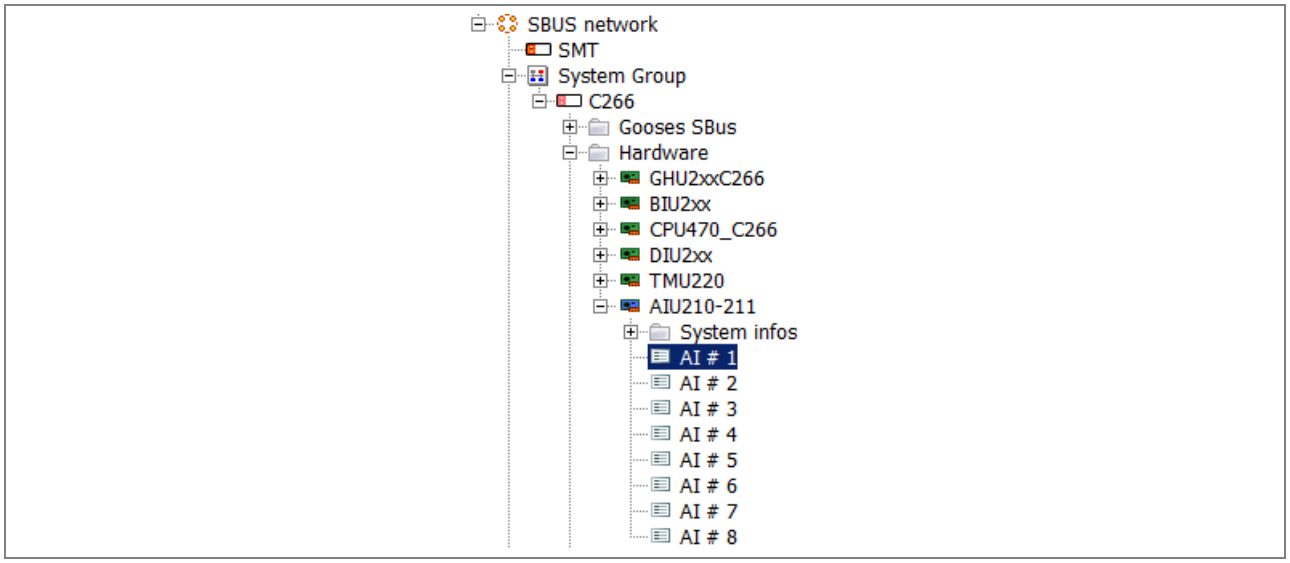


Figure 41: Use of analogue channels

Once associated with an MV, the AI needs to be set in accordance with the acquisition characteristics:

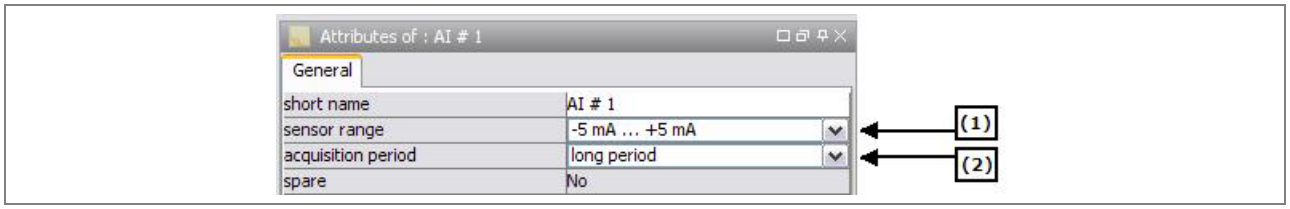


Figure 42: Configuring an AI channel

(1) **sensor range for AIU201**: *-20 mA …+20 mA / -10 mA …+10 mA / -5 mA …+5 mA / -1 mA …+1 mA / 0 mA …+1 mA / 0 mA …+5 mA / 0 mA …+10 mA / 0 mA …+20 mA / 4 mA …+20 mA / -10 V…+10 V / -5 V...+5 V / -2.5 V… +2.5 V / -1.25 V …+1.25 V*

sensor range for AIU210/AIU211: *-20 mA …+20 mA / -10 mA …+10 mA / -5 mA...+5 mA / -1 mA…+1 mA / 0 mA…+1 mA / 0 mA…+5 mA / 0 mA…+10 mA / 0 mA...+20 mA / 4 mA …+20 mA*

(2) **acquisition period** (*short period* / *long period*): see section 3.2.3 Configuring measurement acquisition and transmission.

3.3.7 CONFIGURING AN AO CHANNEL

AO channels are analogue outputs generated with an AOU200 board when it is created in SCE.

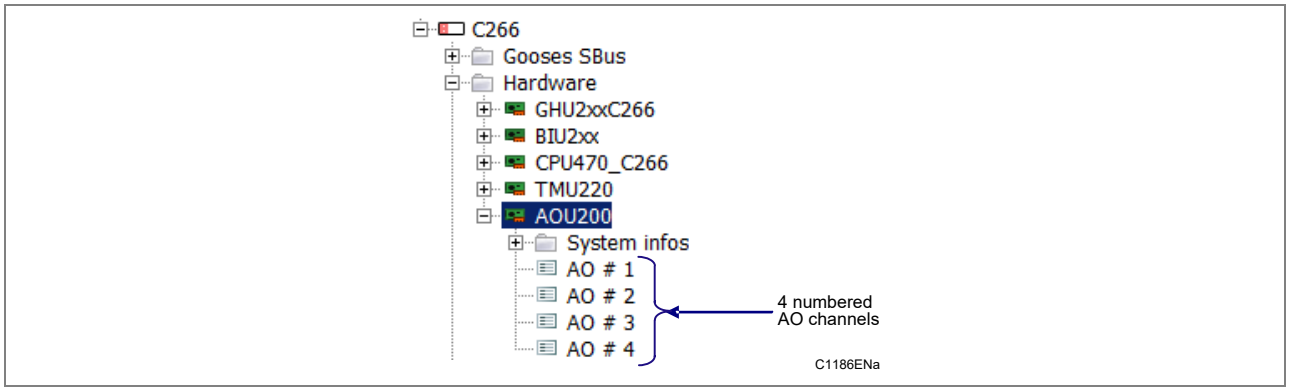


Figure 43: Uses of AO channels

The AO channel has the following attributes:

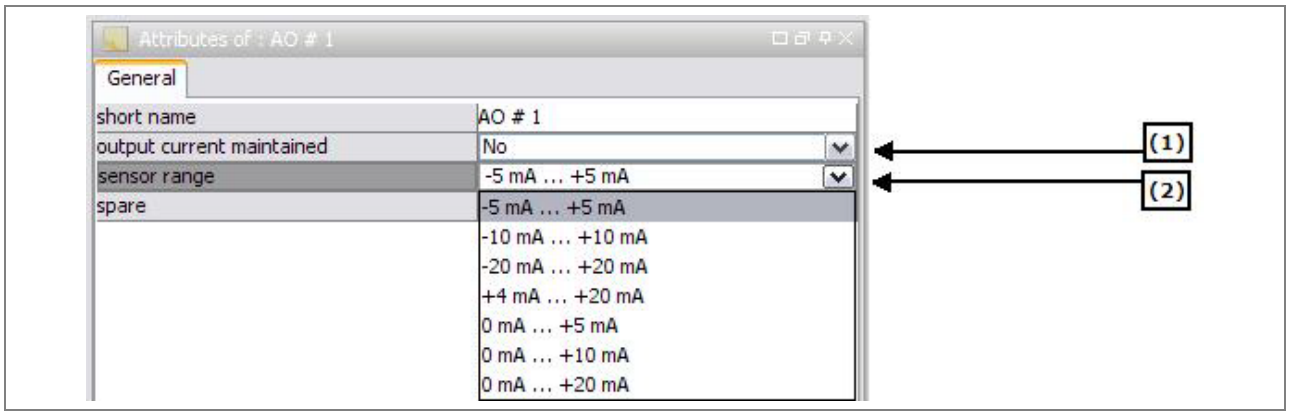


Figure 44: Attributes of AO channels

(1) **Output current maintained** mode: Yes or No

Each current output is individually managed in 2 modes:

- *Maintained mode*: if a C26x is shut down or powered off, the output level is maintained (and the Read inhibit relay is set). The output value will change only when a new setpoint is received.
- *Unmaintained Mode*: if a C26x shuts down, the output is set to 0

(2) **sensor range for AOU200***: -20 mA …+20 mA / -10 mA …+10 mA / -5 mA …+5 mA / 4 mA …+20 mA / 0 mA …+5 mA /0 mA …+10 mA / 0 mA …+20 mA*

3.4 C26X IP ADDRESS AND ROUTING TABLE DEFINITION

Below are two examples of C26x addressing and routing table definition in two typical C26x application cases.

3.4.1 C26X AS A GATEWAY CONNECTED TO A ROUTER AND A REMOTE IEC104 SCADA

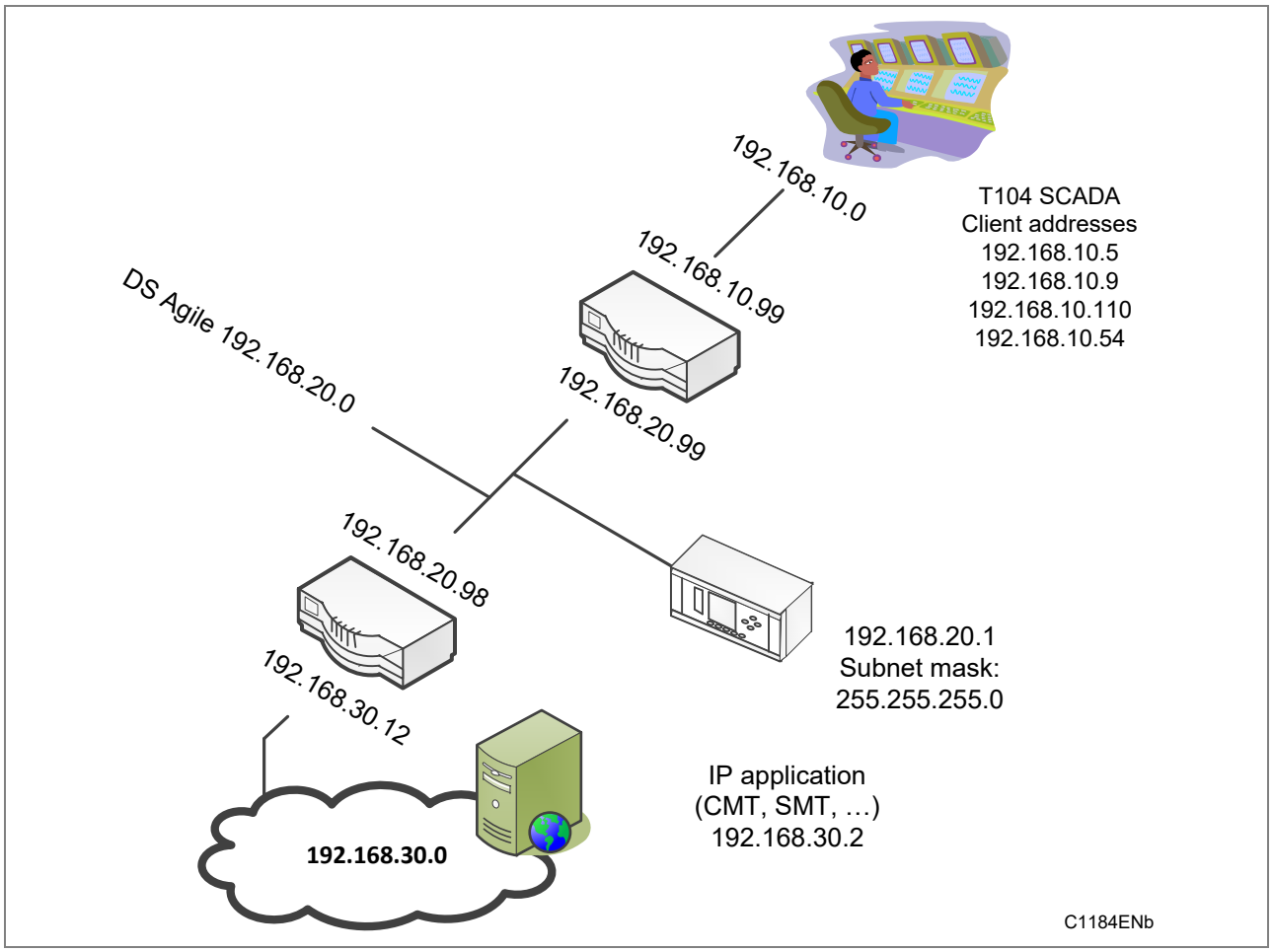


Figure 45: C26x connected to a SCADA via a router

3.4.1.1 C26X ROUTING TABLE PARAMETERS

In the SCE configuration, the C26x's routing table is declared as follows:

- **Gateway TCP/IP address** gives the address of the router.
- **Target TCP/IP address** is the address of the remote "Client" that will be connected through this router.

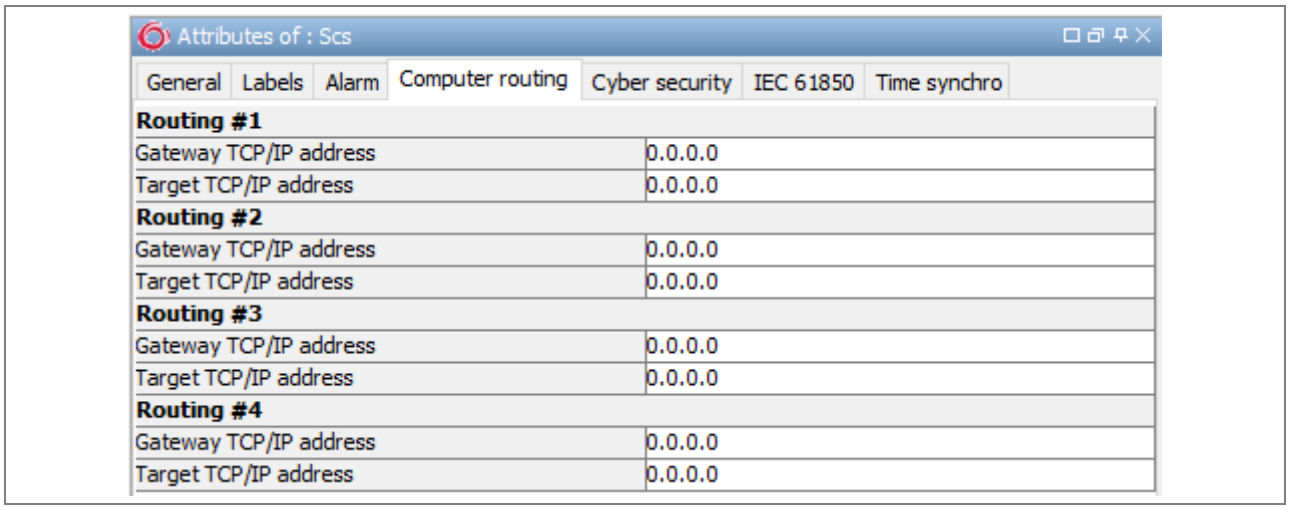


Figure 46: Attributes of an SCS

Example:

192.168.30.0 can be replaced with 192.168.30.2. In that case, the C26x can reply only to the IP address 192.168.30.2.

The label "Gateway TCP/IP address" should be read as "Router IP address" (not linked to the C26x's gateway function) and the label "Target TCP/IP address" should be read as "Target or Network IP address".

3.4.1.2 T104 PROTOCOL CONFIGURATION

It is possible to secure the T104 client remote connection by giving a short list of authorized clients.

In this example, the T104 SCADA link configuration is defined as follows:

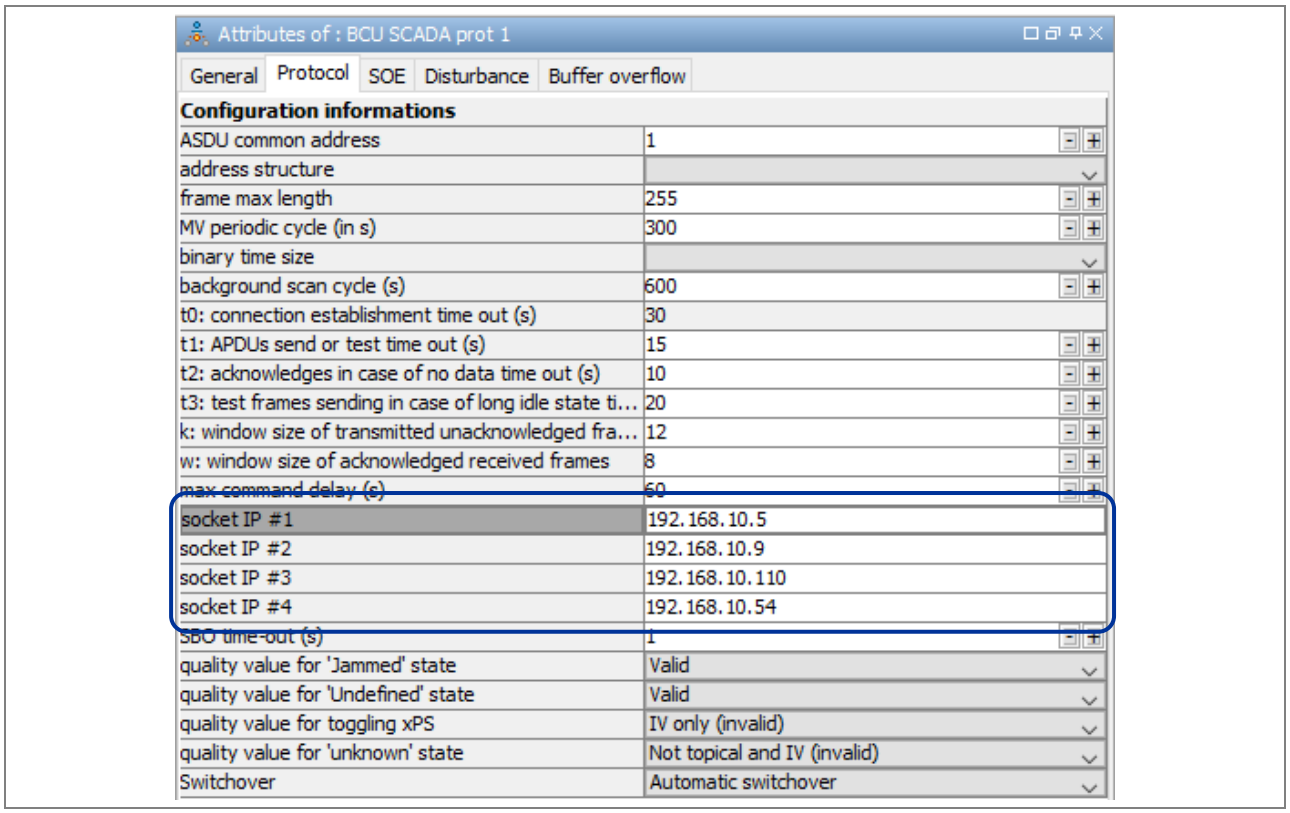


Figure 47: T104 configuration (attributes of the BCU SCADA protocol)

3.4.1.3 C26X IP ADDRESS DEFINITION

The C26x's IP address is defined:

- locally on the C26x's LCD IHM
- using the CMT maintenance tool (over Ethernet)
- using the C26x's maintenance shell (for Maintenance Experts only)

For instance, a C26x has the address 192.168.20.1 and the subnet mask 255.255.255.0 (default value). It can reach all units that have an address in the range 192.168.30.x.

3.4.1.4 C26X IP PARAMETERS USING THE CMT MAINTENANCE TOOL

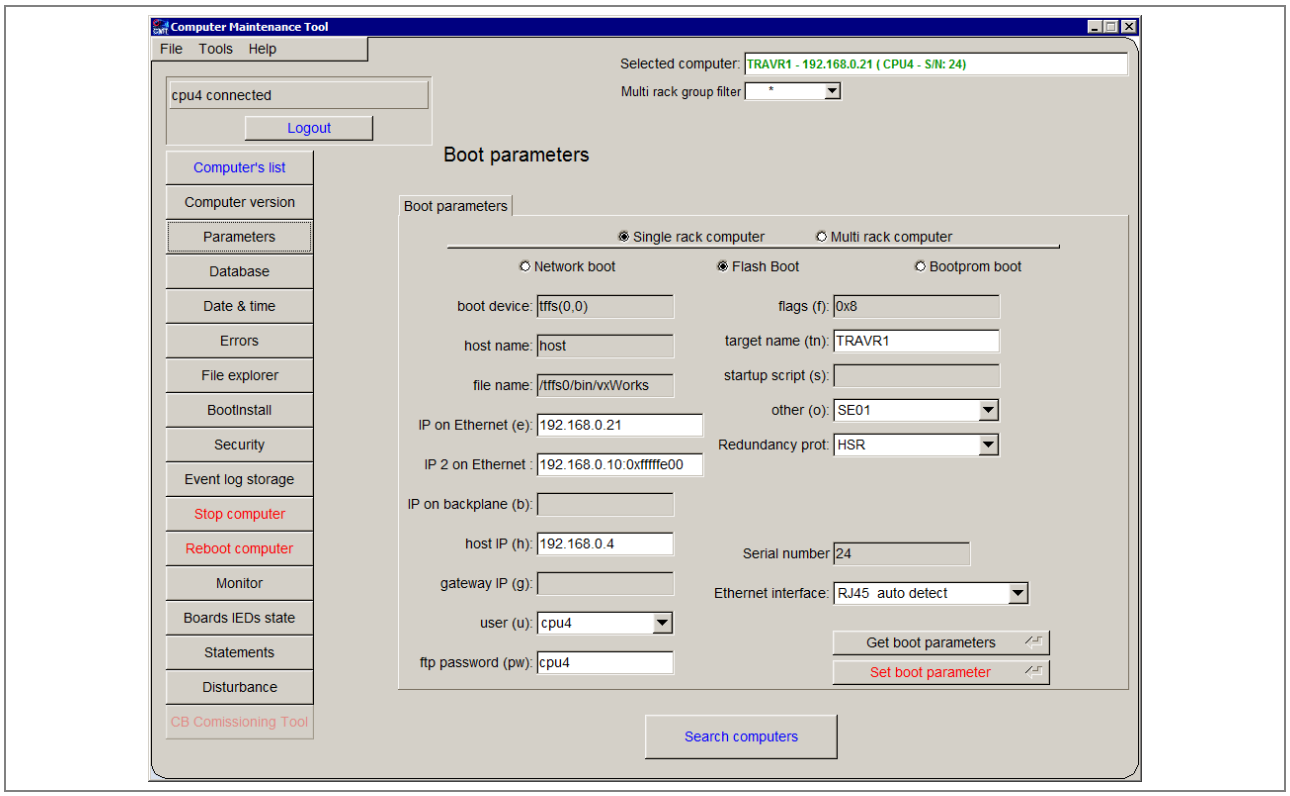


Figure 48: IP on Ethernet: Internet address of the Ethernet interface

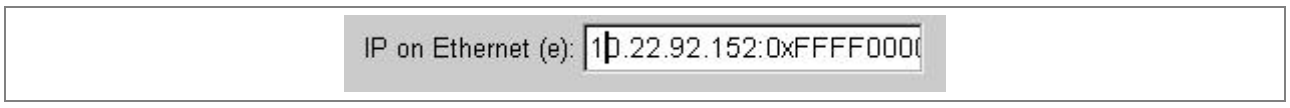
The Internet addresses (IP) are specified in "dot" notation (e.g., 10.22.92.52).

Example: 10.22.92.52

This field can have an optional subnet mask in the form inet_adrs:subnet_mask.

Example: 10.22.92.52:0xFFFF0000 ➔ subnet mask = 255.255.0.0

10.22.92.52:0xFF000000 ➔ subnet mask = 255.0.0.0



By default, the subnet mask is set to 0xFFFFFF00 ➔ subnet mask = 255.255.255.0

3.4.1.5 ROUTER-PC CONFIGURATION (CASE OF A PC RUNNING MS WINDOWS)

In the case of a PC with two Ethernet boards, configure the IP addresses of each board and enable IP routing using a registry key.

1 In the Registry Editor, scroll down to
`HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\services\Tcpip\Parameters`

2 Select the **IPEnableRouter** entry:

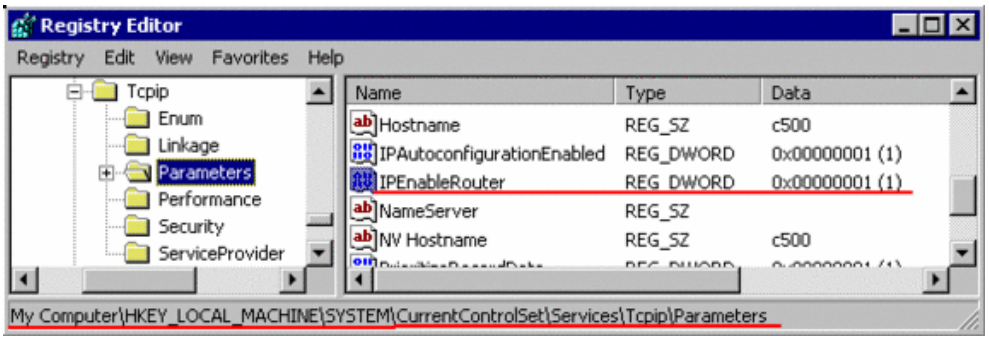


Figure 49: Registry edition

3 To enable IP routing for all network connections installed on and used by this PC, set its value to 1.

This will be taken into account after rebooting.

3.4.1.6 PARTICULAR CASE OF A DHCP NETWORK

The Dynamic Host Configuration Protocol (DHCP) is based on automatic assignment of IP addresses, subnet masks, default gateway, and other IP parameters.

Caution:
The C26x is designed for fixed IP address networks: IP addressing conflicts could be encountered if the C26x were installed on a network with DHCP addressing.

3.5 NETWORKING A C26X ON THE STATION-BUS NETWORK

The connection of a C26x to the station-bus is implicitly done by adding the C26x hierarchically to the **System Group** of the **SBUS network** (see section *3.2 Adding and configuring a C26x in the system's architecture)* and by setting the IP characteristics of the C26x (see *3.2.1 Setting the general attributes of a C26x*).

3.5.1 CONNECTING A C26X TO OTHER STATION-BUS SUB-SYSTEMS

3.5.1.1 OVERVIEW

The IEC 61850 protocol is used to transmit information between DS Agile sub-systems.

Data modeling according to the IEC 61850 protocol is based on a client-server architecture. Each IEC 61850-communicating DS Agile sub-system (aView server, C26x and remote-control gateway) has an IEC 61850 data map of which it is the server. A DS Agile sub-system is the server of a datapoint if it manages it, that is to say if it produces its real-time value (in the case of input datapoints such as states, measurements and counters) or if it executes its real-time controls (in the case of output datapoints such as binary commands and setpoints).

To connect a C26x BCU (A) to a specific IEC 61850-communicating sub-system (B) on the station-bus, an extra relation **has for IEC61850 server** must be created for (A) and point to (B). This means that the C26x BCU (A) is a client of the sub-system (B) and can access the data managed by the sub-system (B), i.e. read the relevant real-time values from (B) and send real-time commands to (B).

Note:
The relation ***has for IEC61850 server*** *is automatically added and configured when the command* IEC61850 > Auto link client / server *is launched after the BCU has been linked to a server's report instance via the relation* ***is used by : <IEC61850 physical device>****.*
See the DS Agile SCE manual, Application chapter (ref. SCE/EN AP) *for configuration details.*

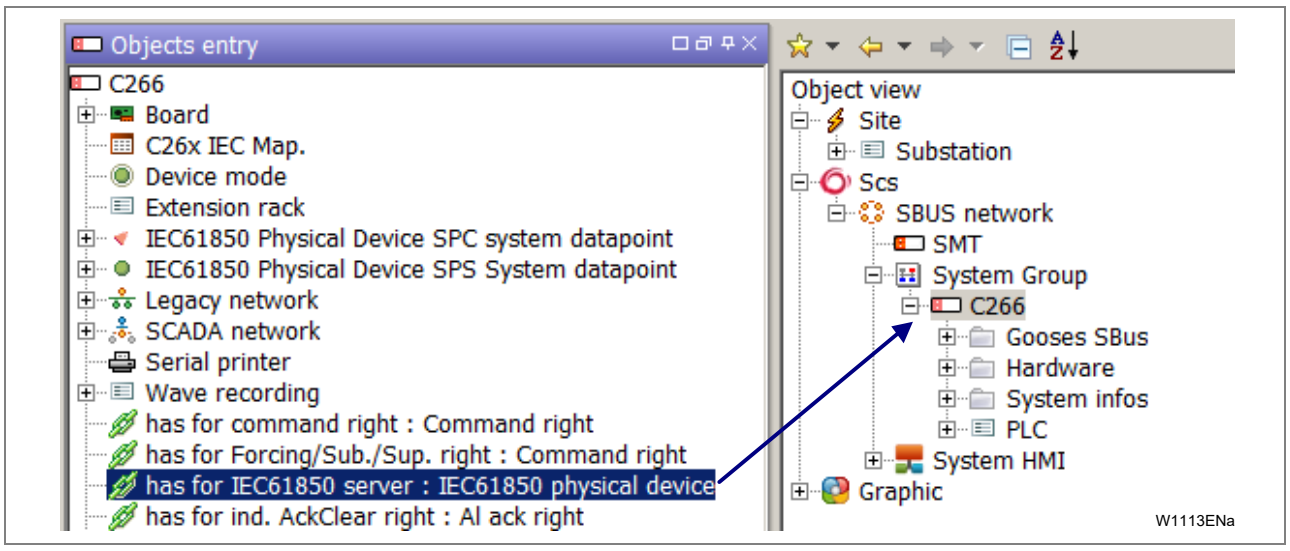


Figure 51: Connecting a C26x BCU to other station-bus sub-systems

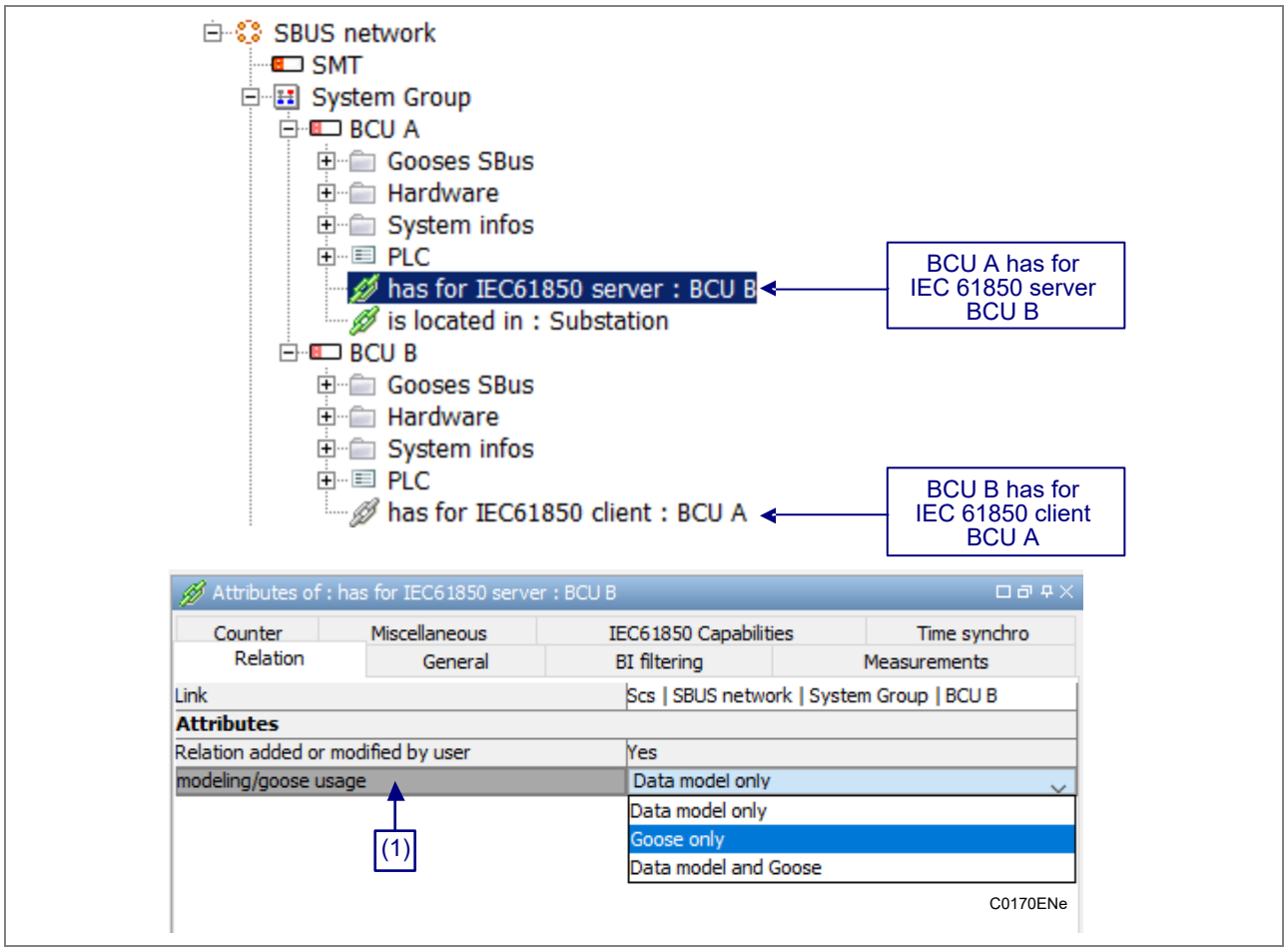


Figure 52: C26x (A) as IEC 61850 client of C26x (B)

When adding the **has for IEC61850 server** relation to BCU A, a specific attribute of the relation, **modeling/goose usage** (1), can be set to define the way that data is transmitted from the server (BCU B) to the client (BCU A). There are three possibilities:

- Data model only (or report mode only)
- Goose only
- Data model and Goose

Basically, the Report mode is used to transmit filtered data for display, printing and archiving. The Goose mode is used to transmit data as soon as possible after its acquisition and as quickly as possible, for automation purposes.

Goose transmission must be used if BCU A uses BIs served by BCU B, for ISaGRAF, FBD or interlock computation (see section *5.7 Defining an electrical regulation by user function*).

During a loss of communication between a client and a server, all the server's BIs are set to UNKNOWN on the client.

Configuration rules and checks

- A client must not be linked to the same server through multiple relations **has for IEC61850 server**

3.5.1.2 REPORT-BASED MODE

DS Agile IEDs, such as the C264, the IEC 61850 gateway and aView servers support reporting function through buffered and unbuffered Report Control Blocks.

Report are used to send data based on events and without explict request by the client.

A BI can be configured to be transmitted in Report mode via its IEC 61850 address. In this mode, a confirmed change of state is spontaneously transmitted to the subscribers.

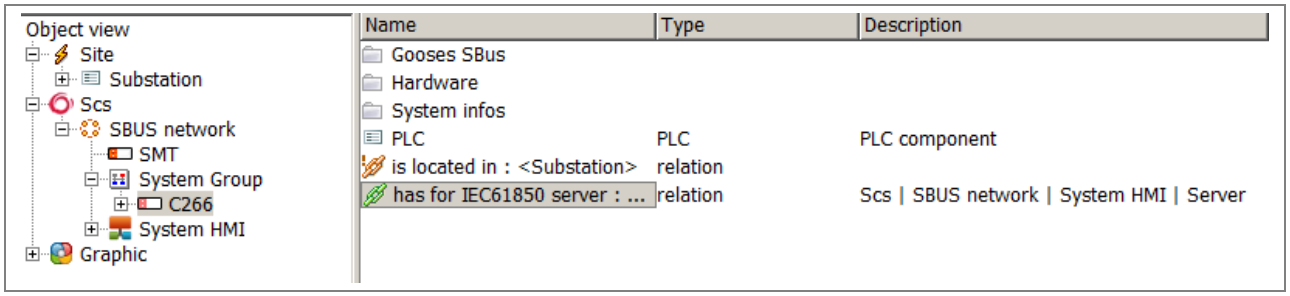
The BI information transmitted in a report is:

- the state and quality (the BI's resulting state is split in state and quality in IEC 61850)
- the time stamp (using GMT time) and time quality
- the reason for change, which could be one of the following:
  - change of data (if the state has changed, before persistence or motion filtering)
  - change of quality (if the quality has changed, before persistence or motion filtering)
  - change due to control (if the state or quality change is due to a control)

BI reports are not transmitted in a chronological order by a server (it is an IEC 61850 client feature to sort, if needed, all the information in a chronological order).

Reports between a C26x and an IEC 61850 server

The relation **has for IEC61850 server** points towards the aView server or a Gateway; its attribute **preferred report type** allows choosing between *Unbuffered report* and *Buffered report*:



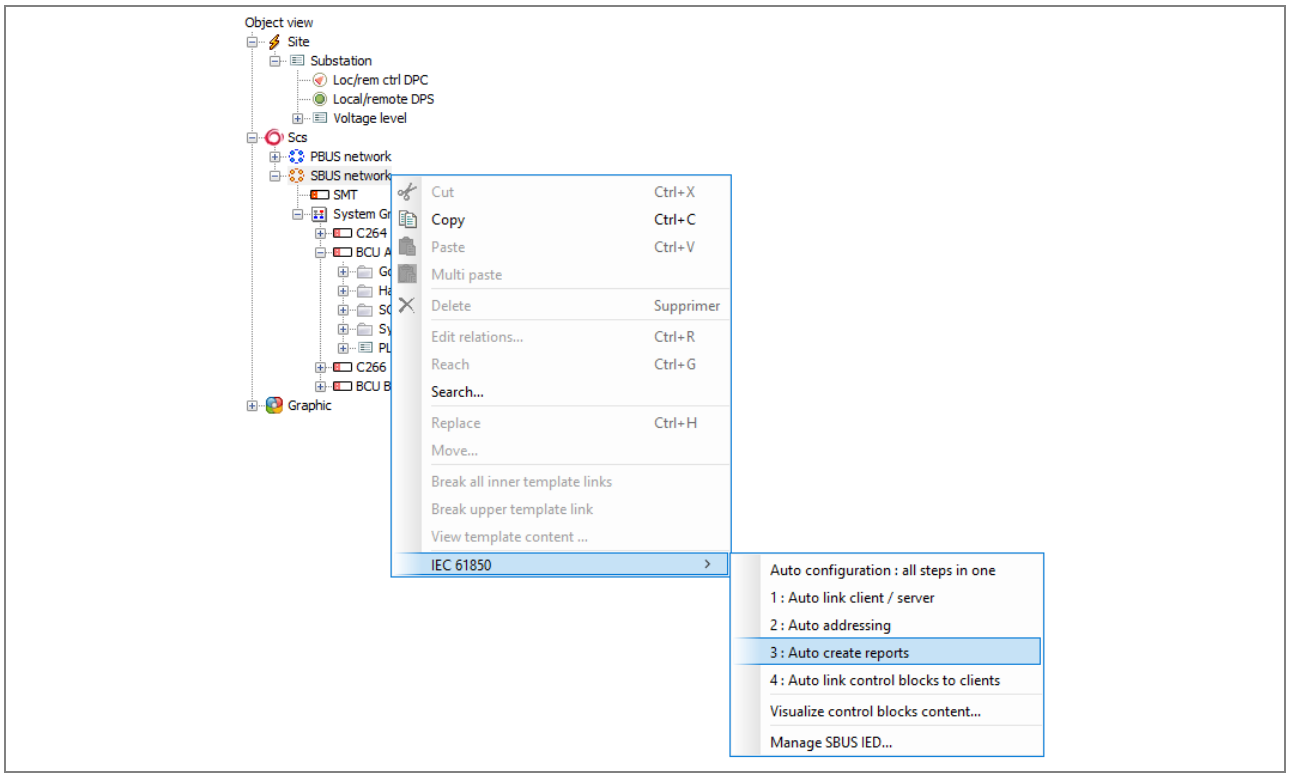
These default values should be kept.

The C26x is reversely an IEC 61850 server for the system HMI (aView) and the Gateway.

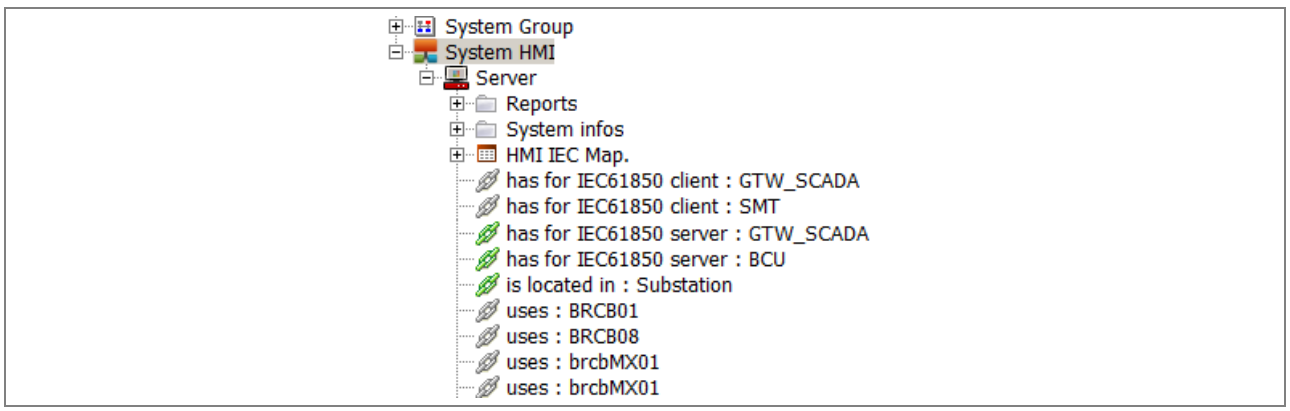
In the event of a communications loss, the reports are lost.

Buffered reports (option described in DS Agile/EN FT)

Assigning the aView server (respectively Gateway) as the recipient of buffered reports is done automatically by running the **IEC 61850 > Auto create reports** command.



This operation retrieves the reports corresponding to datapoints used by the client and creates the corresponding links between the client and the server and creates the relations **uses : <REPORT>**.



If the Gateway is a BRCB client, it is MANDATORY to:

- Leave the attribute **Re-timestamp at server reconnection** set to *No*. Refer to section *"Configuring the Gateway"* available in the **Application** chapter of the **Gateway** user manual.

Should a buffer overflow occur (refer to the **Functional Description** chapter of the C264 user manual), a system SPS would be transmitted upon reconnection. There is now a single datapoint for all buffer overflow reports, shared by all the clients: **Buffer Overflow**.

3.5.1.3 USER-DEFINED REPORTS

Reports can be created manually by the operator. What data is sent and the events that cause report transmission are configured through so called report control blocks (RCB) in the SCE.

The RCB, located in a Logical Node (LN), transmits the dataset (group of data objects) to a client IED through RCB instances.

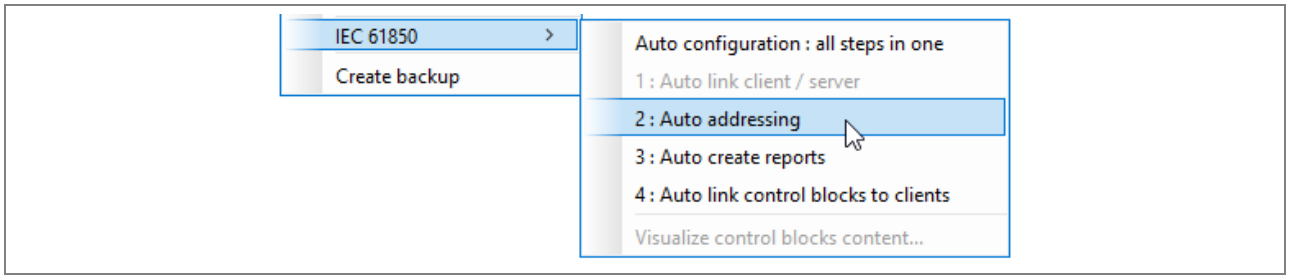
3.5.1.3.1 Adding a new RCB

RCB objects can be added to the following DS Agile IEDs:

- C264 (BCU and SCU)
- IEC61850 gateway on lower network
- aView Server

This action is possible **only** for **IEDs with IEC61850 mapping** in which the LD0 Logical Device node includes the LLN0 Logical Node.

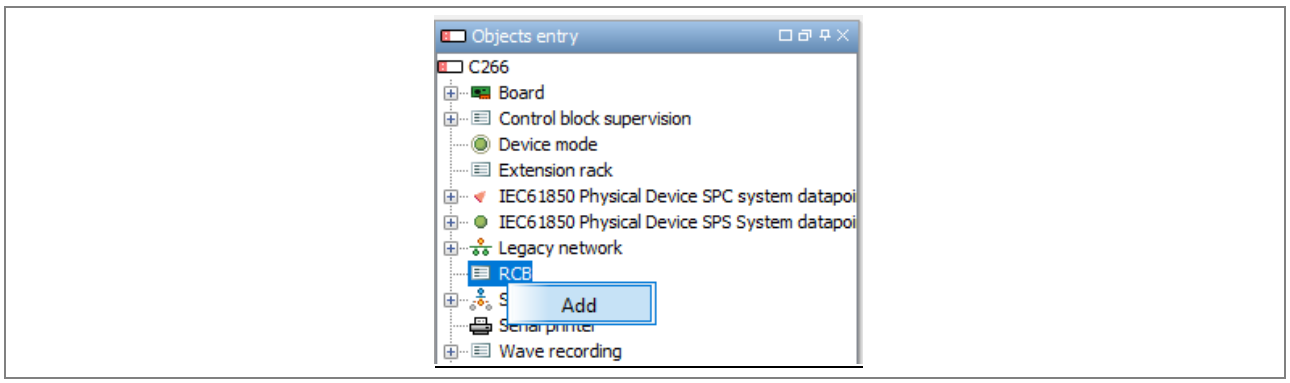
If the IED for which you want to add an RCB has no mapping, first create the mapping to make the RCB object available in the SCE. You may either create the IEC 61850 mapping manually as described in section 3.5.2.2 Manually updating a C26x unit's IEC 61850 mapping or run the **Auto addressing** step in the **IEC 61850** menu:



Then, follow the procedure below:

1 In the **Object view** panel, select the desired **IED**,

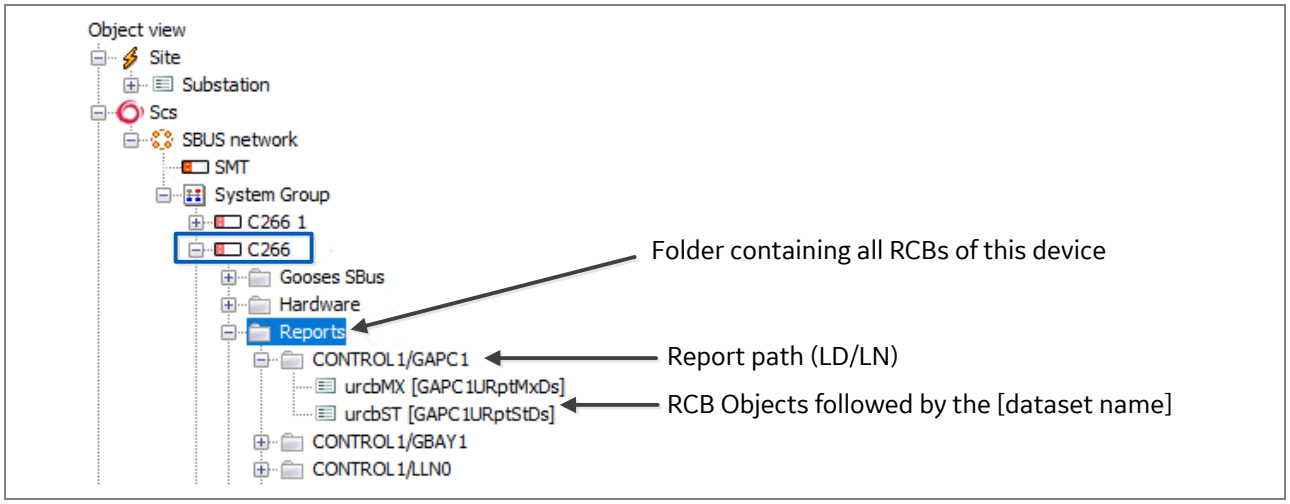
2 In the **Objects entry** panel, right-click on **RCB** and click on **Add**:



Up to 100 report control blocks can be added per Logical Node / Logical Device.

When added, the "**RCB**" objects appear in the **Reports** folder and are hierarchized per Logical Device/Logical Node (LD/LN), under the related DS Agile IED. By default, the **RCB** object is created with the « LD0/LLN0 » path.

The following diagram shows how RCBs are “structured” in the SCE:



Example: RCB structure

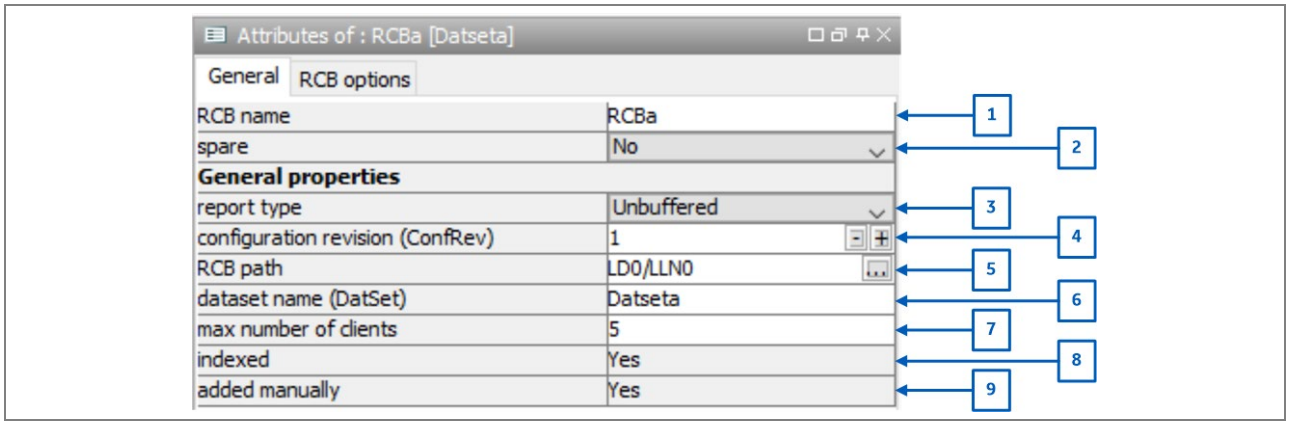
The dataset contains a set of ordered IEC dataobjects (at least one) that will be transmitted by the Report Control Block as a second sentence through the relation link “**transmits: IEC DataObject**”, explained later in this section.

3.5.1.3.2 Setting the attributes of an RCB

When adding an RCB, its general attributes must be set.

Note: RCB attributes may appear as “Read Only” if the report has been created automatically (attribute "added manually" set to "No").

General tab:



(1) **RCB name**: the RCB name is a free label of up to 32 characters. It must be unique in each LD\LN and meet the following rule: the first character must be a letter (upper or lower case); the following ones can be either numeric or alphanumeric charactersr (upper or lower case) or special character "underscore".

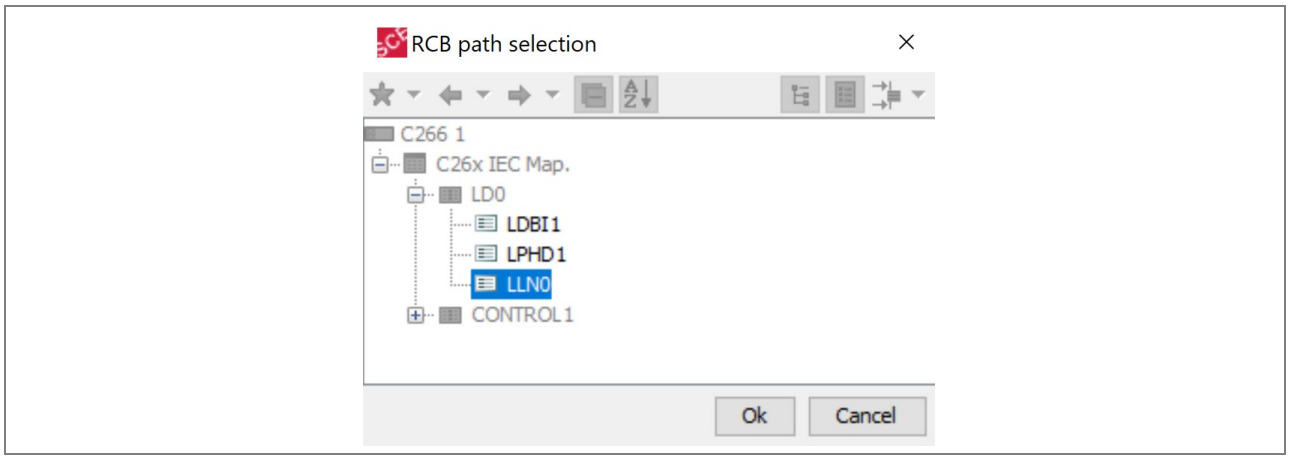
(2) **spare** (*Yes* / *No*)

(3) **report type** (*buffered/unbuffered*): defines the report type.

- In the case of **buffered** reporting, reports are buffered by the server in case a connection to the client is interrupted and made available later when the client is connected again. Buffered reporting is configured through buffered report control blocks (BRCB).
- In **unbuffered** reporting, reports are not saved and are lost if the associated client for the unbuffered report control block is not connected. Unbuffered reporting is configured through unbuffered report control blocks (URCB).

(4) **configuration revision** (range [1, 2 147 483 647], step 1): defines the revision number of the dataset referenced by this RCB. It is managed manually by the user. Every modification in the dataset should increase the **configuration revision** property by one.

(5) **RCB path**: the report path contains the Logical Device (LD) and the Logical Node (LN) separated by the « / » character. The RCB path can be edited manually (for users who know the names of the LD and LN), or from the dialog box by selecting the desired LN among the IEC mapping of the DS Agile IED:



Note: If the "Report Path" entered is not valid (not present in the mapping) then a check error will be raised. If the LD/LN pair does not exist in the IEC mapping, no LD and no LN will be used as default value.

(6) **dataset name (DatSet)**: name of the dataset sent by this RCB. It must be unique in a LD\LN. An IEC61850 dataset contains a group of data transmitted completely or partially depending on trigger options.

(7) **max number of clients**: defines the maximum number of clients using this RCB. This attribute is also called "Report max enabled".

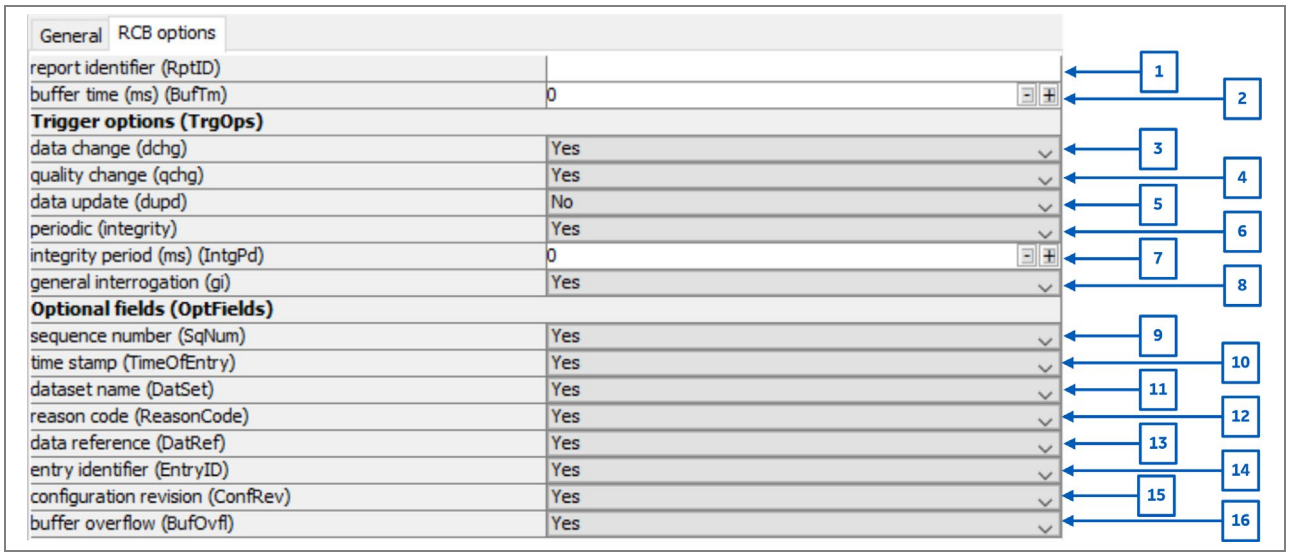
- For **buffered report control blocks** (BRCB), the maximum number of available clients is **8**.
- For **unbuffered report control blocks** (URCB) the maximum number of available clients is **50**.

(8) **indexed** (*Yes/No*): indicates if this RCB is configured with indexed naming convention or not. If the RCB is indexed, one instance is available for each client. If the RCB is not indexed, clients will share the same RCB. All RCBs of DS Agile IED servers are indexed.

(9) **added manually** (*Yes/No*): indicates whether this RCB has been added manually by the user or automatically using the action "**3: Auto create reports**" in the **IEC 61850** menu.

RCB Options tab:

The RCB options depend on the DS Agile IED capabilities. They may be authorized or not at the IED level (in the IEC 61850 Capabilities tab).



(1) **report identifier (RptID)**: Used by the client as a unique identifier of the RCB. DS Agile Client IEDs require to have a unique rptID in each server IED. Empty strings will be replaced with the RCB reference including instance number for the communication.

- If the "rptID edition" IED capability is set to "Conf", this attribute is editable.
- If the "rptID edition" IED capability is set to "Dyn", this attribute is not editable but is configurable at RCB instance level.

(2) **buffer time (BufTm)**: After a change, it is the delay in millisecond before sending Report by the server, in order to group events.

- If IED capability "bufTime edition" is set to "Conf", this attribute is editable.
- If IED capability "bufTime edition" is set to "Dyn", this attribute is not editable, and this information is configurable at RCB instance level.

(3) **data change (dchg)**: If this option is set to "Yes", after a change in the data model of a data (of this dataset) having this trigger, an event is created and transmitted by Report.

Data from type SPS, DPS…, MV used for status or measurement with deadband implement this trigger option.

- If IED capability "trgOps edition" is set to "Conf", this attribute is editable.
- If IED capability "trgOps edition" is set to "Dyn", this attribute is not editable, and this information is configurable at RCB instance level.

(4) **quality change (qchg)**: Specifies whether a report entry will be generated due to a change of the value of the quality attribute. If this option is set to "Yes", an event is created and transmitted by Report after a change of a data quality (of this dataset). Quality is associated with all status and measurement status. It is recommended to set this trigger option to “Yes” when (dchg) or (dupd) options is used.

- If IED capability "trgOps edition" is set to "Conf", this attribute is editable.
- If IED capability "trgOps edition" is set to "Dyn", this attribute is not editable, and this information is configurable at RCB instance level.

(5) **data update (dupd)** *(Yes/No)*: Specifies whether a report entry will be generated due to updating a data value of this dataset. If this option is set to "Yes" and if a data among this dataset has this trigger and is updated, an event will be created and transmitted by Report.

MV, CMV or BCR data used for measurement or counter status implement this trigger option.

- If IED capability "trgOps edition" is set to "Conf", this attribute is editable.
- If IED capability "trgOps edition" is set to "Dyn", this attribute is not editable, and this information is configurable at RCB instance level.

(6) **periodic (integrity)** *(Yes/No)*: Specifies whether a report entry will be generated on the expiration of the integrity period. If this option is set to "Yes", the report with its dataset will be sent periodically.

- If IED capability "trgOps edition" is set to "Conf", this attribute is editable.
- If IED capability "trgOps edition" is set to "Dyn", this attribute is not editable, and this information is configurable at RCB instance level.

(7) **integrity period (ms)**: defines the report sending periodicity in millisecond (0 means no periodicity). If this attribute has a value > 0 ms, an integrity report with all data listed in the data set is sent periodically in this interval.

- If IED capability "trgOps edition" is set to "Conf", this attribute is editable.
- If IED capability "trgOps edition" is set to "Dyn", this attribute is not editable, and this information is configurable at RCB instance level.

(8) **general interrogation (gi)** *(Yes/No)*: Specifies whether a report entry will be sent when a client requests general interrogation from a device.

- If IED capability "trgOps edition" is set to "Conf", this attribute is editable.
- If IED capability "trgOps edition" is set to "Dyn", this attribute is not editable, and this information is configurable at RCB instance level.

(9) **sequence number (SqNum)** *(Yes/No)*: Specifies whether the report header will contain the sequence number of the report or not. The sequence number is used by the client during BRCB synchronisation.

Sequence number starts from 0 when report is enabled and, incremented each time a report is sent.

- If IED capability "optFields edition" is set to "Conf", this attribute is editable.
- If IED capability "optFields edition" is set to "Dyn", this attribute is not editable, and this information is configurable at RCB instance level.

(10) **time stamp (TimeOfEntry)** *(Yes/No)*: Specifies whether the report header will contain the event creation time stamp.

- If IED capability "optFields edition" is set to "Conf", this attribute is editable.
- If IED capability "optFields edition" is set to "Dyn", this attribute is not editable, and this information is configurable at RCB instance level.

(11) **dataset name (DatSet)** *(Yes/No)*: Specifies whether the report header will contain the dataset name.

- If IED capability "optFields edition" is set to "Conf", this attribute is editable.
- If IED capability "optFields edition" is set to "Dyn", this attribute is not editable, and this information is configurable at RCB instance level.

(12) **reason code (ReasonCode)** *(Yes/No)*: Specifies whether the report header will contain the reason for the change. Reason depends on the trigger options set by the client (dchg, gi, periodic…).

- If IED capability "optFields edition" is set to "Conf", this attribute is editable.
- If IED capability "optFields edition" is set to "Dyn", this attribute is not editable, and this information is configurable at RCB instance level.

(13) **data reference (DatRef)** *(Yes/No)*: Specifies whether the report header will contain the reference of the data in relation to the model (Ex: LDName$LNName$FC$DOName…).

- If IED capability "optFields edition" is set to "Conf", this attribute is editable.
- If IED capability "optFields edition" is set to "Dyn", this attribute is not editable, and this information is configurable at RCB instance level.

(14) **entry identifier (EntryID)** *(Yes/No)*: Specifies whether the report header will contain the event ID. The identifier is built by the server and is used to uniquely identify an event for BRCB and also used by the client to resynchronize buffer. It is recommended to set this attribute to “Yes” in case of buffered RCB.

- If IED capability "optFields edition" is set to "Conf", this attribute is editable.
- If IED capability "optFields edition" is set to "Dyn", this attribute is not editable, and this information is configurable at RCB instance level.

(15) **configuration revision (ConfRev)** *(Yes/No)*: Specifies whether the report header will contain the RCB configuration revision.

- If IED capability "optFields edition" is set to "Conf", this attribute is editable.
- If IED capability "optFields edition" is set to "Dyn", this attribute is not editable, and this information is configurable at RCB instance level.

(16) **buffer overflow (BufOvfl)** *(Yes/No)*: Specifies whether the report header will contain information indicating that a loss of event has probably occurred.

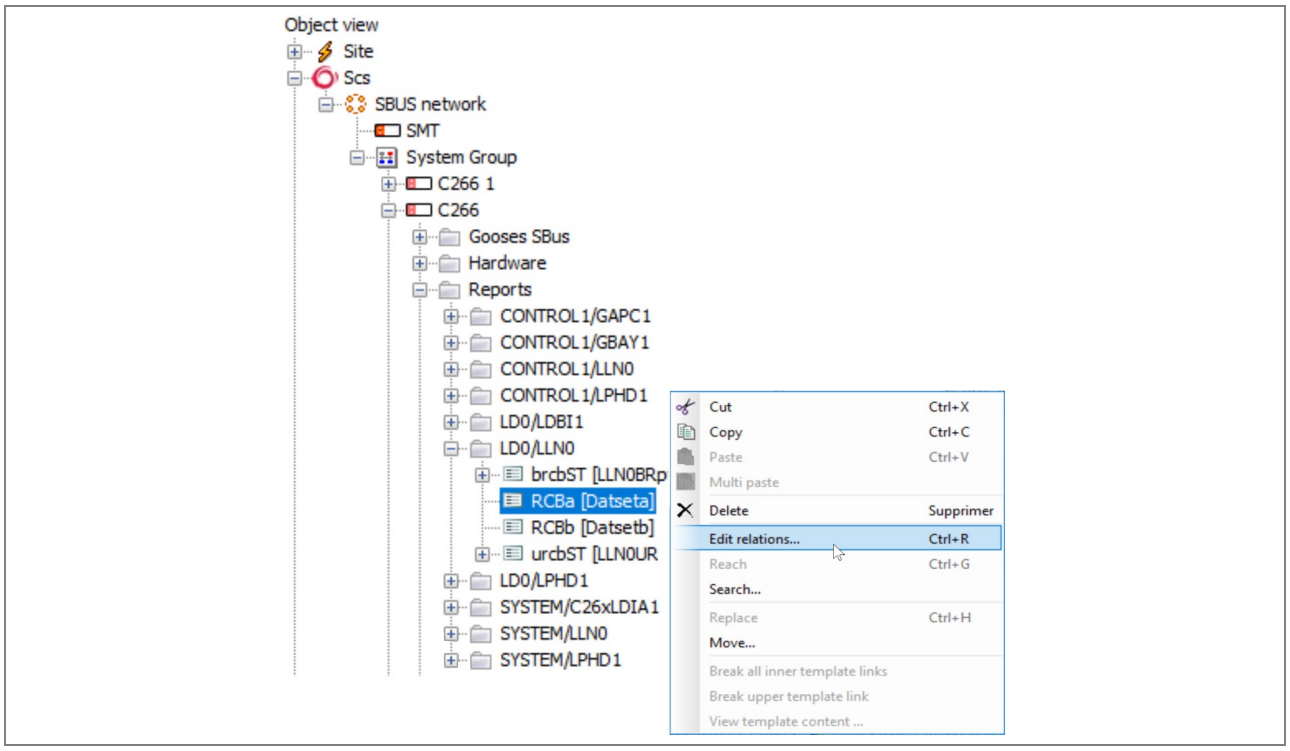
- If IED capability "optFields edition" is set to "Conf", this attribute is editable.
- If IED capability "optFields edition" is set to "Dyn", this attribute is not editable, and this information is configurable at RCB instance level.

3.5.1.3.3 Defining the dataset to be sent

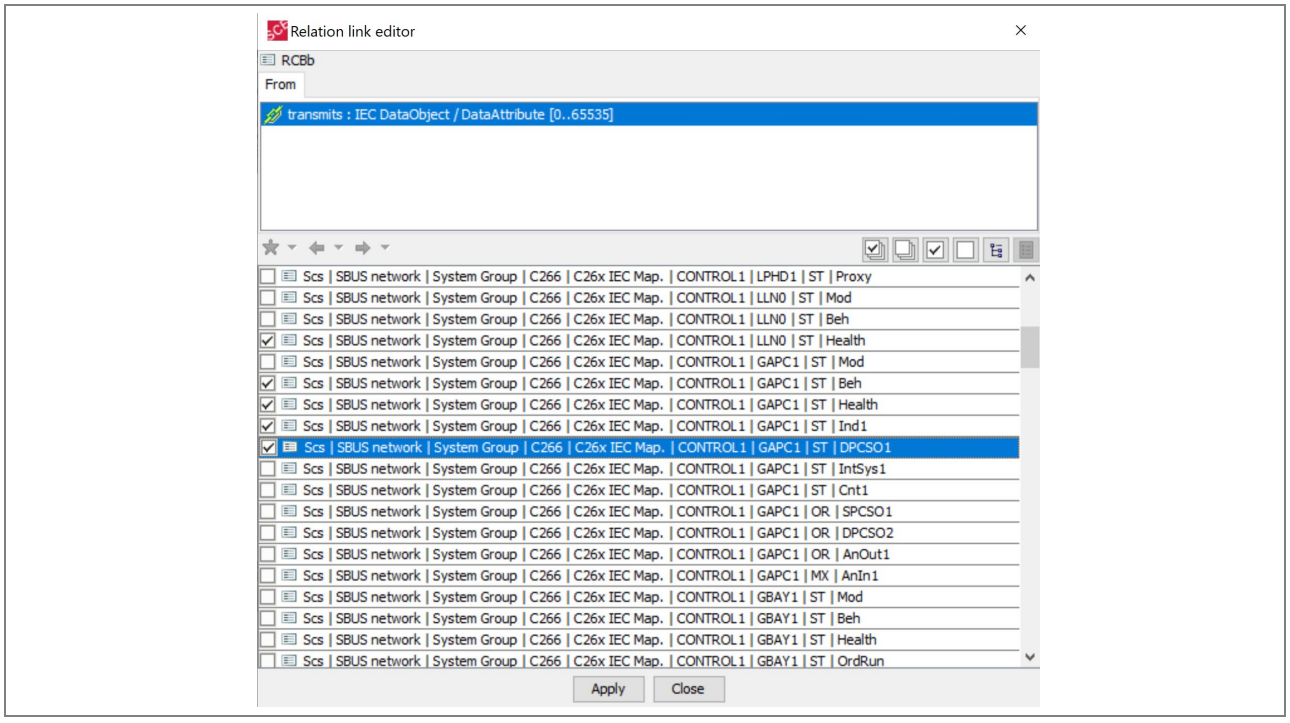
The dataset containing the IEC dataobjects is defined through the relation link "**transmits: IEC DataObject**".

To define a dataset, follow these instructions:

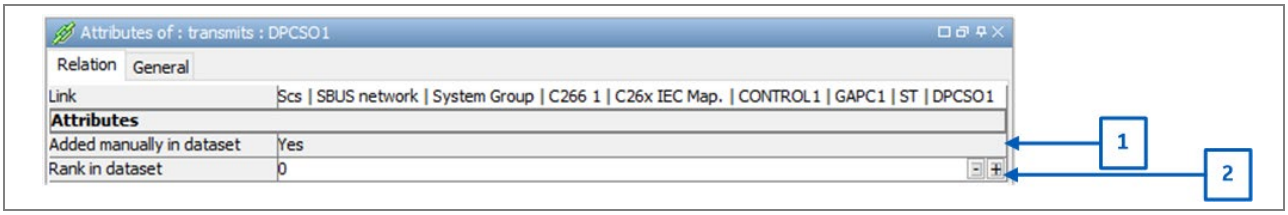
1 In the **Object view** panel, right-click on the desired RCB and click on **Edit relations…**:



2 The **Relation link editor** window containing the list of available datasets appears on screen. Check the boxes to select the desired datasets. Up to 1000 DataObjects can be added per Dataset. Click on **Apply** to validate your selection and then, close the **Relation link editor** window:



3 If necessary, set the relation attributes in the **Attributes** panel:
Click on the **Relation** tab:



(1) **Added manually in dataset** (*Yes* / *No*): indicates if this relation has been added manually by the operator or created automatically.

(2) **Rank in dataset** (range [0, 1000], step 1): this attribute is used to manually modify the position of Data Object in the Report messages. The attribute is set to 0 by default. This value indicates that the position is undefined. You can modify this attribute to the desired rank. When modifying this value, make sure that the subsequent values follow one another. When the SCE auto-addresses all subsystems; the undefined 'rank' (0) is ranked after the last used rank for the whole IEC 61850 mapping.

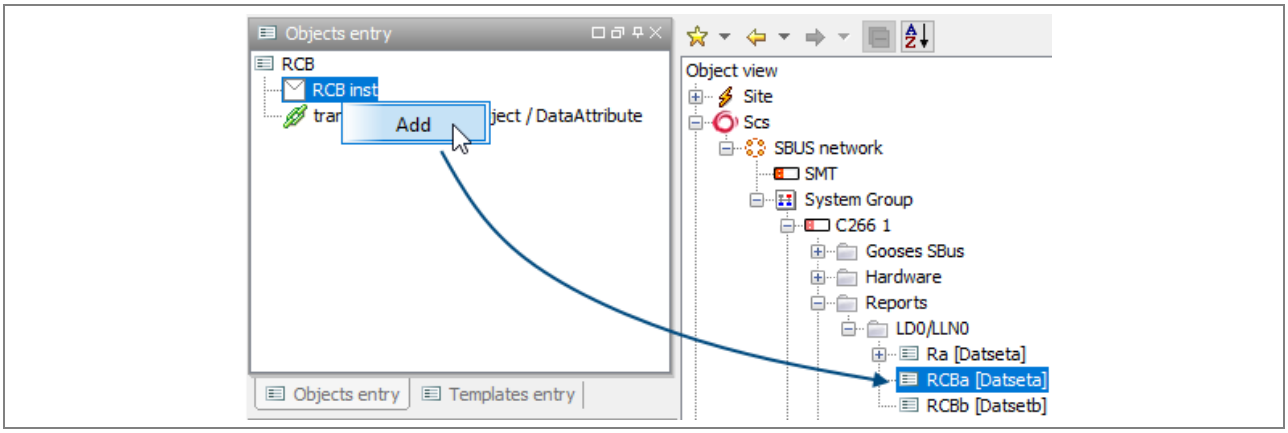
3.5.1.3.4 Allocating a report control block instance to a client IED

The dataset is sent to the Client IED through an RCB instance. An RCB instance is transmitted to **one client**.

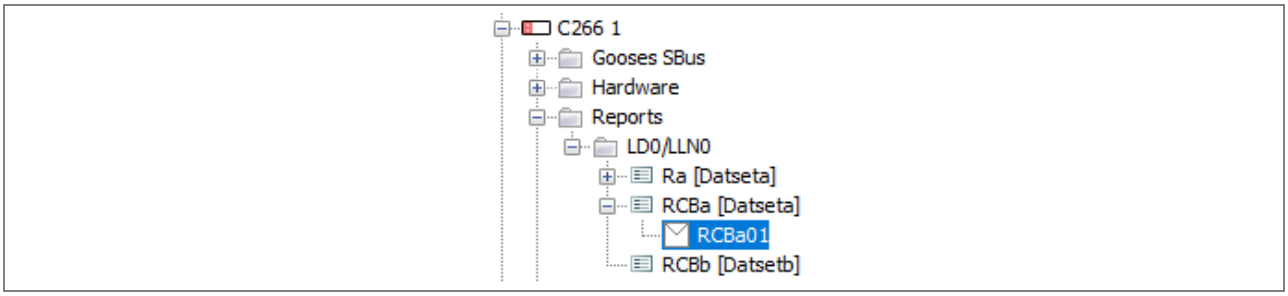
To define the RCB instance:

1 In the **Object View** panel, select the desired RCB under the related DS Agile IED,

2 In the **Object entry** panel, right-click on **RCB inst** and click on **Add** (up to 99 instances maximum can be added per RCB):

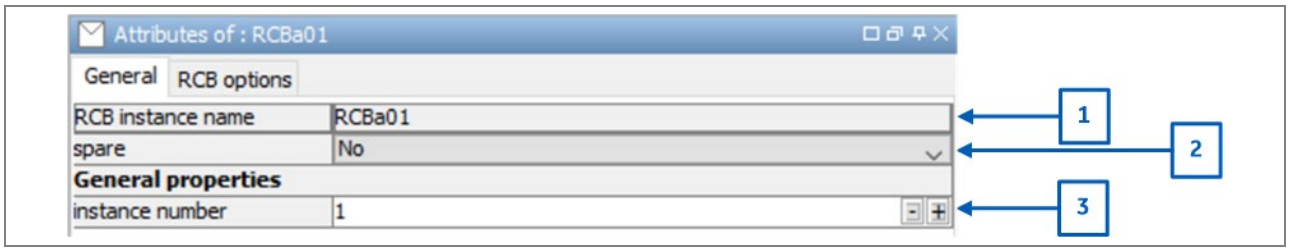


3 The **RCB inst** object appears in the "**RCB [dataset]**" object and is identified with the ✉ icon:



4 If necessary, click on the RCB instance and set its attributes:

In the **General** tab:



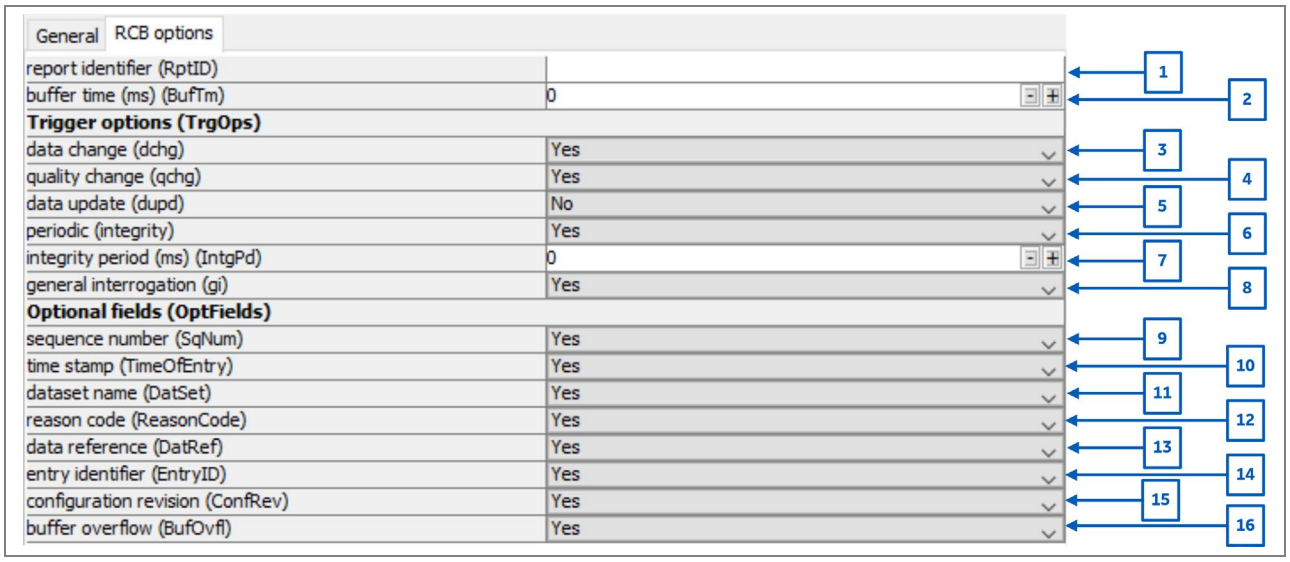
(1) **RCB instance name**: name of this Report Control Block instance. This name is built and updated dynamically from the name of its parent RCB object to which an index on two digits is added (example: RCBa01). When the RCB name is modified, then name of each RCB instance is updated automatically.

(2) **spare** (*Yes* / *No*)

(3) **instance number** (range [1, 99], step 1): defines the number of this RCB instance. This value is managed manually by the user.

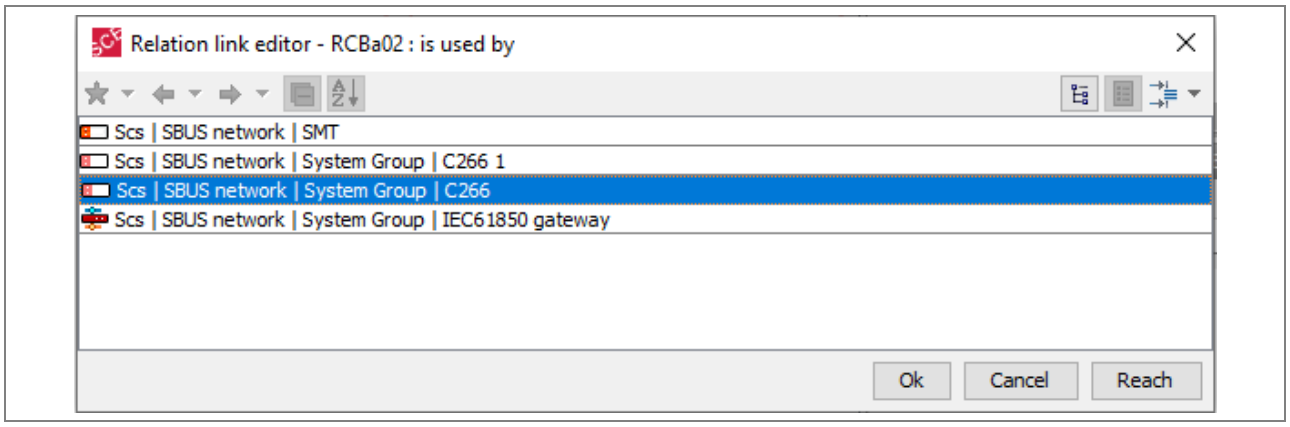
In the **RCB options** tab:

The RCB options depend on the DS Agile IED capabilities. They may be authorized or not at the IED level (in the IEC 61850 Capabilities tab) and configurable at RCB instance level. Refer to section 3.5.1.3.2 for the detail of each **RCB option**.



To be processed, the RCB instance must be allocated to the receiving Client IED through the "**is used by**" relation link:

1 Click on the RCB instance and then, double-click on the "**is used by**" relation to display the **Relation link editor** window that contains the list of available Client IEDs. For each RCB instance, select the corresponding Client IED and click on **OK**:



*Note: The new **instance** of this **Report** is created and configured when the command **IEC61850 > Auto link client / server** is launched after the client IED has been linked to a server's report instance via the relation **is used by: <IEC61850 physical device>**.*

3.5.1.3.5 Editing or Modifying User-defined reports

Editing and modifying RCB is possible ONLY on manually created reports.

3.5.1.4 GOOSE-BASED MODE

A BI (SPS or DPS) can be configured to be transmitted in GOOSE mode. In this mode, the state change is multicasted to the configured subscribers. Only the BI's unfiltered states are transmitted, the time stamp and the reason for change are not.

Because of the GOOSE format, not all BI resulting states given below can be transmitted. The following mapping is therefore applied:

BI Resulting State	GOOSE value
RESET, FORCED RESET, SUBSTITUTED RESET, CLOSE, FORCED CLOSE, SUBSTITUTED CLOSE	01
SET, FORCED SET, SUBSTITUTED SET, OPEN, FORCED OPEN, SUBSTITUTED OPEN	10
JAMMED	00
UNDEFINED, TOGGLING, SELFCHECK FAULTY, SUPPRESSED, UNKNOWN	11

A measurement or an LSP can also be configured to be transmitted in GOOSE mode (refer to the Functional Description chapter of the C264 user manual).

3.5.2 DEFINING THE ADDRESS MAP OF A STATION-BUS NETWORK

An IEC 61850 mapping is an aggregation of logical units, composed of bricks. Generally, a brick corresponds to an electrical device or function. It provides its real-time data (status, measurements, and controls …) and some configuration aspects. To do that, a brick groups data by categories (Status, Measurements, Control, Configuration), called functional components.

A functional component groups data objects. A data object must be seen as a real-time equivalent of a DS Agile datapoint. Therefore, when a DS Agile sub-system (IEC 61850 client) needs the real-time value of a datapoint managed by another sub-system (IEC 61850 server), the latter transmits the information via a data object of its own IEC 61850 mapping. At SCE data modeling level, IEC 61850 clients must indicate which IEC 61850 servers they retrieve information from (see section *3.5.1 Connecting a C26x to other station-bus sub-systems*).

Generally, an IEC 61850 data object has a stereotype, called common class. The structures of these objects are known by all DS Agile IEC 61850-communicating sub-systems. For DS Agile sub-systems, the number and structure of common classes are fixed. They are the terminal description of IEC 61850 DS Agile data modeling.

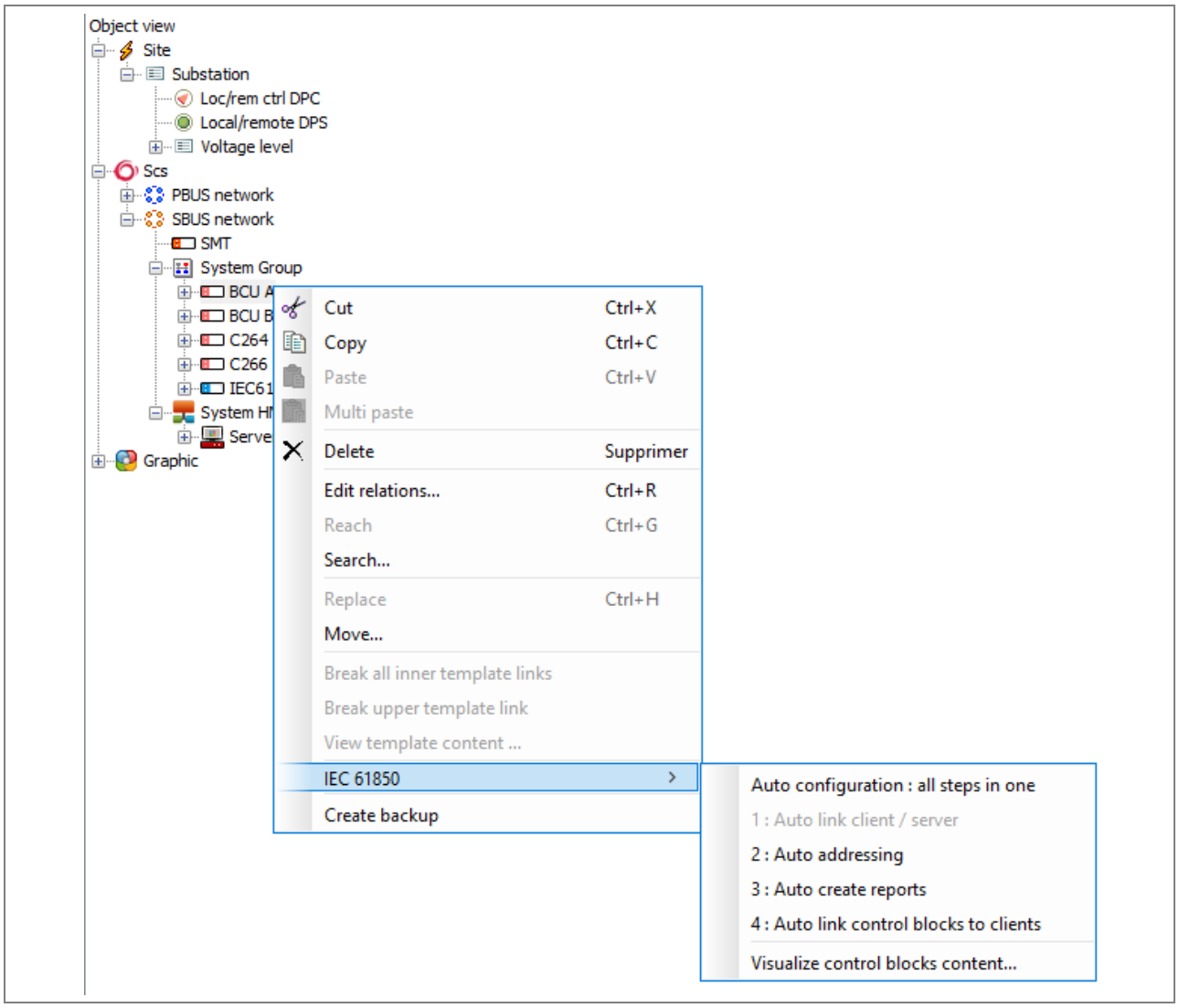
In the IEC 61850 mapping of any DS Agile sub-system, there is a native logical device LD0 with fixed and hard-coded bricks (LDBI, LLN0, LPHD).

When creating a DS Agile C26x at SCE level, an IEC 61850 mapping with an LD0 and its default bricks is also created. LD0 is a system logical device that groups all system diagnostics and controls relevant to the C26x. Datapoints addressed in the LD0 brick are only relevant to system topology.

Extra logical units can be created in the IEC 61850 mapping of a C26x. Generally, there is one logical device for each bay managed by the C26x, and, in each logical device, there is one brick for each module or built-in function.

3.5.2.1 SBUS AUTOMATIC ADDRESSING

The SBUS “Auto addressing” function is based on the substation electrical topology and in particular on bays. The easiest way to add application logical units relevant to the electrical bay(s) managed by a C26x, or a DS Agile Gateway, is to run the **Auto addressing** function for the C26x or Gateway. The contextual menu of the C26x is used to launch this function:



SBUS Automatic Addressing does not process datapoints managed by non-DS Agile IEC 61850 devices (e.g. protection IEDs), since their address map is imported from the import datalist in their IEC 61850 configuration file.

As of version 5.0.5 of the DS Agile System, SBUS Automatic Addressing is incremental: The addresses of non-spared, unmodified datapoints with existing valid addresses (for instance, in case of version upgrade or system extension) are left unchanged. Unused addresses are assigned to as yet unaddressed datapoints and datapoints with invalid addresses if there are any. By allowing existing datapoints to keep their IEC 61850 addresses when new datapoints are added (and addressed), this evolution can be especially useful where an existing system is being expanded or to integrate non-DS Agile devices.

Note:
Only non-spared datapoints are taken into account in automatic addressing. If a formerly spared datapoint is "unspared", repeat the automatic addressing process.

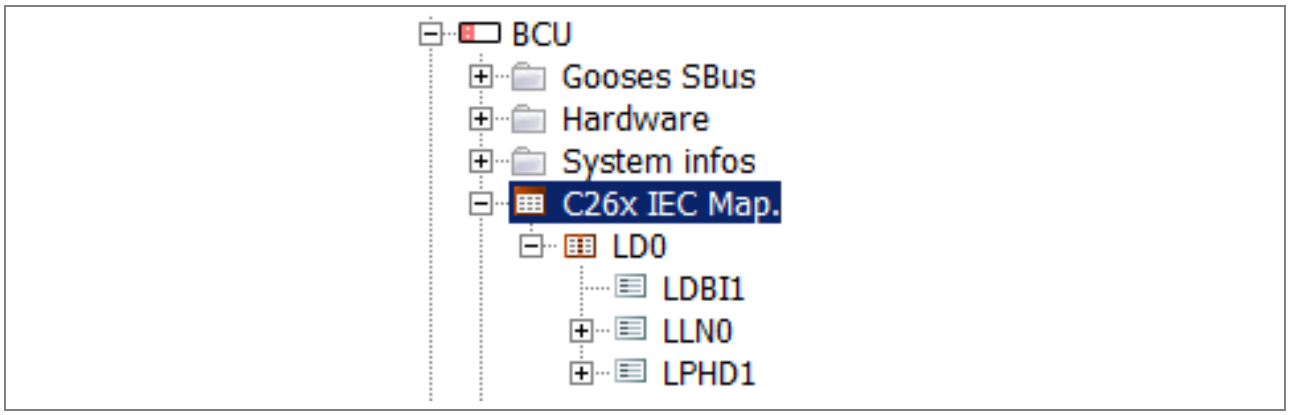
Some datapoints are out of the scope of automatic addressing. Theses datapoints are identified by their data model mnemonic and short name:

Parent object	Excluded datapoints	
	mnemonic	name
Circuit Breaker module	SynCheck_Close_SPC	Sync CB close
	Select_SPC	Selection SPC
	Switch_SPC_PhA	Switch phA SPC
	Switch_SPC_PhB	Switch phB SPC
	Switch_SPC_PhC	Switch phC SPC
	SwitchPos_PhA (DPS)	Switch PhA pos.
	SwitchPos_PhB (DPS)	Switch PhB pos.
	SwitchPos_PhC (DPS)	Switch PhC pos.
	SwitchPos (DPS)	Switchgear pos.
	PhaseNotTogether_SPS	Ph not together
External automatic synchrocheck built-in function	CS_CtrlOnOff_DPC	on/off ctrl DPC
	CS_CtrlOnOff_SPC	on/off ctrl SPC

3.5.2.2 MANUALLY UPDATING A C26X UNIT'S IEC 61850 MAPPING

For a DS Agile C26x, the fixed part is composed of an LD0 folder containing:

- a C26xLDIA1 diagnostic brick
- an LDBI1 (DataBase Identity) brick used for C26x database identification and management
- an LLN0 brick
- an LPHD1 brick (buffer overflow)



When adding the IECxLD brick, it can be supplemented with RDRE (if the C26x manages its own disturbance recording file) and C26xLDIA1.

Objects description

- C26xLDIA1 brick:

Object name	CDC	Description	Comment
Mod	INC	Operating Mode (status only)	Mandatory
SyncSt	SPS	Device Synchronization status	stVal =0= non-synchronized stVal =1= synchronized
AllTMUSt	SPS	All boards (TMU2xx) synthetic status	
AllCCUSt	SPS	All boards (CCU2xx) synthetic status	
AllDIUSt	SPS	All boards (DIU2xx) synthetic status	
AllDOUSt	SPS	All boards (DOU20x) synthetic status	
AllAIUSt	SPS	All boards (AIU2xx) synthetic status	
AllAOUSt	SPS	All boards (AOU20x) synthetic status	
AllHBUSt	SPS	All boards (HBU200) synthetic status	
AllCOMMSt	SPS	All rack synthetic status	
AllIEDSt	SPS	All IED synthetic status	
GHUSt	INS (INS8_ST)	Local HMI (GHU300) Status	stVal =0= OK stVal =1= self-check failure stVal =2= configured but missing stVal =3= not configured but present stVal =4 = missing
BIUSt	INS (INS8_ST)	BIU2xx status	Idem GHUSt
CCUSt<15>	INS (INS8_ST)	I/O board (CCU2xx) status	Idem GHUSt
DIStop	SPS	Digital input acquisition stopped	
DIUSt<15>	INS (INS8_ST)	DI board (DIU2xx) status	Idem GHUSt
DOUSt<15>	INS (INS8_ST)	DO board (DOU20x) status	Idem GHUSt
AIUSt<6>	INS (INS8_ST)	AI board (AIU200) status	Idem GHUSt
AOUSt<4>	INS (INS8_ST)	AO board (AOU) status	Idem GHUSt
TMUSt	INS (INS8_ST)	CT/VT board (TMU) status	Idem GHUSt
RedSt	SPS	Redundancy Mode	stVal = 0 => StandBy stVal = 1 => Active
FailSt	INS (INS8_ST)	Failure Status	
PLCSt	INS (INS8_ST)	PLC Status	
urcbST	URCB	Basic report control block for C26xDiag status	Unbuffered

- LLN0:

Object name	CDC	Description	Comment
Mod	INC	Device Mode (status only)	Mandatory
Beh	INS	Behaviour	Mandatory
Health	INS	Health	Mandatory
NamPlt	LPL	Name plate	Mandatory
brcbST	BRCB	Buffer report control block for all status of LD	Buffered

3.5.2.3 MANUALLY CREATING AN APPLICATION LOGICAL DEVICE

Real-time data exchange between DS Agile sub-systems is required for many purposes:

- At DS Agile aView level:
  - System and electrical process supervision and control (mimic animation, control popup),
  - Alarm management (generation, viewing, acknowledgement, clearing …),
  - Logging (Sequence of event, log book),
  - Event and value archiving (curve viewing, event analysis).
- At DS Agile SMT level:
  - System management (database loading and switching, device mode supervision and control)
  - Waveform file storing.
- At DS Agile C26x level:
  - Sharing datapoints for automation and built-in functions,
  - Feeding acquired data to the system HMI (aView) to ensure system functionality,
  - Feeding acquired data to the DS Agile Gateway to exchange data between the DS Agile system and the SCADA,
  - Responding to system specific needs (command uniqueness).
- At DS Agile Gateway level:
  - Sharing datapoints for automation and built-in functions,
  - Exchange data between the DS Agile system and the SCADA.

To ensure real-time data exchange on the station-bus, specific logical units (called here application logical units) must be created in the IEC 61850 mapping of the DS Agile sub-system that is server of the exchanged data (for client/server definition, see section *3.5.1 Connecting a C26x to other station-bus sub-systems*). The DS Agile C26x is the only DS Agile sub-system that allows user-defined application logical units.

The general philosophy to manually create application logical units is:

- one application logical device per bay managed by a DS Agile C26x, DS Agile Gateway or non-DS Agile IEC 61850-compatible IED
- in each application logical device, one brick per module or function contained in the bay
- for each brick, one data object per datapoint contained in the module/function that needs to be exchanged on the station-bus. In a brick, data objects are grouped by functional component. Datapoint addressing on station-bus network is done by linking a datapoint to the relevant IEC 61850 data object. The available associations between datapoint types and IEC 61850 data object types are listed in this table:

3.5.2.4 MANUAL CREATION OF AN APPLICATION LOGICAL DEVICE

To manually create an application logical device:

- Select the IEC 61850 mapping level and add an **IECxLD** from the contextual **Objects entry** window.
- Update its **IEC name** attribute (1) (it must be unique for a given IEC 61850 mapping).

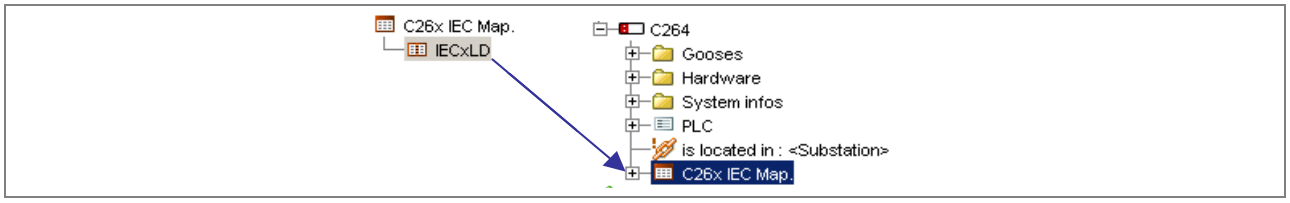


Figure 53: Adding an application logical device

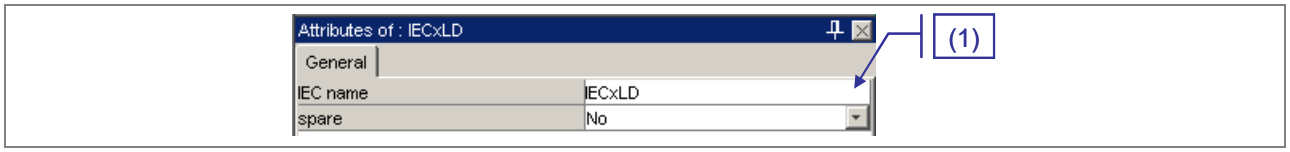


Figure 54: Updating the IEC 61850 name of an application logical device

Naming rule

IEC name is a free label of up to 32 characters, made with the following characters: 0-9, a-z, A-Z. It can not begin with a digit.

Configuration rules and checks

- The name of each Logical Device defined under the IEC 61850/IEC mapping must be unique within the mapping.
- If the Logical Device is a generic one, its name must not contain the sub-string "LD0" (reserved for system Logical Units).

3.5.2.5 MANUAL CREATION OF AN IEC 61850 LOGICAL NODE

To manually create an IEC 61850 LN:

- Select the IEC 61850 logical device level and add a **GenLNxx** from the contextual **Objects entry** window at; do not use an RDRE brick reserved for non-DS Agile IEC 61850 IEDs.
- Update its **IEC name** attribute (1) (it must be unique for a given IEC 61850 logical device).

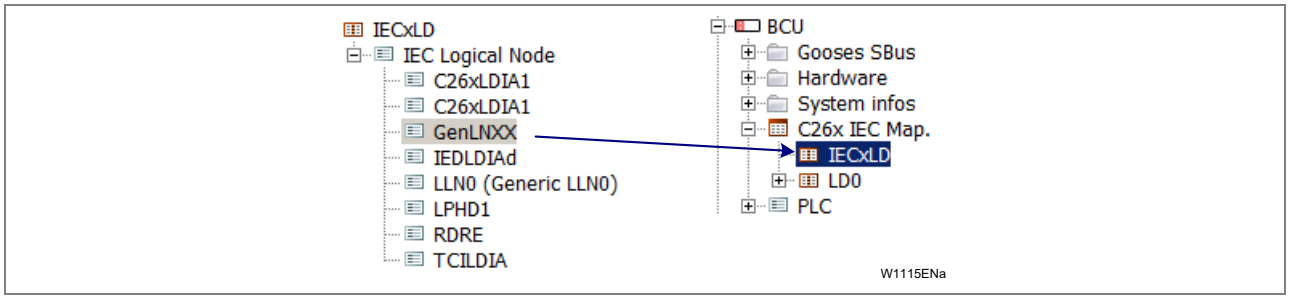


Figure 55: Adding an IEC 61850 Logical Node

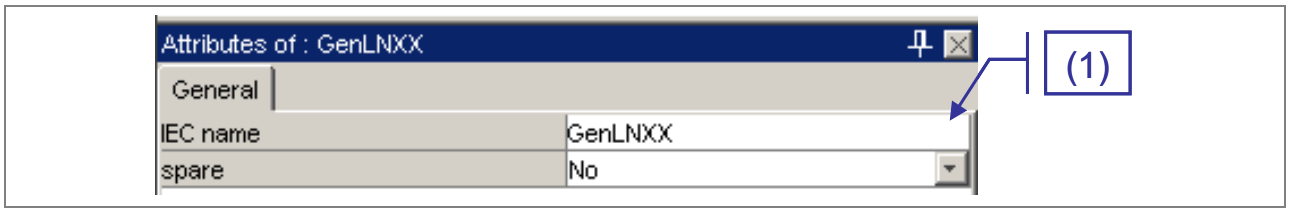


Figure 56: Updating the IEC 61850 name of a brick

Naming rule

'IEC name' is a name made with 3 parts:

- optional wrapper (up to 11 characters), it cannot begin with a digit,
- standard brick name (4 upper case characters),
- index (12 character).

Each part can contain the following characters: 0-9, a-z, A-Z. The sum of wrapper and index is up to 12 characters.

Configuration rules and checks

- The name of each Brick defined under a Logical Device must be unique within the *Logical Device.*

3.5.2.6 MANUAL CREATION OF AN IEC 61850 FUNCTIONAL COMPONENT

To manually create an IEC 61850 functional component, select the DS Agile C26x IEC 61850 brick level and add a specific functional component from the contextual **Objects entry** window. The useable functional components for the DS Agile C26x are:

- CF to group configuration information relevant to controllable data objects
- CO to group controls
- DC to group description information relevant to data objects
- MX to group measurements (MV)
- OR to group results of operate requests relevant to controllable data objects
- ST to group statuses (SI, SIT, SIG)
- SV to group substituted values (FSS indication)

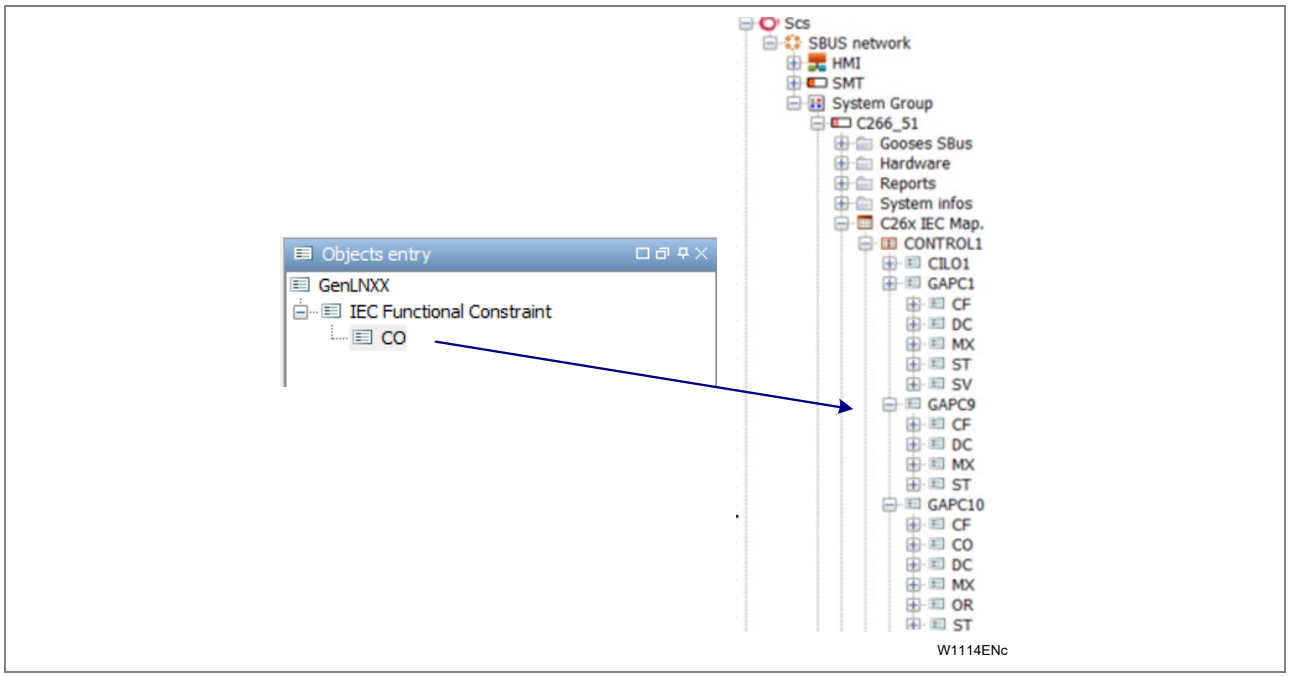


Figure 57: Adding an IEC 61850 functional component

3.5.2.7 MANUAL CREATION OF AN IEC 61850 DATA OBJECT

To manually create an IEC 61850 data object:

- Select the IEC 61850 functional component level and add a specific data object from the contextual **Objects entry** window. Each type of functional component has its own list of available data objects. The following table shows the different lists useful for the DS Agile C26x IEC 61850 mapping:

Functional component	Available data object
ST	ACDxST ACDxPhsxST ACTxST ACTxPhsxST BCRxST BSCxST BSCxOrigxST DPCxST DPCxOrigxST DPSxST ENCxST ENCxOrigxST ENSxST INCxST INCxOrigxST INSxST SPCxOrigxST SPCxST SPSxST VSSxST
MX	APCxMX APCxOrigxMX CMVxMX DELxMX MVxMX WYExMX
CO	APCxDExCO APCxSBOxCO BSCxDExCO BSCxSBOxCO INCxDExCO Mod Mod (IEC CO Generic Mod) SPCDPCxDExCO SPCDPCxSBOxCO
SV	BSCxSV CMVxSV DELxSV DPCxSV DPSxSV ENSxSV INSxSV MVxSV SPCxSV SPSxSV WYExSV

Functional component	Available data object
CF	APCxCF BCRxCF BSCxDExCF BSCxSBOxCF INCxCF SPCxCF INGxCF XXCxDExCF XXCxSBOxCF
OR	XXCxBASICxOR XXCxOPOKxOR Mod TapChg
DC	NamPlt PhyNam

- Update its IEC 61850 name attribute (1) that must be unique for a given IEC 61850 functional component.

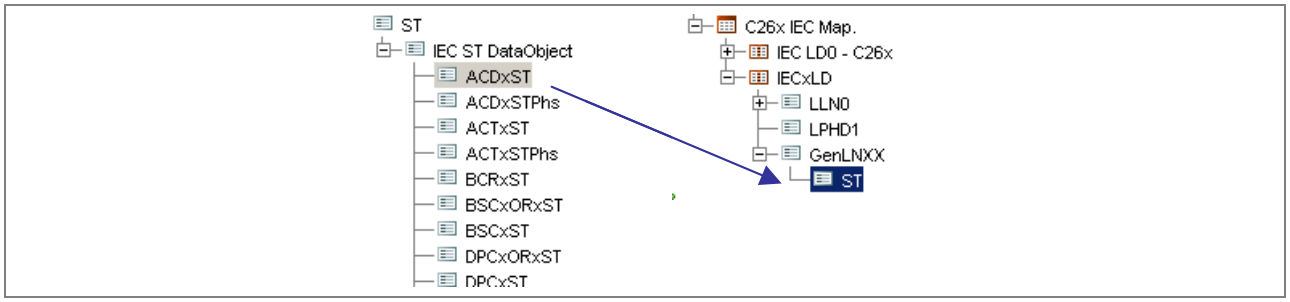


Figure 58: Adding an IEC 61850 data object

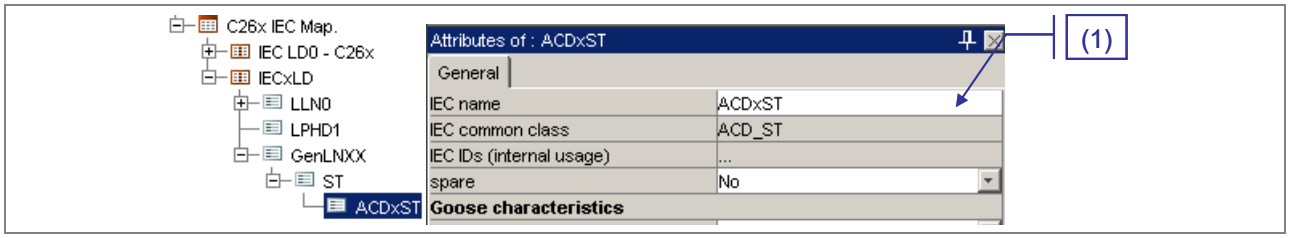


Figure 59: Updating the IEC name of a data object

Naming rule

IEC name is a free name of up to 12 characters, made with the following characters: 0-9, a-z, A-Z. It cannot begin with a digit.

Configuration rules and checks

The name of each Data Object defined under a Functional Component (FC) must be unique within the Functional Component.

3.5.2.8 CREATING AN APPLICATION LOGICAL DEVICE USING SBUS AUTOMATIC ADDRESSING

The IEC 61850 automatic addressing function is based on the substation electrical topology and in particular on bays. For details on how to configure this topology, see section *5 Defining a C26x configuration in the electrical hierarchy*).

The easiest way to create application logical units relevant to the electrical bays managed by a DS Agile C26x is to use the IEC 61850 automatic addressing function. To do so, right-click the C26x icon, first select **IEC 61850**, and then **2 : Auto addressing** (1).

IEC 61850 automatic addressing for any given DS Agile C26x is applicable only to the bays that it manages, i.e. whose relations **is managed by** have been linked to the DS Agile C26x.

The IEC 61850 automatic addressing procedure includes GOOSE addressing: GOOSE bit-pair buffers states are sequentially filled with automation datapoints exchanged between servers. With regards to GOOSE manual addressing, the corresponding result of GOOSE automatic addressing is to set the datapoint to *Manual attachment*, i.e. as a User status bit-pair, thus preserving this association through any new automatic addressing processes.

The size limit of the buffers makes it necessary to establish priority levels for GOOSE addressing: Existing “Manual attachments” (operator’s manual selections and previous GOOSE addressing results) are taken into account first and left unchanged, then fast automation datapoints are processed and finally slow automation datapoints. Any valid pre-existing attachments are left unchanged. A GOOSE buffer overflow event is signaled and stops the process of GOOSE addressing. For details about Goose modeling / configuration see below.

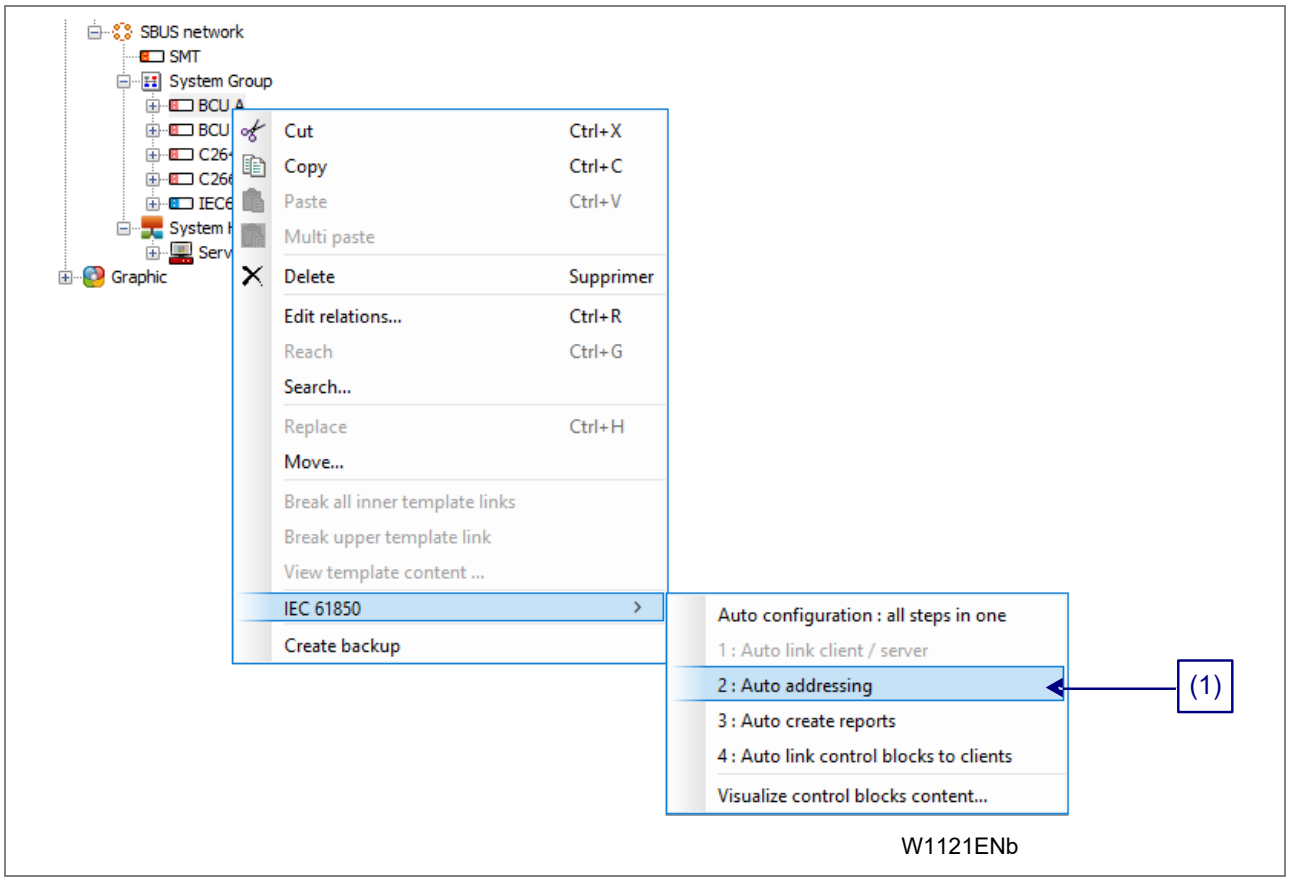


Figure 60: IEC 61850 automatic addressing

3.5.2.9 MANUALLY CONFIGURING GOOSE

GOOSE is a means given by IEC 61850 protocol to send and take into account faster the changes of binary states. That is very useful for time-critical fast automation or interlocking. In a given IEC 61850 mapping, only its ST / MX data objects may be goosed (in addition to the LSPs used for fast load shedding). Goose is attached to and managed by the IEC 61850 server of the goosed data objects.

3.5.2.9.1 Editing GOOSE ranking

The Goose rank is used to manually modify the position of Data Object in the Goose messages. It is defined through the relation link "**transmits: IEC DataObject / DataAttribute**"

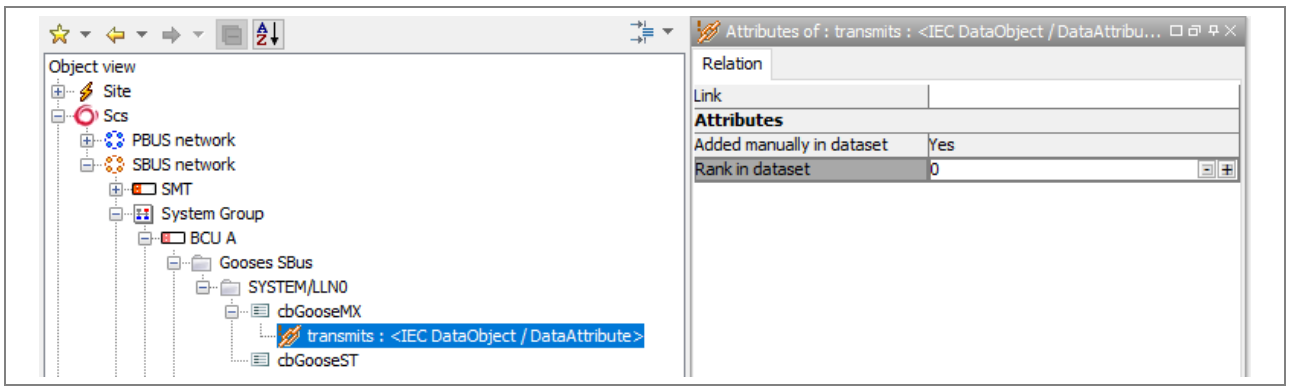


Figure 61: GOOSE rank

(1) **Added manually in dataset** (*Yes* / *No*): indicates if this relation has been added manually by the operator or created automatically.

(2) **Rank in dataset** (range [0, 1000], step 1): this attribute is used to manually modify the position of Data Object in the messages. The attribute is set to 0 by default. This value indicates that the position is undefined. You can modify this attribute to the desired rank. When modifying this value, make sure that the subsequent values follow one another. When the SCE auto-addresses all subsystems; the undefined 'rank' (0) is ranked after the last used rank for the whole IEC 61850 mapping.

Suppose you have generated the database 1.0 for IED1 only. After adding IED2, you generate a version 1.1.

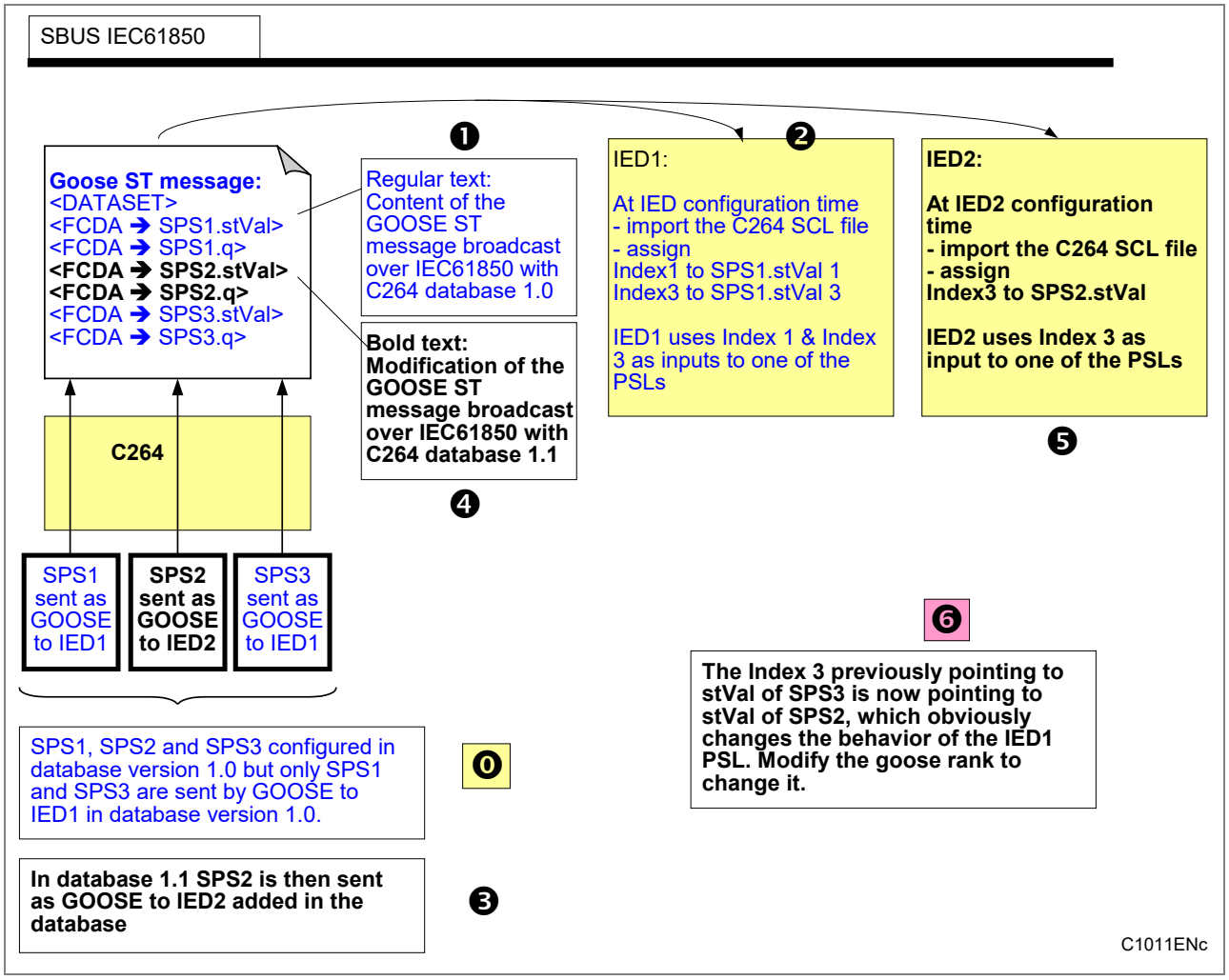


Figure 62: GOOSE rank possible problem

To resolve the conflict, change the position of SPS3.stVal.

The aim is to have goose messages from C26x with new DataObject (DtObj) at the end of the messages to keep the rank of the other DtObjs inside the goose messages.

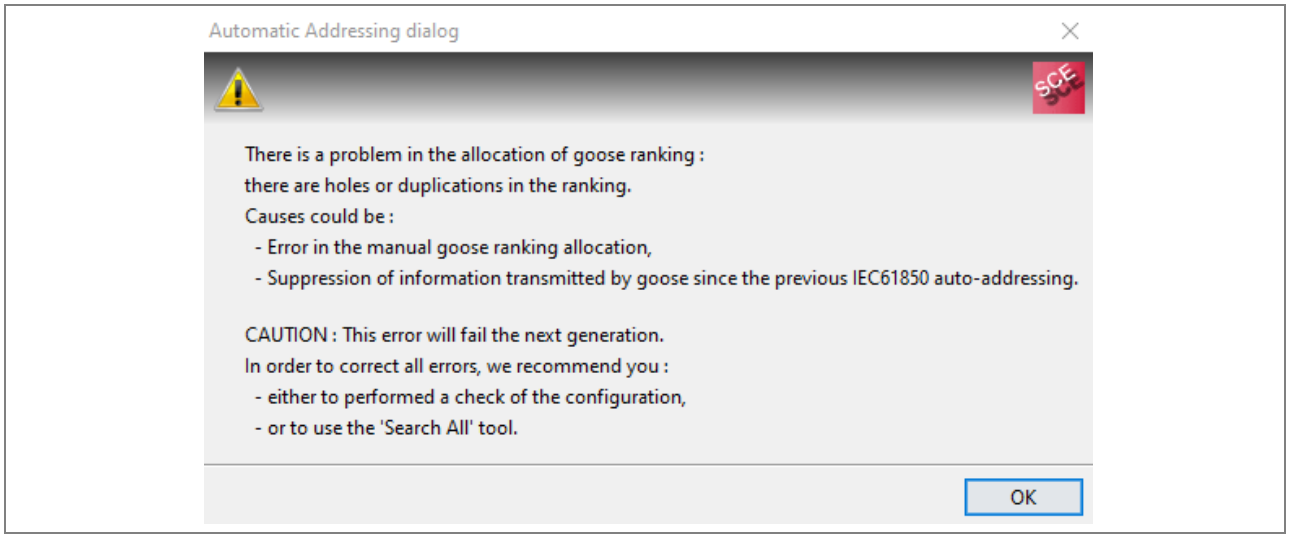
The attribute is set to 0 by default. This value indicates that the position is undefined. You can modify this attribute to the desired rank.

When the SCE auto-addresses all subsystems, these events occur for each DtObj:

- The defined 'Rank in dataset' is not updated if the DtObj is still 'transmitted by goose' (that is either ‘goose transmission’ attribute is set to Yes),
- The undefined 'Rank in dataset' is ranked after the last used rank for the whole IEC 61850 mapping,

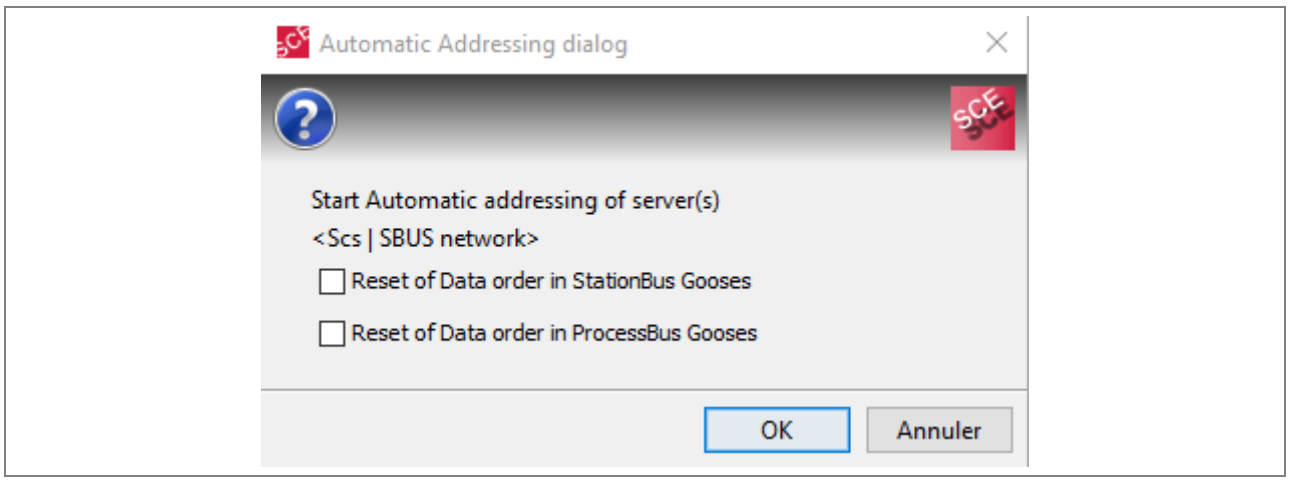
If the Dataobject no longer has to be in a Goose, then auto-addressing will remove the "transmits" relationship.

If gaps show in the goose ranking, the pop-up message shows:



In this event, do a check of the configuration and fix it manually (see the SCE/EN MF chapter)

Note:
The SBUS Automatic addressing function displays a dialog box that can be used to re-address the goose links of some data objects that have been removed.



You can check the box ‘reset of Data order…' to forcefully reset ALL of the Goose ranks of IEC 61850 mapping at the current level in the treelike structure: they are reset with an undefined value (as they are not goosed anymore) & all the remaining goose ranks are re-computed in a new order.

3.5.2.10 SUPERVISING SBUS/PBUS GOOSE & SAMPLED VALUES

The IEC 61850 GOOSE and SV supervision function is used to monitor DS Agile equipments to get information on GOOSE Control Block (GoCB) and Sampled Value (SvCB) communication such as subscription, alarm status, synchronization status...

3.5.2.10.1 IEC GOOSE Supervision

Each GoCB subscribed by an equipment can be supervised using the **GOOSE Sup** object and specific datapoints, as shown on the diagram below:

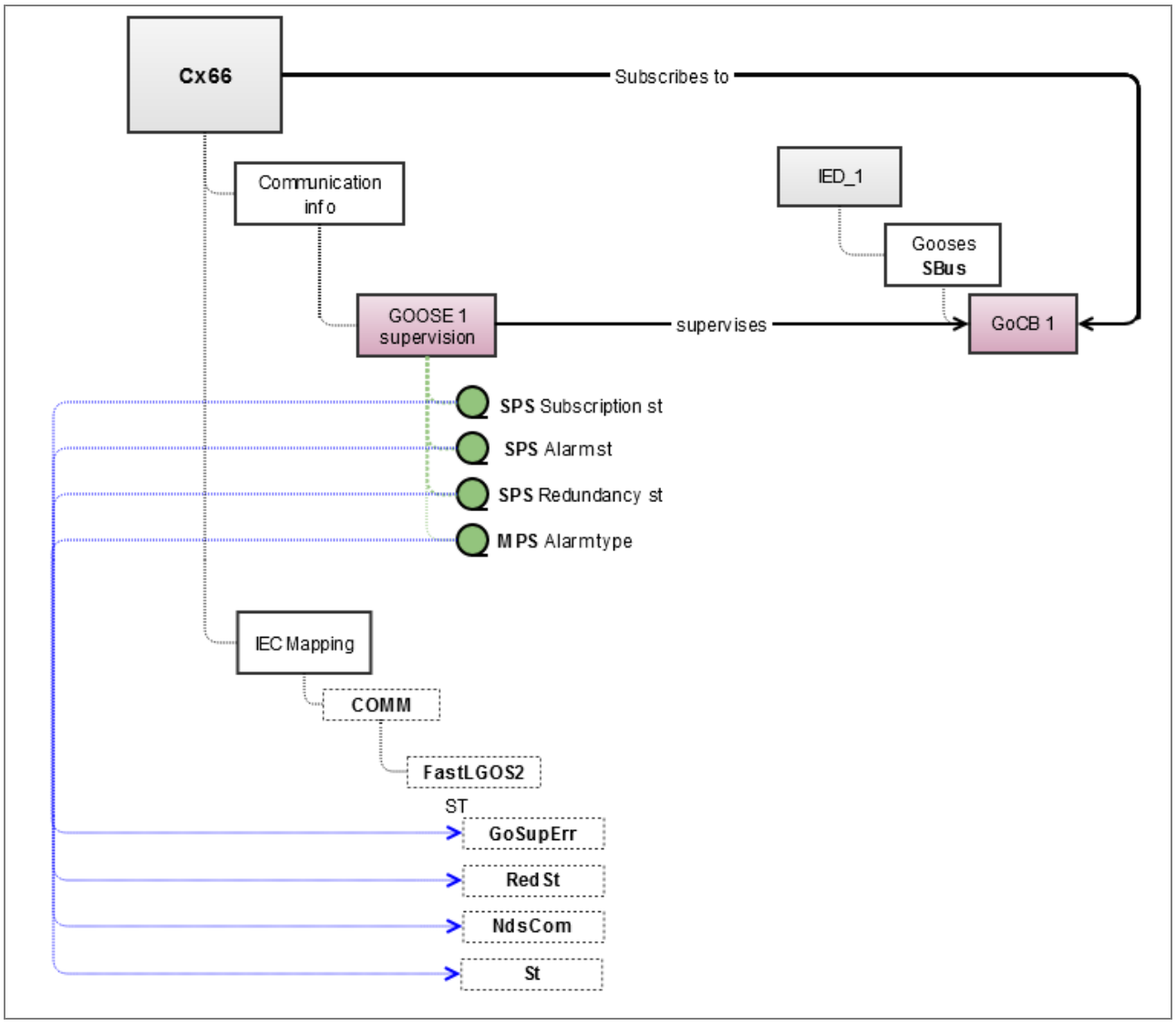


Figure 63: Configuration process of GOOSE supervision

The **GOOSE Sup** object can be added to the following IEDs:

- a C26x (C266 or C066);
- an IEC61850 generic IED.

To supervise a GOOSE, follow these instructions:

1 Select the relevant C26x under **Scs** > **SBUS network** > **System Group**, in the **Object view**.

2 In the **Objects entry** window, open the **Control block supervision** folder and then, double-click on **GOOSE Sup** to add this object to the C26x:

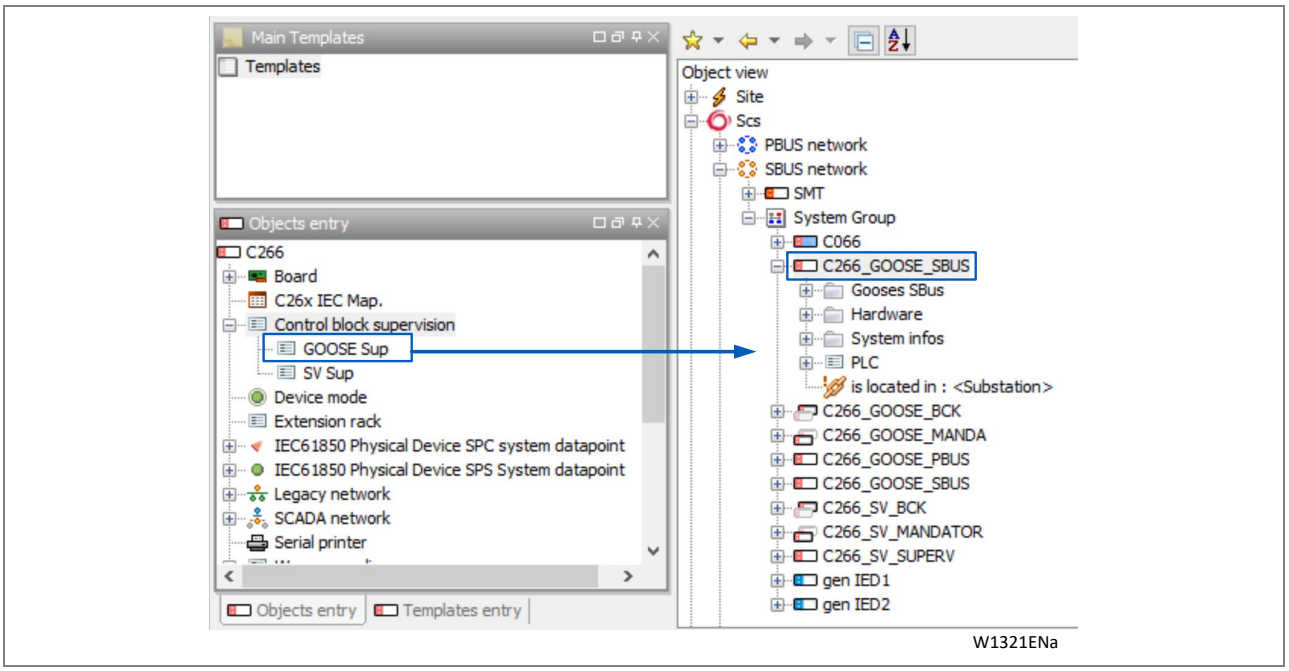


Figure 64: Adding the GOOSE Sup object

When added, the **GOOSE Sup** object appears under the C264, in the **Communication info** folder.

3 Add the relation "**supervises : ControlBlock**" under the GOOSE Sup object and then, double-click this relation to display the Relation link editor window and select the relevant GOOSE control block (GoCB).

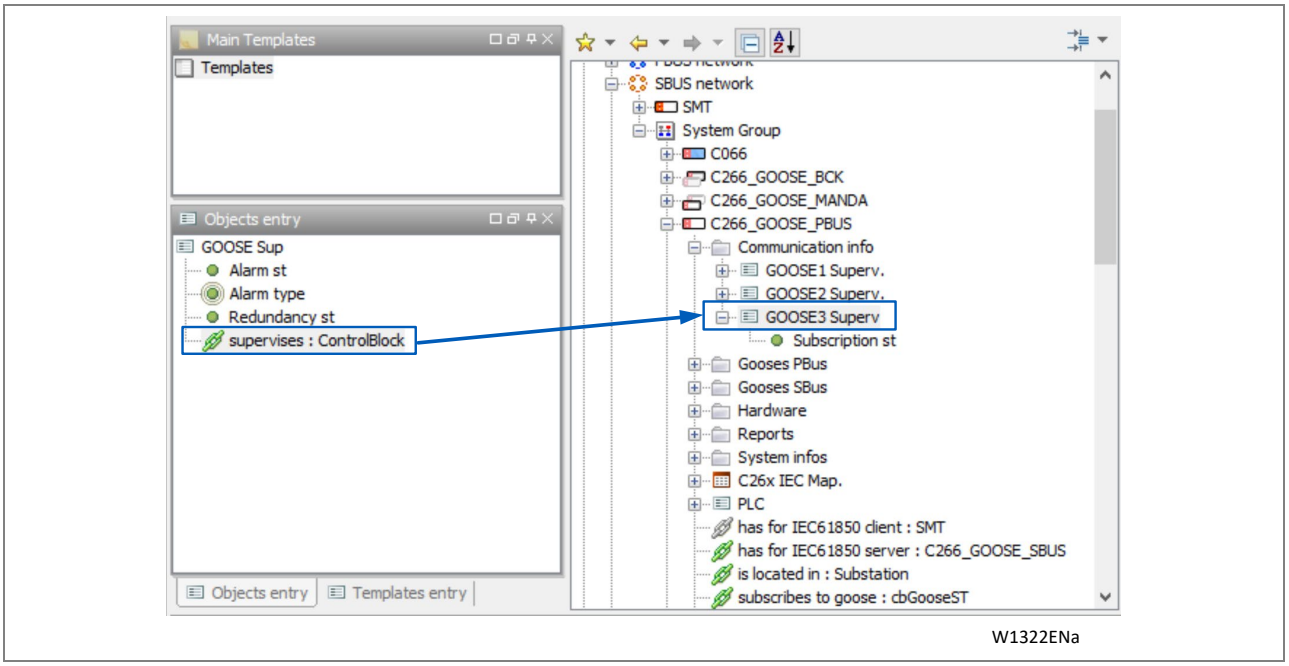


Figure 65: Adding the relation to the supervised GoCB

Note: Only GoCBs subscribed by the equipment managing "GOOSE Sup" objects and which are not already supervised are proposed. If subscribed GoCB comes from redundant devices, only GoCB from the main device appear in the list.

3.5.2.10.1.1 Mandatory datapoints of **GOOSE Sup** object

When adding a **GOOSE Sup** object, the mandatory SPS datapoint **Subscription st** is implicitly added. This datapoint allows DS Agile system to check whether the GOOSE subscription is active or not. This datapoint cannot be deleted and must be configured (see section *4 Defining a datapoint*).

The available states of this datapoint are:

- RESET for GOOSE subscription not OK;
- SET for GOOSE subscription OK (the GOOSE is identified and received)

3.5.2.10.1.2 Additional datapoints of **GOOSE Sup** object

The following optional datapoints can be added to the **GOOSE Sup** object of a C26x (C266 or C066) from the contextual **Objects entry** window:

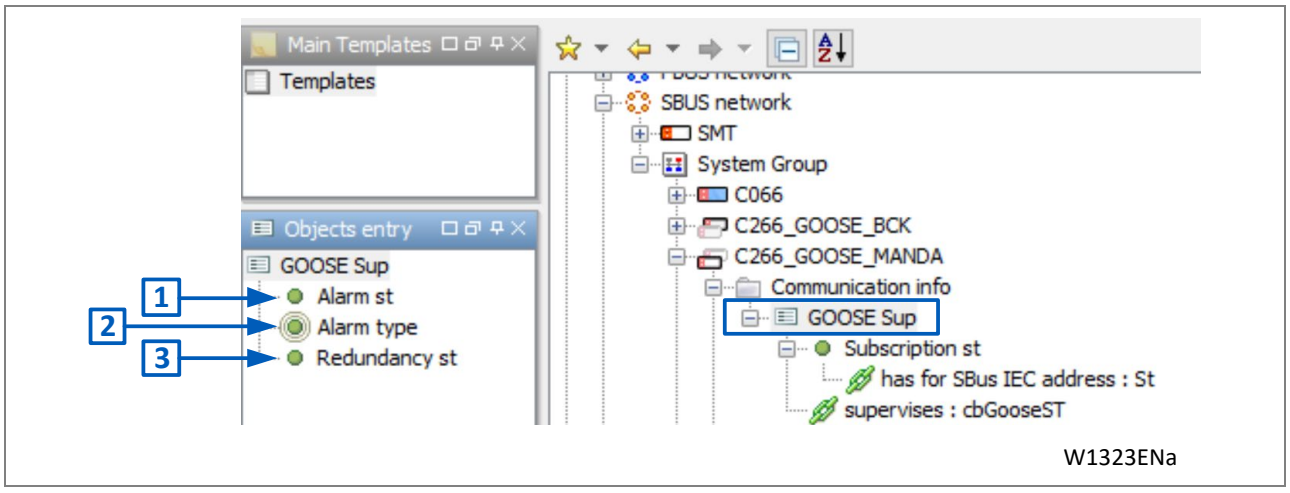


Figure 66: Additional datapoints of the GOOSE Sup object

(1) **Alarm st** (SPS): informs if error occurred during GOOSE subscription (alarm raised or not). When an issue is detected, an alarm is raised. Depending on the critically, GOOSE is rejected or accepted and the connection state of this GoCB is changed or not.

(2) **Alarm type** (MPS): returns the type of error detected during GOOSE subscription. The different states to be added to the corresponding MPS profile are:

- 0: None (No alarm);
- 1: Unknown (GOOSE Subscription not active, but error type could not be identified)
- 2: Not received (GoCB is not received)
- 3: Wrong AppID (Application Identifier is not the expected one)
- 4: Wrong Datset Ref (Dataset reference is not the expected one)
- 5: Wrong GoCBRef (GoCBRef received is not the expected one)
- 6: Wrong GoID (GOOSE Identifier is not the expected one)

- 7: Wrong ConfRev (Configuration revision of GoCB is not the expected one)
- 8: Wrong Nb of Data (Number of data entries is incorrect)
- 9: StNum OutOfOrder (State number is out of order)
- 10: SqNum OutOfOrder (Sequence number is out of order)
- 11: TAL expired (Time Allowed to Live is expired)
- 12: TAL 0 received (Time Allowed to Live with the value 0 has been received)
- 13: NdsCom raised (Needs Commissionning flag has been received)
- 14: Duplicated GoCB (Duplicated GoCB has been detected)
- 15: Wrong Data Type (One dataset entry type is incorrect)
- *16: Wrong Data Ref (One dataset entry reference is not the expected one)*
- *17: Wrong configRev (Config revision of the publisher data model does not match)*

*Note: You can automatically copy these labels in one shot into the MPS profile from the SCE **Help** menu. To do so, right-click on the **GOOSE Sup** object and click on **Help**. Select all labels contained in the text area below the alarm type table and then copy-paste the selection directly in the 'State0' column of the MPS profile table. All colums are automatically filled in. Due to SCE limitations, only 16 labels can be defined.*

(3) **Redundancy st** (SPS): indicates if the GOOSE is accepted (or not) in case of redundancy.

The following optional datapoint can be added to the **GOOSE Sup** object of an IEC61850 gen IED only:

(4) **Simulation st** (SPS): Indicates if that GOOSE subscription uses simulated GOOSE or not. The available states of this datapoint are RESET and SET.

An IEC address for mandatory and optional datapoints are created using SBUS automatic addressing.

3.5.2.10.2 Sampled Values supervision

Each SvCB subscribed by an equipment can be supervised by the same equipment using the **SV Sup** object and specific datapoints, as shown on the diagram below:

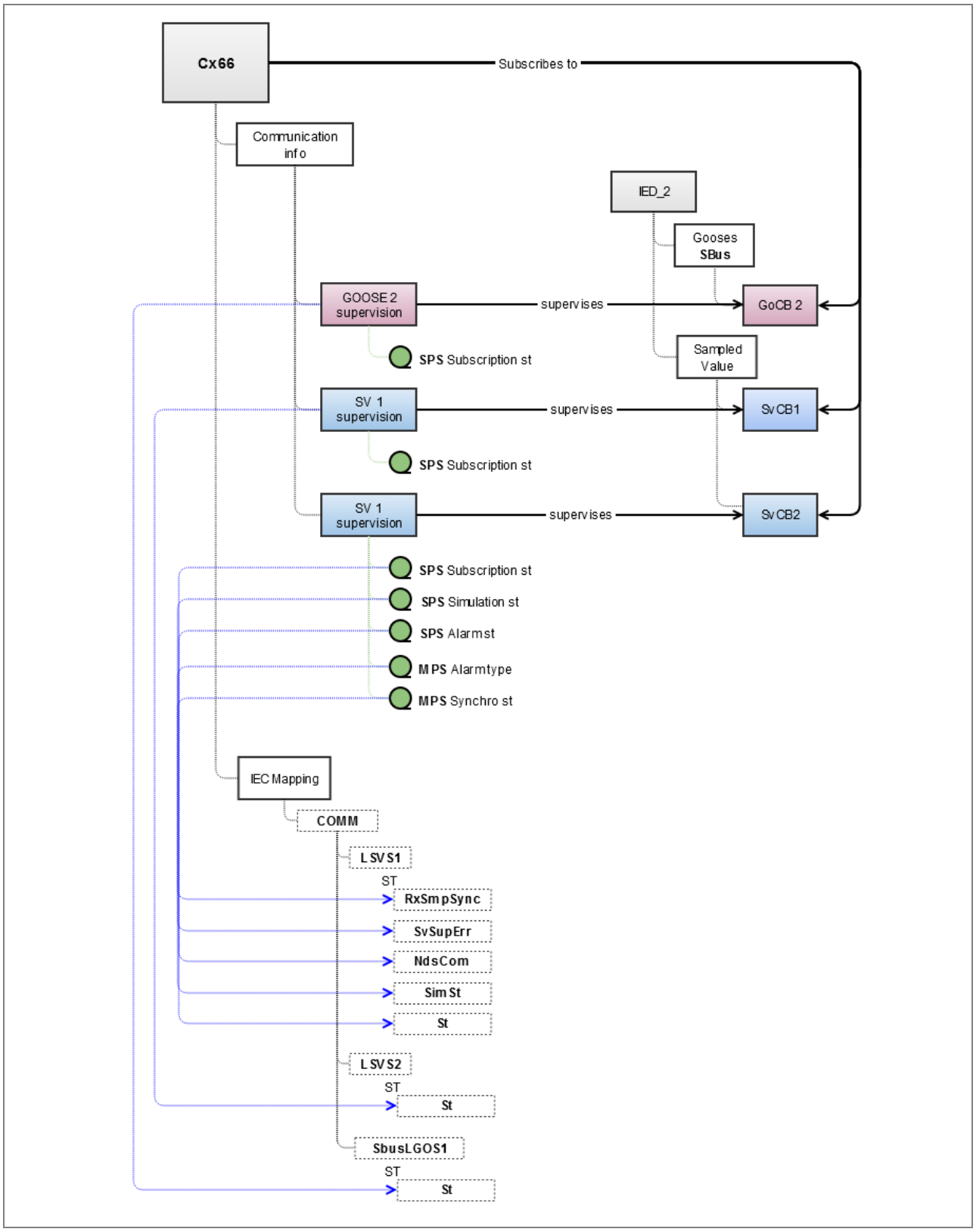


Figure 67: Configuration process of Sampled value supervision

The **SV Sup** object can be added to the following IEDs:

- a C26x (C266 only)
- an IEC61850 generic IED

3.5.2.10.2.1 Configuring SV Supervision

To supervise SV, follow these instructions:

- Select the relevant C26x under **Scs** > **SBUS network** > **System Group**, in the **Object view**.
- In the **Objects entry** window, open the **Control block supervision** folder and then, double-click on **SV Sup** to add this object to the C26x:

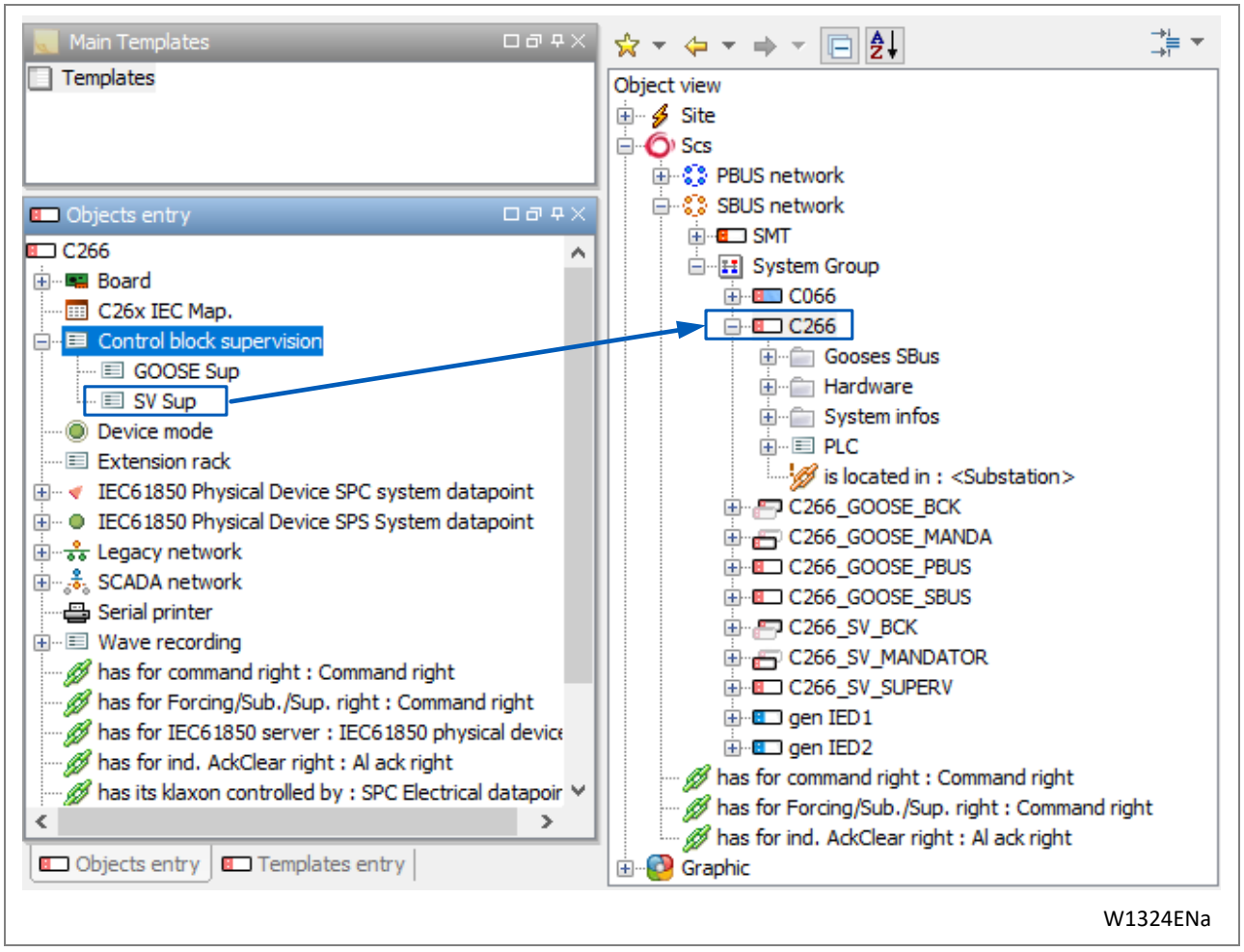


Figure 68: Adding the SV Sup object

When added, the **SV Sup** object appears under the C264, in the **Communication info** folder.

- Add the relation **supervises : SampledValue** under the **SV Sup** object and then, double-click this relation to display the **Relation link editor** window and select the relevant SV control block (SvCB).

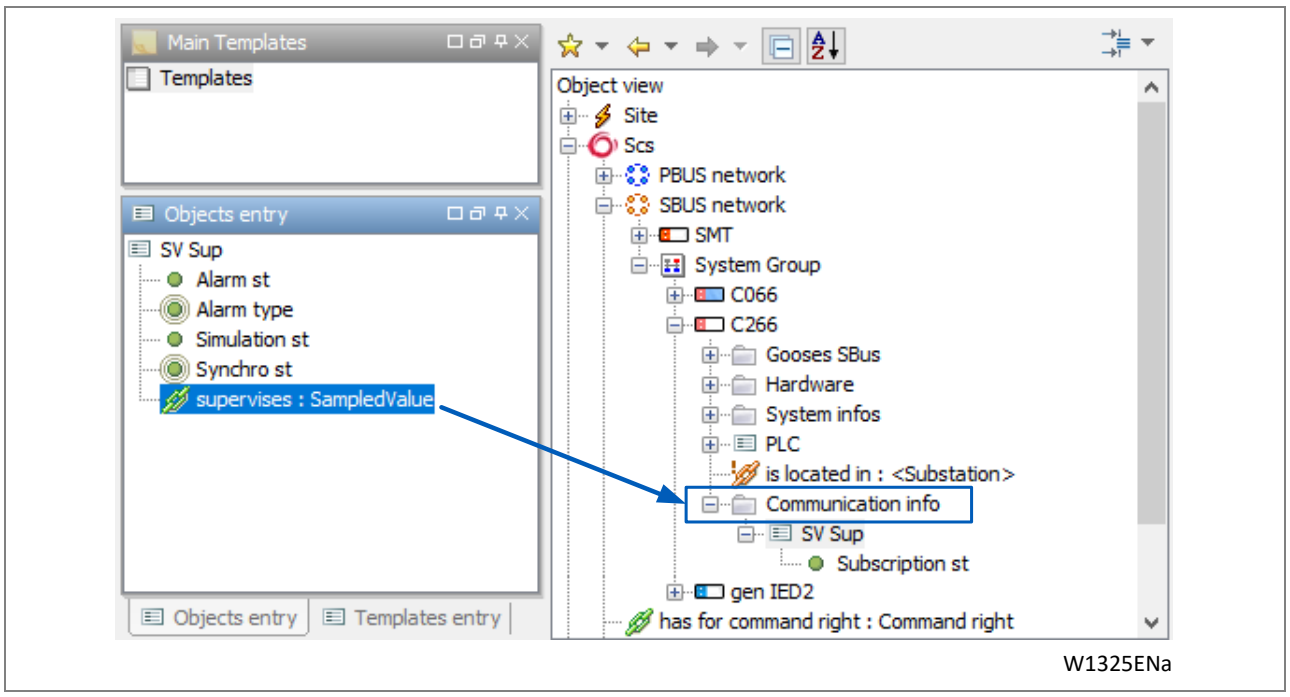


Figure 69: Adding the relation to the supervised SvCB

Note: Only SvCBs subscribed by the equipment managing "SV Sup" objects and which are not already supervised are proposed. If subscribed SvCB comes from redundant devices, only SvCB from the main device appear in the list.

3.5.2.10.2.2 Mandatory datapoints of **SV Sup** object

When adding a **SV Sup** object, the mandatory SPS datapoint **Subscription st** is implicitly added. This datapoint allows DS Agile system to check whether the Sampled value subscription is active or not. This datapoint cannot be deleted and must be configured (see section *4 Defining a datapoint*).

The available states of this datapoint are:

- RESET for SV subscription not OK;
- SET for SV subscription OK (the SV is identified and received);

3.5.2.10.2.3 Additional datapoints of **SV Sup** object

The following optional datapoints can be added to the **SV Sup** object of a C26x (C266) from the contextual **Objects entry** window:

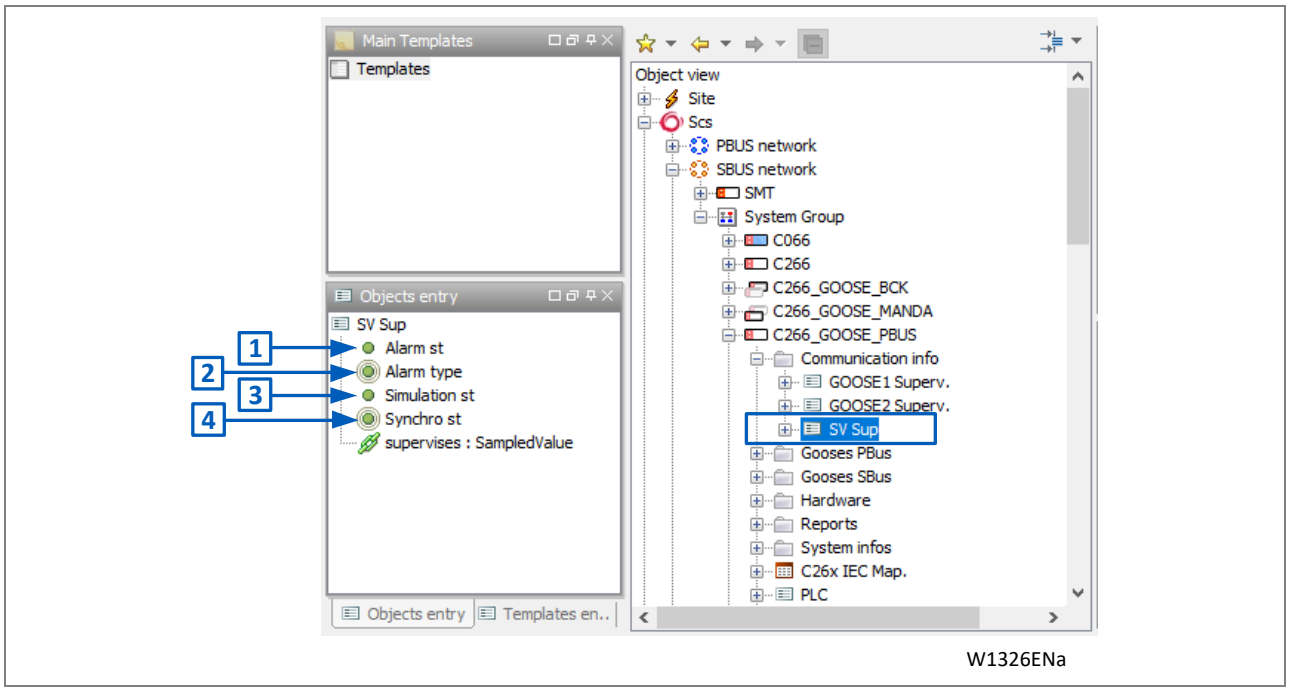


Figure 70: Additional datapoints of the SV Sup object

(1) **Alarm st** (SPS): informs if error(s) occurred during Sample Value subscription (alarm raised or not). When an issue is detected, an alarm is raised.

(2) **Alarm type** (MPS): returns the type of error detected during Sampled value subscription. The different states to be added to the corresponding MPS profile are:

- 0: None (No alarm);
- 1: Unknown (SV Subscription not active, but error type could not be identified);
- 2: Not received (SvCB is not received);
- 3: SmpCnt Alm (The SmpCnt number is out of order);
- 4: Duplicated SvCB (Duplicated SvCB has been detected).

(3) **Simulation st** (SPS): Indicates if Sampled value subscription uses simulated Sampled value or not. The available states of this datapoint are RESET and SET.

(4) **Synchro st** (MPS): Indicates the synchronization status of the SvCB. The different states to be added to the corresponding MPS profile are:

- 0: **Internal synchro**: synchronized internally (device internal clock when local or global synchronization is lost);
- 1: **Local synchro**: substation or bay wide signal;
- 2: **Global synchro**: GPS like clock.

*Note: You can automatically copy state labels in one shot into the SPS or MPS profile from the SCE **Help** menu. To do so, right-click on the **SV Sup** object and click on **Help**. Select all labels contained in the text area below the desired datapoint and then copy-paste the selection directly in the 'State0' column of the SPS or MPS profile table. All columns are automatically filled in.*

3.5.3 ADDRESSING A DATAPOINT ON THE SBUS OR PBUS NETWORK

For details about datapoints, see section *4 Defining a datapoint*.

To exchange datapoint values between sub-systems, datapoints should be linked to specific IEC 61850 data objects. There are 2 ways to resolve this link:

- Doing a manual addressing, by adding at datapoint level the relation **has for IEC61850 address** (1) and filling it with the corresponding IEC 61850 data object in a pre-configured IEC 61850 address mapping:

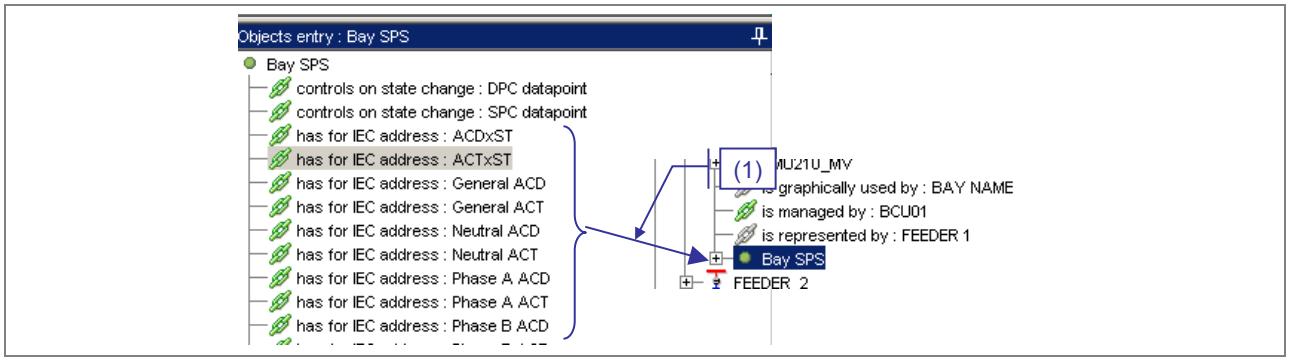


Figure 71: Manual IEC61850 addressing of a datapoint (example for a Bay SPS datapoint)

- Using the automatic SBUS addressing function available at SCE level (see section *3.5.2.1 SBUS automatic addressing*), which performs:
  - automatic IEC 61850 mapping creation at DS Agile C26x level,
  - automatic linking between data objects in this IEC 61850 mapping and datapoints managed by the DS Agile C26x.

3.6 NETWORKING IEDS ON A C26X'S LEGACY NETWORK

3.6.1 CREATING A LEGACY NETWORK OF IEDS

Generally, specific units called protection relays or IEDs are used to protect electrical modules and bays. A legacy network managed by a C26x can connect these IEDs to the DS Agile system.

In the SCE data model, up to four IED legacy networks (associated with specific protocols) can be placed under a DS Agile C26x unit.

Each IED legacy network must be linked to a communication port on a C26x board. Up to sixteen IEDs can be added under each legacy network.

The legacy protocols supported by the C264 are:

- T103 Master
- T101 Master
- MODBUS (serial or IP)

To create a legacy network under a C26x:

- Select the C26x level and add a legacy network, associated with the corresponding protocol, from the contextual **Objects entry** window.
- Update the legacy network attributes relevant to its protocol characteristics.
- Update its **has for main comm. port** relation and the communication port characteristics (see section *3.3.4 Configuring a communication channel*).

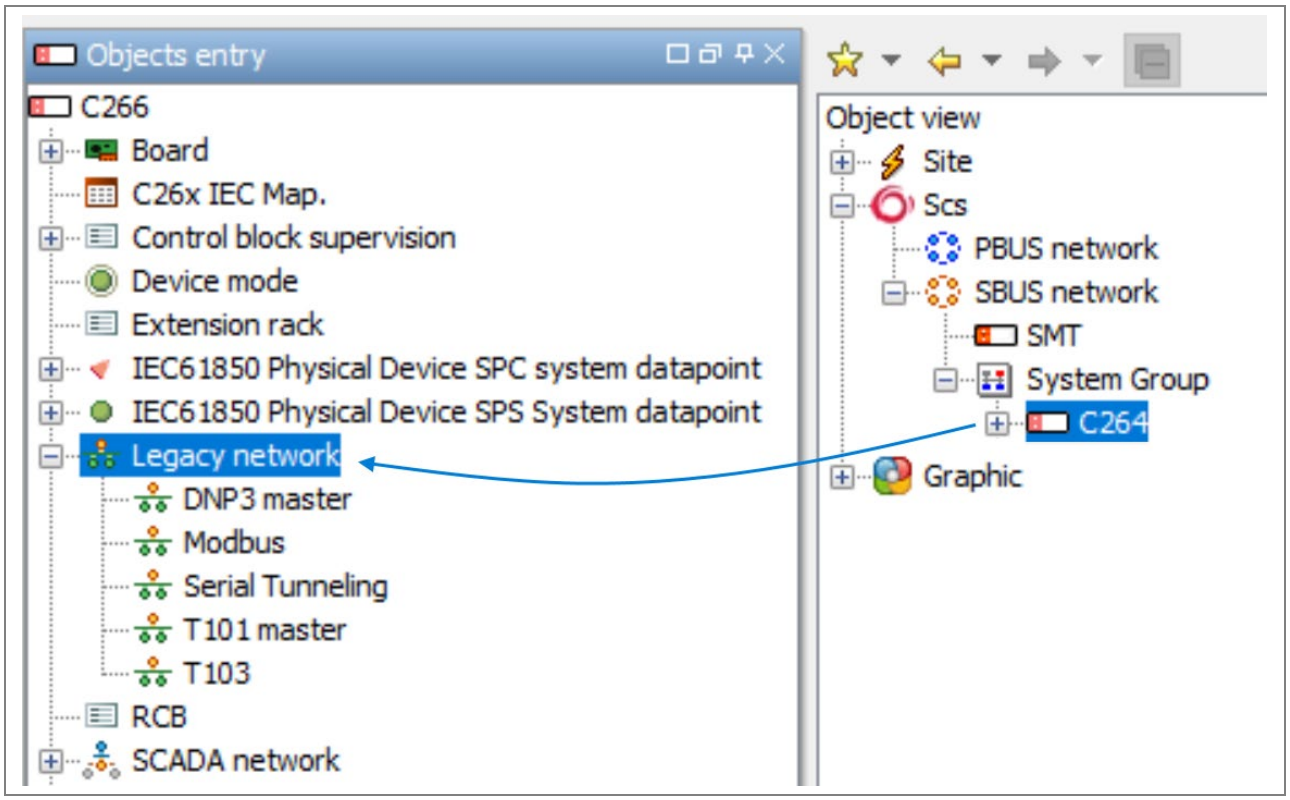


Figure 72: Adding a legacy network

3.6.1.1 SETTING THE GENERAL ATTRIBUTES OF A LEGACY NETWORK

Regardless of the type of legacy network, its **short name** and **long name** (1) attributes must be set in order to ensure correct logging and alarm discrimination of the status datapoints for the IEDs connected to the legacy network.

The time reference (3) must be set to either *UTC* or *Local* time.

3.6.1.2 MODBUS LEGACY NETWORK

3.6.1.2.1 Setting the general attributes of a Modbus legacy network

When adding a Modbus legacy network, set the following parameters (they will be used for all its IEDs)

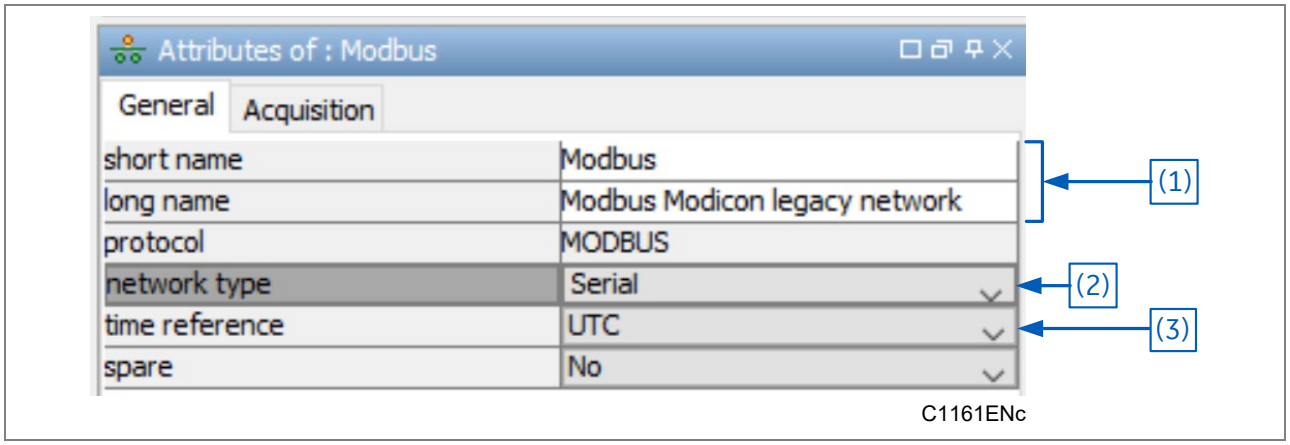


Figure 73: Setting the Acquisition attributes of a Modbus legacy network

(1) **short name** and **long name**: enter a name for the legacy protocol

(2) **network type** *(Serial / IP)*: select the network type supported by the C264. C264 (BCU/SCU) can either be a MODBUS TCP/IP Client or MODBUS TCP/IP Server.

(3) **time reference**: select whether the time reference must be set to either *UTC* or *Local time*.

3.6.1.2.2 Setting the Acquisition attributes of a Modbus legacy network

When adding a Modbus legacy network, set the following attributes (they will be used for all its IEDs):

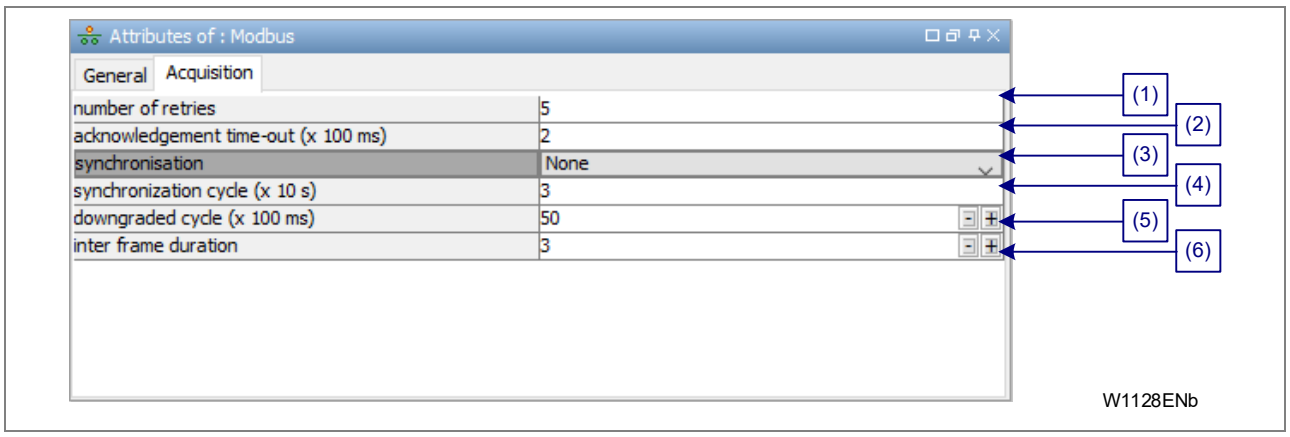


Figure 74: Setting the Acquisition attributes of a Modbus legacy network

(1) **number of retries** (range [1, 10], step 1): number of retries of the same frame without IED response that the C26x will send before declaring the IED as disconnected

(2) **acknowledgement time-out** (range [100 ms, 30 s], step 100 ms): waiting time for an IED answer to a C26x's information request.

(3) **synchronisation** (none / ALSTOM / SEPAM / Flexgate): refer to the Communication chapter of the C264 user manual and the reference document of the connected IED.

(4) **synchronization cycle** (range [10 s, 655350 s], step 10 s): time synchronization period of the IED by the C26x. Only significant if the attribute synchronisation is set to 'ALSTOM', 'Flexgate' or to 'SEPAM'. To keep a Px4x synchronized, the C26x must send the frame at least every 5 minutes; therefore, the value must be lower than 30 in that case.

(5) **downgraded cycle** (range [1 s, 10 s], step 100 ms): time interval at which the C26x regularly tries to re-connect to an IED after it has declared it as disconnected.

(6) **inter frame duration** (range [1, 50], step 1): this attribute represents the minimum time, expressed in number of characters, that must exist between two frames.

3.6.1.3 T103 MASTER LEGACY NETWORK

3.6.1.3.1 Setting the Acquisition attributes of a T103 Master Legacy Network

When adding a T103 legacy network, set the following attributes (they will be used for all its IEDs):

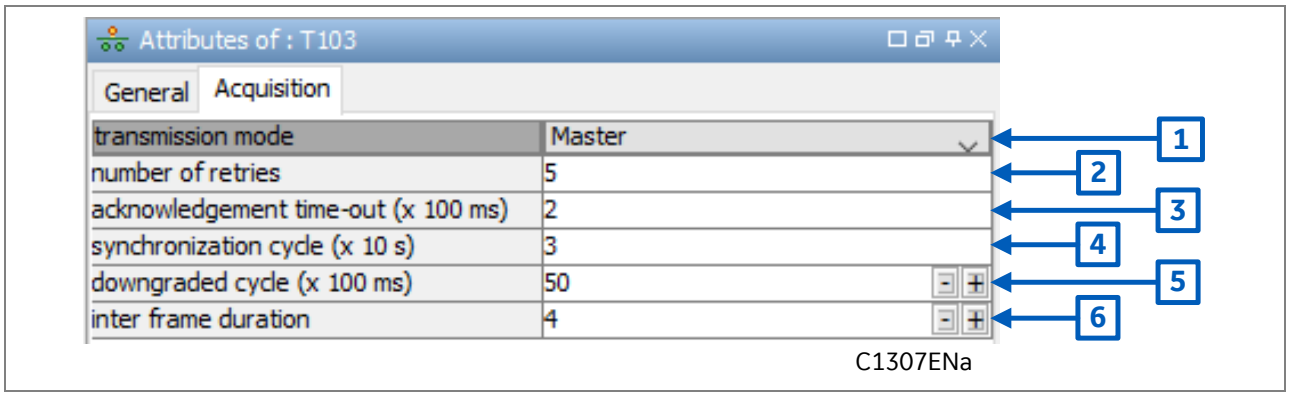


Figure 75: Setting the Acquisition attributes of a T103 legacy network

(1) **transmission mode** (*Master)*: the C264 is the master on the legacy bus regards to protections and IEDs (the protocol is referenced as "Master T103").

(2) **number of retries** (range [1, 10], step 1): number of retries of the same frame without IED response that the C26x will send before declaring the IED as disconnected.

(3) **acknowledgement time-out** (range [100 ms, 30 s], step 100 ms): waiting time for an IED answer to a C26x's information request.

(4) **synchronization cycle** (range [10 s, 655350 s]): time synchronization period of the IED by the C26x.

(5) **downgraded cycle** (range [1 s, 10 s], step 100 ms): time interval at which the C26x regularly tries to re-connect to an IED after it has declared it as disconnected.

(6) **inter frame duration** (range [1, 50], step 1): this attribute represents the minimum time, expressed in number of characters, that must exist between two frames.

3.6.1.4 ADDING AN IED TO A LEGACY NETWORK

To create an IED on a legacy network:

1 Select the **Legacy networks** level and add an IED from the contextual **Objects entry** window.

2 Update the IED attributes relevant to its protocol characteristics

3 For T103, or Modbus IEDs, update the **has for acquisition profile** relation with a previously created IED acquisition type

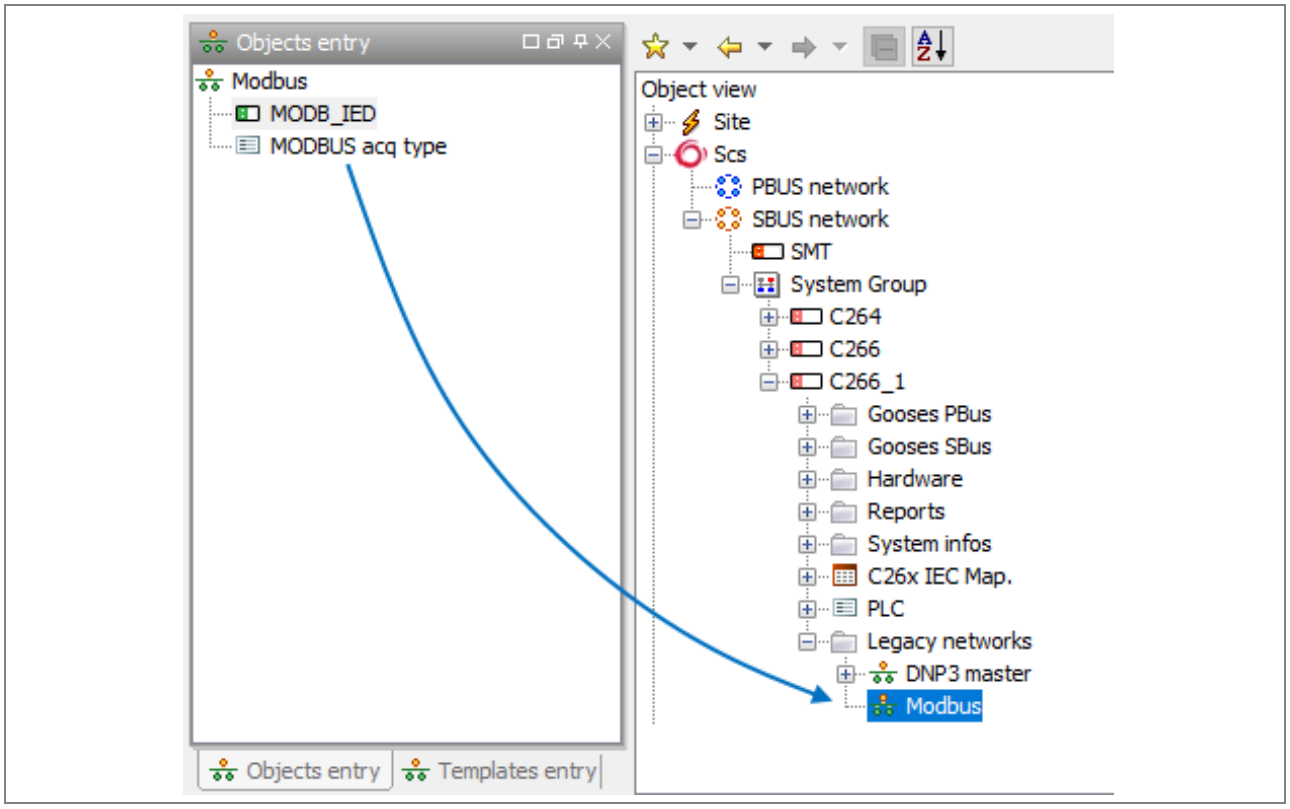


Figure 76: Adding an IED to a legacy network

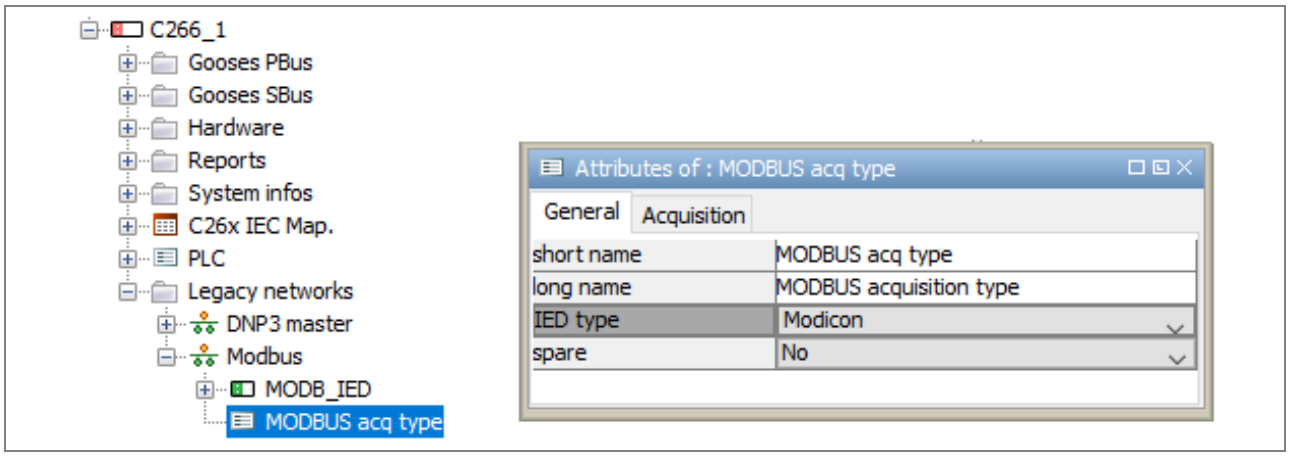


Figure 77: Linking an IED acquisition profile to an IED

3.6.1.4.1 Setting the attributes of a legacy IED

Whatever the type of IED, the attributes below must be updated.

For Serial networks (Modbus, T101 and T103):

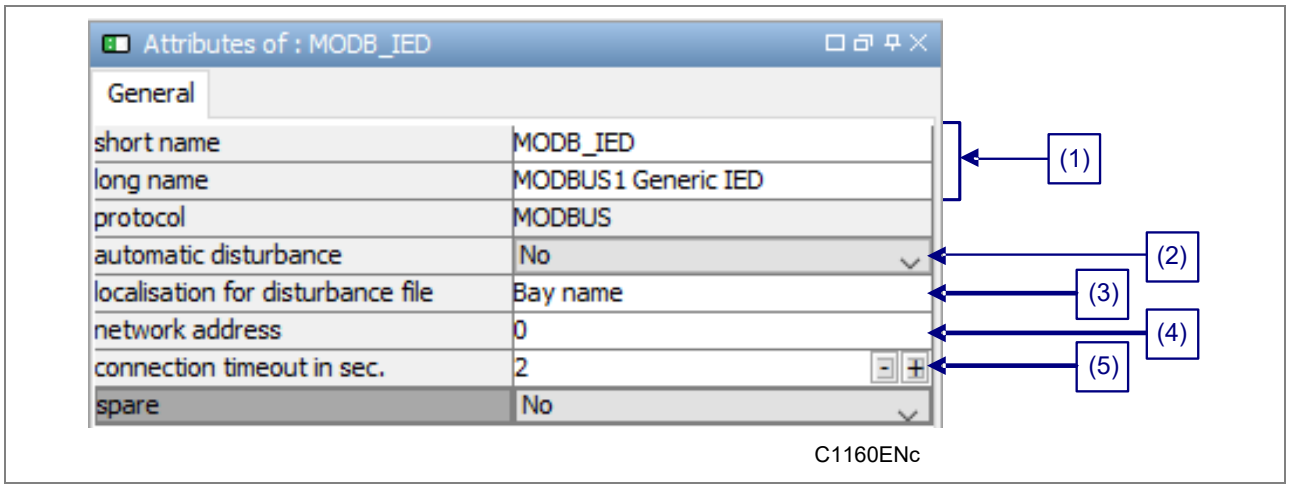


Figure 78: Setting the general attributes of a Serial legacy IED

(1) **short name** and **long name**: used for correct logging and alarm discrimination of IED status datapoint.

(2) **automatic disturbance** (*No* / *Yes*) .

(3) **localisation for disturbance file**: used by the SMT to name the uploaded file on the OWS hard disk: <localisation>_N#.

(4) **network address** of the IED on the legacy network (4-byte address).

(5) **connection timeout in sec.** (range [1, 600], step 1)

Configuration rules and checks

The settings for the **network address** and **short name** attributes of each IED must be unique within a Legacy Network.

3.6.1.5 ADDING AN IED ACQUISITION TYPE TO A LEGACY NETWORK

Common acquisition and communication characteristics are shared by IEDs. These characteristics are grouped in an object called **IED acquisition type**, similar to an acquisition profile. It is available for the Modbus protocols.

To create an IED acquisition type on a legacy network:

1 Select the **Legacy networks** level and add an IED acquisition type from the contextual **Objects entry** windows.

2 Update the IED acquisition type attributes relevant to its protocol characteristics.

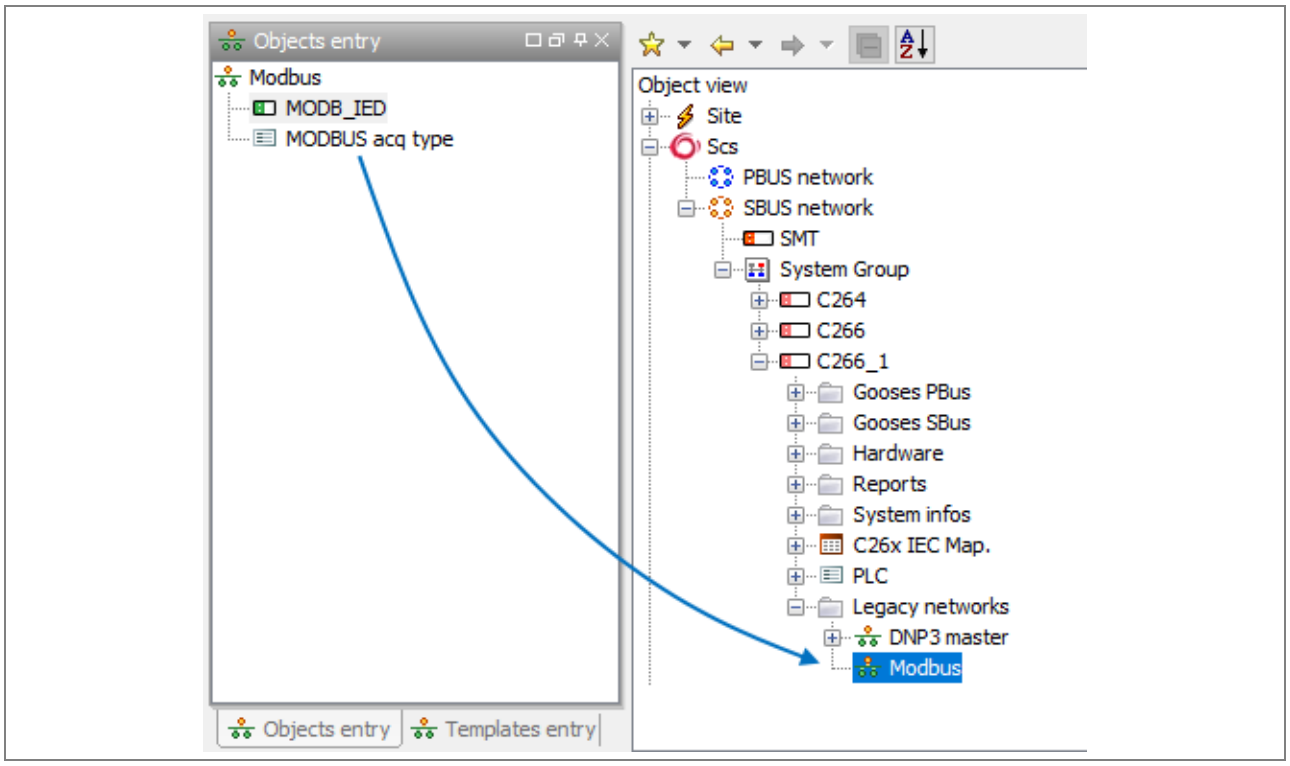


Figure 79: Adding an IED acquisition type to a legacy network (example for Modbus)

Configuration rules and checks

For each C26x and all its Legacy Networks, the maximum number of "xxx acq type" components is **10**.

3.6.1.5.1 Setting the attributes of a MODBUS acquisition type

When adding a Modbus acquisition type, the following attributes, available for all its linked IEDs, must be updated:

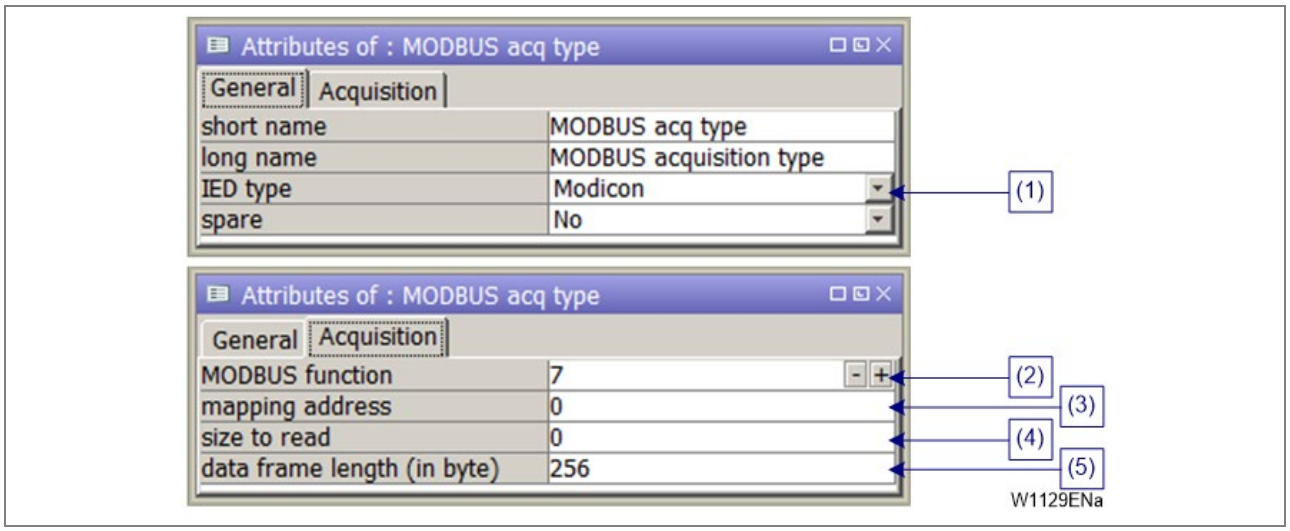


Figure 80: Setting the attributes of a Modbus acquisition type

(1) **IED type:**

- Modicon to use the generic Modbus communications (refer to the Communications chapter of the C264 user manual)
- M300, Px2x series, MiCOM S40 (MiCOM Modbus communications)
- M230, Wago, Rish Pro M10, ABB Flexgate, SEPAM (specific Modbus communications)

(2) **MODBUS function** (1 / 2 / 3 / 4 / 7 / 8): function number used for the polling frame: When testing the IED connection, this attribute indicates which Modbus function is used. For GE Grid Solutions IEDs, the function 7 is generally used.

(3) **mapping address** (range [0, 232-1]): associated with attribute (2), it indicates which start address is used to test the IED connection

- if **MODBUS function** is set to 1 or 2 this attribute defines a bit address
- if **MODBUS function** is set to 3 or 4 this attribute defines a word address
- if **MODBUS function** is set to 7 this attribute is not significant
- if **MODBUS function** is set to 8 this attribute defines a sub-code

(4) **size to read** (range [0, 2048]: associated with attribute (3), it indicates which length of frame is used to test the IED connection.

- if **MODBUS function** is set to 1 or 2 this attribute defines a number of bits
- if **MODBUS function** is set to 3 or 4 this attribute defines a number of words
- if **MODBUS function** is set to 7 or 8 this attribute is not significant

(5) **data frame length** (range [2 bytes, 256 bytes]): if an IED cannot manage frames longer than 256 bytes, this attribute must be set to the length manageable by the IED.

3.6.1.5.2 Setting the attributes of a T103 acquisition type

When adding a T103 acquisition type, set the following attributes (they will be used for all its associated IEDs):

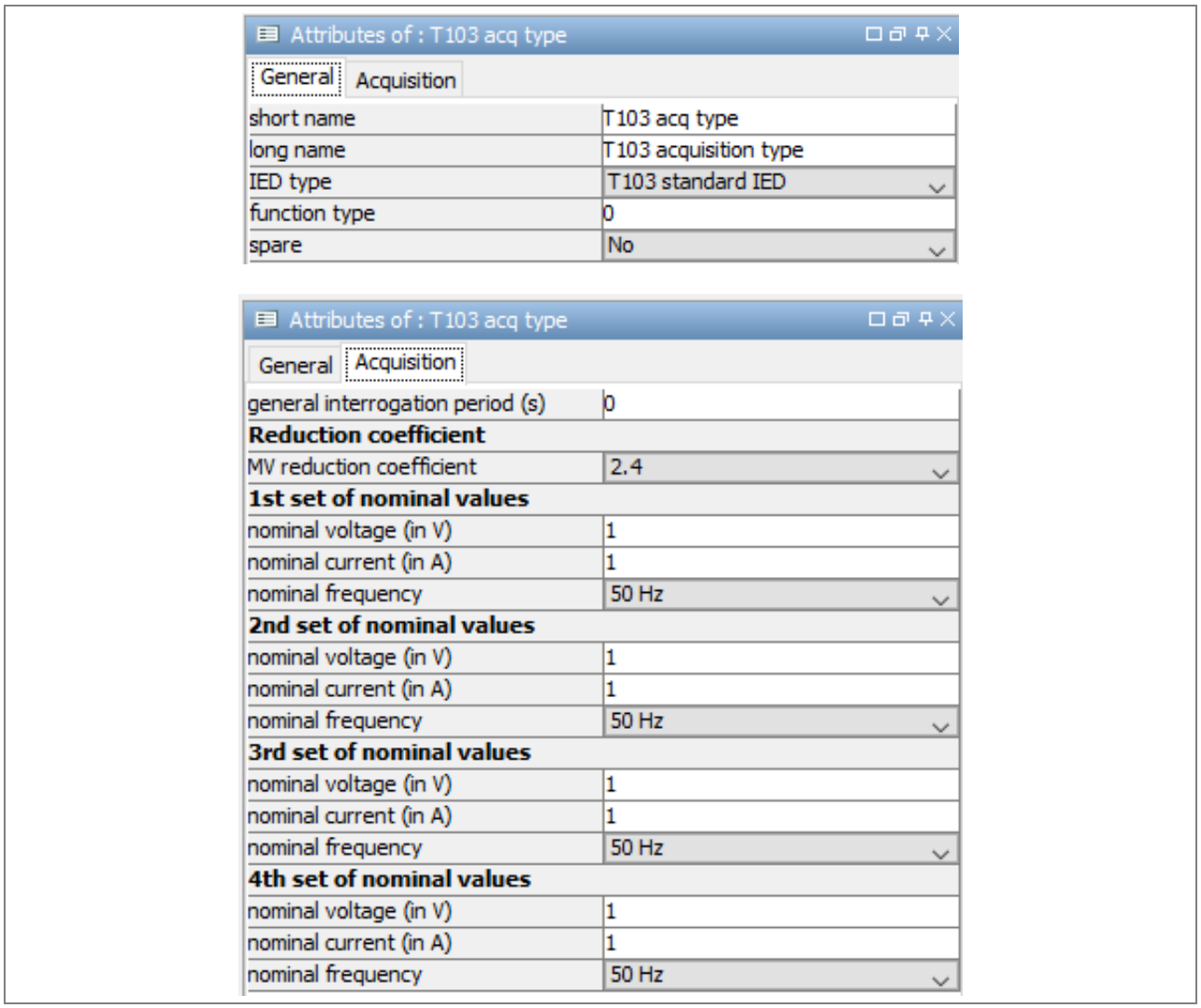


Figure 81: Setting the attributes of a T103 acquisition type

(1) **IED type** (*T103 standard IED* / *(Schneider) Px3x Series* / *(Schneider) Px2x Series* / *REG-D* / *Tapcon 240*)

(2) **function type** (range [0, 255]: function type number used for acquisition: see IED documentation to correctly set this attribute

(3) **general interrogation period** (range [0, 24 h], step 1 s): cycle used to regularly retrieve states and measurements from IED and to avoid losing event information

(4) **MV reduction coefficient** (*1.2* / *2.4*): used for scaling (ASDU 3 usage): refer to T103 documentation for details about this scaling

(5) Four **sets** of three **nominal values** (voltage, current and frequency) used for scaling. Refer to International Standard IEC 60870-5-103 for details about this scaling.

3.6.2 DEFINING THE ADDRESS MAP OF A LEGACY IED

To transmit information between IEDs and the DS Agile system, an IED legacy network connected to a DS Agile C26x is used.

In order for information to be exchanged between a legacy IED and the DS Agile system, each relevant data must have a specific address on the legacy network that must be compliant with its protocol. General modeling of legacy network address mapping can be done. At SCE level, an IED of a legacy network owns an “IED mapping” object, that is split in categories of mapping on a per datapoint type basis. In each category of mapping, elementary IED addresses can be created. For information on datapoints, see section *4 Defining a datapoint*. This mapping is implicitly created when an IED is added at the legacy network level. It is not possible to address an MPS datapoint on a legacy IED.

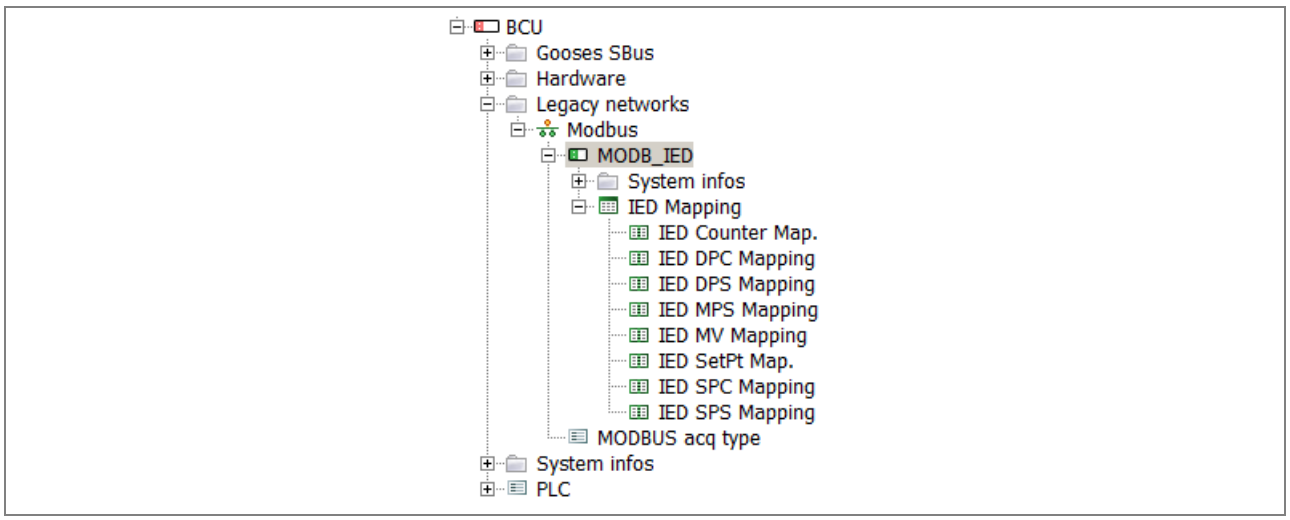


Figure 83: Address mapping structure for a legacy IED (example for Modbus IED)

For details about address mapping of a given IED on a specific protocol, refer to the protection IED documentation.

Configuration rules and checks

In the IED Mapping, the address identification of each "xxx addr. on IED" must be unique.

- MODBUS: The address identifier is made of the following combination of its attribute values:
  - {mapping address, function}
- T103: The address identifier is made of either of the following combinations of its attribute values:
  - {ASDU number, function type, information number, common address of ASDU}
  - {ASDU number, function type, information number}
- T101: The address identifier is made of the following combination of its attribute values:
  - {information object address}

There are two ways to map the datapoints

- Set the attributes of the subnodes of the various IED xxx Mapping folders
- To save time, especially after a file import from MS Excel, use in the Wiring editor's smart table, linking the individual tables to the hierarchy

3.6.2.1 SMART TABLE

Select a node <protocol name>_IED in the browser as shown in the screenshot below.

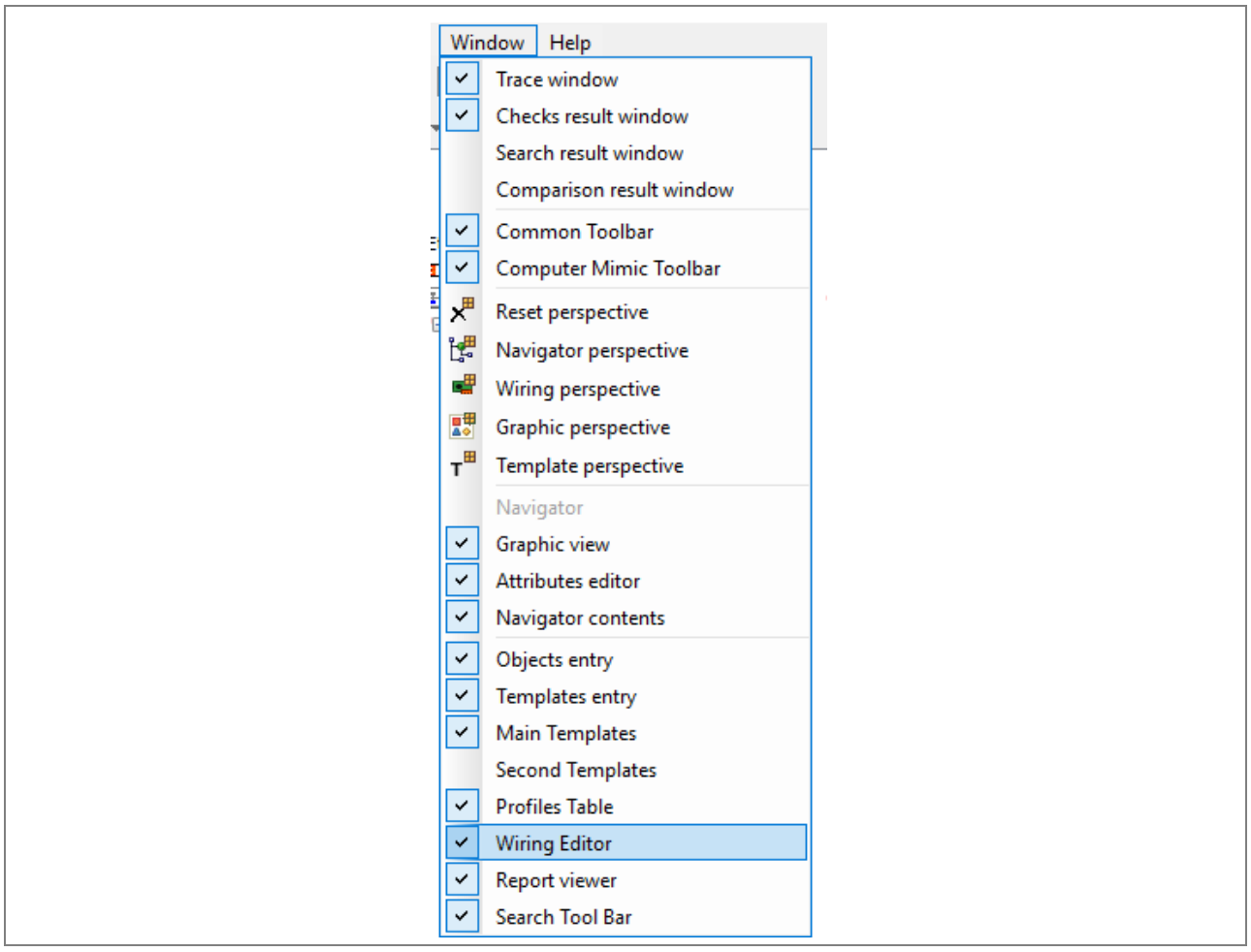


Figure 84: Wiring editor selection

Select **Wiring editor** in the **Window** menu. If it is grayed out, click the **Wiring** button in the lower area. If that button is not present, click the button **Reset perspective** in the toolbar. The window **Wiring: …** is displayed. It allows to enter all datapoint addresses for the IED mapping. The datapoints are tabbed by type; there are 5 types:

- xPS for SPS / DPS addresses
- xPC for SPC / DPC addresses
- MV for measurement addresses
- SetPoint for SetPoint addresses
- Counter for Counter addresses

Each tab contains a table featuring:

- on the left-hand side (white background), the variants (pictogram) and the attributes needed for address uniqueness (they depend on the protocol, see sections *3.6.2.2 to 3.6.2.9*); copy/paste is enabled
  - in the middle, other attributes (**Contact**, **Label**); copy/paste is enabled
  - on the right-hand side (blue background), other attributes (**path**, **short name**, **meaning**, **profile**, **long name**)

To adjust a column width, move the cursor over the border in the header until the cursor becomes ↔; then "drag and drop".

If the table is empty, click **Insert** in the upper left corner; this creates a row with **Addr** at *0*.

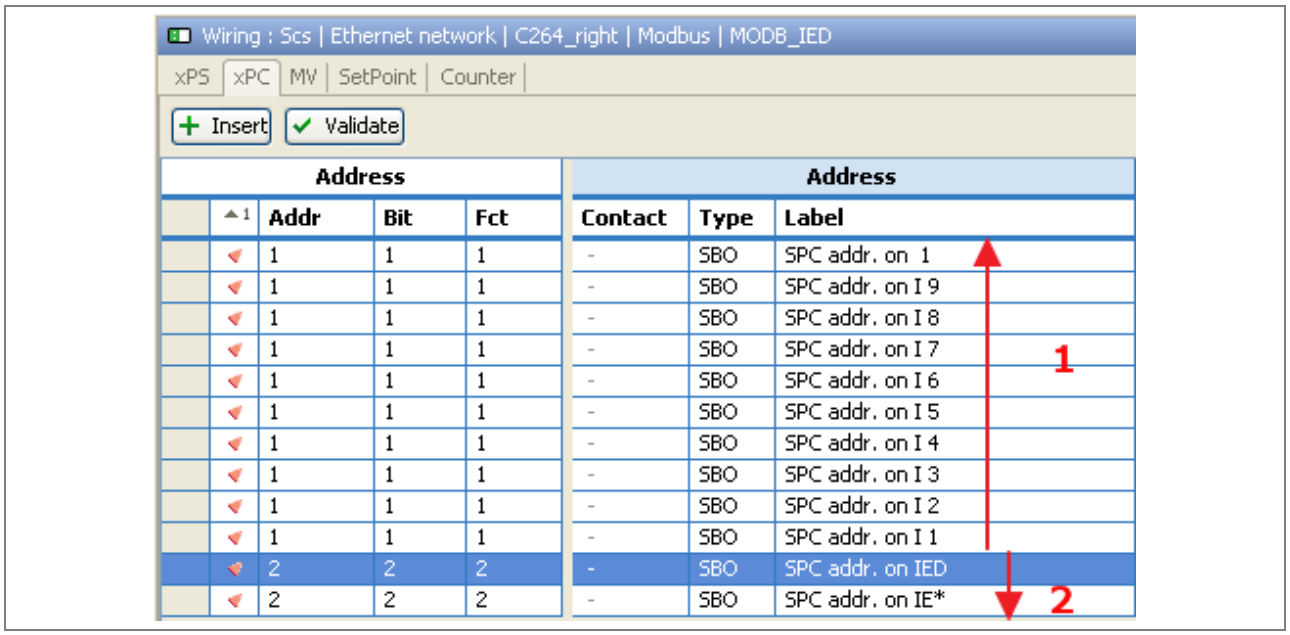
To populate the table with default values, select one or several contiguous rows, then:

- click **Insert**; this adds as many rows below with the same **Addr**; this copies the DEFAULT values as **Address** attributes and duplicates the path

Note:
The Label field is automatically filled in various ways; in the picture, the first created row is in blue

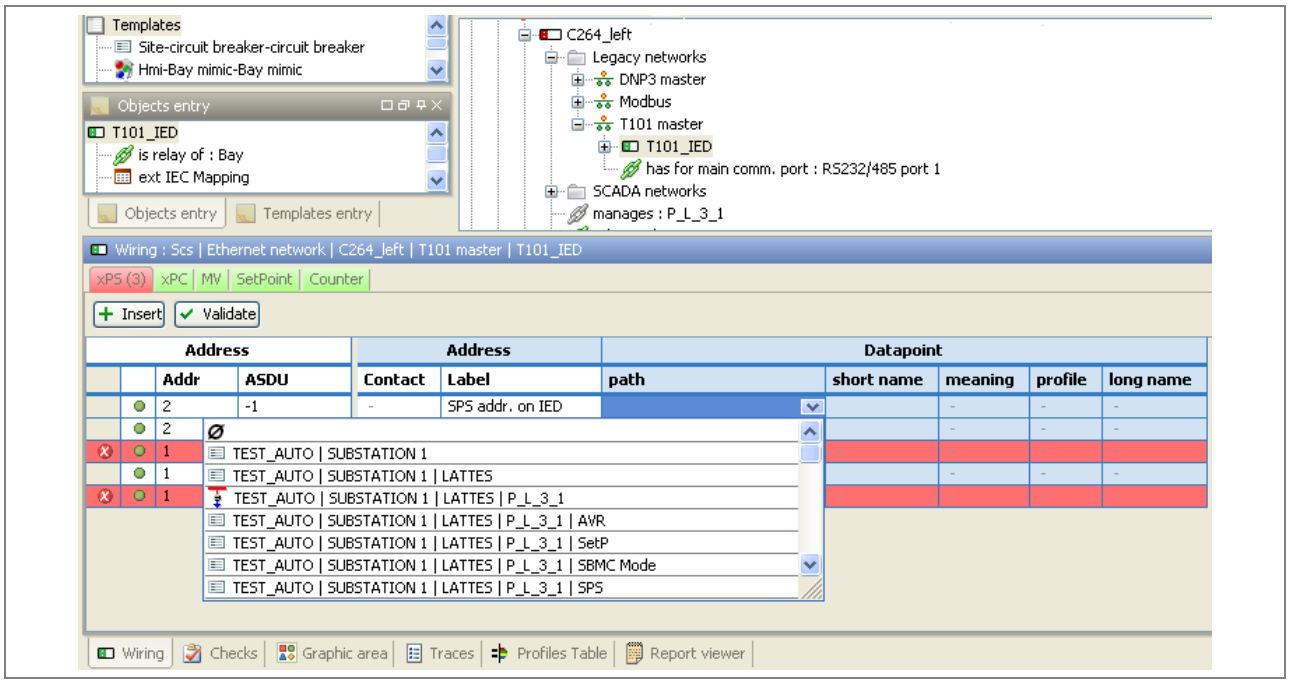
1: no row selection (click the sub-header to deselect): the rows pile up; the last characters are replaced by digits and incremented

2: the row is selected: the label last character is incremented if it is a digit, replaced with * if it is a letter



Procedure to fill in the blue part

- Click in a cell to fill in
- Type one character or click two more times; click the bottom arrow button v overlaid at the right of the cell and select one value in the drop-down list (it contains all the created datapoint values); ∅ refers to a void value; the type can be changed in this manner.



- To check the address uniqueness, click **Validate** in the upper left corner:
  - The errored lines turn red and a red pictogram is displayed in the first column
  - If there are errors, the tab tag becomes red and indicates the number of errored lines. To display a tooltip, move the cursor over a red line:

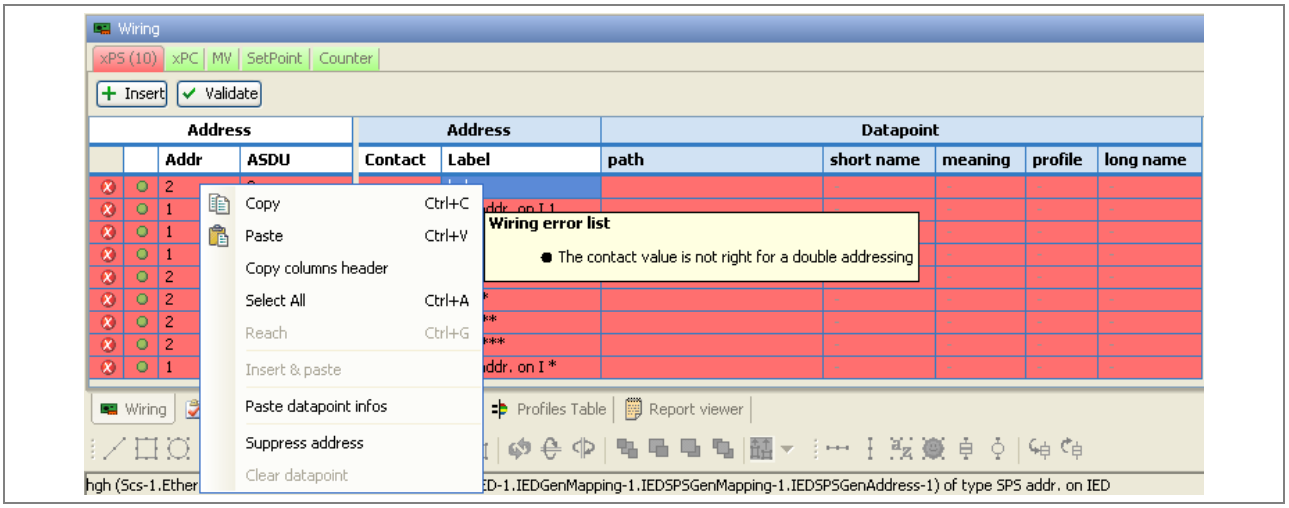
Possible errors

- An address is not unique in the mapping
- A datapoint has more than one acquisition source
- An address is 0 (invalid)
- The **Contact** attribute for a DPS/DPC address does not have the correct value. If one DPS/DPC uses 2 addresses, the **Contact** value must be *Open* for one address and *Close* for the other.

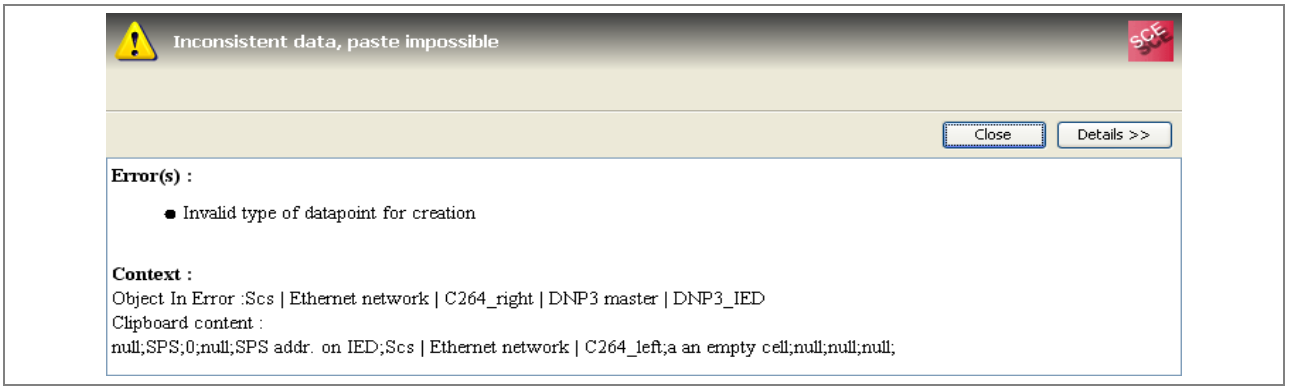
Only the address attributes can be edited in errored lines.

The tag tab becomes green again when all the errors have been corrected.

- To delete a set of addresses in contiguous rows, click on the first column and drag to select the rows, right click and select **Suppress address.**



- To sort the rows alphabetically/numerically, click on any column sub-header once (ascending order, symbol ▲1 after the column label) or twice (descending order, symbol ▼1)
- To export the table into a spreadsheet editor such as Excel, select the rows and copy/paste them; the empty cells are filled with the word 'null' (for the headers, use the menu item **Copy columns header**)
- To import a table from a spreadsheet editor such as Excel, select and copy the rows in the editor; select a row in the table, right click and select **Insert & paste**. Restrictions: the source must be free of any information in the blue part, otherwise a message like this pops up:



with three items:

  - Error(s): a diagnostic on the possibility of pasting
  - Context: the path of the selected IED
  - Clipboard content: the values copied from the contiguous columns separated with a semi-colon (an empty cell produces 'null')

- Click the button **x** in the upper right corner: When you resume the procedure, the entered values are retrieved.

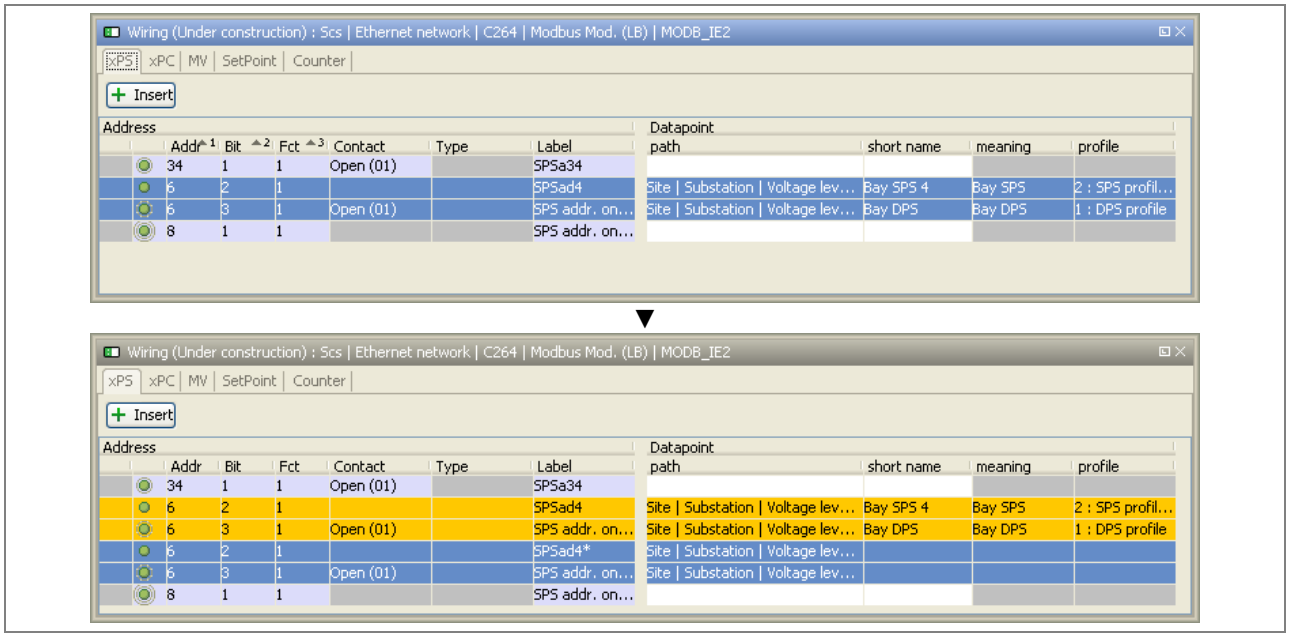
The smart table is flexible and allows a variety of time-saving operations described hereinafter.

3.6.2.1.1 Insert a new address in the address map

Click the button **+ Insert** to insert a new line in the address map:

- If no lines are selected, a new address of the default type is created.
- If one or several lines are selected, the same number of lines of the same types are added to the map and the address information is duplicated as much as possible.

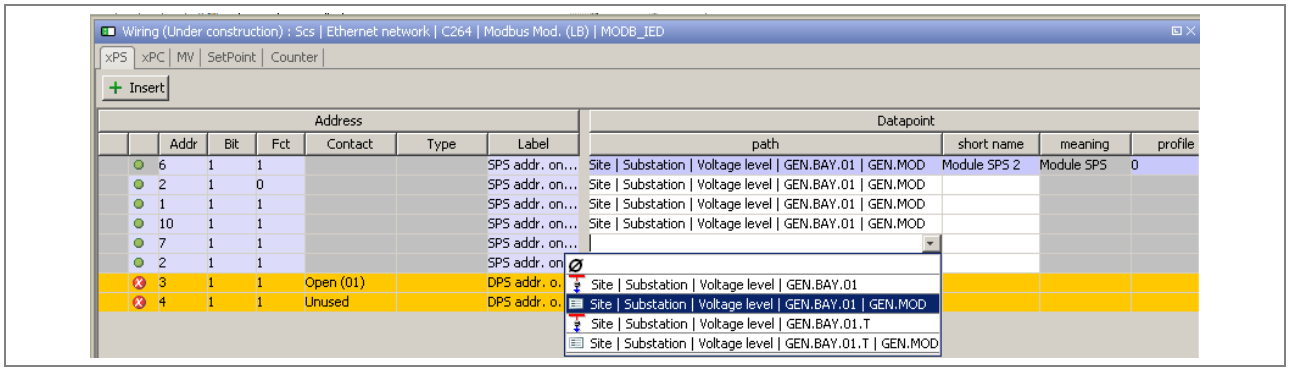
For example, if a DPS address is selected at the time you click **+ Insert**, this will add a DPS address with the same **Address** attribute values. For the **Datapoint** part, only the path is duplicated from the selected lines.



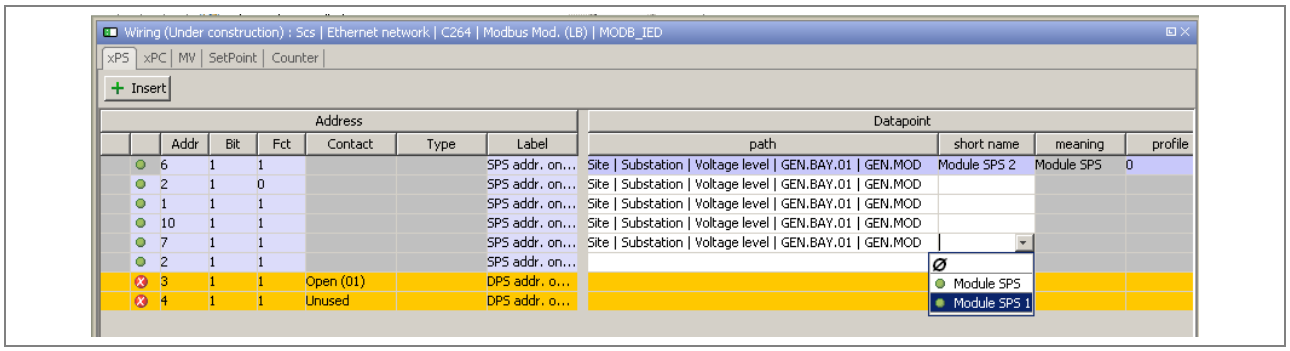
3.6.2.1.2 Edit an existing address in the address map

To set the address of a datapoint in the IED table follow these two steps:

- Select a path

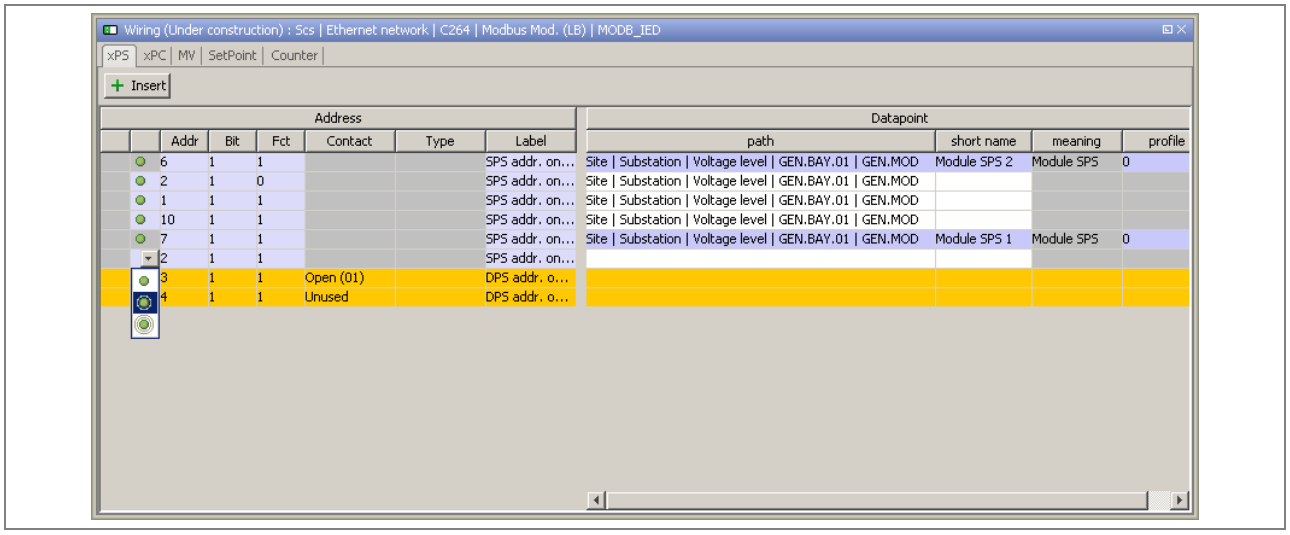


- Select a Short name



3.6.2.1.3 Change the datapoint type of an address

If an address is not used by a datapoint it's possible to change the type of the address, for example user can transform SPS address into a DPS address by changing its datapoint type icon at the beginning of the line. In the example below, SPS address 2/1/1 can be transformed into a DPS or MPS address:



The other values of the address are not updated, only the datapoint type of the address is changed.

3.6.2.1.4 Copy / Insert and Paste

It is possible to insert copied rows into the IED table.

Copy of rows

To copy one or several selected address rows, right-click the left-hand side cell of one of them. Select **Copy**.

The copied rows are stored in the operating system's clipboard. They can then be pasted into an external spreadsheet editor (such as MS Excel). Any empty cells will be filled with the word "null".

Excel offers more cell manipulation features than the SCE smart table editor: cells can be more easily copied, modified or moved around; formulas may be used, etc. However, always make sure that the format remains compatible and to type the word "null" into any empty cells before copy-pasting back into the SCE smart table.

Insert and Paste rows

Assuming the clipboard contains well formed data (such as rows directly copied from the SCE smart table), select the row after which the copied rows must be inserted. Right-click the left-hand side cell of that row. Select **Insert & paste**.

After a paste operation, any unused datapoints and/or addresses are kept and it is up to the user to manually update or remove them.

The behaviour of a row insertion into the IED table is based on the key (address + datapoint) present in that row:

- If the key already exists in the table, the existing address is moved to its new insertion point. Some attributes of the associated address and datapoint may be updated using attribute values from the clipboard if they are different from the original's.
- If the address already exists in the table, but the datapoint does not, a new row is inserted in the table for the address and datapoint from the clipboard, with their clipboard attribute values. The already existing address is set to its default value and its associated datapoint is kept.
- If the datapoint already exists in the table, but the address does not, a new row is inserted in the table for the address and datapoint from the clipboard, with their clipboard attribute values. The already existing address row is kept, but without datapoint.
- If the address of a datapoint is assigned another datapoint, the previous datapoint is kept with a default address, but the other address attributes remain unchanged.
- If neither the address nor the datapoint already exist in the table, a new row is inserted in the table for the address and datapoint from the clipboard, with their clipboard attribute values.

When inserting and pasting from clipboard, the user may refer to datapoints that no longer exist in the database. In that case, they are automatically created upon insertion.

The insert and paste operation are disabled for template instances or cloned IEDs.

Possible errors on Insert & Paste operations

The error mechanism is the same as for the other mapping tables.

General errors:

- The clipboard structure is invalid

Address errors:

- The address type is invalid
- The address for 'xxx address on IED' is not unique in the address map
- Updating mapping address attributes is not permitted
- The map address is an instance/clone of a template, but the mapped object is not

Datapoint errors:

- Creation of an invalid type of datapoint
- It is impossible to create a datapoint under the path object
- The path is invalid for this mapping
- The datapoint mapping relations do not comply with the relations from the clipboard
- The datapoint has several acquisition sources
- The contact value is not permitted for a double addressing
- The datapoint profile is a read-only attribute
- The datapoint mapping relations are read-only

3.6.2.1.5 Copy/Paste datapoint information

It is not possible to copy datapoint information cells only in the IED table. Only entire rows can be copied.

Copy action

By row selection, user can copy one or more datapoint information. The result of the copy is stored in the system clipboard that can be pasted into an external editor (like Excel). In this clipboard, empty cells are filled with keyword “null”.

Excel offers more cell manipulation features than the SCE smart table editor: cells can be more easily copied, modified or moved around; formulas may be used, etc. However, always make sure that the format remains compatible and to type the word "null" into any empty cells before copy-pasting back into the SCE smart table.

Paste datapoint information cells

Assuming the clipboard contains well formed data (such as rows directly copied from the SCE smart table), select the row after which the copied rows must be inserted. Right-click the left-hand side cell of that row. Select **Paste datapoint infos**.

The copy-paste operation is disabled for template instances or cloned IEDs.

3.6.2.1.6 Copy/Paste of cells

The copy operation is available for all the cells in the table, but not all of them can be pasted INTO: Pasting is possible only into **Type** and **Label** cells in the **Address** part and into **Path** and **Profile** cells in the **Datapoint** part.

3.6.2.1.7 Deleting a set of IED addresses

By selecting a set of rows, the user can delete one or more addresses via the contextual menu, using the command **Suppress address**.

3.6.2.2 DEFINING A LEGACY IED ADDRESS FOR AN SPS DATAPOINT

To add an IED address to an SPS datapoint, select the IED SPS mapping level and add the address from the contextual **Objects entry** window.

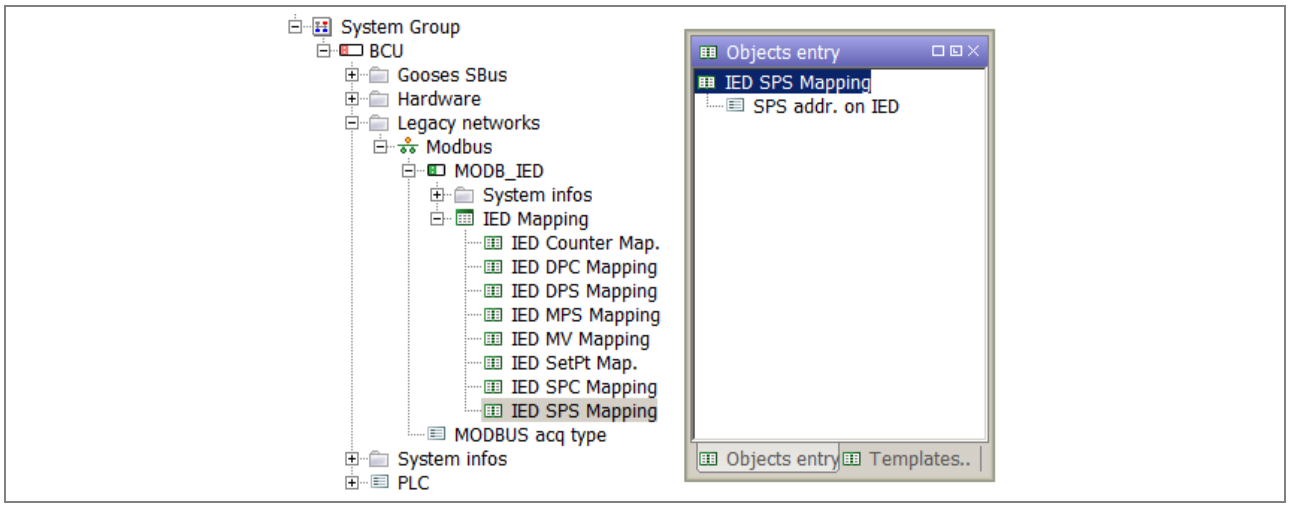


Figure 85: Adding a legacy IED SPS address (example for aModbus IED)

Once added, the IED SPS address attributes must be set:

For Modbus protocol:

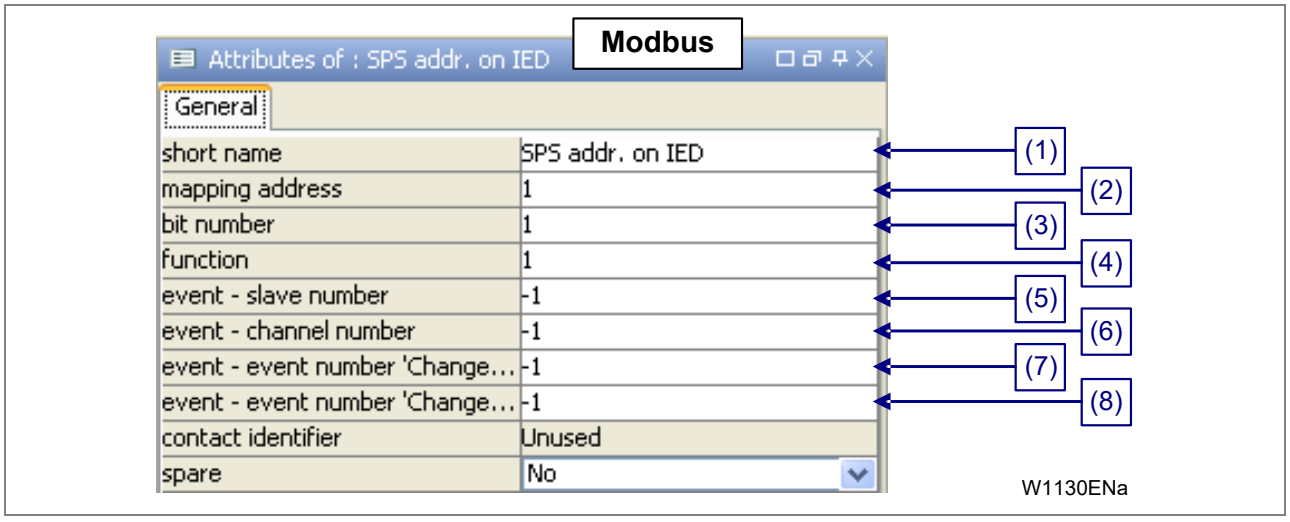


Figure 86: Defining a legacy IED address for an SPS datapoint

(1) **short name**: used for internal SCE identification

(2) **mapping address** (range [0, 65534], step 1): word address or bit address depending on the function

(3) **bit number** (range [0, 65534], step 1): used only if read word or read status is selected

(4) **function** (range [0, 65534], step 1): number of the Modbus function used to read the SPS:
- 1, 2: *read bit*,
- 3, 4: *read word*,
- 7 : *read status*

(5) **event - slave number** (range [-1, 99], step 1), -1 = not used

(6) **event - channel number** (range [-1, 999], step 1), -1 = not used

(7) **event - event number 'Change 0 to 1'** (range [-1, 999], step 1), -1 = not used

(8) **event - event number ' Change 1 to 0'** (range [-1, 999], step 1), -1 = not used

For T101 master protocol:

(1) **short name**: used for internal SCE identification

(2) **information object address** (range [0, 16777215], step 1)

(3) **common address of ASDU** (range [-1, 65534], step 1): the default setting (-1) forces the datapoint's address to the same value as the IED's **network address** (see section *3.6.1.9 Setting the attributes of a legacy IED*)

For T103 protocol:

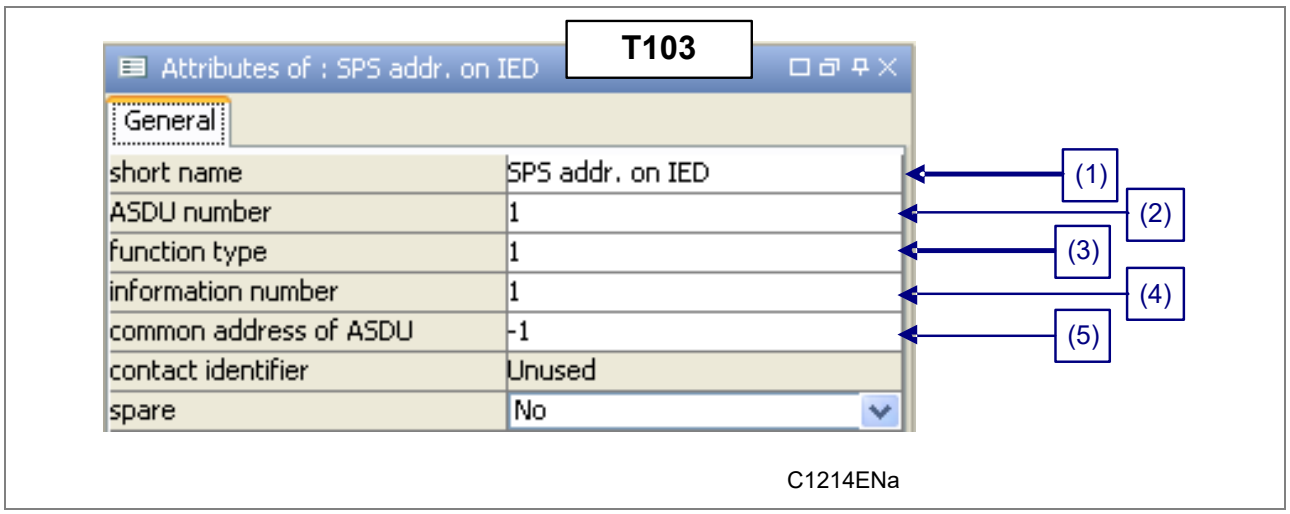
(1) **short name**: used for internal SCE identification

(2) **ASDU number** (range [0, 65534], step 1):
- 1, 2 (for all IEDs)
- 65,66,67,68 (Only for Schneider Px3x)

(8) **function type** (range [0, 65534], step 1).

(9) **information number** (range [0, 65534], step 1).

(10) **common address of ASDU** (range [-1, 65534], step 1): the default setting (-1) forces the datapoint's address to the same value as the IED's **network address** (see section *3.6.1.4.1 Setting the attributes of a legacy IED*).



3.6.2.3 DEFINING A LEGACY IED ADDRESS FOR A DPS DATAPOINT

To add an IED address to a DPS datapoint, select the IED DPS mapping level and add the address from the contextual **Objects entry** window.

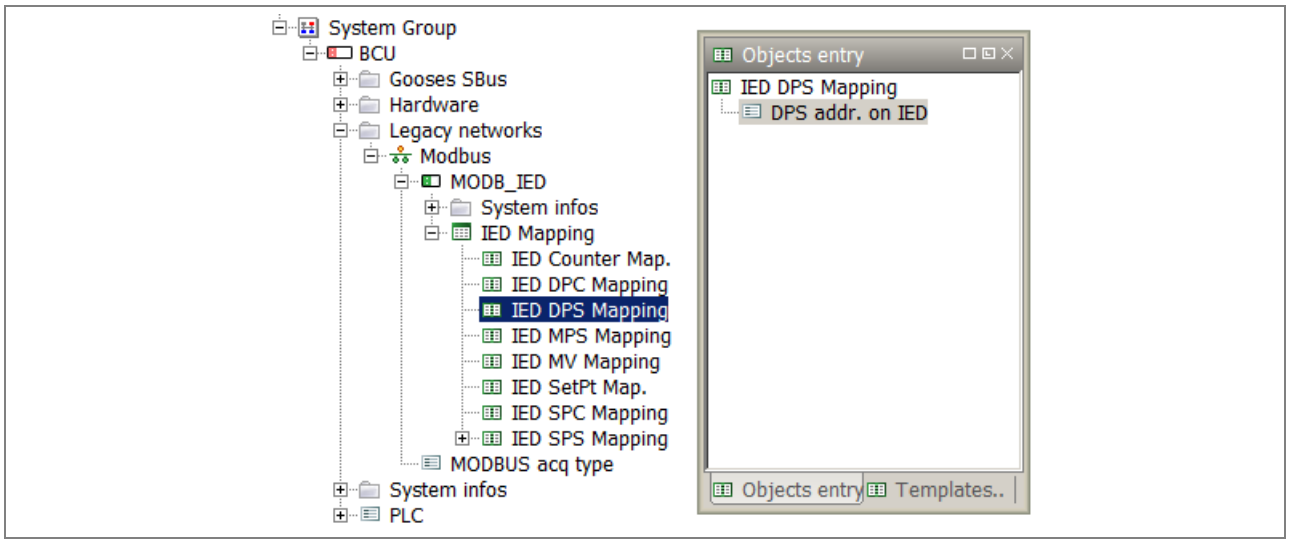


Figure 87: Adding a legacy IED DPS address (example for a Modbus IED)

Once added, IED DPS address attributes must be set:

For Modbus protocol:

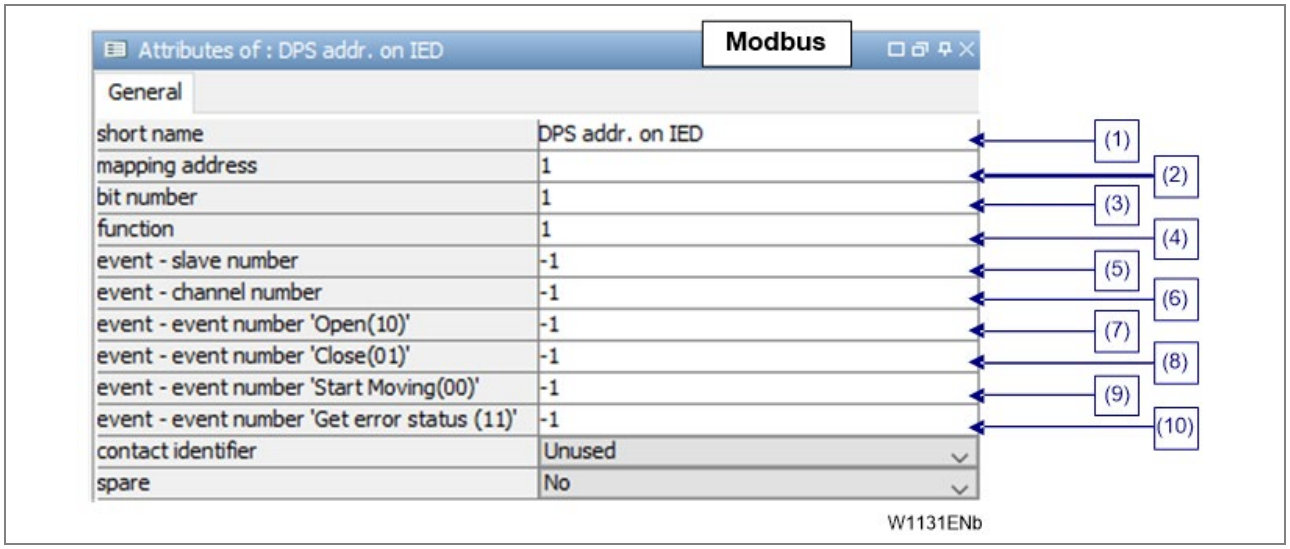


Figure 88: Defining a legacy IED address for a DPS datapoint

(1) **short name of the address**: used for internal SCE identification

(2) **mapping address** (range [0, 65534], step 1): Word address or Bit address depending on the function

(3) **bit number** (range [0, 65534], step 1): Used only if read word or read status is used

(4) **function** (range [0, 65534], step 1): Modbus function to use to read the DPS:

- 1, 2: *read bit*
- 3, 4: *read word*
- 7 : *read status*

(5) **event - slave number** (range [-1, 99], step 1), -1 = not used

(6) **event - channel number** (range [-1, 999], step 1), -1 = not used

(7) **event - event number 'Open(10)'** (range [-1, 999], step 1), -1 = not used

(8) **event - event number 'Close(01)'** (range [-1, 999], step 1), -1 = not used

(9) **event - event number 'Start Moving(11)'** (range [-1, 999], step 1), -1 = not used

(10) **event - event number 'Get error status (11)'** (range [-1, 999], step 1), -1 = not used

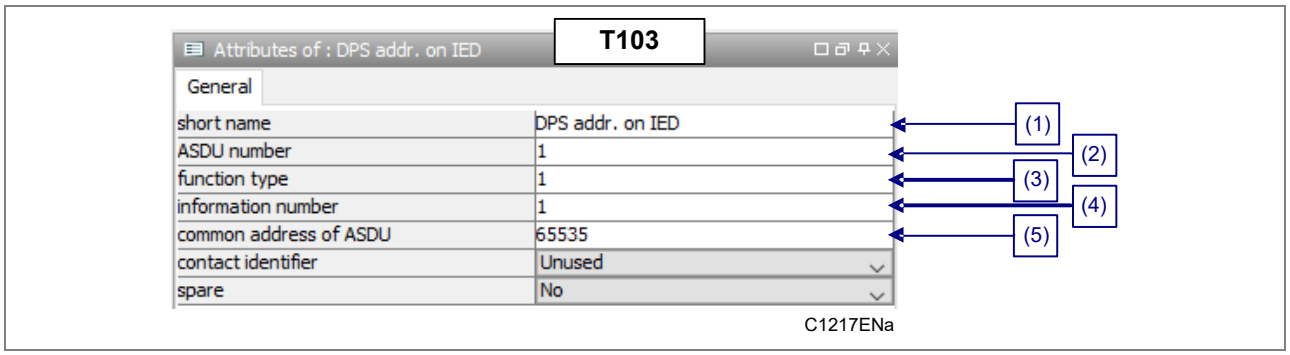
For T101 Master protocol:

(1) **short name** of the address: used for internal SCE identification

(2) **information object address** (range [0, 16777215], step 1)

(3) **common address of ASDU** (range [-1, 65534], step 1): the default setting (-1) forces the datapoint's address to the same value as the IED's network address (see section 3.6.1.9 Setting the attributes of a legacy IED.

For T103 protocol:



(1) short name of the address: used for internal SCE identification

(2) **ASDU number** (range [0, 65534], step 1):

- 1, 2 (for all IEDs)
- 65,66,67,68 (Only for Schneider Px3x)

(3) function type (range [0, 65534], step 1).

(4) information number (range [0, 65534], step 1).

(5) common address of ASDU (range [-1, 65534], step 1): the default setting (-1) forces the datapoint's address to the same value as the IED's network address (see section 3.6.1.9 Setting the attributes of a legacy IED).

For all protocols:

The acquisition of the DPS on the IED can also be done via two different addresses. In that case, two **DPS address on IED** fields must be created for this DPS. For each of them, the attribute **contact identifier** (11) must be set to *'Open'* or *'Closed'*, to indicate which state of the DPS is assigned to the IED address. If the DPS state is given by only one IED address, set **contact identifier** to *'unused'*.

3.6.2.4 DEFINING A LEGACY IED ADDRESS FOR AN MV DATAPOINT

To add an IED address to an MV datapoint, select the IED MV mapping level and add the address from the contextual **Objects entry** window.

Once added, the IED MV address attributes must be set.

For Modbus protocol:

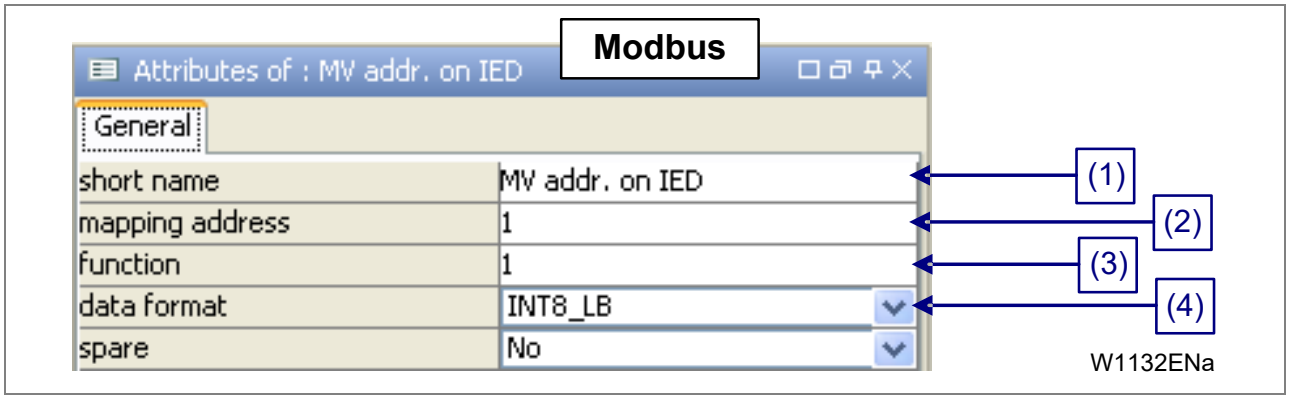


Figure 89: Defining a legacy IED address for an MV datapoint

(1) **short name** of the address: used for internal SCE identification

(2) **mapping address** (range [0, 65534], step 1): Word address

(3) **function** (range [0, 65534], step 1): Modbus function to use to read the MV

- 3, 4: read word
- 7 : read status

(4) **data format**: see section 3.6.2.5.1 Measurement formats that can be used with the MODBUS protocol.

For T101 Master protocol:

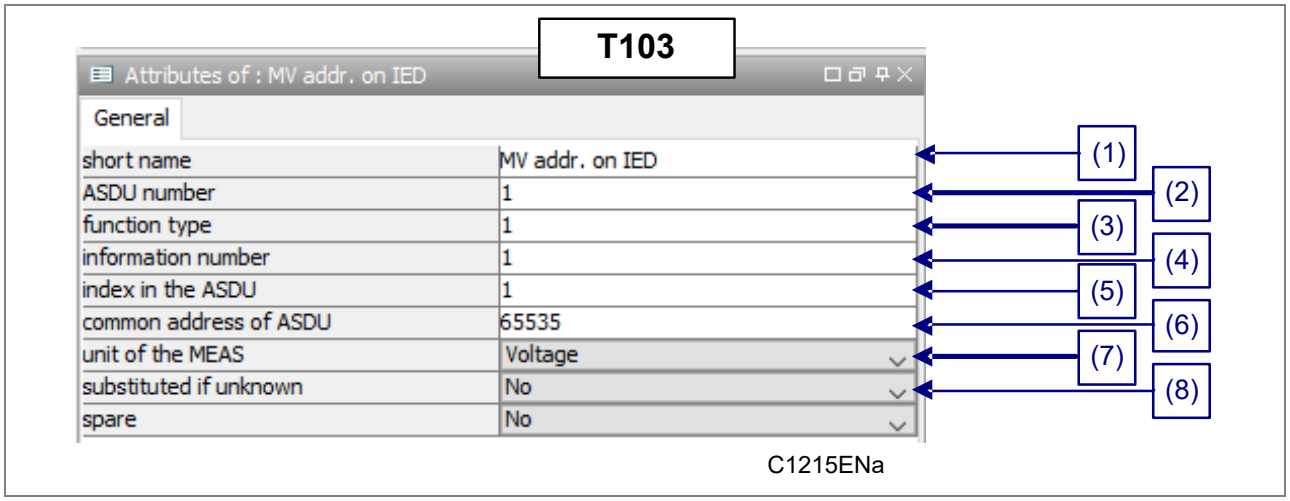
(1) **short name** of the address: used for internal SCE identification

(2) **information object address** (range [0, 16777215], step 1)

(3) **common address of ASDU** (range [-1, 65534], step 1): the default setting (-1) forces the datapoint's address to the same value as the IED's network address (see section 3.6.1.9 Setting the attributes of a legacy IED.

(4) **output format** (*Short float*, *Normalized*, *Scaled*)

For T103 protocol:



(1) **short name** of the address: used for internal SCE identification

(2) **ASDU number** (range [0, 65534], step 1):

- 3, 4, 9 (for all IEDs)
- 10 (for acquisition of measurement with "generic Services")
- 77 (Only for Schneider Px2x)
- 73 (Only for Schneider Px3x)

(3) **function type** (range [0, 65534], step 1)

(4) **information number** (range [0, 65534], step 1)

(5) **index in the ASDU** (range [0, 65534], step 1)

(6) **common address of ASDU** (range [-1, 65534], step 1): the default setting (-1) forces the datapoint's address to the same value as the IED's **network address**

(7) **unit of the MEAS** (*Voltage* / *Current* / *Power* / *Frequency* / *No Unit*)

(8) **substituted if unknown** (*No* / *Yes*)

For this protocol it is possible to perform acquisition of measurements only using the Generic Services of IEC 60870-5-103 protocol by polling. This can be done by setting some parameters as follows:

- ASDU number: 21
- function type: 254
- information number: 244
- index in the ASDU: Generic Identification Number given by the mapping of the IED.

3.6.2.4.1 Measurement formats that can be used with the MODBUS protocol

Because the Modbus standard only describes the transmission of 16-bit values (transmission of the high order byte first), other formats must be defined to describe the different ways to transmit 32-bit values (whatever their type: signed or unsigned integers, real values) or 8-bit values.

Thus, the format to apply to an analog input depends on the way it is transmitted and consequently on the representation of the value in the memory of the device.

In the following table, the “transmission order” column (4) indicates the way a value is transmitted, i.e. the order in which the bytes of the value are transmitted. The bytes are numbered from 1 (lowest order byte) to 4 (highest order byte).

Format	Description	Transmission order
INT8_LB	Transmission of an 8-bit signed integer in a 16-bit value. The significant byte is the low order byte of the word.	/
INT8_HB	Transmission of an 8-bit signed integer in a 16-bit value. The significant byte is the high order byte of the word.	/
UINT8_LB	Transmission of an 8-bit unsigned integer in a 16-bit value. The significant byte is the low order byte of the word.	/
UINT8_HB	Transmission of an 8-bit unsigned integer in a 16-bit value. The significant byte is the high order byte of the word.	/
INT16	Transmission of a 16-bit signed integer. The high order byte is transmitted first (see Modbus standard)	2-1
UINT16	Transmission of a 16-bit unsigned integer. The high order byte is transmitted first (see Modbus standard)	2-1
INT32_LW_LB	Transmission of a 32-bit signed integer. The low order word of the long value is transmitted first. The low order byte of each word is transmitted first.	1-2-3-4
INT32_LW_HB	Transmission of a 32-bit signed integer. The low order word of the long value is transmitted first. The high order byte of each word is transmitted first.	2-1-4-3
INT32_HW_LB	Transmission of a 32-bit signed integer. The high word of the long value is transmitted first. The low byte of each word is transmitted first.	3-4-1-2
INT32_HW_HB	Transmission of a 32-bit signed integer. The high order word of the long value is transmitted first. The high order byte of each word is transmitted first.	4-3-2-1
UINT32_LW_LB	Transmission of a 32-bit unsigned integer. The low order word of the long value is transmitted first. The low order byte of each word is transmitted first.	1-2-3-4
UINT32_LW_HB	Transmission of a 32-bit unsigned integer. The low order word of the long value is transmitted first. The high order byte of each word is transmitted first.	2-1-4-3
UINT32_HW_LB	Transmission of a 32-bit unsigned integer. The high order word of the long value is transmitted first. The low order byte of each word is transmitted first.	3-4-1-2
UINT32_HW_HB	Transmission of a 32-bit unsigned integer. The high order word of the long value is transmitted first. The high order byte of each word is transmitted first.	4-3-2-1
REAL32_LW_LB	Transmission of a 32-bit real value. The low order word is transmitted first. The low order byte of each word is transmitted first.	1-2-3-4
REAL32_LW_HB	Transmission of a 32-bit real value. The low order word is transmitted first. The high order byte of each word is transmitted first.	2-1-4-3

Format	Description	Transmission order
REAL32_HW_LB	Transmission of a 32-bit real value. The high order word is transmitted first. The low order byte of each word is transmitted first.	3-4-1-2
REAL32_HW_HB	Transmission of a 32-bit real value. The high order word is transmitted first. The high order byte of each word is transmitted first.	4-3-2-1
M230_T5_TYPE	Transmission of a 32-bit value: Unsigned Measurement Bit 31 to 24: decimal exponent (signed 8 bytes) Bit 23…00: binary unsigned value 24 bytes	4-3-2-1
M230_T6_TYPE	Transmission of a 32-bit value: Signed Measure Bit 31 to 24: decimal exponent (signed 8 bytes) Bit 23…00: binary signed value 24 bytes	4-3-2-1
M230_T7_TYPE	Transmission of a 32-bit value: power factor Bit 31 to 24 Signed: Import / Export (00/FF) Bit 23…16 Signed: Inductive / capacitive (00/FF) Bit 15…00 Unsigned value (16 bytes)	4-3-2-1
ION_MODULUS_ 10000_unsigned	Transmission of a 32-bit value: ION Energy values Bit 31 to 16: High reg: HR = unsigned value/10000 Bit 15…00: Low reg: LR = unsigned value modulus 10000 Value = RH*10000+LR	4-3-2-1
ION_MODULUS_ 10000_signed	Transmission of a 32-bit value: ION Energy values Bit 31 to 16: reg High: RH= signed value/10000 Bit 15…00: reg Low: RL = signed value modulus 10000 Value = RH*10000+RL; Both high and low reg are signed	4-3-2-1

3.6.2.5 DEFINING A LEGACY IED ADDRESS FOR A COUNTER DATAPOINT

To add an IED address to a Counter datapoint, select the IED Counter mapping level and add the address from the contextual **Objects entry** window.

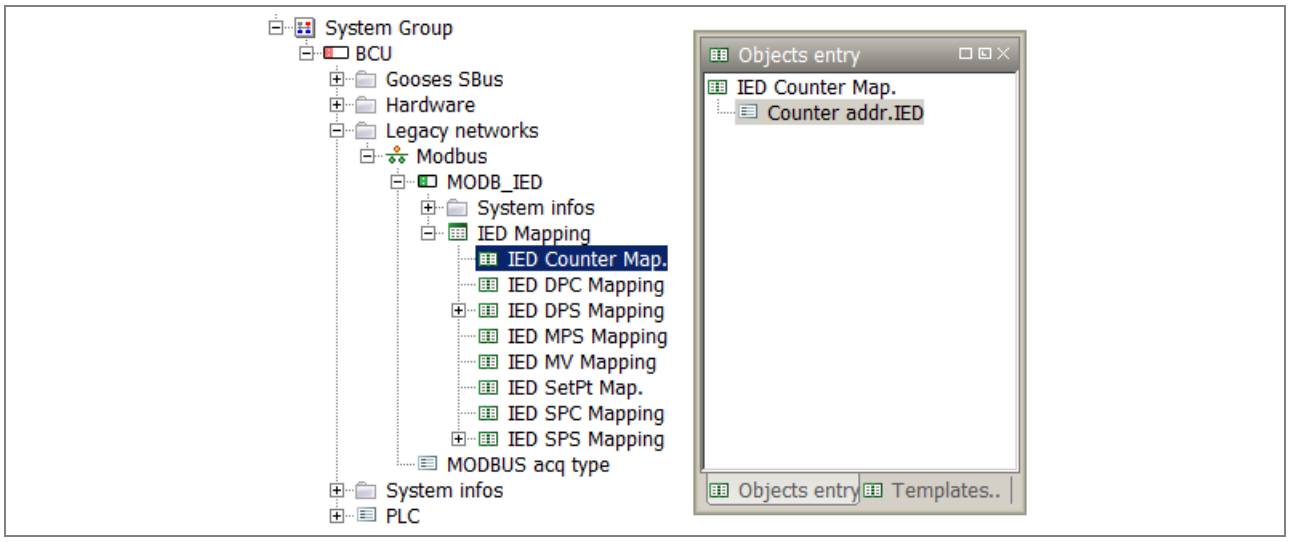


Figure 90: Adding a legacy IED counter address (example for aModbus IED)

Once added, an IED Counter address attributes must be set at SCE level.

For T101 Master protocol:

(1) **short name** of the address: used for internal SCE identification

(2) **information object address** (range [0, 16777215], step 1)

(3) **common address of ASDU** (range [-1, 65534], step 1): the default setting (-1) forces the datapoint's address to the same value as the IED's **network address**

(4) **output format** (*Short float*, *Normalized*, *Scaled*)

For Modbus protocol:

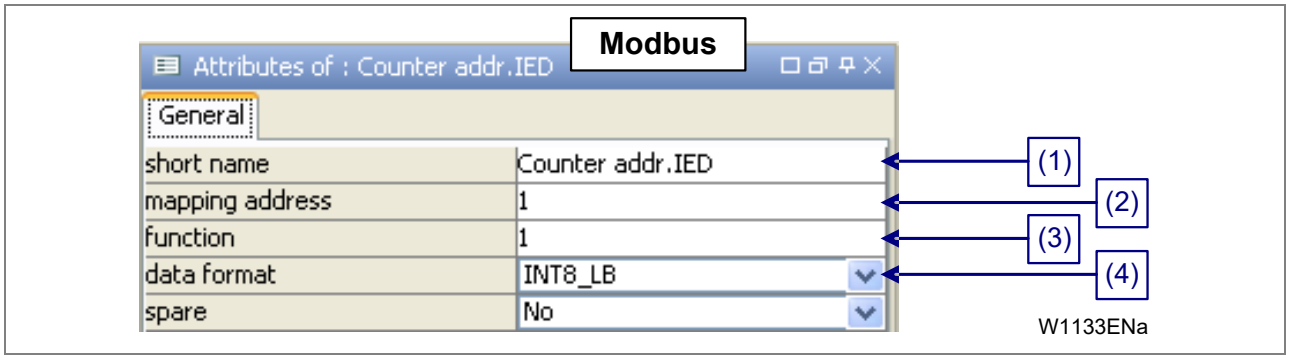


Figure 91: Defining a legacy IED address for a Counter datapoint

(1) **short name** of the address: used for internal SCE identification

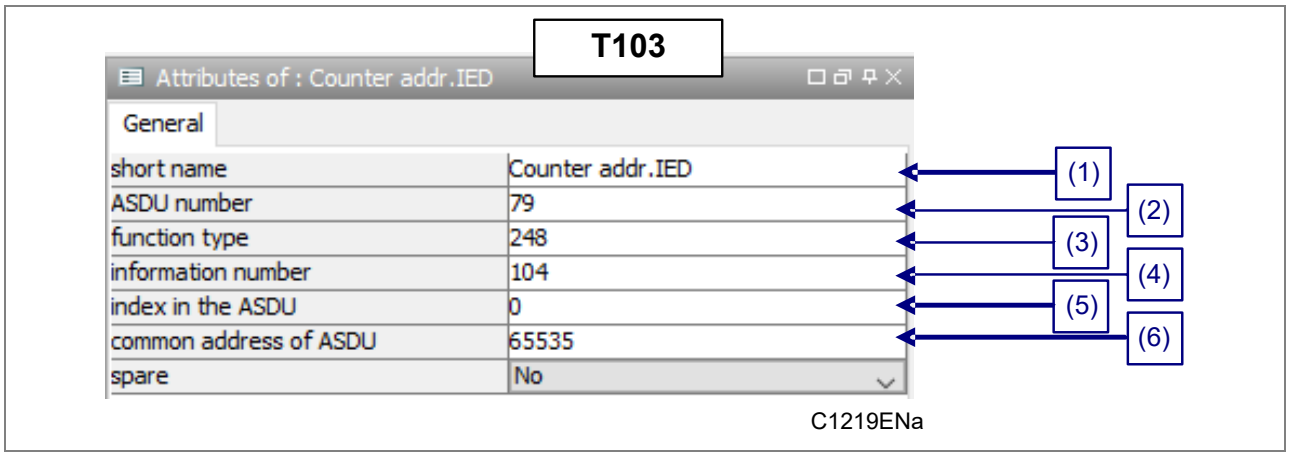
(2) **mapping address** (range [0, 65534], step 1): word address

(3) **function** (range [0, 65534], step 1): Modbus function used to read the MV:

- 3, 4: read word

(4) **data format**: similar to MV

For T103 protocol:



(1) **short name** of the address: used for internal SCE identification

(2) **ASDU number** (range [0, 65534], step 1)

(3) **function type** (range [0, 65534], step 1)

(4) **information number** (range [0, 65534], step 1)

(5) **index in the ASDU** (range [0, 65534], step 1)

(6) **common address of ASDU** (range [-1, 65534], step 1): the default setting (-1) forces the datapoint's address to the same value as the IED's **network address**

3.6.2.6 DEFINING A LEGACY IED ADDRESS FOR AN SPC DATAPOINT

To add an IED address to an SPC datapoint, select the IED SPC mapping level and add the address from the contextual **Objects entry** window.

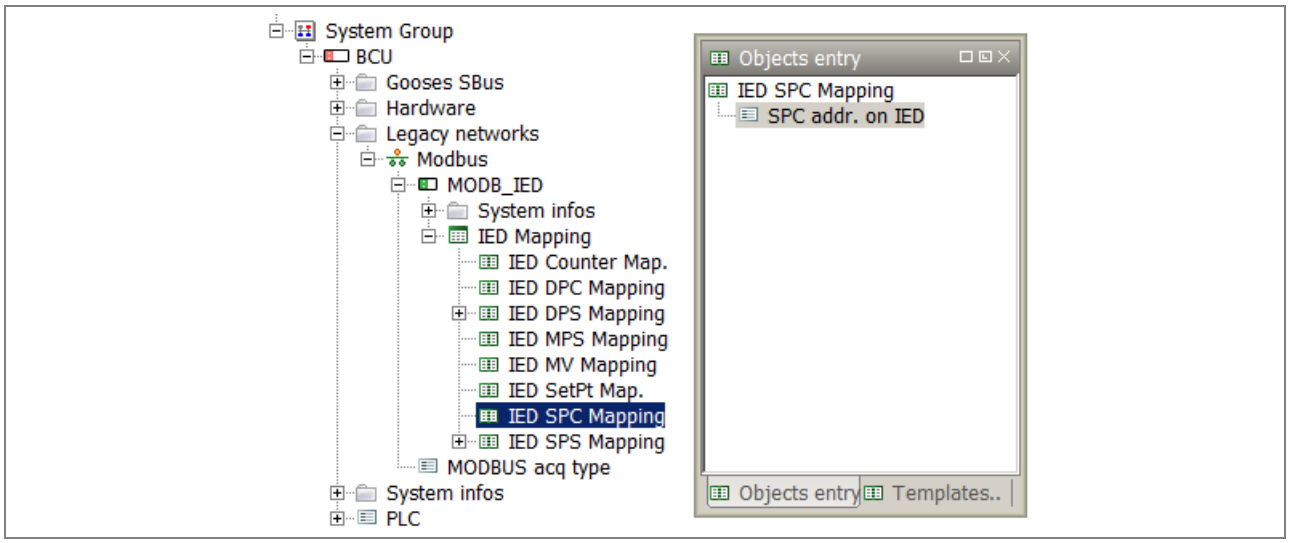


Figure 92: Adding a legacy IED SPC address (example for a Modbus IED)

Once added, the IED SPC address attributes must be set.

For T101 Master protocol:

(1) **short name** of the address: used for internal SCE identification

(2) **information object address** (range [0, 16777215], step 1)

(3) **common address of ASDU** (range [-1, 65534], step 1): the default setting (-1) forces the datapoint's address to the same value as the IED's **network address**

For Modbus protocol:

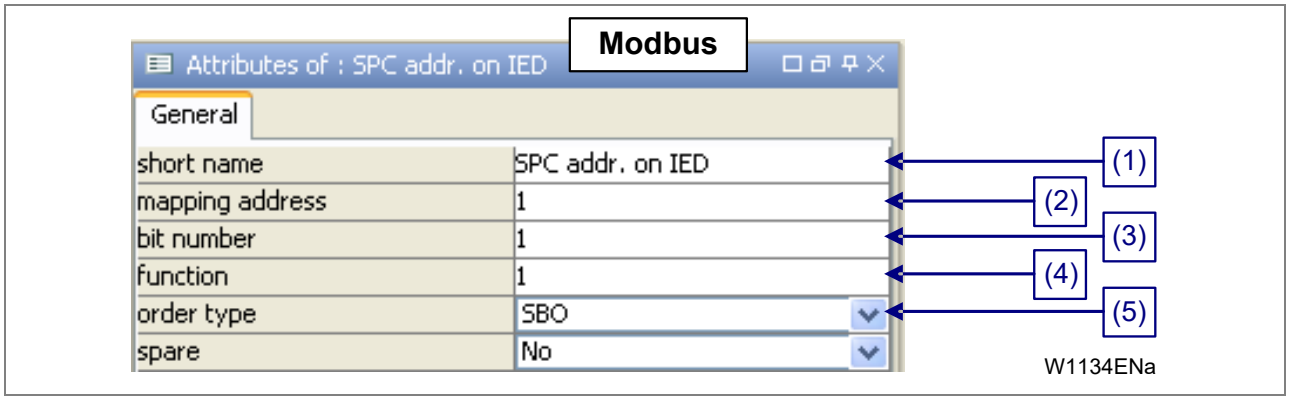


Figure 93: Defining a legacy IED address for an SPC datapoint

(1) **short name** of the address: used for internal SCE identification

(2) **mapping address** (range [0, 65534], step 1): Bit address for function 5 or 15, Word address for function 6

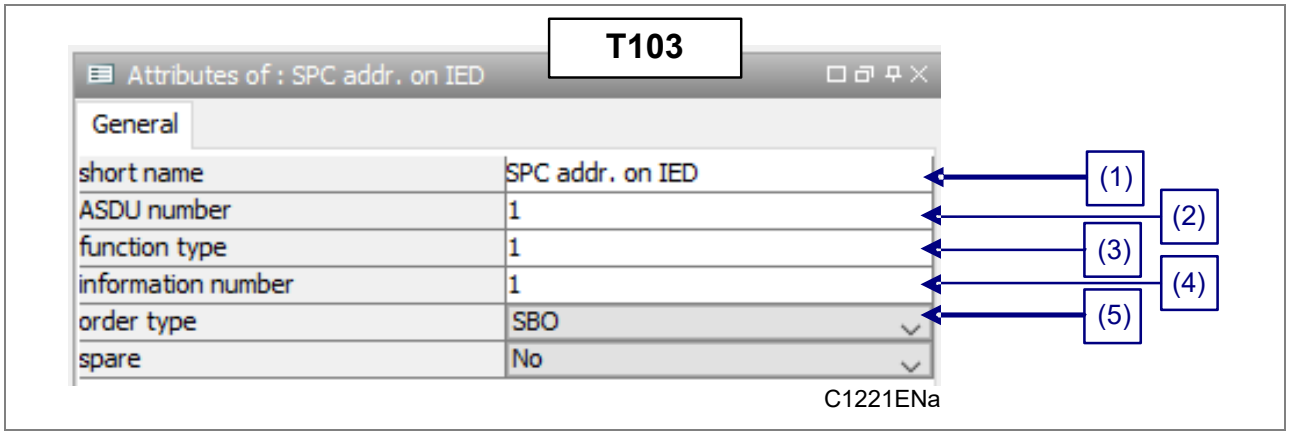
(3) **bit number** (range [0, 65534], step 1): Used only if Function **6** is used (see function attribute)

(4) **function** (range [0, 65534], step 1): Modbus function to use to send the SPC:

- 5: write 1 bit (**mapping address** is the address of the bit)
- 6: write 1 word (**mapping address** is the address of the word, **bit number** is the position of the bit in the word)
- 15: write N bits (used to set only 1 bit at a time, **mapping address** is the address of the bit)

(5) **order type** *(SBO / Direct execute)*

For T103 protocol:



(1) **short name** of the address: used for internal SCE identification

(2) **ASDU number** (range [0, 65534], step 1):
- 20 (for all IEDs)
- 45,46 (Only for Px3x)

(3) **function type** (range [0, 65534], step 1): refer to IED documentation

(4) **information number** (range [0, 65534], step 1): refer to IED documentation

(5) **order type** (*SBO* / *Direct execute*)

3.6.2.7 DEFINING A LEGACY IED ADDRESS FOR A DPC DATAPOINT

To add an IED address to a DPC datapoint, select the IED DPC mapping level and add the address from the contextual **Objects entry** window.

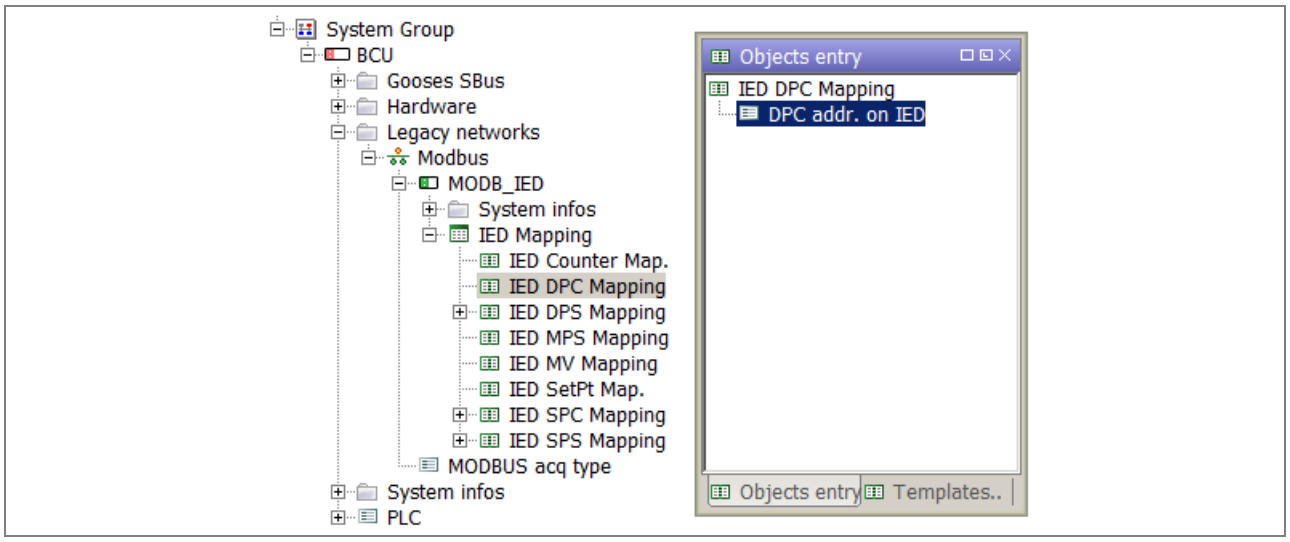


Figure 94: Adding a legacy IED DPC address (example for a Modbus IED)

Once added, the IED DPC address attributes must be set:

For T101 Master protocol:

(1) **short name** of the address: used for internal SCE identification

(2) **information object address** (range [0, 16777215], step 1)

(3) **common address of ASDU** (range [-1, 65534], step 1): the default setting (-1) forces the datapoint's address to the same value as the IED's **network address**

For T103 protocol:

(1) **short name** of the address: used for internal SCE identification

(2) **ASDU number** (range [0, 65534], step 1):

- 20 (for all IED)
- 45,46 (Only for Schneider Px3x)

(3) **function type** (range [0, 65534], step 1): refer to IED documentation

(4) **information number** (range [0, 65534], step 1): refer to IED documentation.

(5) **order type** (*SBO* / *Direct execute)*

(6) **contact type** *(open* / *close* / *unused*): For all protocol types, DPC control on an IED can also be done via two different addresses. In that case, two **DPC address on IED** must be created for that DPC. For each of them, this attribute must be set to *'Open'* or *'Close'*, to indicate which order of the DPC is concerned by the IED address. If the DPC control is given by only one IED address, set **contact type** to *'unused'*.

For Modbus protocol:

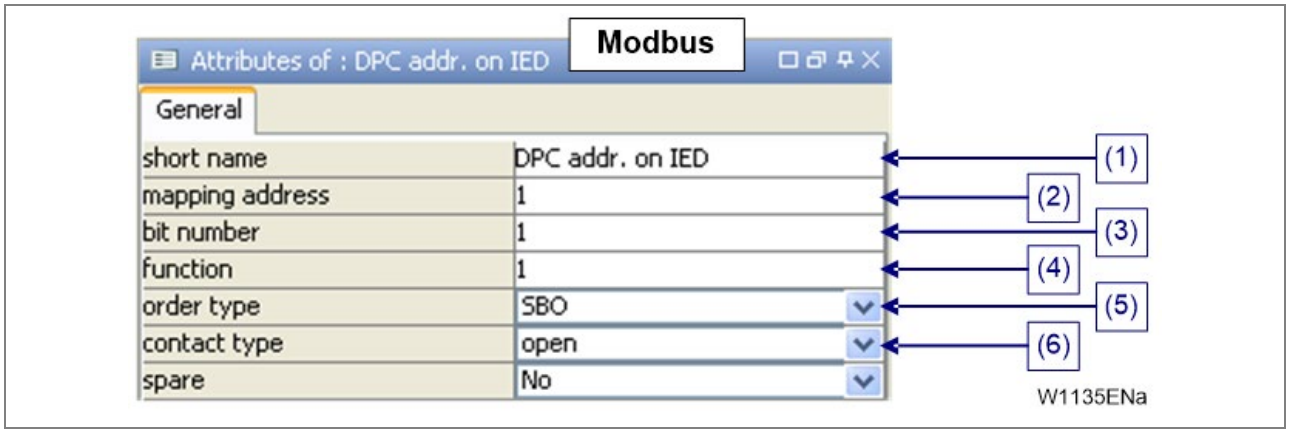


Figure 95: Defining a legacy IED address for a DPC datapoint

(1) **short name** of the address: used for internal SCE identification

(2) **mapping address** (range [0, 65534], step 1): Bit address for function 5 or 15, Word address for function 6

(3) **bit number** (range [0, 65534], step 1): used only if Function **6** is used (see function attribute)

(4) **function** (range [0, 65534], step 1): Modbus function to use to send the DPC:

- 5: write 1 bit (**mapping address** is the address of the bit)
- 6: write 1 word (**mapping address** is the address of the word, **bit number** is the position of the bit in the word)
- 15: write N bits (used to set only 1 bit at a time, **mapping address** is the address of the bit)

(5) **order type** (*SBO* / *Direct execute)*

(6) **contact type** *(open* / *close* / *unused*): For all protocol types, DPC control on an IED can also be done via two different addresses. In that case, two **DPC address on IED** must be created for that DPC. For each of them, this attribute must be set to *'Open'* or *'Close'*, to indicate which order of the DPC is concerned by the IED address. If the DPC control is given by only one IED address, set **contact type** to *'unused'*.

3.6.2.8 DEFINING A LEGACY IED ADDRESS FOR A SETPOINT DATAPOINT

To add an IED address to a SetPoint datapoint, select the IED SetPoint mapping level and add the address from the contextual **Objects entry** window.

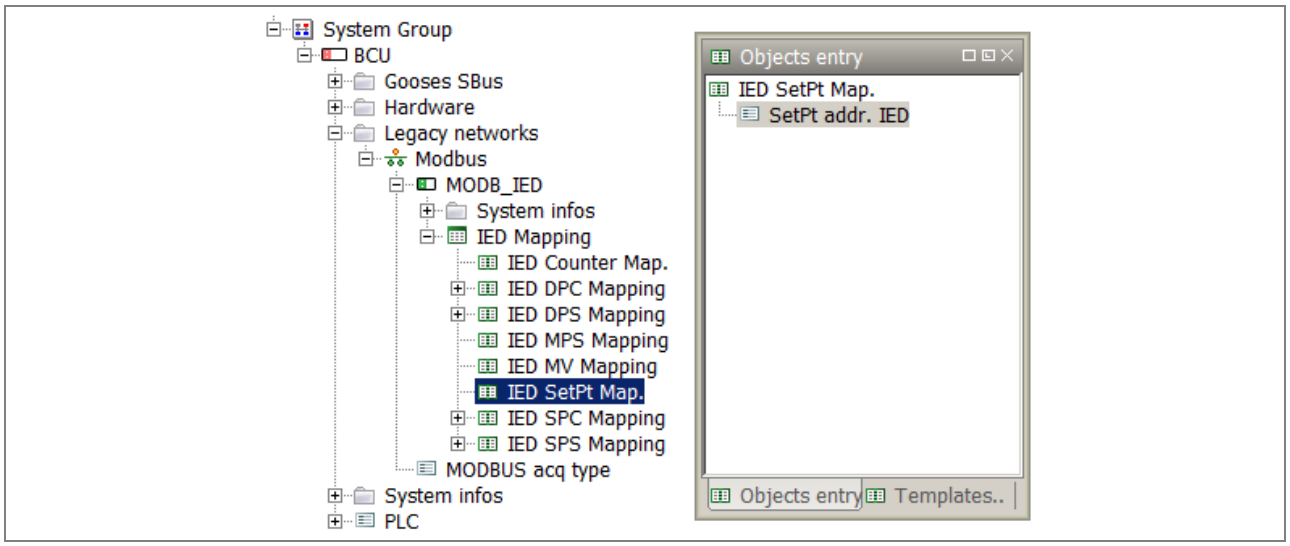


Figure 96: Adding a legacy IED SetPoint address (example for a Modbus IED)

Once added, IED SetPoint address attributes must be set at SCE level:

For T101 Master protocol:

(1) **short name** of the address: used for internal SCE identification

(2) **information object address** (range [0, 16777215], step 1)

(3) **common address of ASDU** (range [-1, 65534], step 1): the default setting (-1) forces the datapoint's address to the same value as the IED's **network address**

(4) **output format**: (*Short float* / *Normalized* / *Scaled*)

For Modbus protocol:

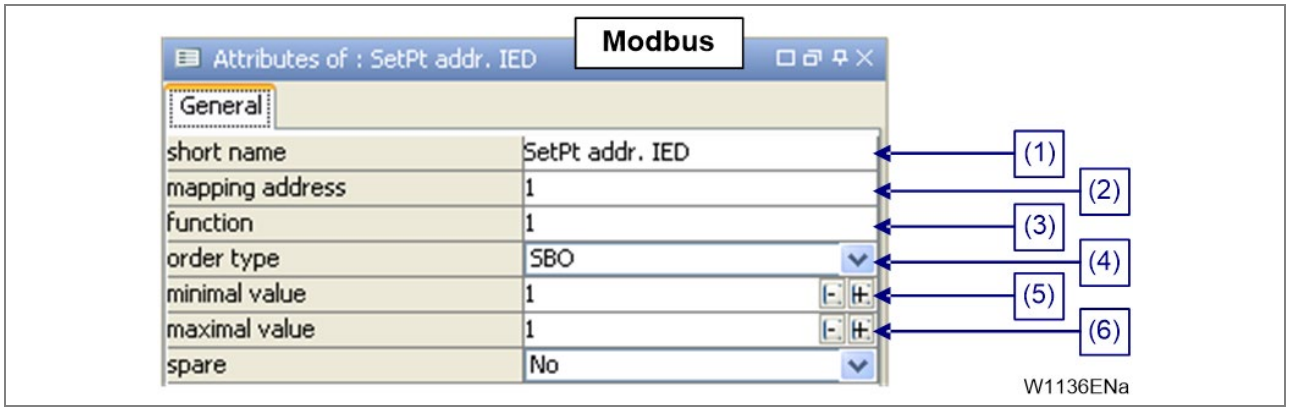


Figure 97: Defining a legacy IED address for a SetPoint datapoint (example for a MODBUS IED)

(1) **short name** of the address: used for internal SCE identification

(2) **mapping address** (range [0, 65534], step 1): Word address for function 6

(3) **function** (range [0, 65534], step 1): Modbus function to use to send the SetPoint:

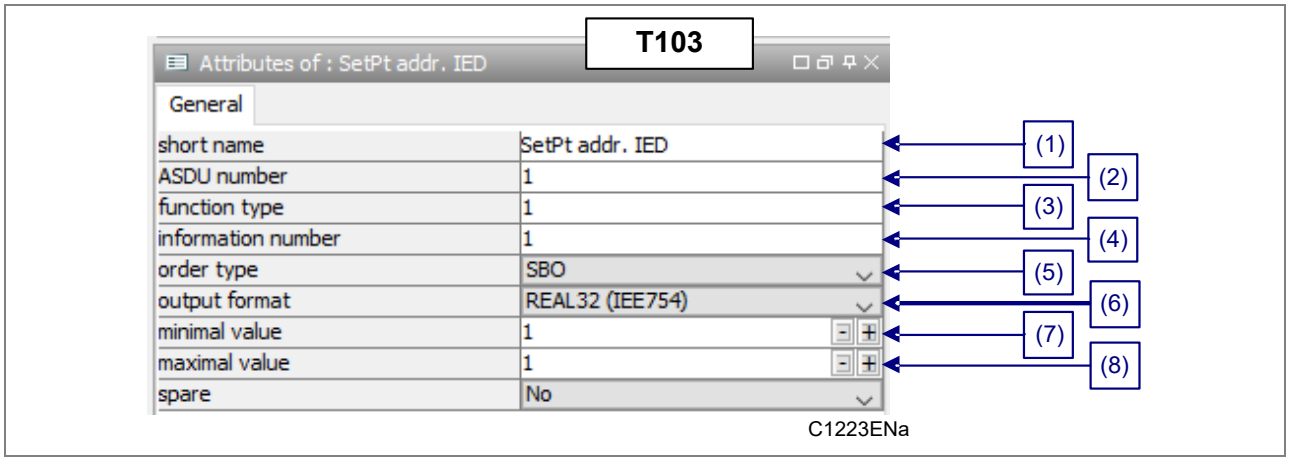
- 6: write 1 word **(mapping address** is the address of the word, **bit number** is the Position of the bit in the word)

(4) **order type** *(SBO / Direct execute)*

(5) **minimal value** and **maximal value**: for *Scaled* and *Normalized* output formats, the values of a SetPoint control on an IED must be checked and scaled according to the output format, before transmission. This is done via two extra attributes **minimal value** (5) and **maximal value** (6).

Note:
SetPoint addresses on Modbus are only available for WAGO IEDs, for which the output format is fixed to UINT15 (unsigned integer, only 15 out of 16 bits are used). The IED type must be set to WAGO.

For T103 protocol:



(1) **short name** of the address: used for internal SCE identification

(2) **ASDU number** (range [0, 65534], step 1): refer to IED documentation

(3) **function type** (range [0, 65534], step 1): refer to IED documentation

(4) **information number** (range [0, 65534], step 1): refer to IED documentation

(5) **order type** (*SBO* / *Direct execute*)

(6) **output format** (*INT8* / *UINT8* / *INT16* / *UNIT16* / *REAL32 (IEEE754)*)

For *Scaled* and *Normalized* output formats, the values of a SetPoint control on an IED must be checked and scaled according to the output format, before transmission. This is done via two extra attributes **minimal value** (7) and **maximal value** (8)

*Note: SetPoint **address** on T103 is only available for REGD IEDs, for which the output format is configurable.*

3.6.3 ADDRESSING A DATAPOINT ON AN IED LEGACY NETWORK

			Protocol		
DP type	**Identifier**		**Modbus**	**T103**	**T101**
Counter	basic address default		Mapping address	ASDU number	Not used
	extra address #1 default		Not used	function type	Not used
	extra address #2 default		function	information number	Information object address
	extra address #3 default		Not used	index in the ASDU	common address of ASDU
	extra address #4 default		Not used	common address of ASDU	Not used
xPC	basic address		Mapping address	ASDU number	Not used
	extra address #1 default		bit number	function type	Not used
	extra address #2 default		function	information number	Information object address
	extra address #3 default		Not used	Not used	common address of ASDU
xPS	basic address		Mapping address	ASDU number	Not used
	extra address #1 default		bit number	function type	Not used
	extra address #2 default		function	information number	Information object address
	extra address #3 default		Not used	common address of ASDU	common address of ASDU
MV	basic address		Mapping address	ASDU number	Not used
	extra address #1 default		Not used	function type	Not used
	extra address #2 default		function	information number	Information object address
	extra address #3 default		Not used	index in the ASDU	Not used
	extra address #4 default		Not used	common address of ASDU	common address of ASDU
Setpoint	basic address		Mapping address	ASDU number	Not used
	extra address #1 default		bit number	function type	Not used
	extra address #2 default		function	information number	Information object address
	extra address #3 default		Not used	common address of ASDU	common address of ASDU

3.7 NETWORKING A SCADA ON A C26X SCADA NETWORK

3.7.1 CREATING A SCADA NETWORK

An electrical substation can be supervised and controlled from many points inside the substation via DS Agile system HMIs (Substation Control Point or SCP) and/or DS Agile C26x bay panels (Bay Control Point or BCP), and outside the substation. Generally, the distant control of the substation (Remote Control Point or RCP) is done via a specific network called SCADA legacy network.

Several SCADA legacy networks can be connected to a DS Agile system, via DS Agile C26x or DS Agile remote-control gateway sub-systems. SCADA legacy networks are managed as master by the distant SCADA and can be redunded for safety reasons. A DS Agile C26x can manage up to two SCADA networks.

At SCE data modeling level, only SCADA legacy networks and their protocol are modeled and connected to gateway sub-systems. Each SCADA network has to be linked to a main communication port and an optional auxiliary communication port in case of redundancy.

3.7.1.1 ADDING A SCADA NETWORK

To create a SCADA network on a C26x:

- Add a SCADA network from the **Objects entry** window associated with the C26x level.
- Update the SCADA network attributes relevant to its protocol characteristics (see section ***3.7.2. Defining the address map of a SCADA network***)
- If the SCADA does not use the substation network to communicate with the C26x, update the relation "**has for main communication port**" and the communication port characteristics.
- For T101 protocols on serial links, SCADA links can be redundant. To create a redundant SCADA link, add the extra relation **has for auxiliary communication port** (2) to the C26x SCADA network and fill it in with the relevant serial port.
- A C26x can manage up to 4 Ethernet (T104) SCADA protocol connections. They are configured separately but may have the same data.
- T104 only: For each SCADA protocol connection, up to four front end ports can be defined: one active port and three standby ports. Thus, up to four IP addresses will be defined during the configuration of each T104 protocol connection (see section ***3.7.1.5.1. Setting specific attributes of a T104 SCADA network***). If two SCADAs are communicating with the C26x, they must manage their own redundancy to ensure command consistency.

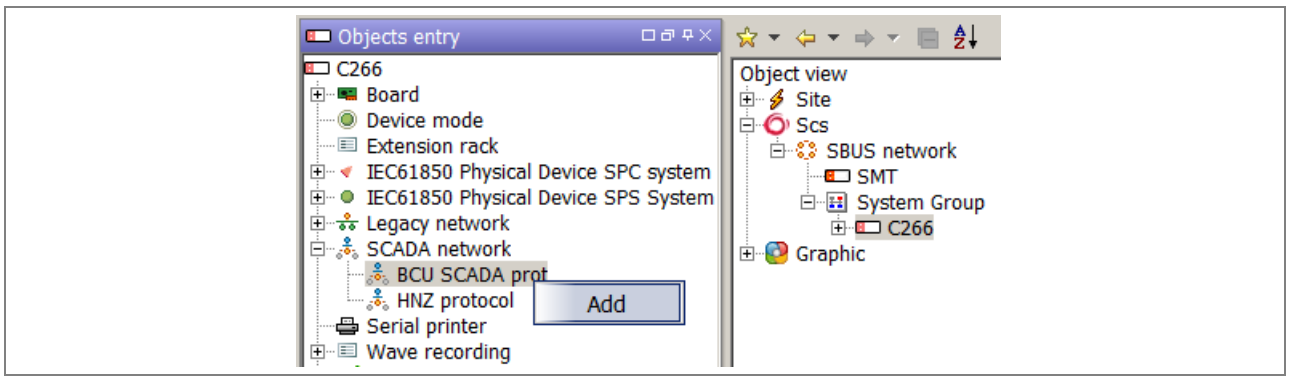


Figure 98: Adding a SCADA network

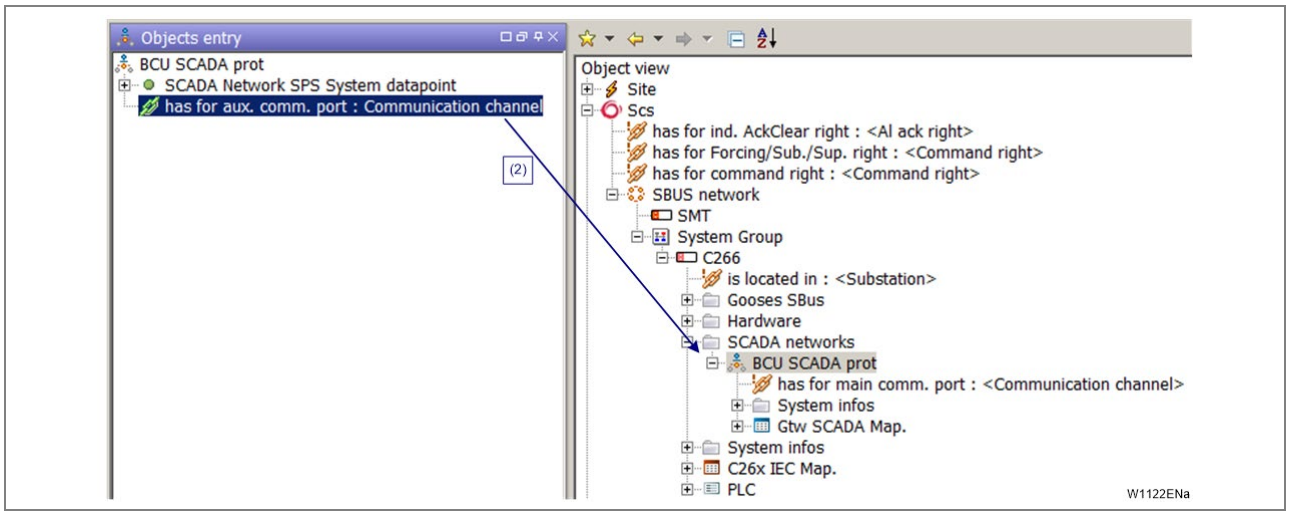


Figure 99: Adding a redundant SCADA link

3.7.1.2 COMPONENTS OF A SCADA NETWORK

When a SCADA network is added, the following sub-tree is automatically created with implicit components and optional components that can be added from the contextual **Objects entry** window:

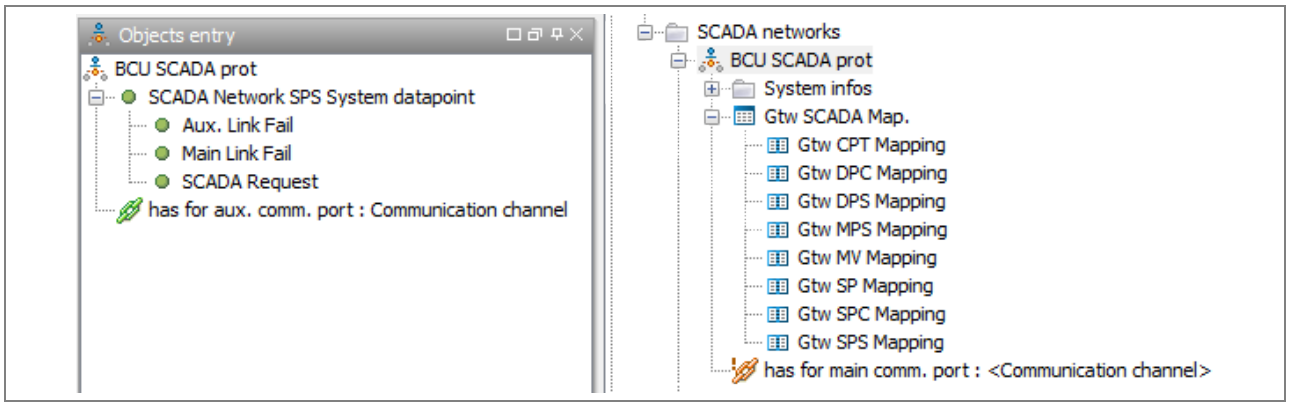


Figure 100: Optional and default components of a SCADA network

- Folder **System infos**: contains SPS system datapoints relevant to the communications channel with the SCADA. Two datapoints are implicitly added along with the SCADA network:
  - **Redundancy SPS**: communications port redundancy status
  - **SCADA SPS com.**: state of the communication link between the C26x and the SCADA

An additional 3 SPS datapoints can be added from the contextual **Objects entry** window:

- **Aux. Link Fail** (T101 only): *SET* when the redundant SCADA link is lost, whether this is due to equipment failure or to a C26x reboot. This signal is sent to the SCADA over the main link.
- **Main Link Fail** (T101 only): *SET* when the main SCADA link is lost, whether this is due to equipment failure or to a C26x reboot. This signal is sent to the SCADA over the auxiliary link.
- **SCADA Request** (T101/T104 only): *SET* while a request is being received from the SCADA

- Mapping **Gtw SCADA Map.**: set of datapoints sent to the SCADA. Their definition is described in section *3.7.2.8 Defining a SCADA address for a SetPoint datapoint*.
- Relation **has for main comm.port : <Communication channel>**: double-click this relation to display the **Relation link editor** window and select the appropriate communications port on the C26x.

A second relation, **has for aux. comm. port : Communication channel**, is available for use with a redundant SCADA link: double-click this relation to display the **Relation link editor** window and select the appropriate communications port on the C26x.

3.7.1.3 SETTING THE GENERAL ATTRIBUTES OF A SCADA NETWORK

Regardless of the type of SCADA network, its **short name** and **long name** attributes must be set in accordance with each connected SCADA network in order to ensure correct logging and alarm discrimination of the status datapoints managed by the C26x. Then the supported **protocol** (2) must be selected (T101 in the example given below). The contents of the SCADA attributes tab-panes (Protocol, SOE and Disturbance) depend on the selected protocol.

3.7.1.4 T101 SCADA NETWORK

3.7.1.4.1 Setting the general attributes of a T101 SCADA network

When adding a T101 SCADA network its general attributes must be set:

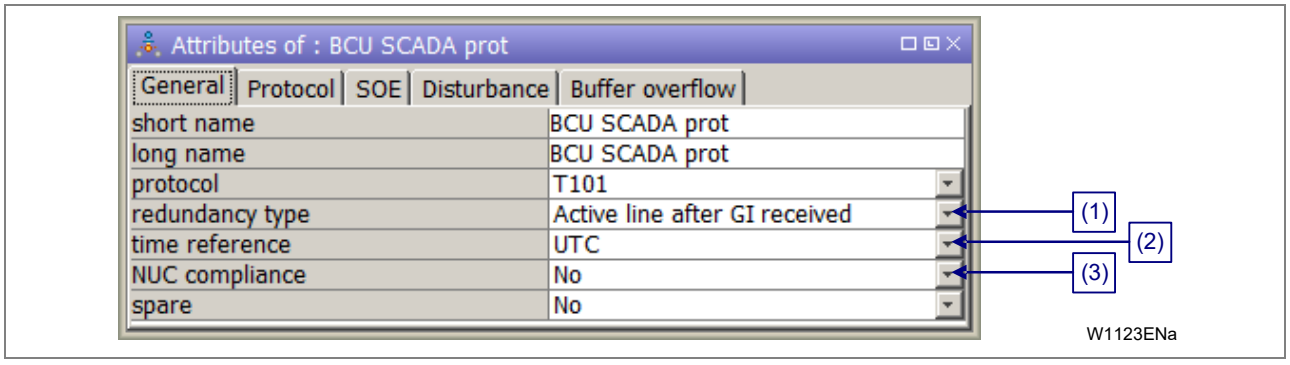


Figure 101: Setting the general attributes of a SCADA network

(1) **redundancy type** (*Active line after GI received* / *Active line after Reset Line received* / *Active line on traffic*)

(2) **time reference** (*UTC* / *local*)

(3) **NUC compliance** (*No* / *Yes*): Compliance with the Norvegian IEC 870-5-101 User Conventions

3.7.1.4.2 Setting the specific attributes of a T101 SCADA network

When adding a T101 SCADA network, the following attributes, available for this protocol, must be set (Protocol and SOE tab-panes):

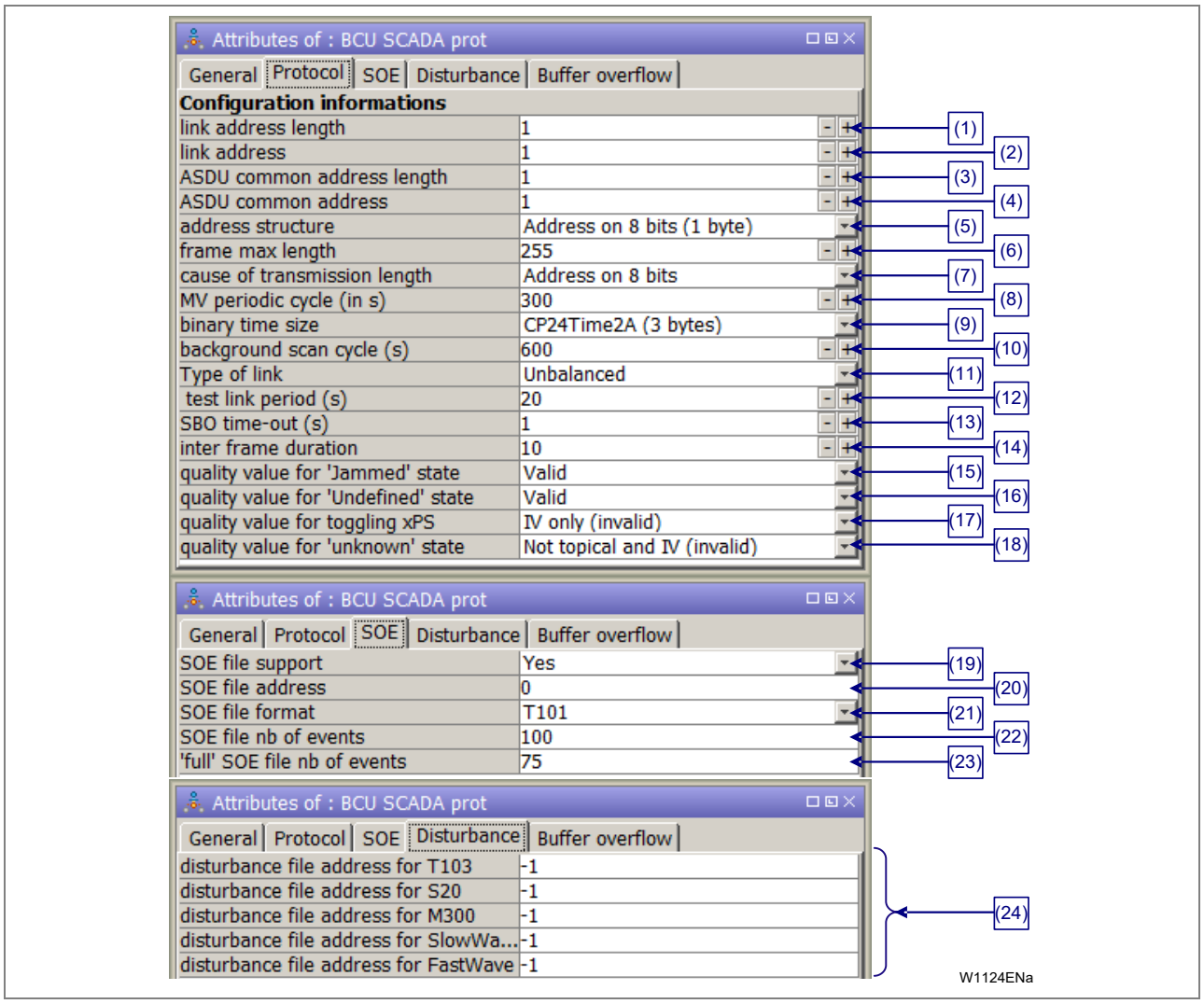


Figure 102: Setting the protocol and SOE/disturbance recording attributes of a T101 SCADA network

(1) **link address length** (1 byte / 2 bytes)

(2) **link address** (range [1, 65534], step 1)

(3) **ASDU common address length** (1 byte / 2 bytes)

(4) **ASDU common address** (range [1, 65534], step 1)

(5) **address structure** (*Address on 8 bits (1 byte)* / *Address on 16 bits (2 bytes)* / *Address on 8 bits.8 bits* / *Address on 8 bits.16 bits* / *Address on 16 bits.8 bits* / *Address on 8 bits. 8 bits. 8 Bits* / *Address on 24 bits (3 bytes)*)

(6) **frame max length** (range [1, 255], step 1)

(7) **cause of transmission length** (*Address on 8 bits* / *Address on 16 bits*)

(8) **MV periodic cycle** (range [0 s, 65534 s], step 1 s)

(9) **binary time size** (*CP24Time2A (3 bytes)* / *CP56Time2A (7 bytes)*)

(10) **background scan cycle (s)** (range [0 s, 65535 s], step 1 s)

(11) **Type of link** (*unbalanced* / *balanced*)

(12) **test link period (s)** (range [1 s, 65535 s], step 1 s)

(13) **SBO time-out** (range [0 s, 65535 s], step 1 s)

(14) **inter frame duration** (range [1, 50], step 1): this attribute represents the minimum time, expressed in number of characters, that must exist between two frames

(15) **quality value for 'Jammed' state** (*Valid* / *Invalid*)

(16) **quality value for 'Undefined' state** (*Valid* / *Invalid*)

(17) **quality value for toggling xPS** (*BL only (blocked)* / *IV only (invalid)*)

(18) **quality value for 'unknown' state** (*Not topical only* / *Not topical and IV (invalid)*)

(19) **SOE file support** (*No* / *Yes*)

(20) **SOE file address**: this attribute is visible and significant only if the attribute **SOE file support** is set to *Yes*

(21) **SOE file format** (*T101* / *S900*): this attribute is visible and significant only if the attribute **SOE file support** is set to *Yes*

(22) **SOE file nb of events** (range [0, 1000], step 1): this attribute is visible and significant only if the attribute **SOE file support** is set to *Yes*

(23) **'full' SOE file nb of events** (range [0, 1000], step 1): file message sent to SCADA (this attribute is visible and significant only if the attribute **SOE file support** is set to Yes)

(24) Tab-pane **Disturbance**: the addresses of the IED disturbance files are defined in this tab-pane

Configuration rules and checks

The following constraints between the attributes must be respected:
"SOE file nb of events" > "'full' SOE file nb of events".

Note:
For several T101/T104 SCADA links, refer also to the C26x attribute Arbitration support

Tab-pane **Buffer overflow**:

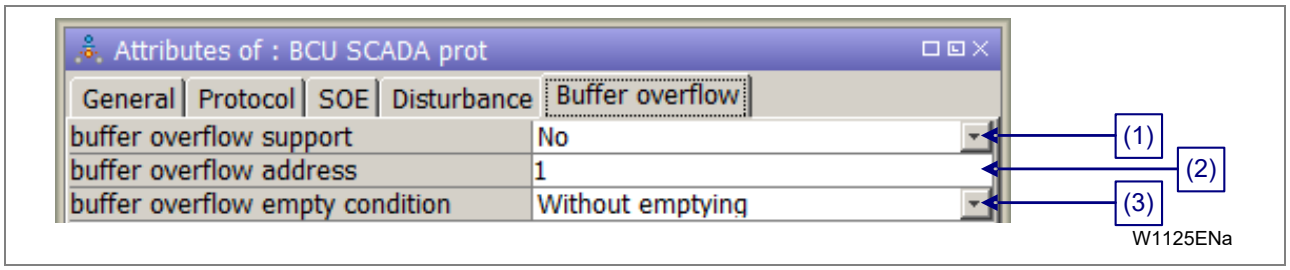


Figure 103: Setting the Buffer overflow attributes of a T101 SCADA network

(1) **Buffer overflow support**: activates the SPS Buffer overflow

(2) **Buffer overflow address**: defines the SPS Buffer overflow address in Scada

(3) **Buffer overflow empty condition**: defines the way the 1000-event buffer is managed:

- *Without emptying*: the buffer is circular; when it is full, the “Last in” event replaces the “First in” event. The buffer is never flushed.
- *FIFO full / SCADA (re)connection*: when the buffer is full, the overflow indication is recorded, and new events are not recorded in the buffer. At SCADA reconnection:
  - the buffer overflow information is sent to the SCADA
  - the buffer is flushed without any event transfer to the SCADA
- *FIFO full only*: when the buffer is full, the overflow indication is recorded, and new events are not recorded in the buffer. At SCADA reconnection:
  - the buffer overflow information is sent to the SCADA
  - all the events recorded are sent to the SCADA
  - the buffer is flushed

3.7.1.5 T104 SCADA NETWORK

3.7.1.5.1 Setting the general attributes of a T104 SCADA network

In the following figure the selected protocol for the SCADA link is ‘T104’ and the selected time reference is UTC.

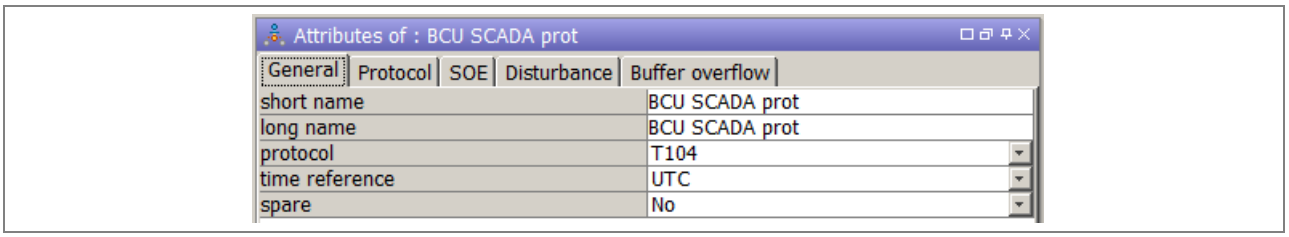


Figure 104: Setting the general attributes of a SCADA network

3.7.1.5.2 Setting the specific attributes of a T104 SCADA network

When setting a T104 SCADA network, some attributes specific to the protocol must be updated (Protocol and SOE tab-panes):

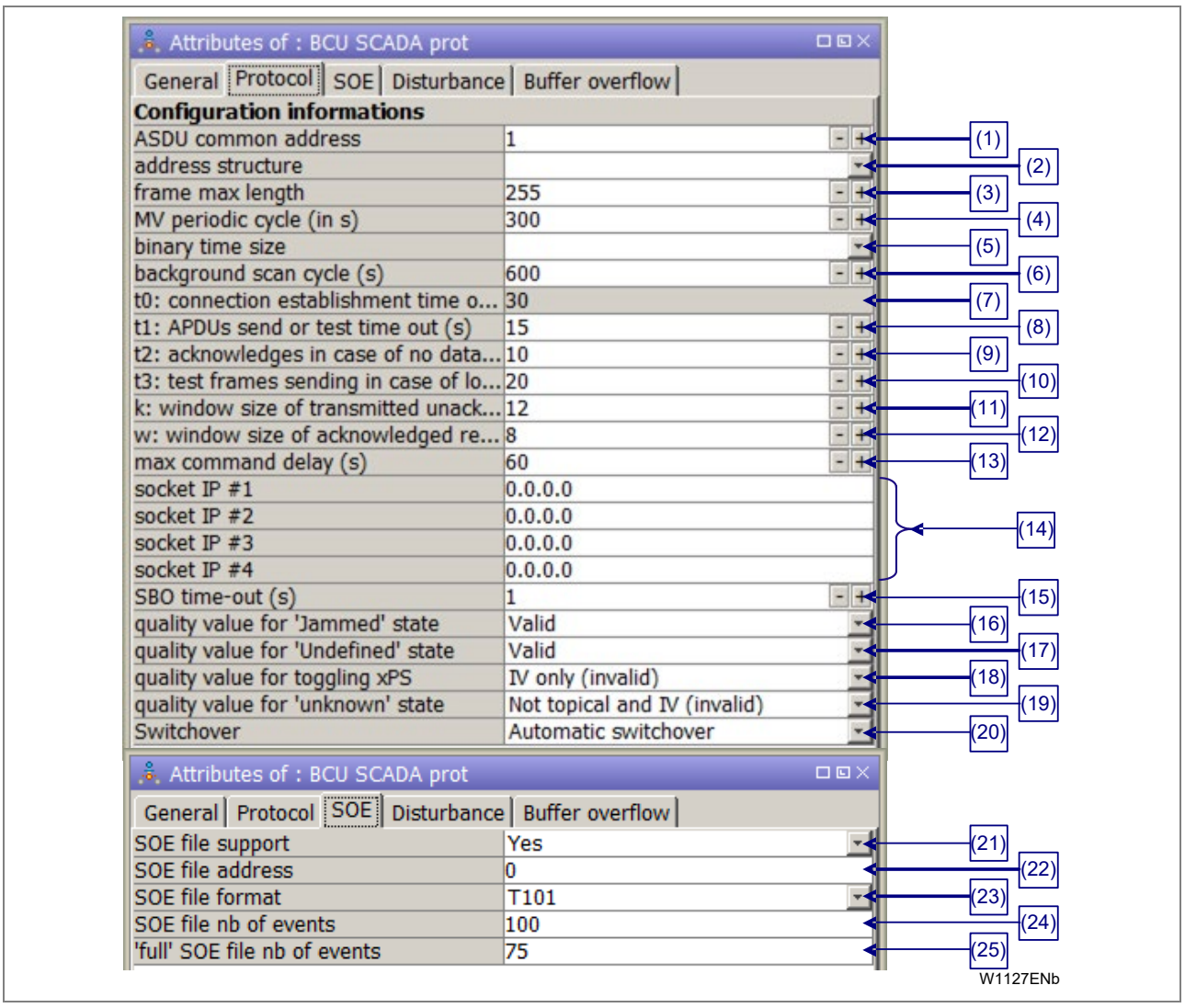


Figure 105: Setting the specific attributes of a T104 SCADA network

(1) **ASDU common address** (range [1, 65534], step 1)

(2) **address structure** (Address on 8 bits.16 bits / Address on 16 bits.8 bits / Address on 8 bits.8bits.8bits / Address on 24 bits (3 bytes))

(3) **frame max length** (range [1, 255], step 1)

(4) **MV periodic cycle** (range [0 s, 65534 s], step 1 s)

(5) **binary time size** (*CP24Time2A (3 bytes)* / *CP56Time2A (7 bytes)*)

(6) **background scan cycle** (range [0 s, 65535 s], step 1 s)

(7) **t0: connection establishment time out (s)** (range [1 s, 255 s], step 1 s)

(8) **t1: APDUs send or test time out** (range [1 s, 255 s], step 1 s)

(9) **t2: acknowledges in case of no data time out (s)** (range [1 s, 255 s], step 1 s)

(10) **t3: test frame sending in case of long idle state time out (s)** (range [1 s, 255 s], step 1 s)

(11) **k: window size of transmitted unacknowledged frames** (range [1, 255], step 1)

(12) **w: window size of acknowledged received frames** (range [1, 255], step 1)

(13) **max command delay** (range [0 s, 32767 s], step 1 s)

(14) **socket IP #i** ($i \in [1, 4]$)

(15) **SBO time-out** (range [0 s, 65535 s], step 1 s)

(16) **quality value for 'Jammed' state**: (*Valid* / *Invalid*) this attribute defines the value of the Quality Descriptor field when the event to transmit is an xPS in the 'Jammed' State

(17) **quality value for 'Undefined' state**: (*Valid* / *Invalid*) this attribute defines the value of the Quality Descriptor field when the event to transmit is an xPS in the 'Undefined' State

(18) **quality value for toggling xPS** (*BL only (blocked)* / *IV only (invalid)*: this attribute defines the value of the Quality Descriptor field when the event to transmit is an xPS in the 'Toggling' state

(19) **quality value for 'unknown' state**: (*Not topical* / *Not topical and IV invalid*) this attribute defines the value of the Quality Descriptor field when the event to transmit is an xPS in the 'Unknown' state

(20) **Switchover** (*Automatic switchover* / *Manual switchover*)

(21) **SOE file support** *(No / Yes)*

(22) **SOE file address** (this attribute is visible and significant only if attribute **SOE file support** is set to Yes)

(23) **SOE file format** *(T101 / S900)* (this attribute is visible and significant only if attribute SOE file support is set to Yes)

(24) **SOE file nb of events** (range [0, 1000], step 1) (this attribute is visible and significant only if attribute SOE file support is set to Yes)

(25) **'full' SOE file nb of events** (range [0, 1000], step 1) file message sent to SCADA (this attribute is visible and significant only if attribute SOE file support is set to Yes)

Configuration rules and checks

The following constraints between the attributes must be respected:

SOE file nb of events > **'full' SOE file nb of events**
T2 < **T1**
T3 > **T1**
W ≤ **K**

Tab-pane **Disturbance**: the IED disturbances files addresses are defined.

Tab-pane **Buffer overflow**:

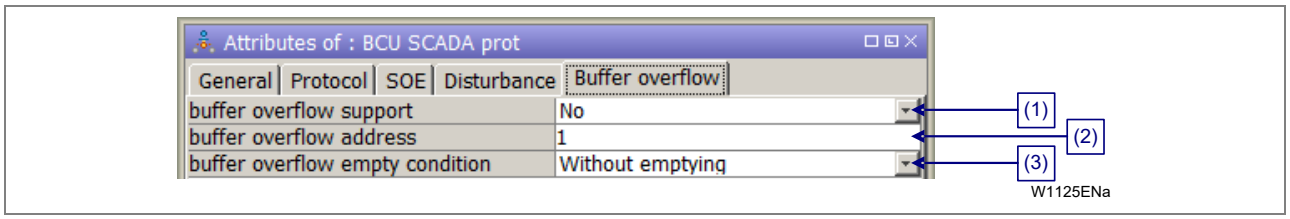


Figure 106: Setting the Buffer overflow attributes of a T104 SCADA network

(1) **Buffer overflow support**: activates the SPS Buffer overflow

(2) **Buffer overflow address**: defines the SPS Buffer overflow address in Scada

(3) **Buffer overflow empty condition**: defines the way the buffer is managed:

- Without emptying: the buffer is circular; when it is full, the “Last in” event replaces the “First in” event. The buffer is never flushed.
- FIFO full / SCADA (re)connection: when the buffer is full, the overflow indication is recorded; new events are not recorded in the buffer. At SCADA reconnection:
  - the buffer overflow information is sent to the SCADA
  - the buffer is flushed without any event transfer to the SCADA
- FIFO full only: when the buffer is full, the overflow indication is recorded, and new events are not recorded in the buffer. At SCADA reconnection:
  - the buffer overflow information is sent to the SCADA
  - all the events recorded are sent to the SCADA
  - the buffer is flushed

3.7.1.6 MODBUS SCADA NETWORK

3.7.1.6.1 Setting the general attributes of a MODBUS SCADA network

In the following figure the selected protocol for the SCADA link is ‘Modbus’.

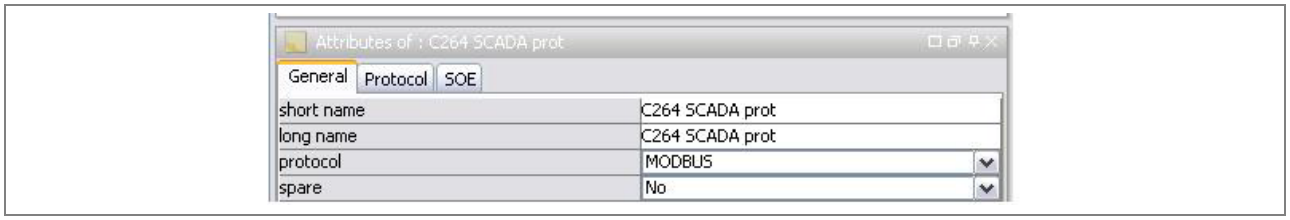


Figure 97: Setting the protocol type of a SCADA network

3.7.1.6.2 Setting the specific attributes of a MODBUS SCADA network

When setting a MODBUS SCADA network, some attributes specific to the protocol must be updated (Protocol tab-pane):

(1) **TCP/IP usage** (*No / Yes*): no choice for Modbus: SET IT TO ‘No’.

(2) **link address**.

(3) **inter frame duration** (range [1, 50], step 1): this attribute represents the minimum time, expressed in number of characters, that must exist between two frames.

For a MODBUS SCADA network, the SOE tab-panes attributes are not significant (not implemented).

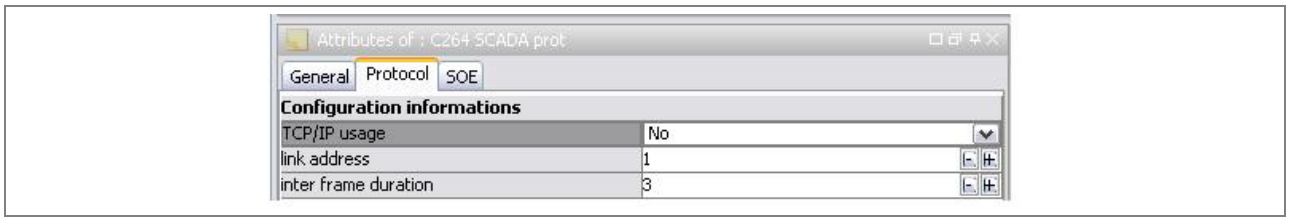


Figure 98: Setting the protocol attributes of a Modbus SCADA network

3.7.2 DEFINING THE ADDRESS MAP OF A SCADA NETWORK

To transmit information between DS Agile system and SCADA, a SCADA legacy network is used. To receive or send information between legacy IED and DS Agile system, each concerned data must have a specific address on the legacy network relatively to its protocol. General modeling of SCADA legacy network address mapping can be done.

At SCE level, a SCADA legacy network owns a “Gtw SCADA mapping” object, that is split into categories of mapping on a per datapoint type basis. In each category of mapping, elementary SCADA addresses can be created. For details about datapoint, see section *4 Defining a datapoint*. This mapping is implicitly created during IED adding at legacy network level.

Warning:
Addressing an MPS datapoint on a SCADA network is not possible.

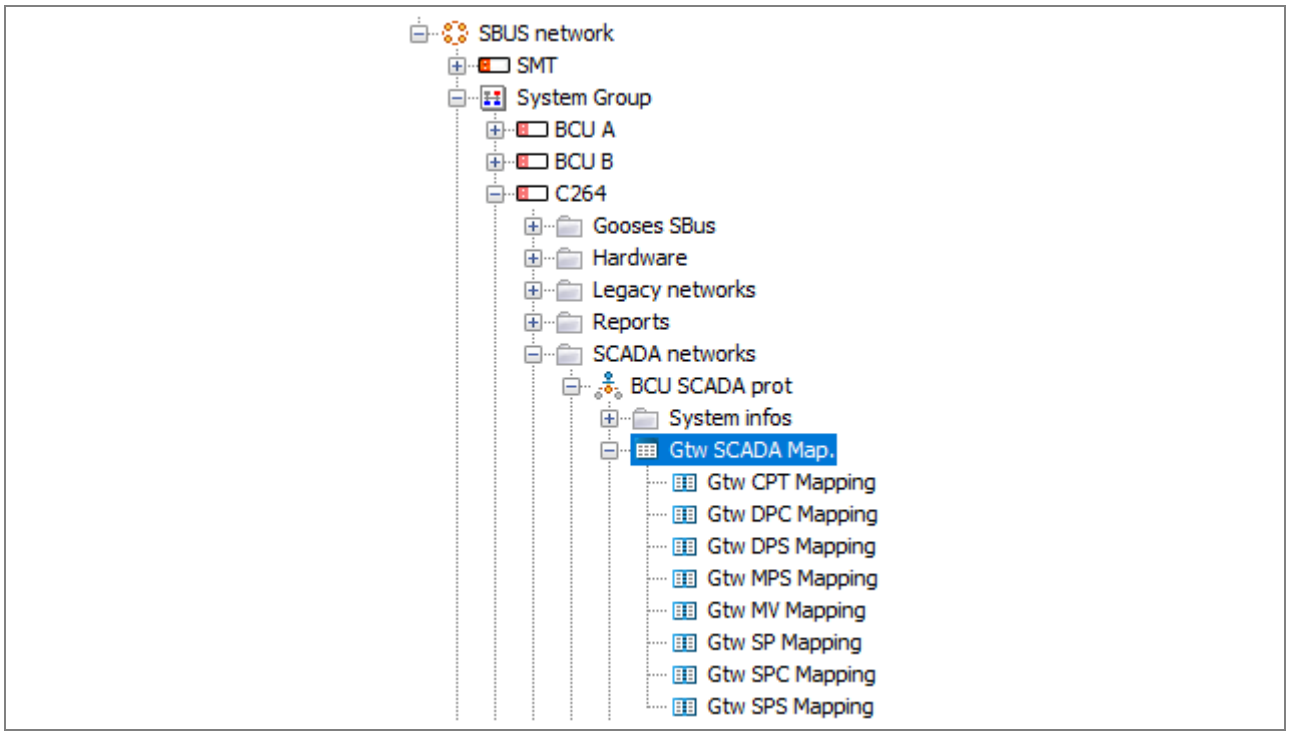


Figure 109: Structure of the address map of a SCADA network

There are two ways to map the datapoints:

- Select the attributes of the subnodes of the various Gtw xxx Mapping folders
- To go faster (or import a file from Excel), use a smart table, linked to the individual tables (see sections *3.7.2.2, 3.7.2.4*, and *3.7.2.5* for details on attributes)

Configuration rules and checks

In the SCADA Mapping, the address identification of each "Gtw xxx addr." must be unique. In the particular cases of T101 and T104 protocols, the uniqueness constraint is applicable only for addresses of the same type. Addresses of different types can have identical addresses and therefore this does not lead to an error but to a warning. .

3.7.2.1 SMART TABLE

When a SCADA network is selected in the browser, an extra item is present in the contextual menu: “Edit Scada mapping”. When selected, a window appears. It allows to enter all datapoint addresses for the SCADA mapping. The datapoints are tabbed by type; 5 types exist:

- xPS for SPS / DPS addresses
- xPC for SPC / DPC addresses
- MV for measurement addresses
- SetPoint for SetPoint addresses
- Counter for Counter addresses

Each tab presents a table featuring:

- in the left part (white background), the predefined list of datapoints
- in the right part (blue background), empty cells for addresses, labels and protocol-dependent attributes

The white part indicates for each datapoint of the type:

- Variants (pictogram)
- Path (read only)
- Short name (read only)
- Long name (editable, copy/paste enabled)

To adjust a column width, pass the cursor over the border in the header till the cursor turns to ↔; then drag and drop.

Procedure to fill the blue part

1 Click in an address cell

2 Enter the address

3 Click another cell to change the selection; the other cells in the row are automatically filled with default values (an address which contains letters is corrected to 255)

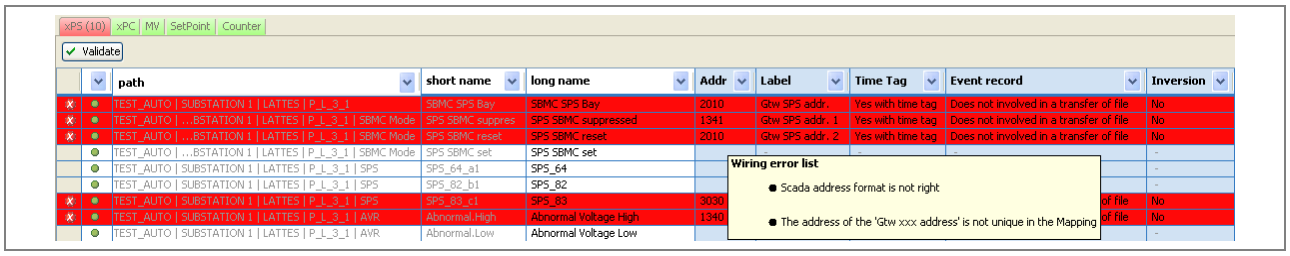
4 Click two times a cell in the column Label and edit the text

5 Click three times a cell in a column different than Addr or Label; click the button [v] and select one value in the drop-down list

6 Select a cell or several contiguous cells with at least one Addr cell; copy, select target, paste the label is recomputed; if the Addr is void, 255 is pasted

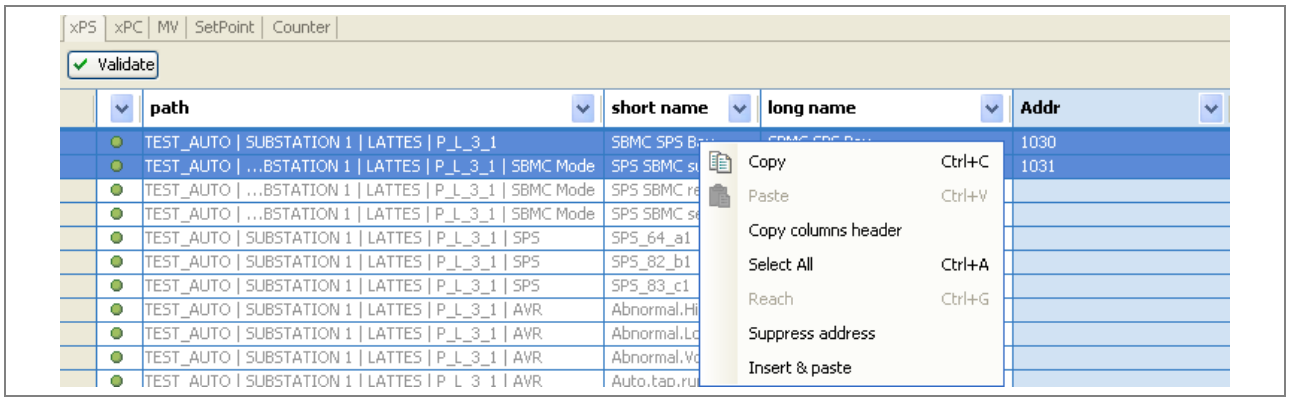
7 To check the address uniqueness, click button Validate in upper left corner:

- the wrong lines turn red and show a red pictogram in the first column
- the tab tag turns red (resp. green) if it contains errors (resp. it is error-free); to display a tooltip, pass the mouse over a red line:

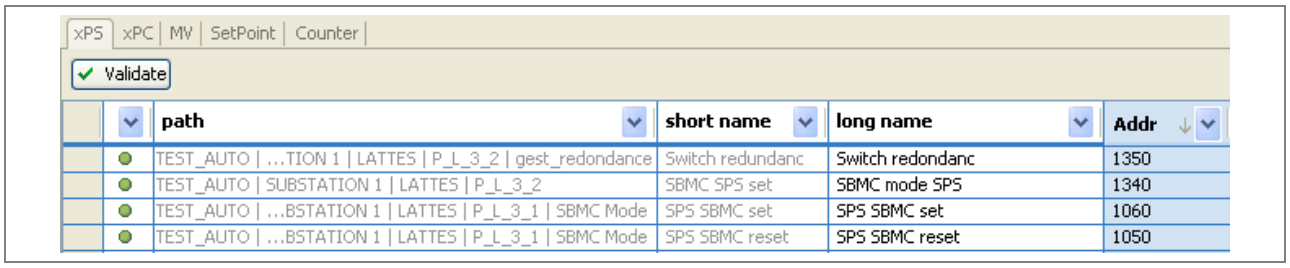


Possible errors

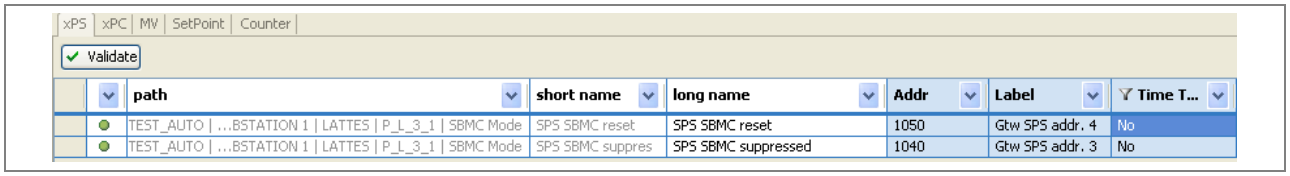
- Address is not unique in the mapping
- Address is not associated with a datapoint (delete the address)
- Address value doesn't respect the predefined format
- Datapoint is not visible by the SCADA equipment
- To delete a set of addresses in contiguous rows, click in the first or Addr column and drag to select the rows, right click and click Suppress address



- To sort out the rows alphabetically/numerically/hierarchically in decreasing order, click each column header several times till the arrow ↓ shows after the column label

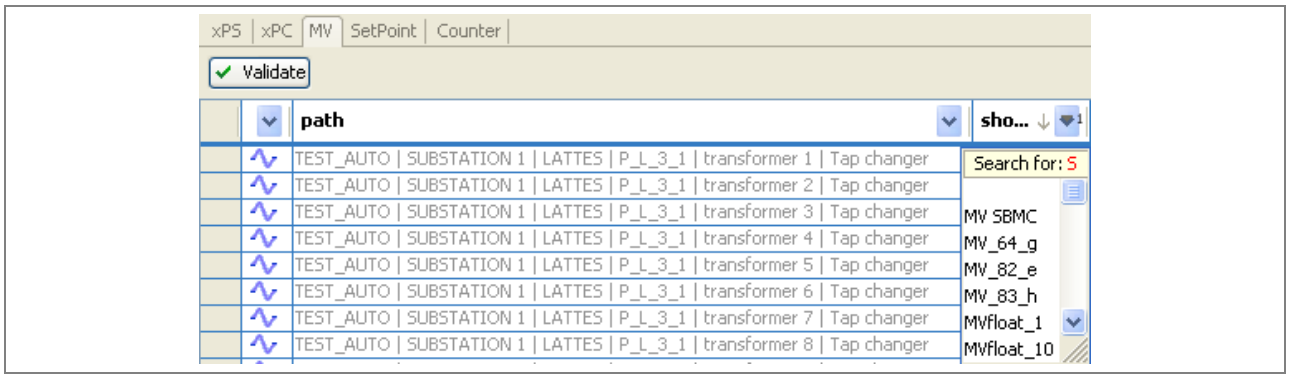


- To filter the rows according to a column field, click [v] and select one value in the combo list; as a result, a funnel shows before the column label. To suppress the filter, select the value (All).



For the path column, the sub-nodes of the selected nodes are displayed as well.

If the desired value is not in the list, stop the cursor on any value and type in the value (in red):



- Click the button Close; when you resume the procedure, click [v] in the Addr header and select Defined address to retrieve the entered values.

3.7.2.2 DEFINING A SCADA ADDRESS FOR AN SPS DATAPOINT

A SCADA address is added to an SPS datapoint from the contextual **Objects entry** window at the SCADA SPS mapping level:

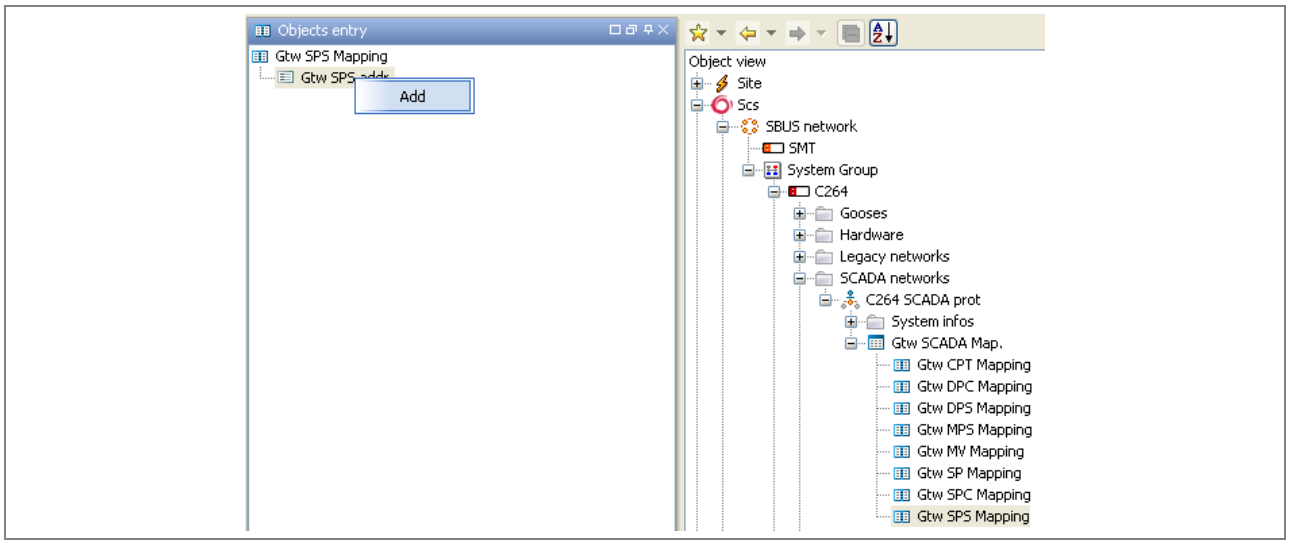
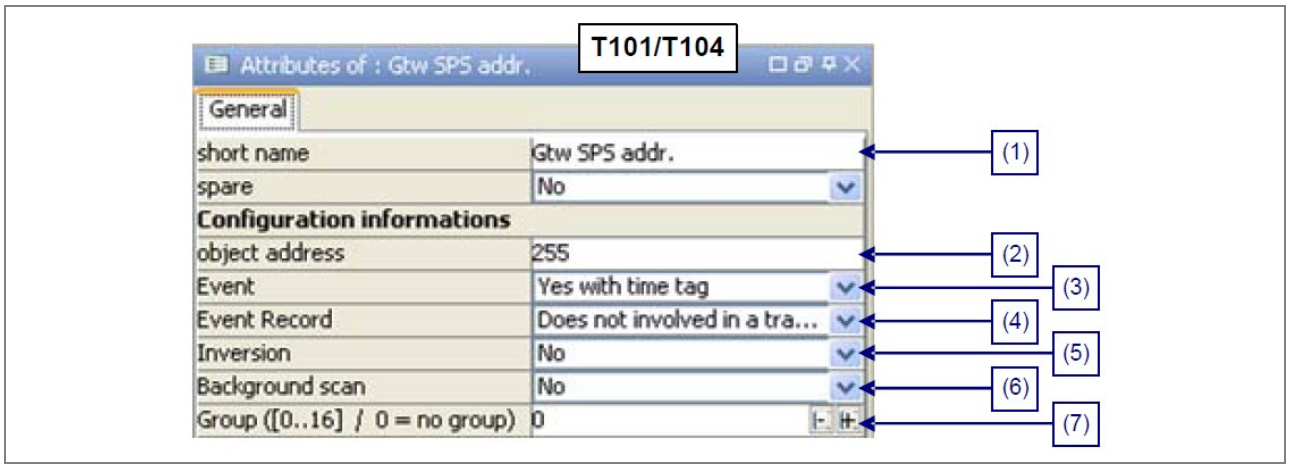


Figure 110: Adding a SCADA SPS address

Once added, SCADA SPS address attributes must be set at SCE level:

(1) **short name** of the address used for internal SCE identification.

For T101/T104 protocol:



(1) **object address**

(2) **Event** (*No / Yes with time tag / Yes without time tag*): when set to 'Yes with time tag', indicates that change of state of the datapoint are transmitted spontaneously with time tag

(3) **Event record** (*Does not involved in a transfer of file / Create a RECORD EVENT if there is not it current / Add to the current record EVENT / Create a RECORD EVENT and adds to the current record EVENT*): when set to a value different from 'Does not involved in a transfer of file', indicates if change of state of the datapoint must be saved in Sequence of Event file. At C26x level, values different from 'Does not involved in a transfer of file' are associated with the same treatment,

because only one SOE file is managed by C26x. The set of available values is maintained for compatibility with DS Agile gateway addressing in a DS Agile gateway

(4) **Inversion** *(No / Yes)*: Indicates that the datapoint value needs to be inverted before transmission

(5) **Background scan** *(No / Yes)*: indicates if the datapoint belongs to the background scan cycle

(6) **Group** (*[0..16)] / 0=no group*): indicates to which “T101/T104 General Interrogation group” the datapoint is assigned. 0 means ‘no group’ assignation

For Modbus protocol:

(2) object address – register

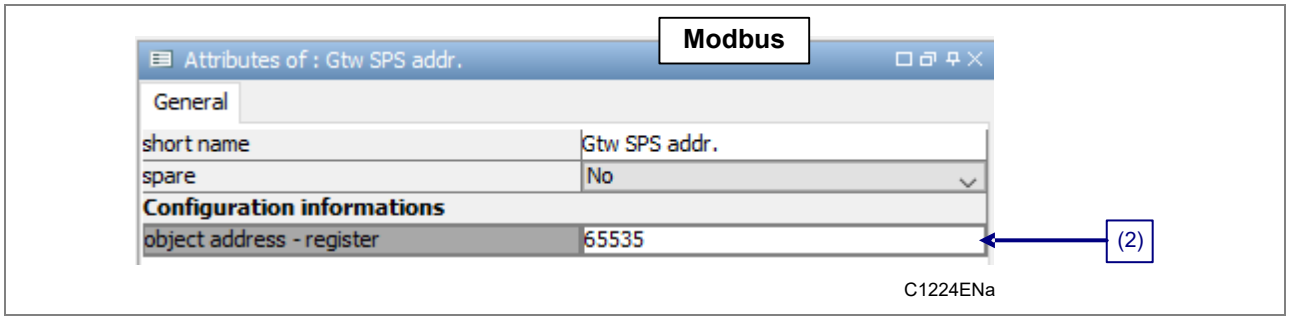


Figure 111: Defining a SCADA address for an SPS datapoint

3.7.2.3 DEFINING A SCADA ADDRESS FOR A DPS DATAPOINT

A SCADA address is added to a DPS datapoint from the contextual **Objects entry** window at the SCADA DPS mapping level:

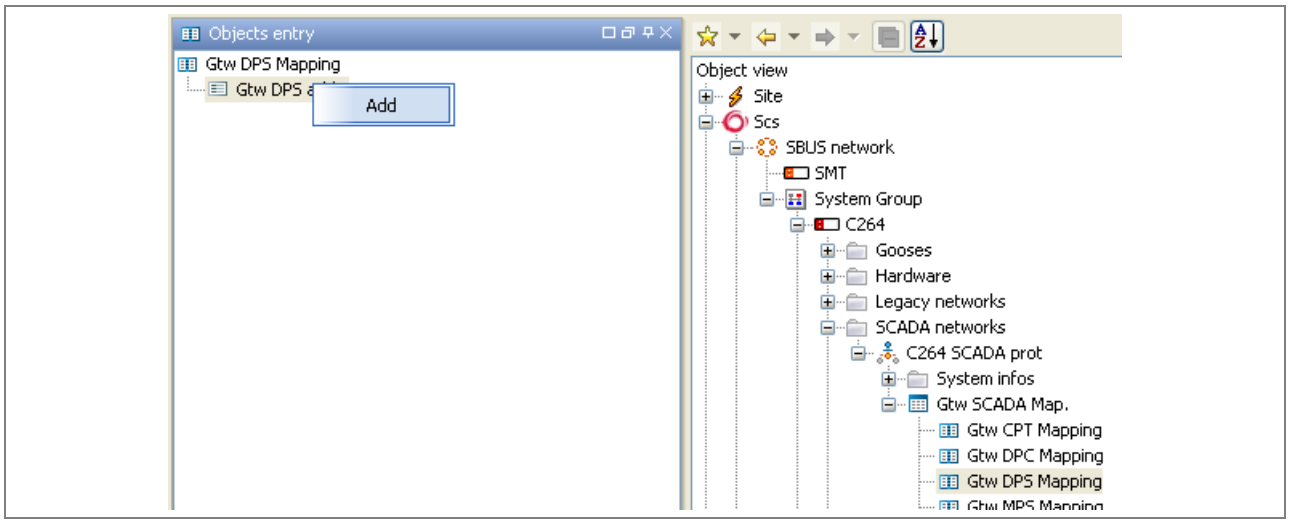


Figure 112: Adding a SCADA DPS address

Once added, SCADA DPS address attributes must be set at SCE level:

(1) **short name**: used for internal SCE identification

For T101/T104 protocol:

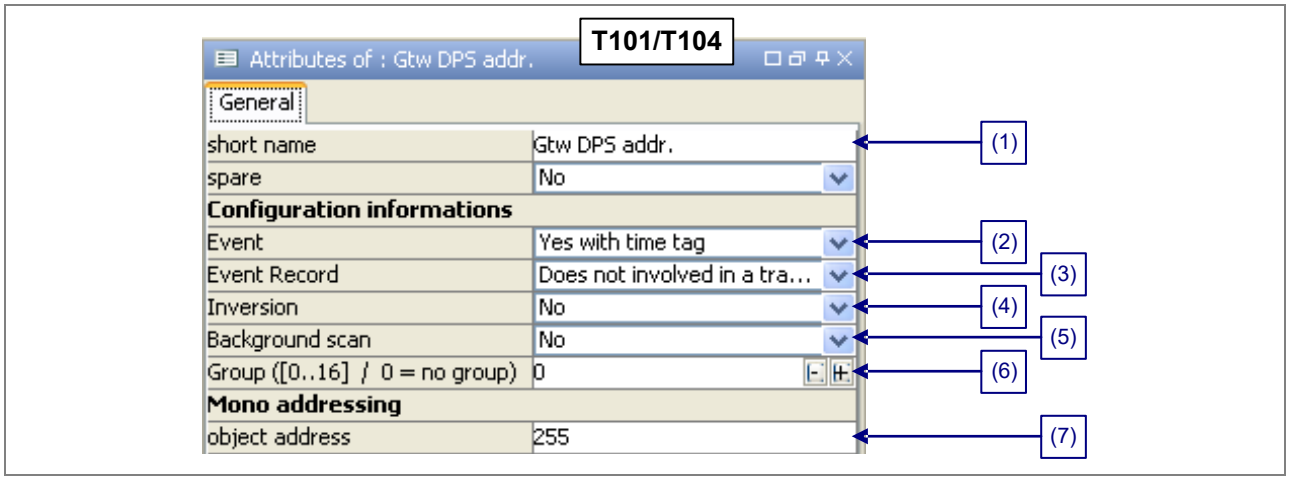


Figure 71: Defining a SCADA address for a DPS datapoint

(2) **Event** (*No / Yes with time tag / Yes without time tag*): when set to 'Yes with time tag', indicates if change of state of the datapoint are transmitted spontaneously with time Tag

(3) **Event record** (*Does not involved in a transfer of file / Create a RECORD EVENT if there is not it current / Add to the current record EVENT / Create a RECORD EVENT and adds to the current record EVENT*): when set to a value different from 'Not involved in a transfer of file', indicates if change of state of the datapoint must be saved in Sequence of Event file. At C26x level, values different from 'Not involved in a transfer of file' are associated with the same treatment, because only one SOE file is managed by C26x. The set of available values is maintained for compatibility with DS Agile gateway addressing in a DS Agile gateway.

(4) **Inversion** (*No / Yes*): indicates that the datapoint value needs to be inverted before transmission

(5) **Background scan:** (*No / Yes*): indicates if the datapoint belongs to the background scan cycle.

(6) **Group (0..16)**: indicates to which "T101/T104 General Interrogation group" the datapoint is assigned. 0 means 'no group' assignation

(7) **object address** (index)

For Modbus protocol:

(2) **double address usage** (No / Yes): only available for Modbus SCADA protocol. If set to Yes, DPS is transmitted to SCADA via two distinct SCADA address, one for the open state, the other one for the close state

(3) **object address - register**: used if Double address usage is set to No

(4) **open state address**: used if Double address usage is set to Yes. This attribute defines the SCADA address for the open state of the DPS

(5) **closed state address**: used if Double address usage is set to Yes. This attribute defines the SCADA address for the closed state of the DPS.

3.7.2.4 DEFINING A SCADA ADDRESS FOR AN MV DATAPOINT

A SCADA address is added to an MV datapoint from the contextual **Objects entry** window at the SCADA MV mapping level:

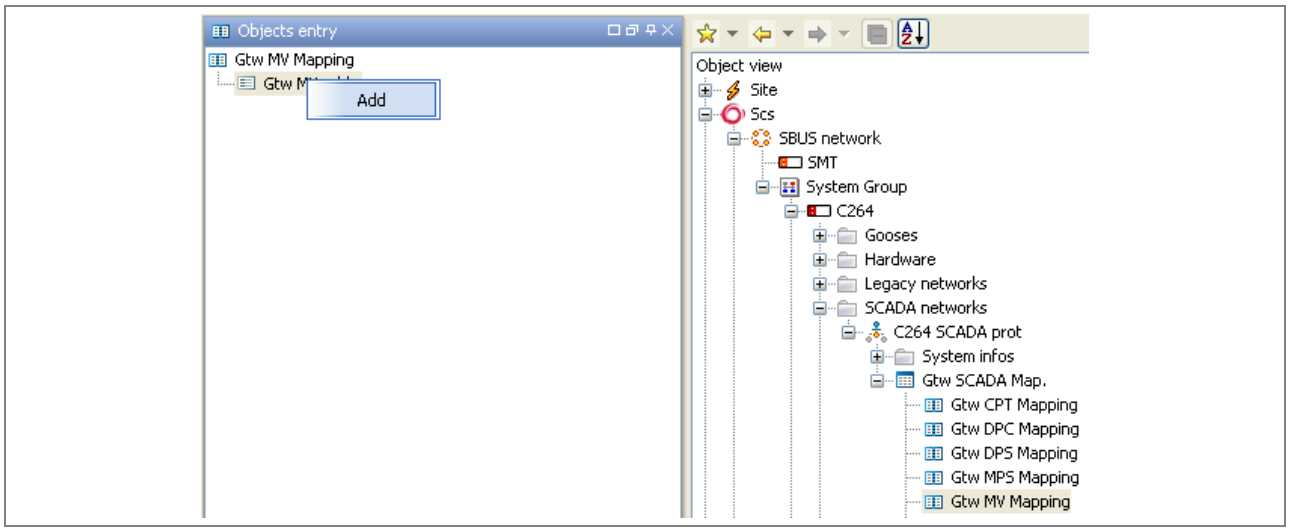


Figure 113: Adding a SCADA MV address

Once added, SCADA MV address attributes must be set at SCE level:

(1) **short name** of the address used for internal SCE identification.

For T101/T104 protocol:

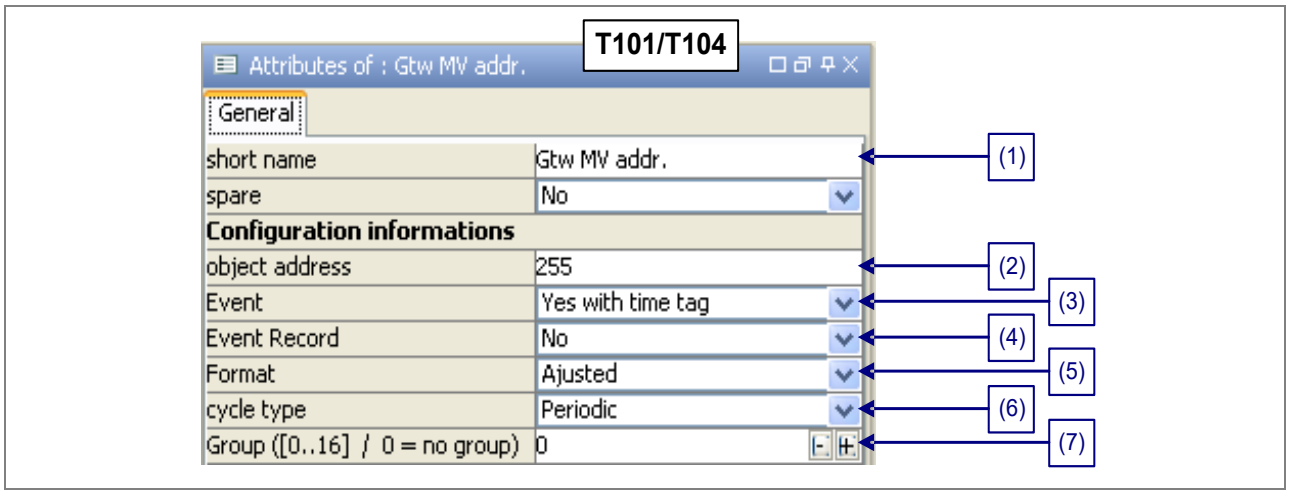


Figure 114: Defining a SCADA address for an MV datapoint

(2) **object address**.

(3) **Event** (No / Yes with time tag / Yes without time tag): when set to Yes with time tag, indicates that change of state of the datapoint are transmitted spontaneously with time Tag.

(4) **Event record** (No / Yes): indicates if change of state of the datapoint must be saved in Sequence of Event file or not.

(5) **Format** (Normalized / Scaled / Short float / Normalized unipolar): transmission format.

(6) **cycle type** (None / Periodic / Background scan): indicates which transmission cycle the MEAS belongs to.

(7) **Group ([0..16)] / 0=no group)**: indicates which “T101/T104 General Interrogation group” the datapoint is assigned to. 0 means ‘no group’ assignation.

For Modbus protocol:

(2) **object address - register**

(3) **Format** (Natural / Unsigned normalized / Signed normalized /Real IEEE754 – little endian / Real IEEE754 – big endian): transmission format.

(4) **Precision ([8..16])**: number of transmitted bits.

3.7.2.5 DEFINING A SCADA ADDRESS FOR A COUNTER DATAPOINT

A SCADA address is added to a Counter datapoint from the contextual **Objects entry** window at the SCADA Counter mapping level:

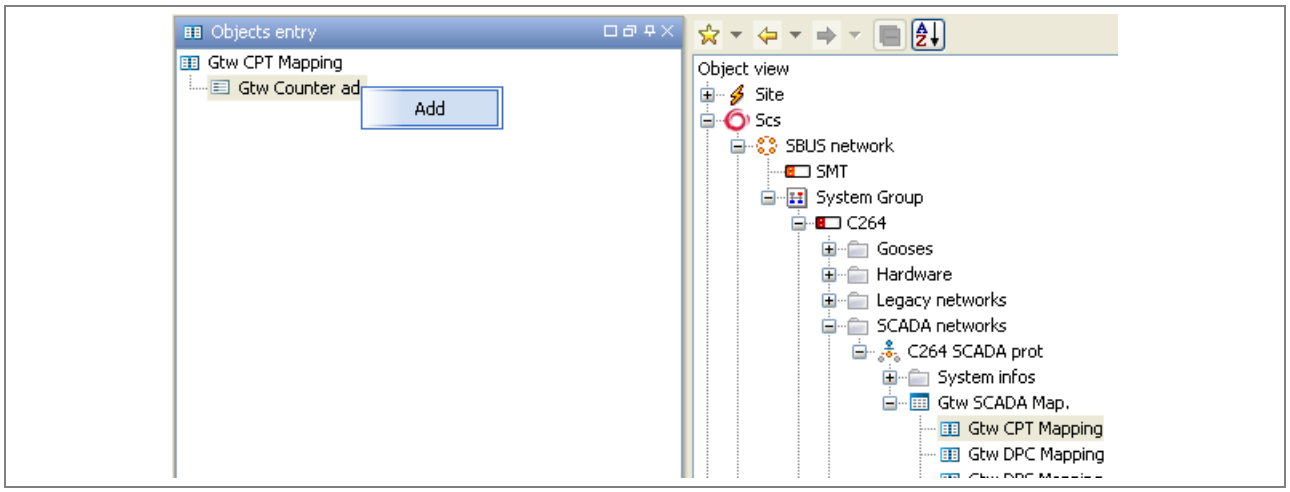


Figure 115: Adding a SCADA counter address

Once added, SCADA Counter address attributes must be set at SCE level:

(1) **short name** of the address used for internal SCE identification.

For T101/T104 protocol:

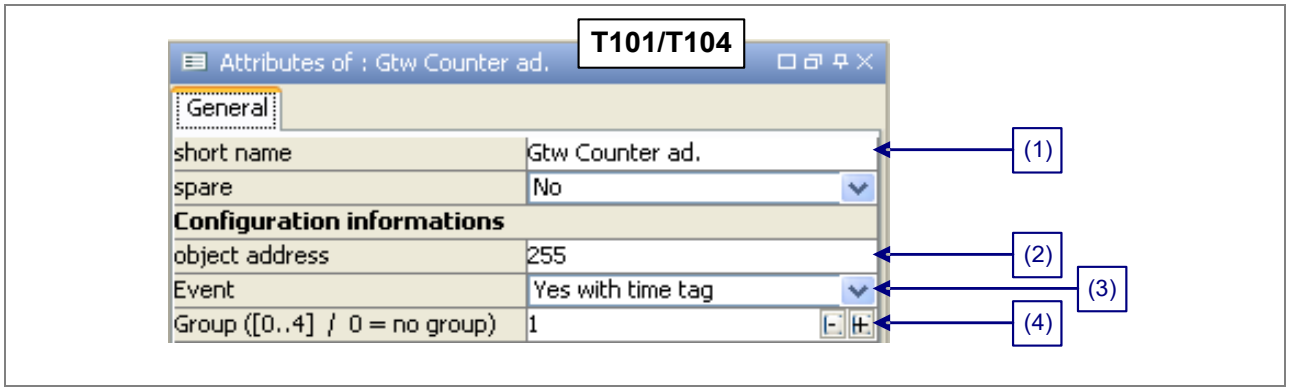


Figure 116: Defining a SCADA address for a Counter datapoint

(2) **object address**.

(3) **Event** (No / Yes with time tag / Yes without time tag): when set to 'Yes with time tag', indicates if changes of state of the datapoint are transmitted spontaneously with time Tag.

(4) **Group ([0..4] / 0=no group)**: indicates which "T101/T104 General Interrogation group" the datapoint is assigned to. 0 means 'no group' assignation.

For Modbus protocol:

(2) **object address - register**

(3) **Format** (Natural / Unsigned normalized / Real IEEE754 – little endian / Real IEEE754 – big endian): transmission format.

3.7.2.6 DEFINING A SCADA ADDRESS FOR AN SPC DATAPOINT

A SCADA address is added to an SPC datapoint from the contextual **Objects entry** window at the SCADA SPC mapping level:

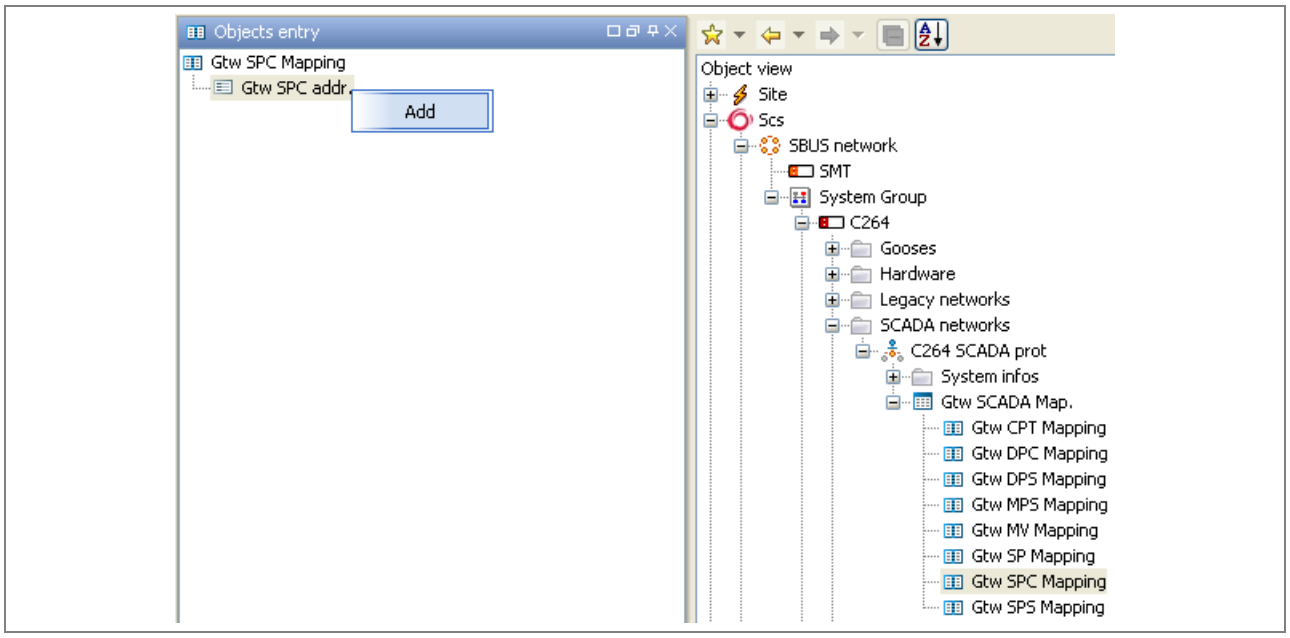


Figure 117: Adding a SCADA SPC address

Once added, SCADA SPC address attributes must be set at SCE level:

(1) **short name**: used for internal SCE identification.

For T101/T104 protocol:

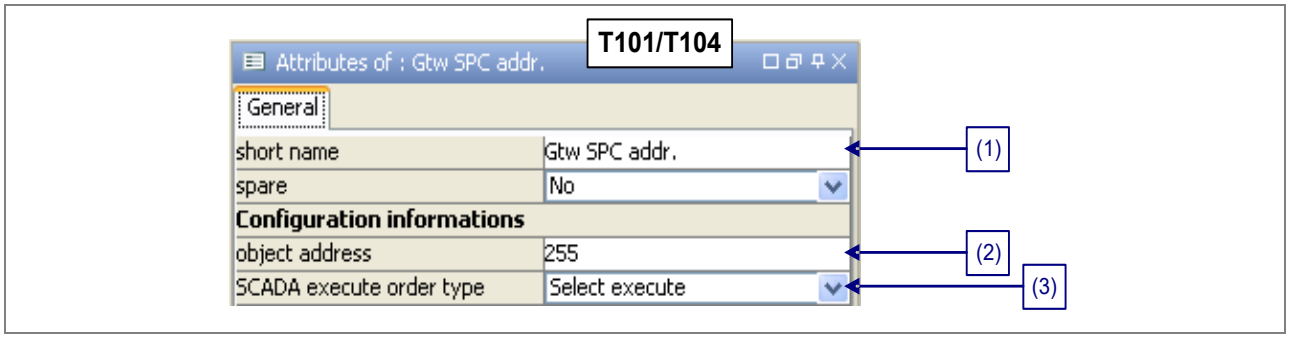


Figure 118: Defining a SCADA address for an SPC datapoint

(2) **object address**

(3) **SCADA execute order type** (Select execute / Direct execute): defines if SCADA uses a 'Select execute or a 'Direct execute' sequence to send a control to the datapoint.

For Modbus protocol:

(2) **object address - register**.

3.7.2.7 DEFINING A SCADA ADDRESS FOR A DPC DATAPOINT

A SCADA address is added to a DPC datapoint from the contextual **Objects entry** window at the SCADA DPC mapping level:

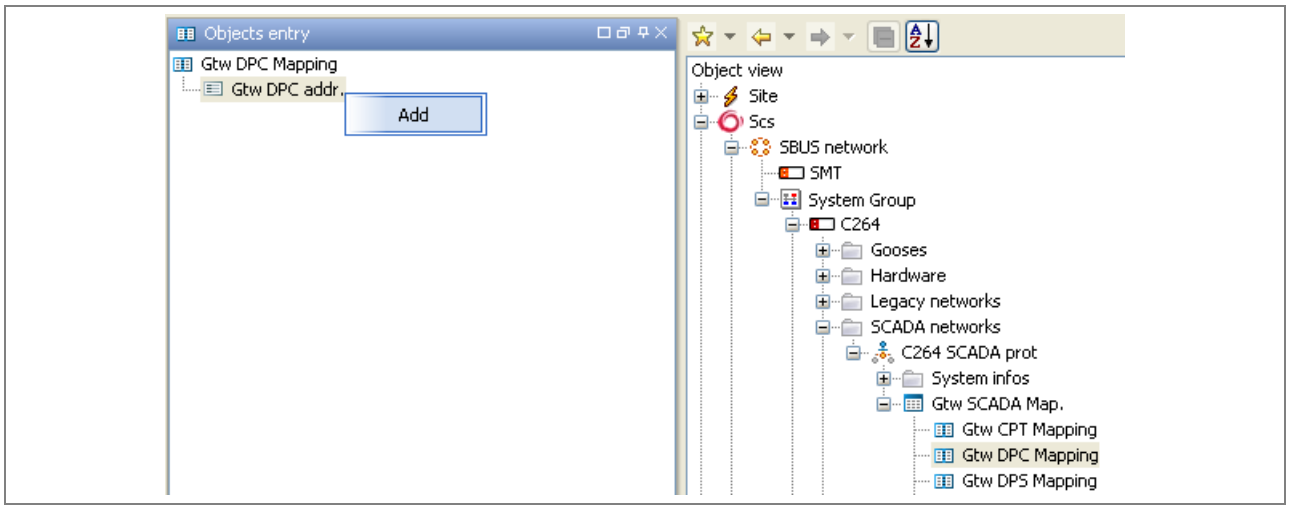


Figure 119: Adding a SCADA DPC address

Once added, SCADA DPC address attributes must be set at SCE level:

(1) **short name** of the address used for internal SCE identification

For T101/T104 protocol:

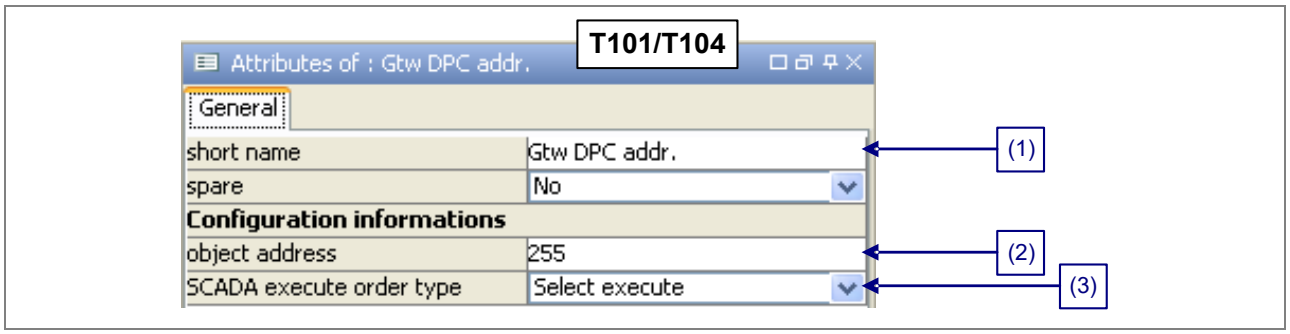


Figure 120: Defining a SCADA address for a DPC datapoint

(2) **object address**

(3) **SCADA execute order type** (Select execute / Direct execute): defines if SCADA uses a 'Select execute or a 'Direct execute' sequence to send a control to the datapoint

For Modbus protocol:

(2) **object address - register**

3.7.2.8 DEFINING A SCADA ADDRESS FOR A SETPOINT DATAPOINT

A SCADA address is added to a SetPoint datapoint from the contextual **Objects entry** window at the SCADA SetPoint mapping level:

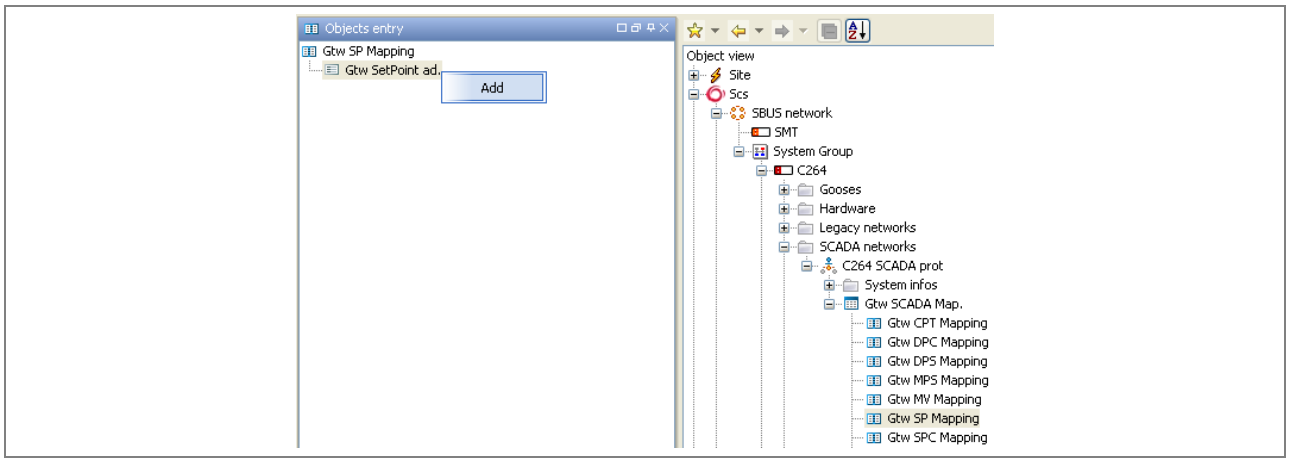


Figure 121: Adding a SCADA setpoint address

Once added, SCADA SetPoint address attributes must be set at SCE level:

(1) **short name** of the address used for internal SCE identification

For T101/T104 protocol:

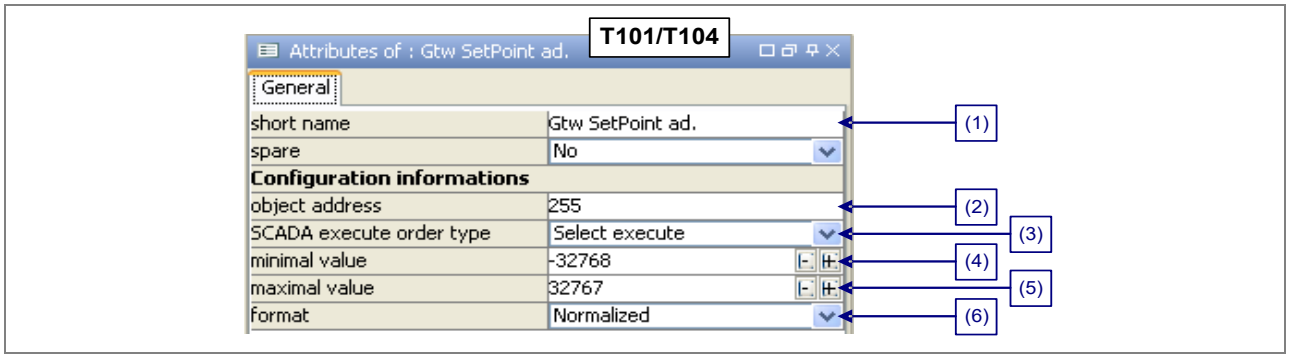


Figure 122: Defining a SCADA address for a SetPoint datapoint

(2) **object address**

(3) **SCADA execute order type** (Select execute / Direct execute): this attribute defines if SCADA uses a 'Select execute or a 'Direct execute' sequence to send a control to the datapoint

(4) **Minimal value**: available minimal value on the protocol (used for scaling and checks)

(5) **Maximal value**: available maximal value on the protocol (used for scaling & checks)

(6) **Format** (Normalized / Scaled / Short float)

For Modbus protocol

(2) **object address - register**.

(3) **format** (signed 16 bits / Real IEEE754 – little endian: the lower byte is transmitted first / Real IEEE754 – big endian: the higher byte is transmitted first)

3.7.3 ADDRESSING A DATAPOINT ON A SCADA LEGACY NETWORK

For details about datapoints, see section *4 Defining a datapoint*.

To exchange datapoint values between station-bus sub-systems and a SCADA, datapoints must be linked to specific SCADA addresses, by adding at datapoint level the relation **has for SCADA address** (1) and filling it with the corresponding SCADA address in a pre-configured SCADA address mapping (see section ***3.7.2 Defining the address map of a SCADA network***, for SCADA mapping definition).

Addressing an MPS datapoint on the SCADA legacy network is not available.

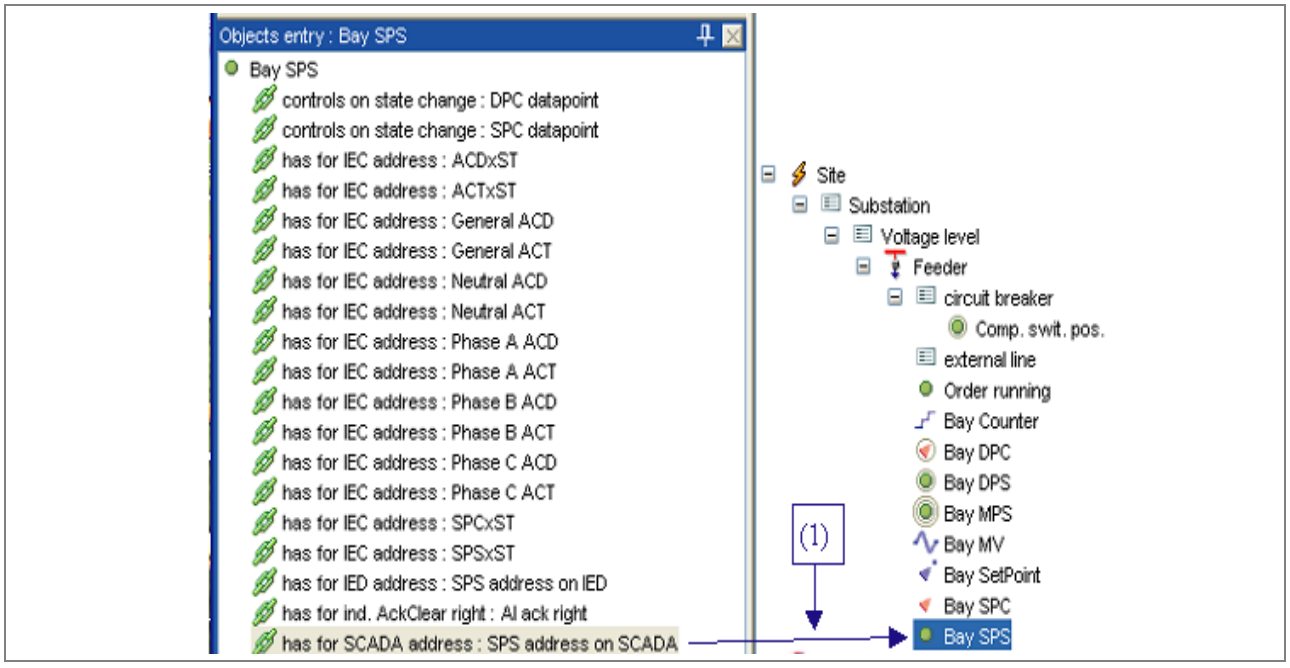


Figure 123: SCADA addressing of a datapoint (example for Bay SPS datapoint)

Datapoints automatically sent by GOOSE

In the case of datapoints that are automatically received by GOOSE (e.g. SBMC and Local/Remote states, control feedbacks…) to a BCU that should also forward their states to a SCADA, the information must also be manually included into a report for the receiving BCU to be able to forward it to the SCADA.

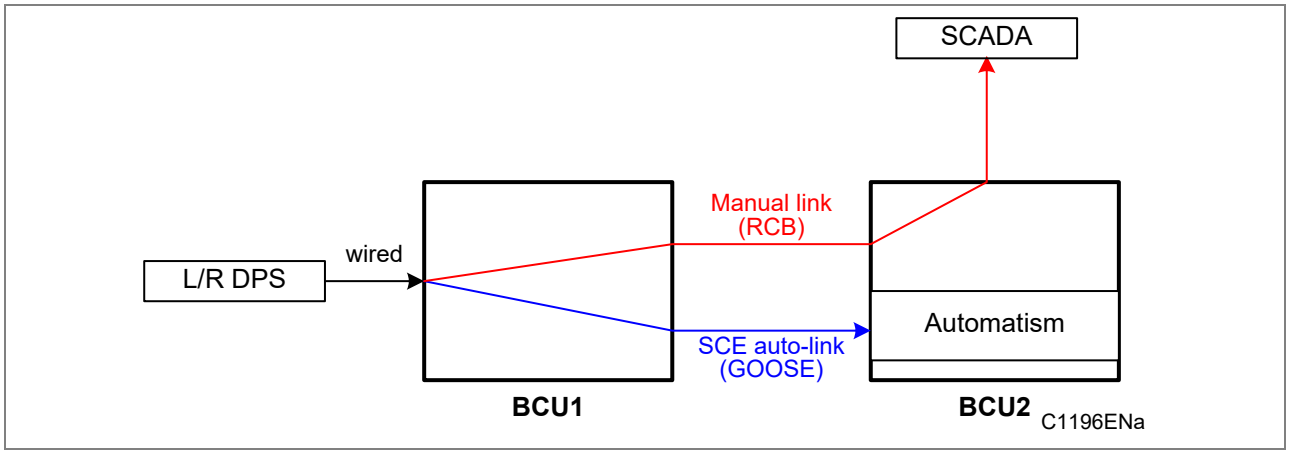


Figure 124: Transmission of a datapoint to a SCADA via a BCU to which it is sent by GOOSE by default (example for Local/Remote SPS datapoint)

3.8 DEFINING THE MANAGEMENT OF WAVEFORM RECORDS

The C26x units manage two types of wave recording files:

- IED connected to C26x legacy network can produce disturbance files. In that case, C26x monitors their availability. As soon as available, they are uploaded and stored at C26x level. The C26x computes for System Management Tool (SMT) a real-time data on a per IED basis that gives the availability of a disturbance file, via station-bus network. Then, SMT downloads it from C26x. At the end of successful downloading, C26x erases the real-time data of availability.
- Via a CT/VT board (TMU220), the C26x can manage its own waveform record files. Waveform channels are directly acquired on CT/VT board channels and buffered. Triggered by pre-defined change of state, associated buffers are flushed on files that correspond to waveform record files. In that case C26x computes for SMT a real-time data that gives the availability of a C26x waveform record file, via station-bus network.

3.8.1 DEFINING THE MANAGEMENT OF IED DISTURBANCE RECORDS

Allowing C26x to manage IED disturbance is done at IED configuration level by:

- Setting its 'automatic disturbance' attribute to yes.
- Adding the system SPS datapoint 'DREC ready' at IED level, linked to a pre-defined datapoint profile.
- Fill the mandatory IEC address for this datapoint.

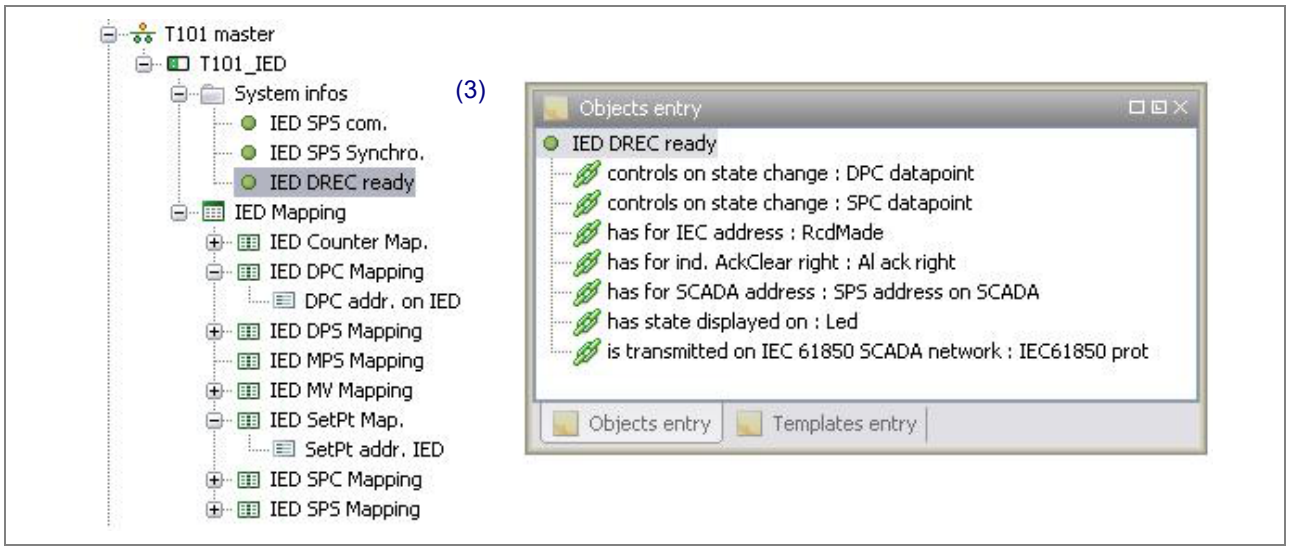


Figure 125: Setting the IEC 61850 address of an IED's DREC Ready datapoint

For T103 IEDs, extra information must be configured to process correct disturbance file COMTRADE structure at C26x level (see following section).

3.8.2 DEFINING T103 IED EXTRA INFORMATION FOR DISTURBANCE RECORDS

T103 extra information for disturbance files is located at the T103 acquisition type and concerns the definition of analog/digital channels, stored in disturbance files, relatively to the COMTRADE format.

3.8.2.1 ADDING AN ANALOG CHANNEL

To add an analog channel definition under a T103 network, select the T103 acquisition type level and add an analog channel from the contextual Objects entry window. Up to 15 analog channels can be created under a T103 acquisition type.

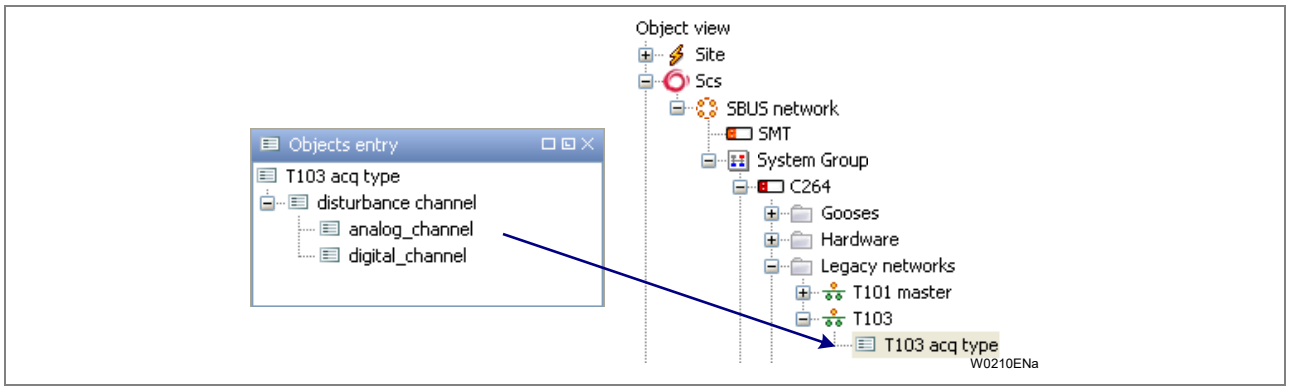


Figure 82: Adding a T103 analog channel

Once added, analog channel definition attributes must be set at SCE level:

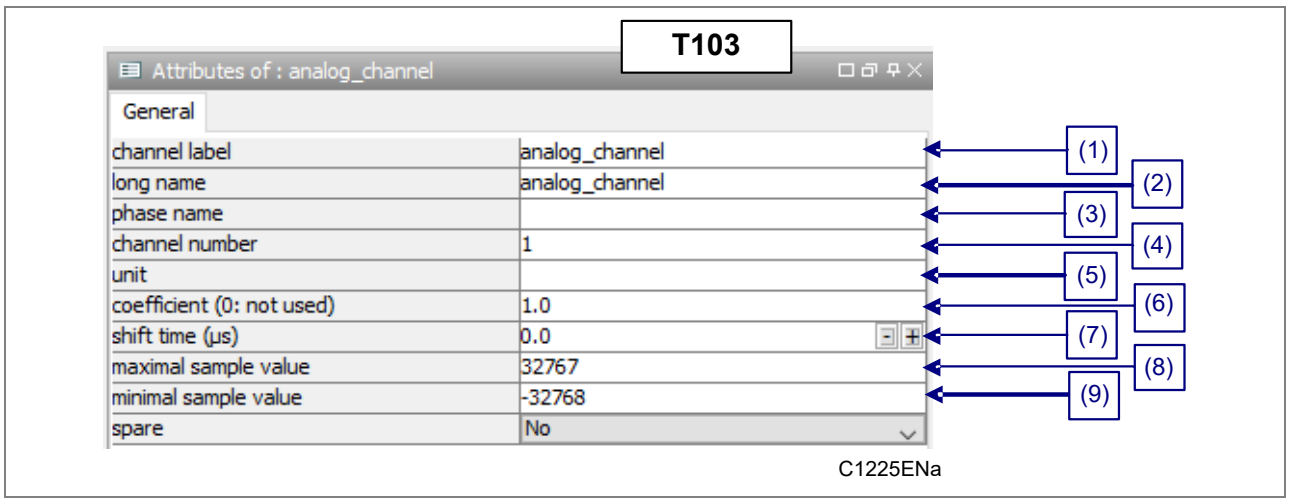


Figure 82: Setting a T103 analog channel

(1) channel label

(2) long name of the channel used for internal SCE identification

(3) phase name: label of the phase corresponding to the channel

(4) channel number: (cf. mapping IED– field ACC in IEC 60870-5-103 documentation)

(5) unit: unit corresponding to the channel

(6) coefficient (0: not used): value which the samples must be multiplied by in order to get the real value (0: not used). Generally, data uploaded from IED allows to compute this 'multiply coefficient'. Unfortunately, some IED don't give correct data. In this case, this coefficient must be set here

(7) shift time (range [0 s, 1 s], step 1 µs): elapsed time since the beginning of the sampling period

(8) maximal sample value (range [0 , 32767], step 1)

(9) minimal sample value (range [-32768, 0], step 1)

For details about analog channel definition, refer to COMTRADE (IEEE C37.11) document.

3.8.2.2 ADDING A DIGITAL CHANNEL

To add a digital channel definition under a T103 network, select the T103 acquisition type level and add a digital channel from the contextual Objects entry window. Up to 255 digital channels can be created under a T103 acquisition type.

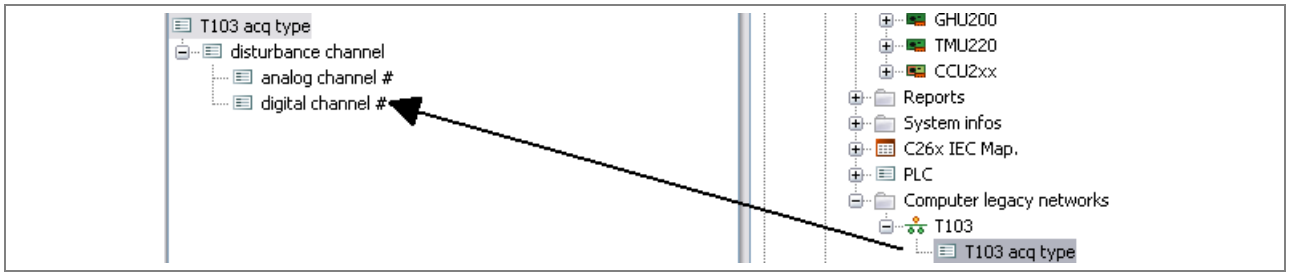


Figure 84: Adding a T103 digital channel

Once added, channel definition attributes must be set at SCE level:

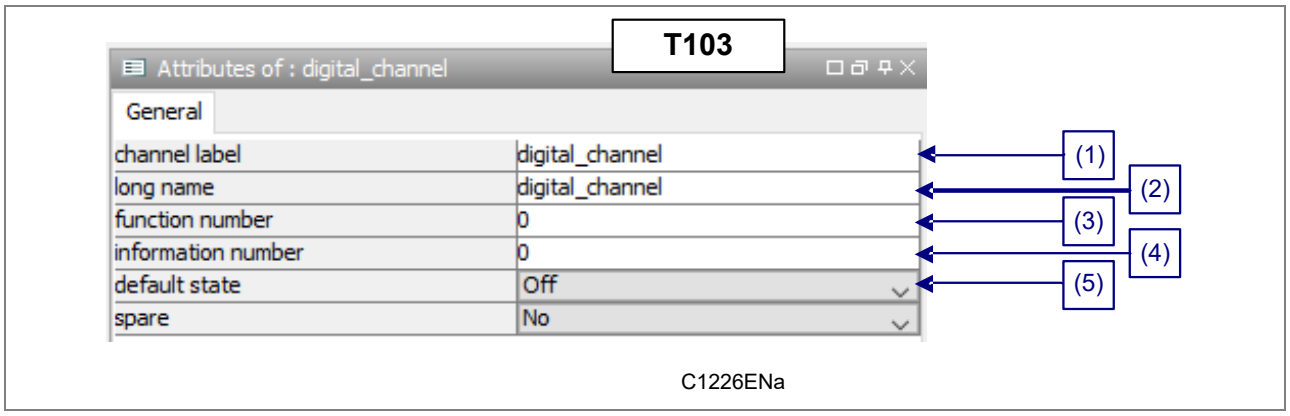


Figure 85: Setting a T103 digital channel

(1) **channel label**

(2) **long name** of the channel used for internal SCE identification

(3) **function number** (range [0 , 255], step 1): corresponds to function type of the channel in T103 protocol

(4) **information number** (range [0 , 255], step 1): corresponds to information number of the channel in T103 protocol

(5) **default state** (Off / On)

For details about digital channel definition, refer to COMTRADE (IEEE C37.11) document.

3.8.3 DEFINING THE MANAGEMENT OF WAVEFORM RECORDS ACQUIRED VIA THE C26X'S CT/VT BOARD

Allow the C26x to manage its own wave record file at C26x configuration level by:

- defining a fast and/or slow waveform recording (see following sections):
  - fast waveform recording gives access to samples acquired via the CT/VT board.
  - slow waveform recording gives access to analogue (MV) and digital values (SPS, DPS, SPC, DPC) file recording.
- adding the system SPS datapoint 'DREC ready' (1) at C26x level, linked to a pre-defined datapoint profile.

The RDRE brick (2) for the C26x in LD0 logical device of the IEC 61850 mapping of the C26x and the address (3) are added automatically.

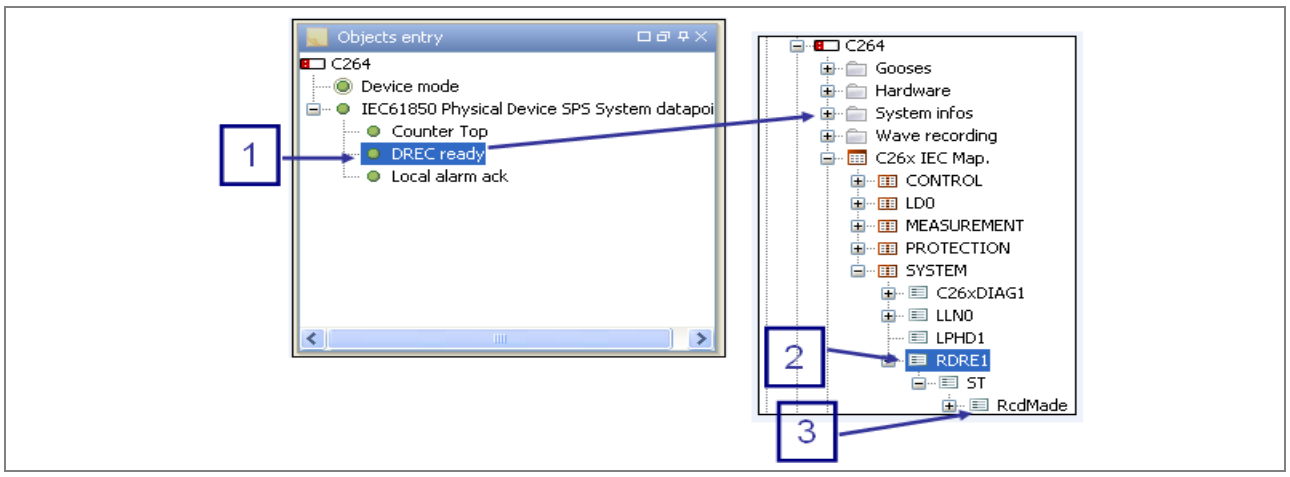


Figure 126: RDRE IEC 61850 brick and its address

3.8.3.1 DEFINING FAST WAVEFORM RECORDING

The “Fast Waveform" feature records data relating to datapoint state changes and Current and Voltage information from the TMU2xx boards or Sample values into a **COMTRADE** format (Common Format for Transient Data Exchange).

Recording can be triggered by the state of datapoint or by the threshold of measurement.

The waveform recorder can be triggered by the following events, each of which is user-configurable:

- Changes in state of binary inputs (SPS or DPS datapoint)
- Changes in state of digital outputs (SPC or DPC datapoint)
- Measurement threshold violations (MV datapoint)
- Operator request

Only one re-trigger is allowed: it means that a new trigger can only be accepted after the end of recording of the current waveform.

For in-depth description of Fast Waveform, see the **Function description** chapter of the C264 user manual.

3.8.3.1.1 Adding a Fast Waveform

To add fast waveform recording to a C26x, select the C26x and from the contextual **Objects entry** window click on **Wave recording > Fast recorder**.

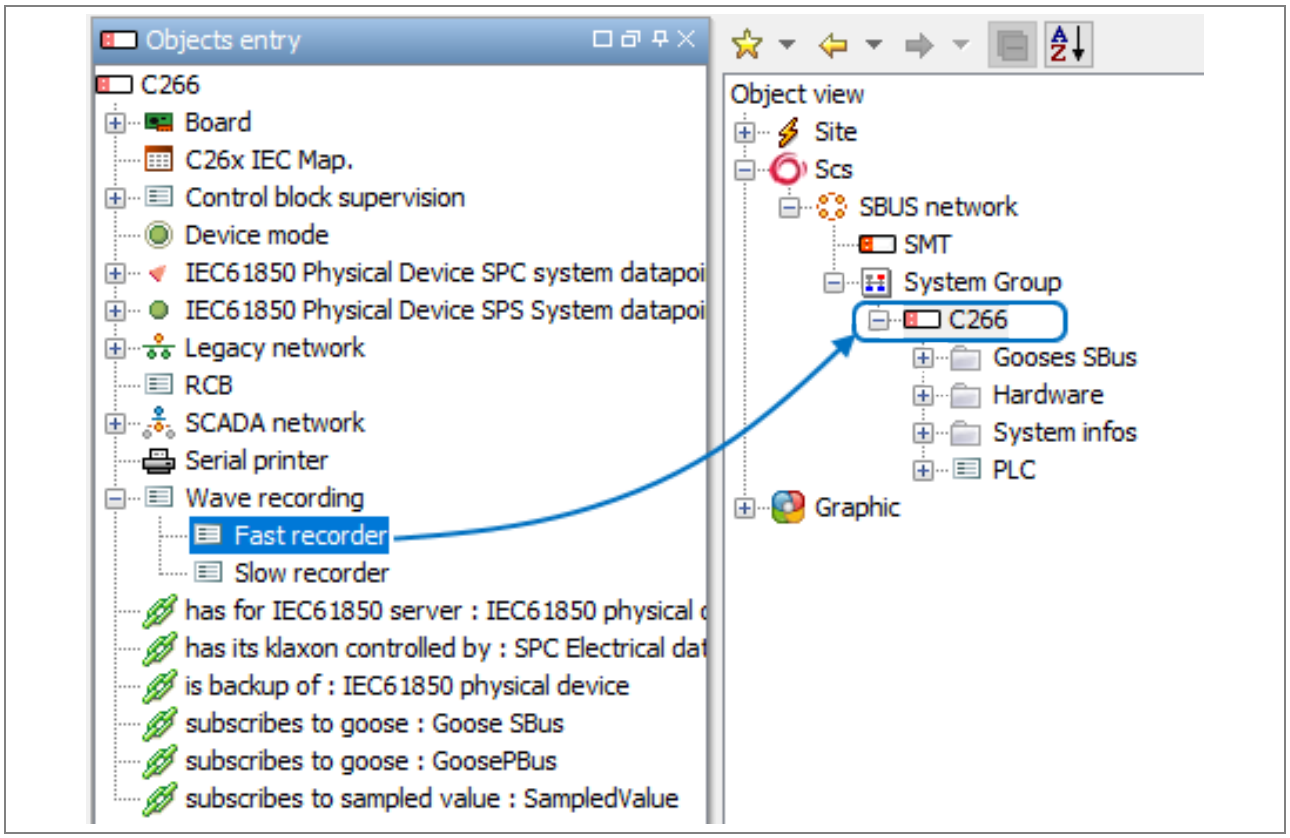


Figure 127: Adding a fast waveform recording

Once added, fast waveform recording attributes must be set at SCE level:

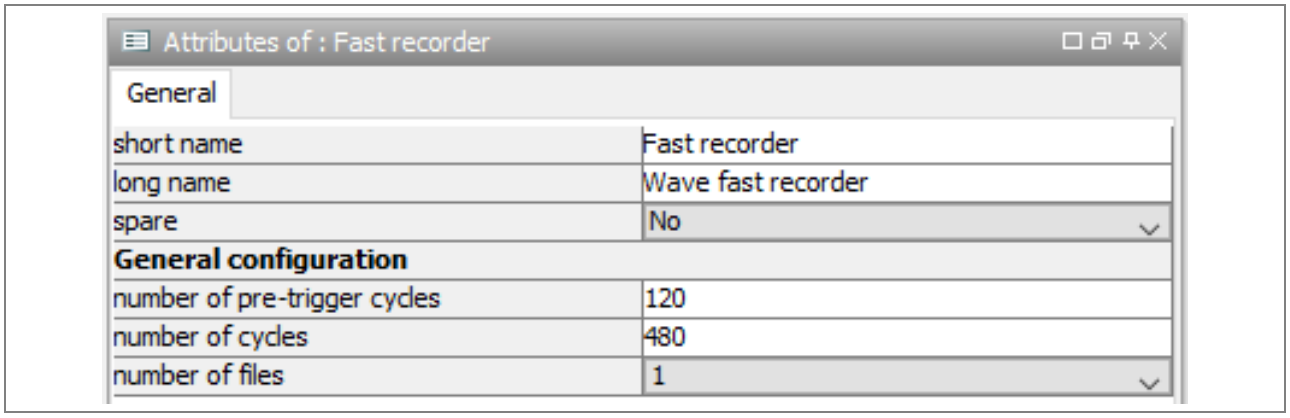


Figure 128: Setting a fast waveform recording

(1) **short name** and **long name**: used for internal SCE identification

(2) **Number of pre-trigger cycles** (range 1, 477): number of cycles (up to 477), that are stored before triggering

(3) **number of cycles** (range [1 , 480]): Total number of recorded cycles (1 cycle = 1 record)

(4) **number of files** (1 / 2 / 3 / 4 / 5): Maximum number of files that can be created

Then, fill in the mandatory relation link "**is used by**" with the corresponding bay.

The maximum number of "**Fast recorder**" per C264 depends on the BCU configuration:

- If an electrical bay uses 1 TMU2xx board or 1 SV group, the maximum number is 2,
- If an electrical bay uses 1 TMU210 board and 1 TMU220 board, the maximum number is 1,
- If an electrical bay uses 1 SV Group of Protection type and 1 SV Group of Measurement type, the maximum number is 1.

Trigger

A "**Fast recorder**" has several optional relation links "**has for trigger**" with different electrical datapoints types such as SPS, DPS, SPC, DPC and MV which act as trigger of recording.

To define the triggers of a fast waveform recording:

1 Select the **Fast recorder** and add the relevant relation "**has for trigger**"

2 Fill in the relation with proper datapoint. Be careful, only datapoints acquired on the C26x can be defined as input of its fast waveform recording.

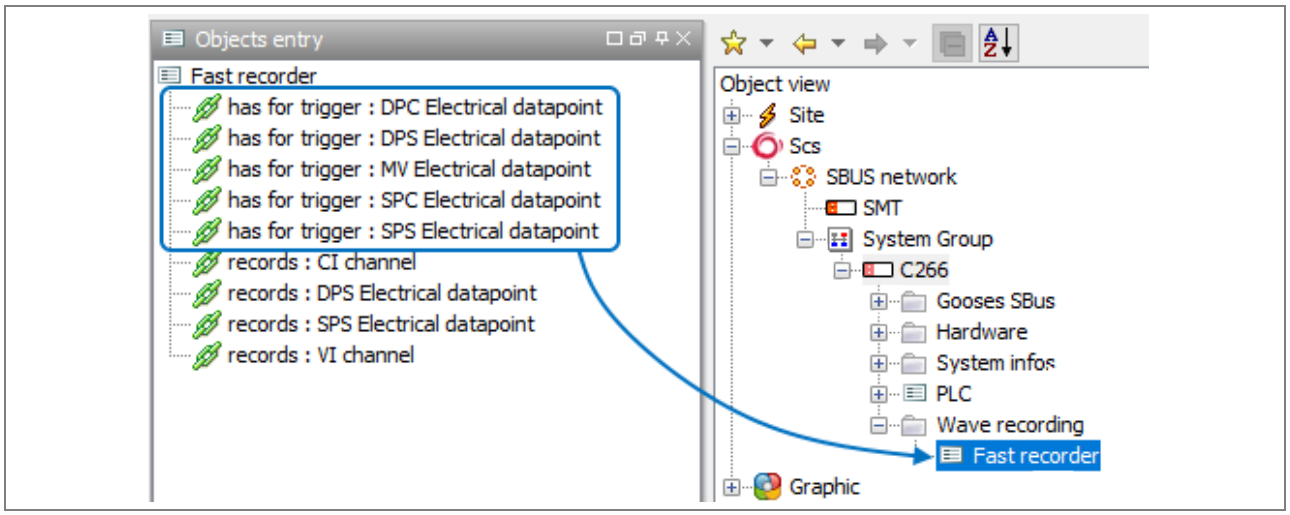
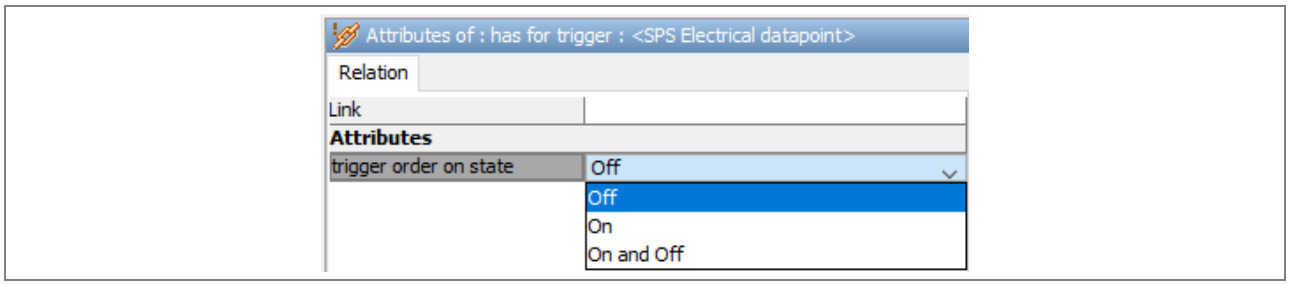


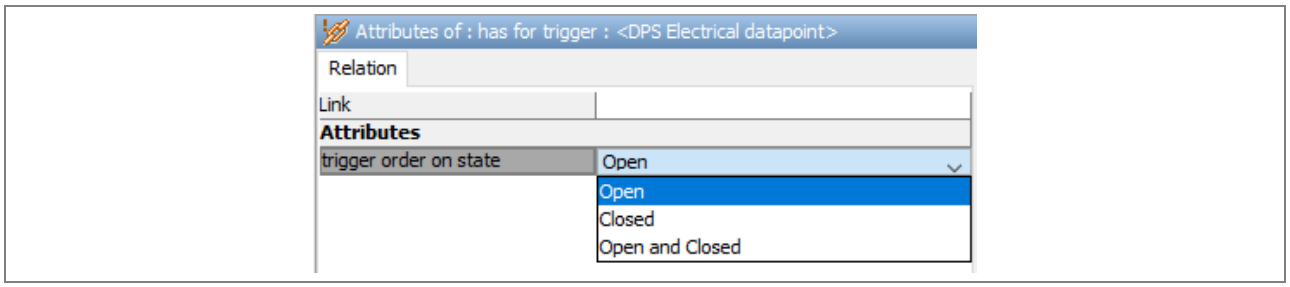
Figure 129: Defining triggers for fast waveform recording

Depending on the datapoint type, extra attributes must be set for **has for trigger** relation. These attributes give the datapoint states (or thresholds for MV) that trigger the record:

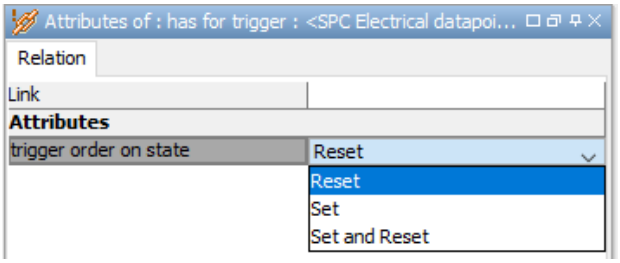
- The "**trigger order on state**" attribute of the relation link "**has for trigger**" to **SPS** datapoint allows to define the state of the datapoint used to trigger the recorder (Off / On / On and Off):



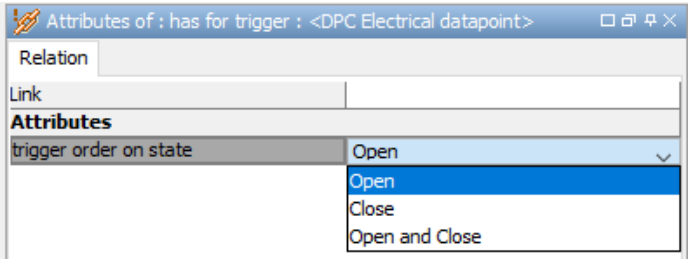
- The "**trigger order on state**" attribute of the relation link "**has for trigger**" to **DPS** datapoint allows to define the state of the datapoint used to trigger the recorder (Open / Closed / Open and Closed):



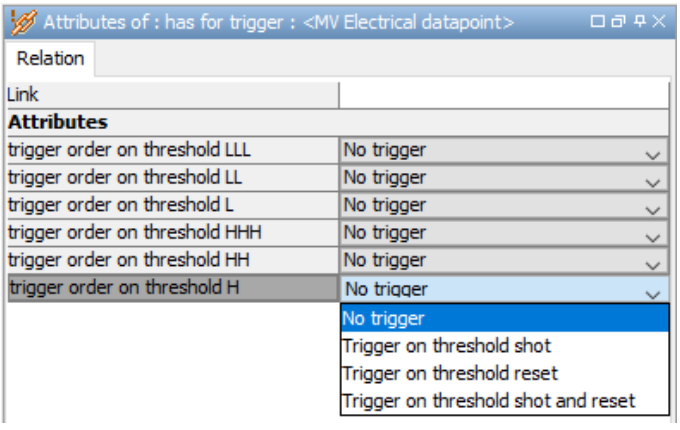
- The “**trigger order on state**” attribute of the relation link "**has for trigger**" to **SPC** datapoint allows to define the state of the datapoint used to trigger the recorder (Reset / Set / Set and Reset):



- The “**trigger order on state**” attribute of the relation link "**has for trigger**" to **DPC** datapoint allows to define the state of the datapoint used to trigger the recorder (Open / Close / Open and Close):



- The “**trigger order on state**” attribute of the relation link "**has for trigger**" to **MV** datapoint allows to define the measurement threshold used to trigger the recorder (*No trigger / Trigger on threshold shot / Trigger on threshold reset / Trigger on threshold shot and reset*)



Inputs

To define the inputs of a fast waveform recording, select the **fast recorder**, add the relevant relation “**records**” and fill in the proper CT/VT channel or datapoint. Be careful, only CT/VT channels and datapoints acquired on the C26x can be defined as inputs of its fast waveform recording:

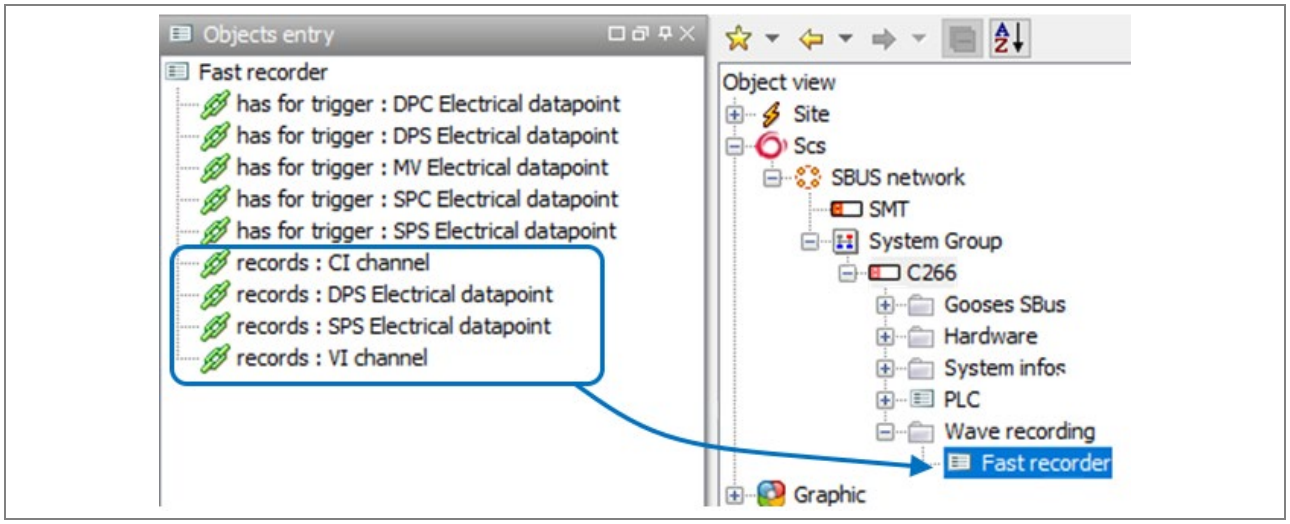


Figure 130: Defining inputs for fast waveform recording

A "**Fast recorder**" of waveform can record **until 128** SPS and/or DPS.
All these SPS, DPS belong to bays managed by the computer having this "Fast recorder".

A "**Fast recorder**" of waveform can record until 10 analogues channels. All these analogues belong to the bay managed by the computer having this "Fast recorder".

The number of "**Fast recorder**" can be configured per C264 as described in previous section **3.8.3.1.1 Adding a Fast Waveform**.

Configuration rules and checks

- The following constraints between the attributes must be respected:
  - "pre-trigger cycle" ≤ "total cycles"
  - "number of files" ∗ "total cycles" ≤ 480 cycles

3.8.3.2 DEFINING SLOW WAVEFORM RECORDING

A slow waveform recorder of a C264 (BCU) may be used to record data relative to datapoint state changes.

Recording can be triggered by the state of datapoint or by the threshold of measurement.

The inputs for the slow waveform records are:

- MV datapoint coming from CT VT computation.
- MV datapoint coming from AIU boards.
- SPS or DPS datapoints.
- SPC or DPC datapoints.

The slow wave form manages up to 24 analogues (MV) and 48 digital values (SPS, DPS, SPC, DPC).
DS Agile C26x stores at most 5000 integrated values as follows:

Number of Files	Number of integrated values
1	5000
2	2500
5	1000
10	500
20	250
50	100

The integrated value has a duration of up to one hour. It is defined in configuration.

For analogue samples, the stored value is the average value of the signal during the integration time.

In order for the value to be 1, the signal must remain at 1 for at least the duration of the arbitration period, if it drops off before, the value will be 0.

The slow waveform recorder can be triggered by the following events, each of which is user configurable:

- Changes in state of binary inputs (SPS or DPS datapoint)
- Changes in state of digital outputs (SPC or DPC datapoint)
- Measurement threshold violations (MV datapoint)
- Operator request (controls)

To add slow waveform recording to a C26x, select the C26x level and add a **Wave slow record** field from the contextual **Objects entry** window. Only one slow waveform recording item can be created under a C26x.

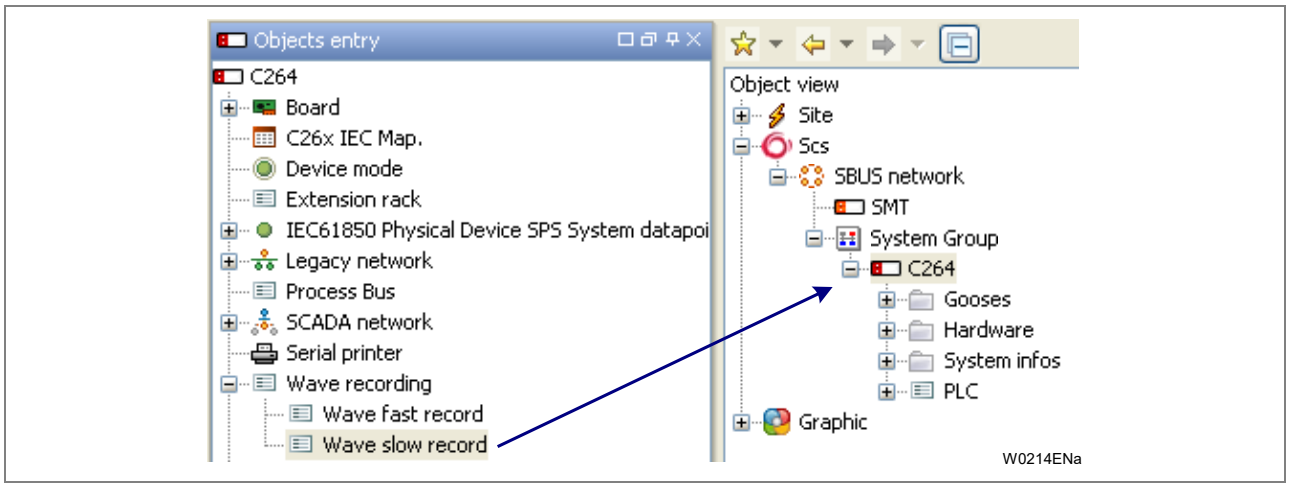


Figure 131: Adding a slow waveform recording

Once added, slow waveform recording attributes must be set at SCE level:

(1) **short name** and **long name** of the recording used for internal SCE identification

(2) **pre-trigger cycle** (range [1, 4998], step 1): number of records that are stored before triggering

(3) **total records** (range [20 , 5000], step 1): see previous description

(4) **number of files** (1 / 2 / 5 / 10 / 20 / 50): see previous description

(5) **arbitration period** (range [10, 100], step 1): percentage of time during which the logical data must be set to 1 to consider the integrated data set to 1

(6) **integration time** (range [1, 216000], step 1): number of cycles (see before)
- [1, 180000] for a power system frequency of 50 Hz
- [1, 216000] for a power system frequency of 60 Hz
(for power system frequency configuration, see section *3.2.3*)

(7) **activation period** (Non periodic/Daily trigger/weekly trigger/Daily & weekly trigger; daily: time 0 to 23:00 when the record starts, weekly: day and time

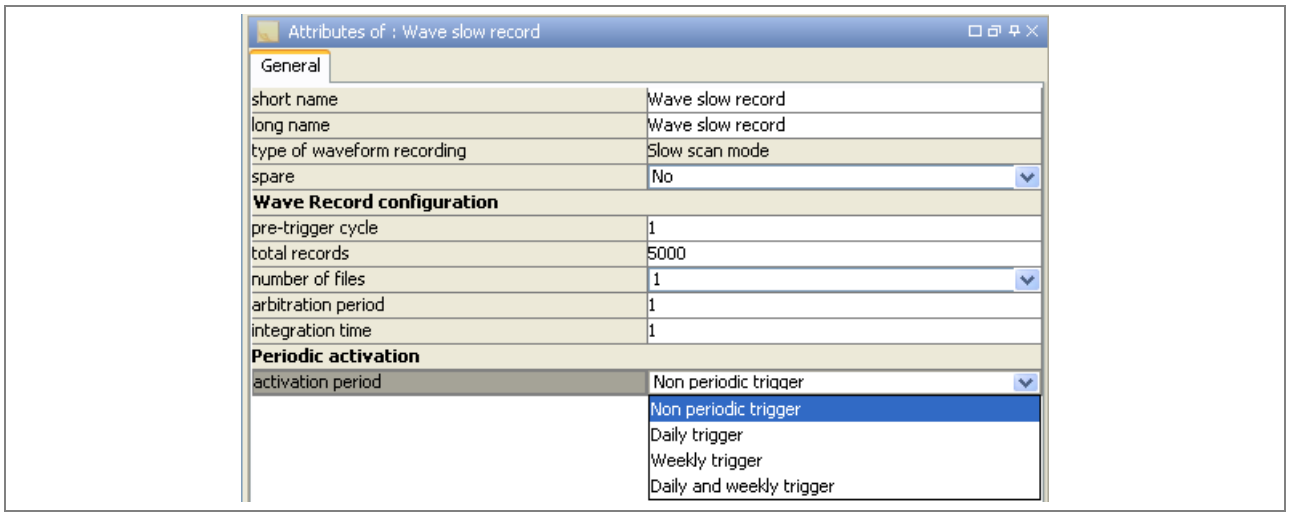


Figure 132: Setting a slow waveform recording

To define the inputs of a slow waveform recording, select the recording level, add the relevant relation (1) and fill in the relation with proper datapoint. Be careful, only datapoints acquired on the C26x can be defined as inputs of its slow waveform recording.

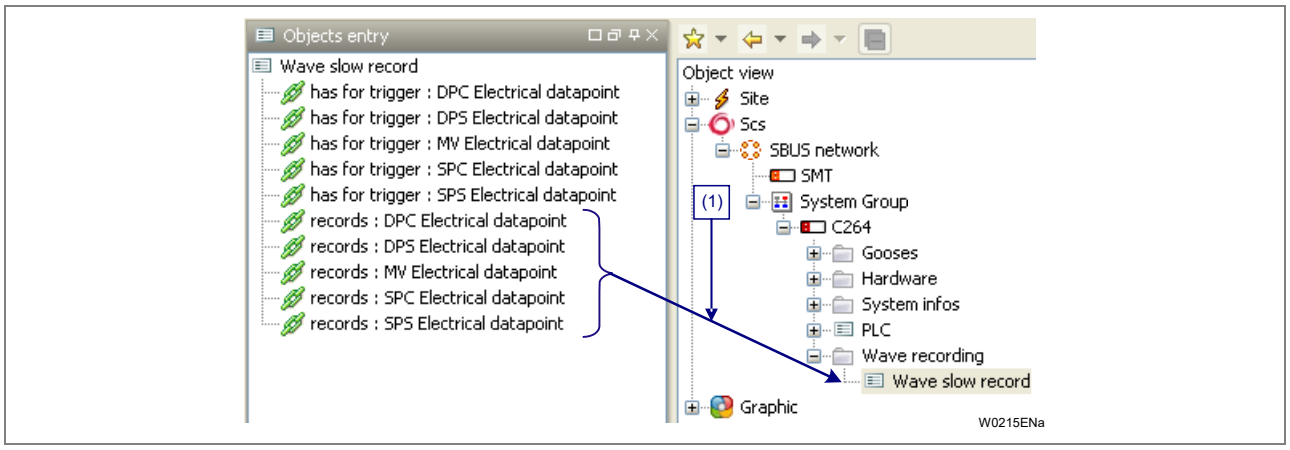


Figure 133: Defining inputs for slow waveform recording

To define the datapoint-triggers of a slow waveform recording, select the recording level, add the relevant relation (2) and fill in the relation with proper datapoint. Be careful, only datapoints acquired on the C26x can be defined as inputs of its slow waveform recording. A slow waveform can be configured without any datapoint-trigger, if a daily or weekly activation period has been defined for it.

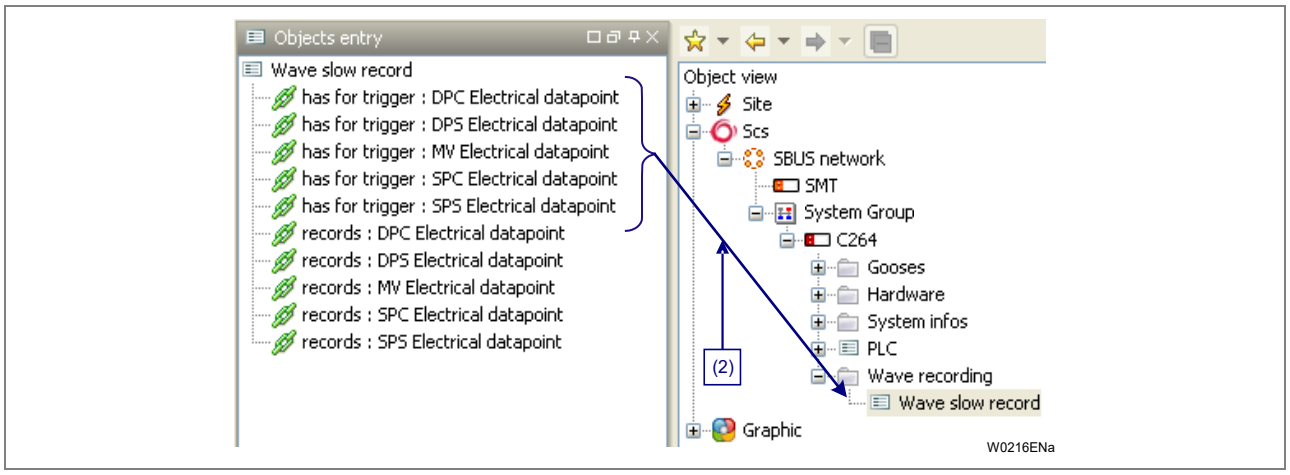


Figure 134: Defining triggers for slow waveform recording

Depending on the datapoint type, extra attributes must be set to a **has for trigger** relation. These attributes give the datapoint states (or thresholds for MV) that trigger recording (see following figure). The Link attribute is automatically filled.

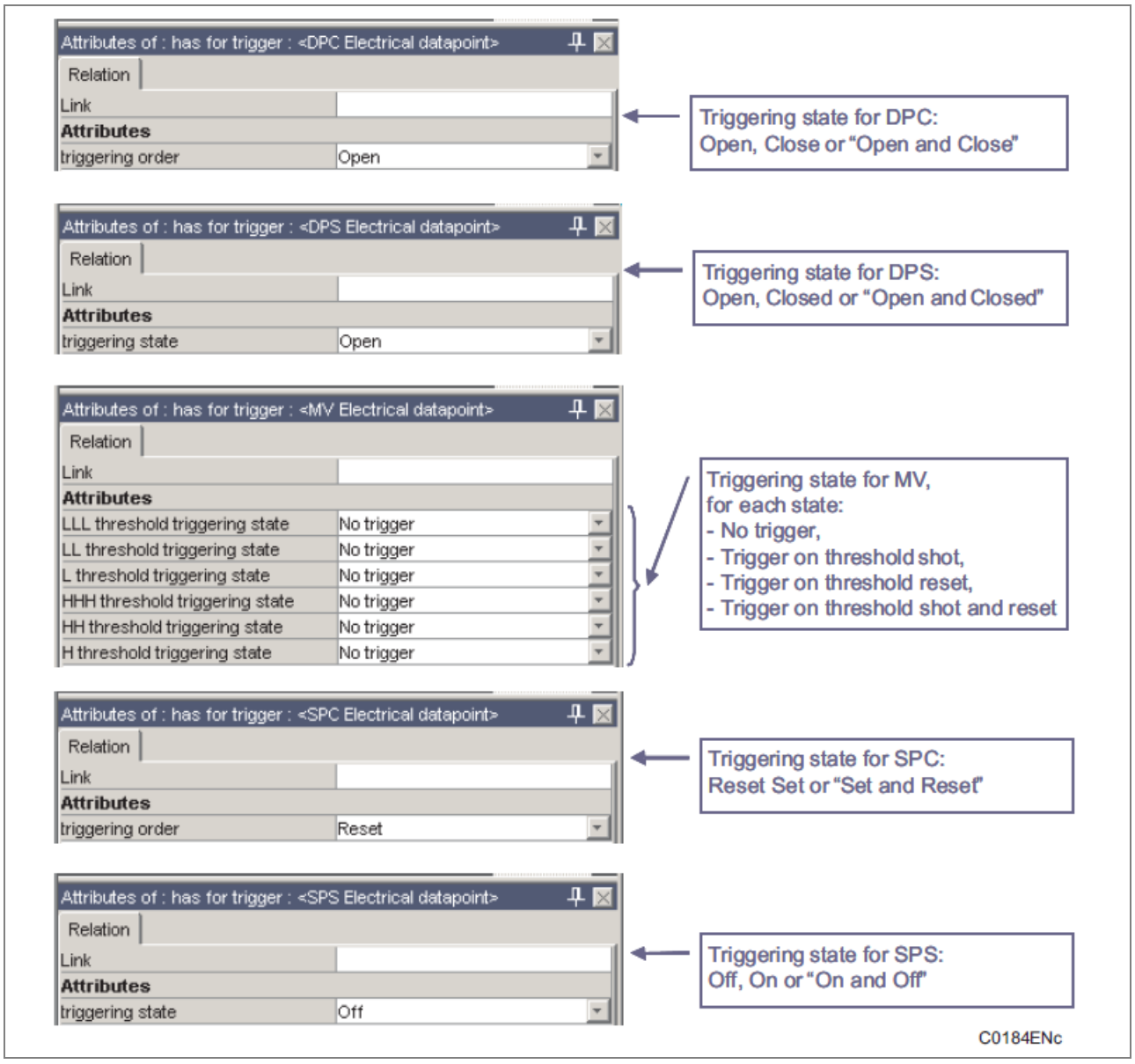


Figure 135: Defining triggers conditions for slow waveform recording

Configuration rules and checks

- The following constraints between the attributes must be respected:
  - "pre-trigger cycle" < "total records"
  - "number of files" ∗ "total records" ≤ 5000 records
- If "electrical frequency" ≡ 50 Hz:
  - The "integration time" value must be in the range [1..180000].
  - If the "integration time" value is > 5, then NO DPC, SPC, DPS, SPS recording is allowed.
- If "electrical frequency" ≡ 60 Hz:
  - The "integration time" value must be in the range [1..216000].
  - If the "integration time" value is > 6, then NO DPC, SPC, DPS, SPS recording is allowed.

3.9 DEFINING A C26X KLAXON

A C26x can manage up to one external klaxon, that is started as soon as an audible local alarm is raised on C26x (to define audible alarm see section *4 Defining a datapoint*). The external klaxon is managed by a specific SPC datapoint wired on the C26x ('ON' command starts the klaxon, 'OFF' command stops it).

To define an external klaxon at C26x level, just add the relation **has its klaxon managed by** at C26x level and fill it with the relevant SPC.

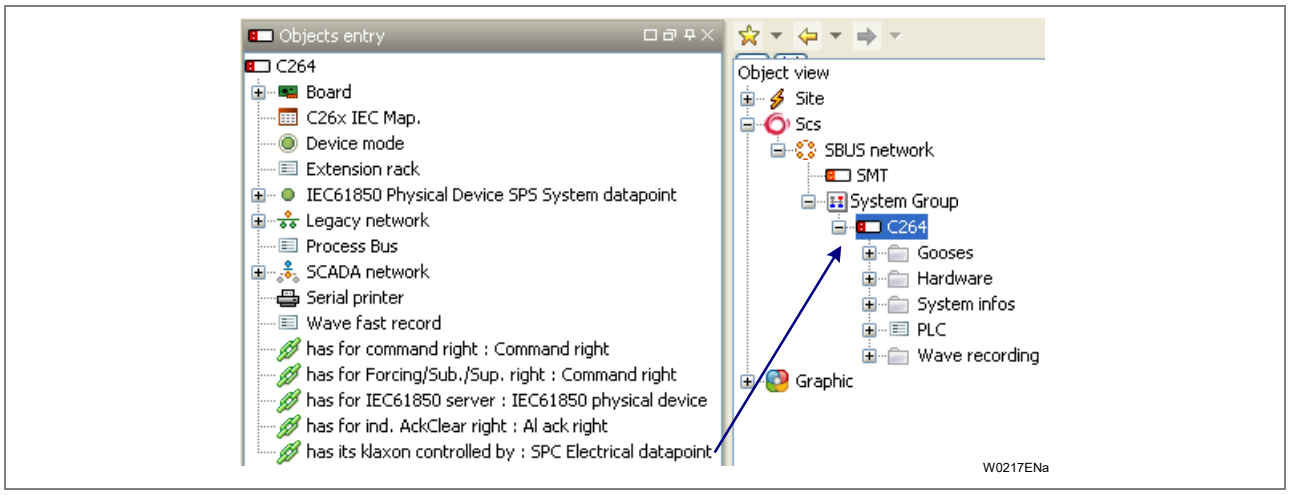


Figure 136: Defining a C26x klaxon

Configuration rules and checks

- The "SPC" link of the relation **has its klaxon controlled by** must be wired on a DO channel of the C26x.

3.10 SETTING SYSTEM INFORMATION FOR C26X COMPONENTS

When creating a C26x, specific datapoints are automatically added in 'system infos' folder (1) at C26x level or PLC sub-component, as for instance, when adding a board (2)an IED on legacy network (3) or a SCADA network (5) attached to a C26x. In that case, the 'system infos' folder is located under the relevant added object.

For extra C26x functionalities (wave recording, redundancy) some optional datapoints can be required.

SCE calls such 'system infos' datapoints, system datapoints.

System datapoints provide real-time statuses and controls on system software or hardware components, and generally can not be wired on board channels except for redundancy function.

As datapoint, system datapoints must be linked to a profile. For details about datapoint and datapoint profile configuration, see section *4 Defining a datapoint*). Depending on its type, the system datapoint and its relevant profile have specific attributes to be set correctly to ensure a healthy behaviour from the C26x. Below are listed the datapoint and profile requirements for each type of system datapoint.

Generally, system datapoints are automatically addressed in IEC 61850 mapping of the relevant C26x at their creation. If manual addressing is necessary, it is indicated in following sections by giving the associated available data object for a given C26x brick in LD0 (⇔<brick name>.<data object name>). For details about SBUS addressing, see section *3.5 Networking a C26x on the station-bus network.*

3.10.1 SETTING GENERAL SYSTEM INFORMATION OF A C26X

At C26x creation, the mandatory datapoints are implicitly added. They are shown below in alphabetical order:

Name	Type	Description
All AIU status	All AIU status	All AIU status
All AOU status	All AOU status	All AOU status
All CCU status	All CCU status	All CCU status
All DIU status	All DIU status	All DIU status
All DOU status	All DOU status	All DOU status
All DPU status	All DPU status	All DPU status
All HBU status	All HBU status	All HBU status
All IED status	All IED status	All IED status
All Printer stat	All Printer stat	All Printer status
All SVU status	All SVU status	All SVU status
All TMU status	All TMU status	All TMU status
All rack status	All rack status	All rack status
Block mode	Block mode	Block mode
Buffer Overflow	Buffer Overflow	Report buffer overflow
DB incoh. SPS	DB incoh. SPS	DB incoherency SPS
DB switch ctrl	DB switch ctrl	DB switch control
DI acq stopped	DI acq stopped	DI acquisition stopped
DefInstructions	DefInstructions	Default reading saved instructions
Device link	Device link	Device link
Goose bck con. 1	Goose bck con. 1	Goose backup connection state 1
Goose bck con. 2	Goose bck con. 2	Goose backup connection state 2
Goose bck con. 3	Goose bck con. 3	Goose backup connection state 3
Goose bck con. 4	Goose bck con. 4	Goose backup connection state 4
Goose bck con. 5	Goose bck con. 5	Goose backup connection state 5
Goose bck con. 6	Goose bck con. 6	Goose backup connection state 6
Goose bck con. 7	Goose bck con. 7	Goose backup connection state 7
Goose bck con. 8	Goose bck con. 8	Goose backup connection state 8
Goose bck sel. 1	Goose bck sel. 1	Goose backup selection state 1
Goose bck sel. 2	Goose bck sel. 2	Goose backup selection state 2
Goose bck sel. 3	Goose bck sel. 3	Goose backup selection state 3
Goose bck sel. 4	Goose bck sel. 4	Goose backup selection state 4
Goose bck sel. 5	Goose bck sel. 5	Goose backup selection state 5
Goose bck sel. 6	Goose bck sel. 6	Goose backup selection state 6
Goose bck sel. 7	Goose bck sel. 7	Goose backup selection state 7
Goose bck sel. 8	Goose bck sel. 8	Goose backup selection state 8
Goose con. 1	Goose con. 1	Goose connection state 1
Goose con. 2	Goose con. 2	Goose connection state 2
Goose con. 3	Goose con. 3	Goose connection state 3
Goose con. 4	Goose con. 4	Goose connection state 4
Goose con. 5	Goose con. 5	Goose connection state 5
Goose con. 6	Goose con. 6	Goose connection state 6
Goose con. 7	Goose con. 7	Goose connection state 7
Goose con. 8	Goose con. 8	Goose connection state 8
Goose sel. 1	Goose sel. 1	Goose selection state 1
Goose sel. 2	Goose sel. 2	Goose selection state 2
Goose sel. 3	Goose sel. 3	Goose selection state 3
Goose sel. 4	Goose sel. 4	Goose selection state 4
Goose sel. 5	Goose sel. 5	Goose selection state 5
Goose sel. 6	Goose sel. 6	Goose selection state 6
Goose sel. 7	Goose sel. 7	Goose selection state 7
Goose sel. 8	Goose sel. 8	Goose selection state 8

Figure 137: Mandatory System infos datapoints for a C26x 1/2

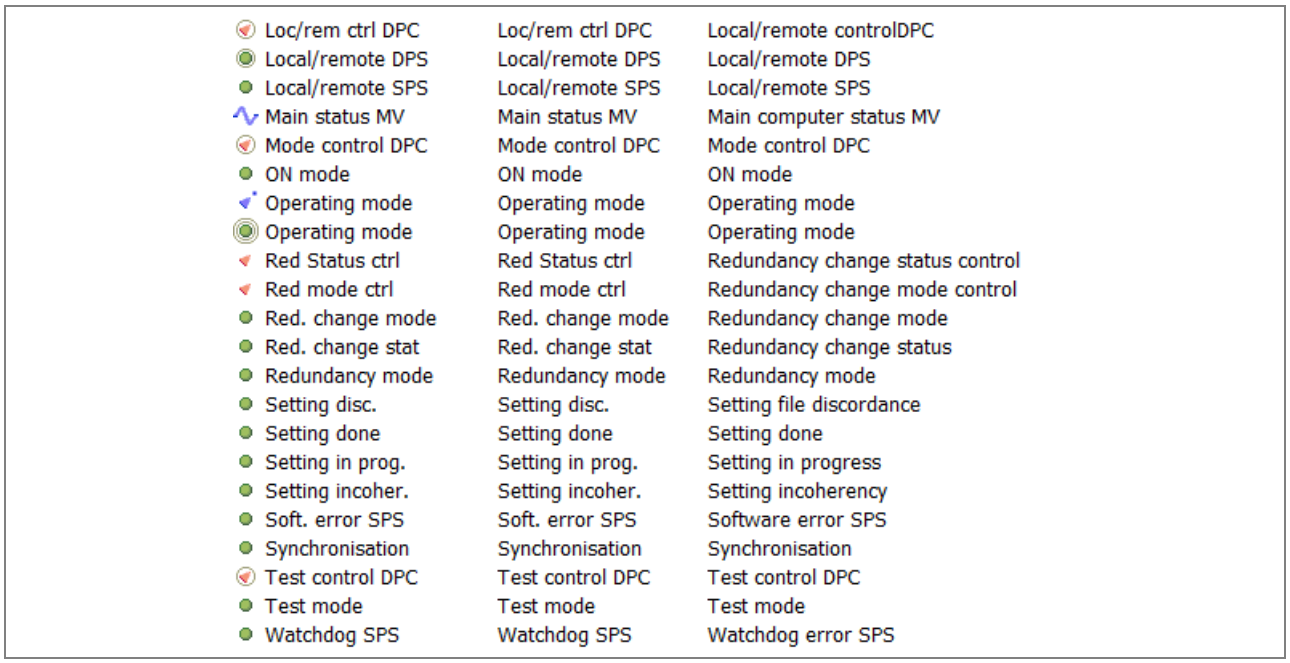


Figure 138: Mandatory System infos datapoints for a C26x 2/2

These datapoints must be configured (see section *4*) according to their described features; the manager of the datapoint is mentioned whenever it is different from the C26x itself.

Type	Manager	Datapoint	States	IEC address
Health		All [board] status	RESET: Board type not OK (for multirack, not available with system version 7.0.0)	SBUS auto
		DI acq stopped	RESET: Acquisition running SET: Acquisition stopped due to saturation	SBUS automatic
		Soft error SPS	RESET: Software running SET: Software error **	no
		Watchdog SPS	RESET: Watchdog OK SET: Expired time-out **	no
		ISaGRAF status	STATE 0: ISaGRAF is running normally STATE 1: Not activated STATE 2: Cycle too long STATE 3: Queue overflow STATE 4: Program Organization Unit faulty	SBUS automatic
	IEC clients	Device link	RESET:IEC real time link with C26x not OK	no
		Main status MV	VALID: Main C26x between min-max high-low	SBUS automatic
		Synchronisation	RESET: Device out of synchronisation SET: Synchronised device	SBUS automatic
Buffer report overflow		Buffer overflow	RESET: No report buffer overflow SET: Buffer report overflow	SBUS automatic
Database management		DB incoh. SPS	RESET: Coherent database SET: Incoherent database *	no
	SMT	DB switch ctrl	ON: Switchover to standby database ***	no
Local/ Remote		Loc/rem ctrl DPC	OPEN: Remote mode CLOSE: Local mode	no

Type	Manager	Datapoint	States	IEC address
		Local/remote ctrl DPS	OPEN: Remote mode CLOSED: Local mode	SBUS automatic
		Local/remote ctrl SPS	RESET: Remote mode (all DPSs are open) SET: Local mode (at least one DPS closed)	SBUS automatic
Operating mode	SMT	Mode control DPC	OPEN: Maintenance mode CLOSE: Operational/Run mode	SBUS automatic
		Operating mode	STATE 0: Faulty mode STATE 1: Operational mode STATE 3: Test/blocked mode (single C26x)/Test mode (redundant C26x) STATE 5: Maintenance mode	SBUS automatic
		Block mode	SET: Operating mode is ON.BLOCK or TEST.BLOCK	no
		ON mode	SET: Operating mode is ON or ON.BLOCK	No
		Test mode	SET: Operating mode is TEST or TEST.BLOCK	no
	SMT	Test control DPC	OPEN: Test mode CLOSE: Normal mode	no
Redundancy		Red mode ctrl	ON: Active mode indication (DO1)	no
		Red status ctrl	ON: Network connection indication (DO2)	no
		Red. change mode	RESET: Active mode indication (DI1)	no
		Red. change stat	RESET: Network connection indication (DI2)	no
		Redundancy mode	RESET: Active mode indication to SCADA	SBUS automatic
Settings (MiCOM S1)		Setting disc.	SET: Discordance of value, format …	
		Setting done	SET: Transfer with MiCOM S1 completed	SBUS automatic
		Setting in prog.	SET: Transfer C26x-MiCOM S1 in progress	
		Setting incoher.	SET: Incoherency in setting file version	
Process Bus	SCU	Goose con. x	SET: Goose connection state x enabled for main SCU	PBUS manual
		Goose bck con. x	SET: Goose connection x enabled for backup SCU	PBUS manual
		Goose sel. x	SET: Goose selection x enabled for main SCU	PBUS manual
		Goose bck sel. X	SET: Goose selection x enabled for backup SCU	PBUS manual
		DefInstructions	Obsolete	SBUS automatic

the C26x switches to mode * Maintenance, ** Faulty, *** Maintenance or Operational/Run.

At C26x level, the following optional datapoints can be added.

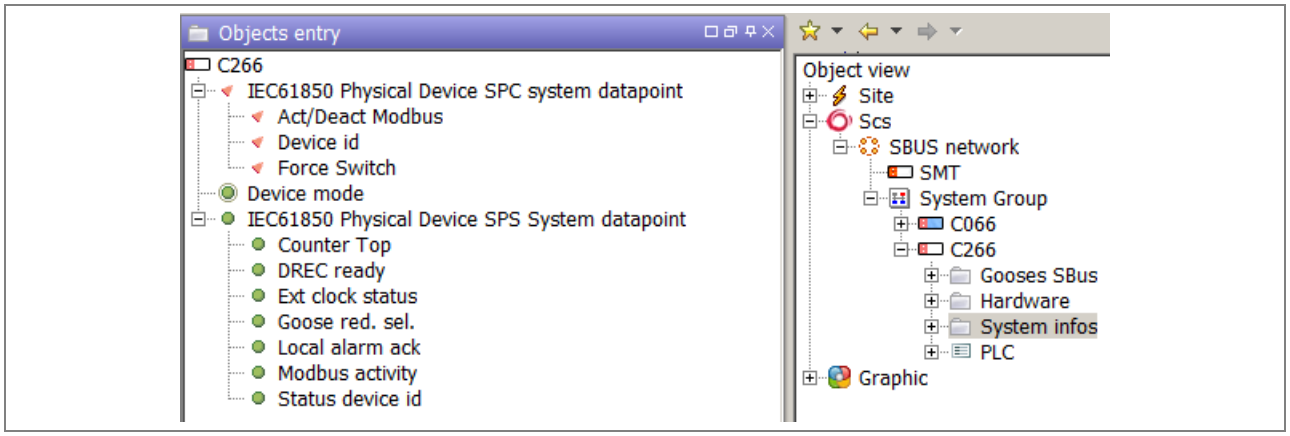


Figure 139: Optional System infos' datapoints for a C26x

These datapoints must be configured (see section *4 Defining a datapoint*) according to their described features:

Datapoint	Description	Application
Act/Deact Modbus SPC	Command to enable/disable the serial Modbus protocol (required if a serial Modbus protocol is present under redundant SCUs)	SCU/BCU
Device id SPC	Command to launch the "LED chaser" on the front panel.	SCU/BCU
Force Switch SPC	Command to force the main/standby switch between redundant BCUs	BCU only
Device mode DPS	OPEN: Maintenance mode CLOSED: Operational mode JAMMED: Test/blocked mode (single C26x)/Test mode (redundant BCU) UNDEFINED: Operational mode	SCU/BCU
Counter Top SPS (generally wired)	RESET: no transmission SET: launch transmission of counter value on IEC & SCADA networks	SCU/BCU
DREC ready SPS	RESET: no waveform record available SET: waveform record file available, see section 3.8	BCU only
Ext clock status SPS	RESET: Time-synchronisation signal present SET: No time-synchronisation signal	BCU/SCU
Goose red. sel. SPS	RESET: the GOOSE published by the "main" SCU is used by the BCU SET: the GOOSE published by the "backup" SCU is used by the BCU	BCU only
Local alarm ack SPS	RESET: no immediate acknowledgement of all the C26x alarms SET: immediate acknowledgement of all the C26x alarms *	BCU/SCU
Modbus activity SPS	Feedback of *Act/Deact Modbus* SPC. RESET: Modbus serial connection on master is disabled SET: Modbus serial connection on master is enabled	SCU/BCU
Status device id SPS	Feedback of *Device id* SPC. RESET: LED chaser inactive SET: LED chaser active	SCU/BCU

* in addition to the Global Alarm Acknowledgement SPS, you can define a Local Alarm Acknowledgment SPS, one for each C26x; it can be wired, managed by an automation or associated with a control. It cannot be transmitted over the Station Bus network, but only used locally. When the Local alarm ack is configured in a C26x, the Global alarm Ack is no more taken into account by this C26x.

3.10.2 SETTING SYSTEM INFORMATION OF BOARD

When creating a board (except CPU board) the following mandatory datapoint is implicitly added.

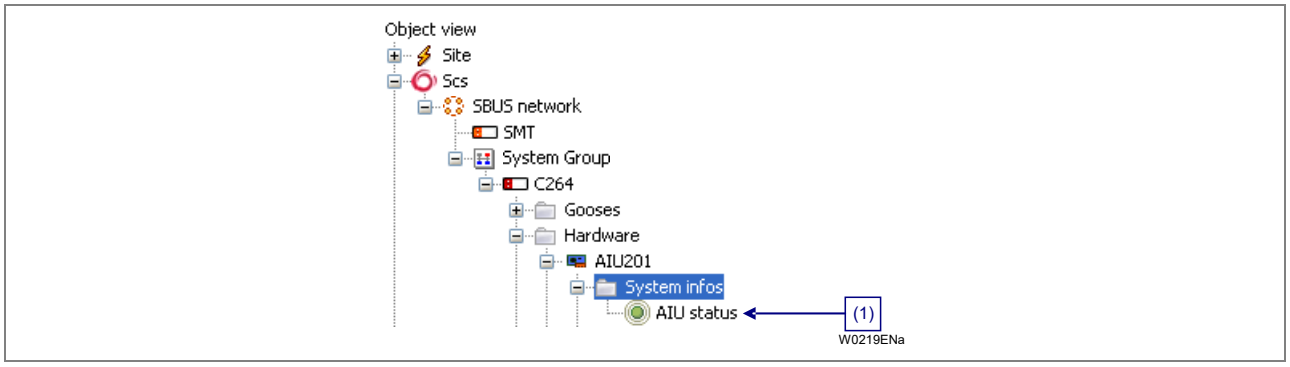


Figure 140: Mandatory System infos datapoint for a board (example for an AIU board)

- **Board status MPS** (1): this datapoint indicates the status of the board. Addressing this datapoint can be done:
  - using SBUS automatic addressing.

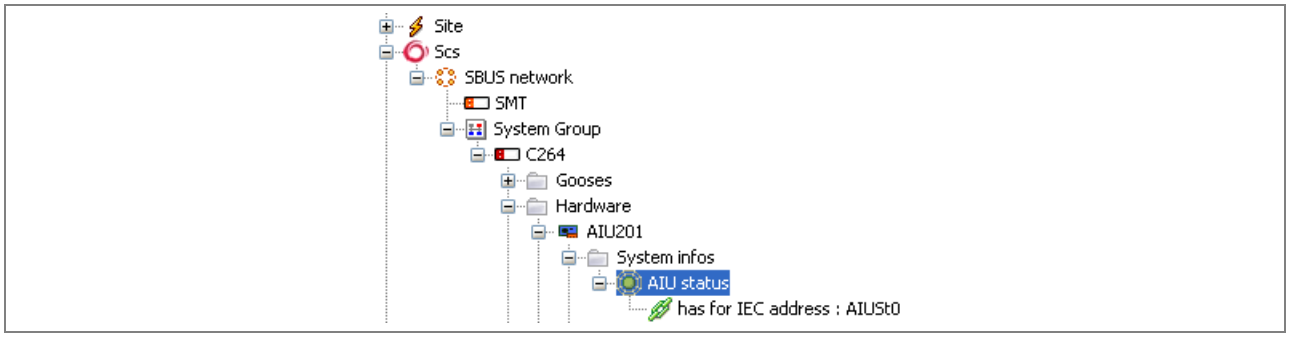


Figure 141: Automatic IEC addressing of a board status datapoint

  - Manually. In that case, the relevant data object given the IEC address of the status, must be coherent with the board number (e.g. if AIU board number is 3, corresponding data object is AIUSt).

    The available states of this datapoint are:

    “STATE 0” for board OK

    “STATE 1” for self-check failure

    “STATE 2” for configured but missing

    “STATE 3” for not configured but present

    “STATE 4” for board not present

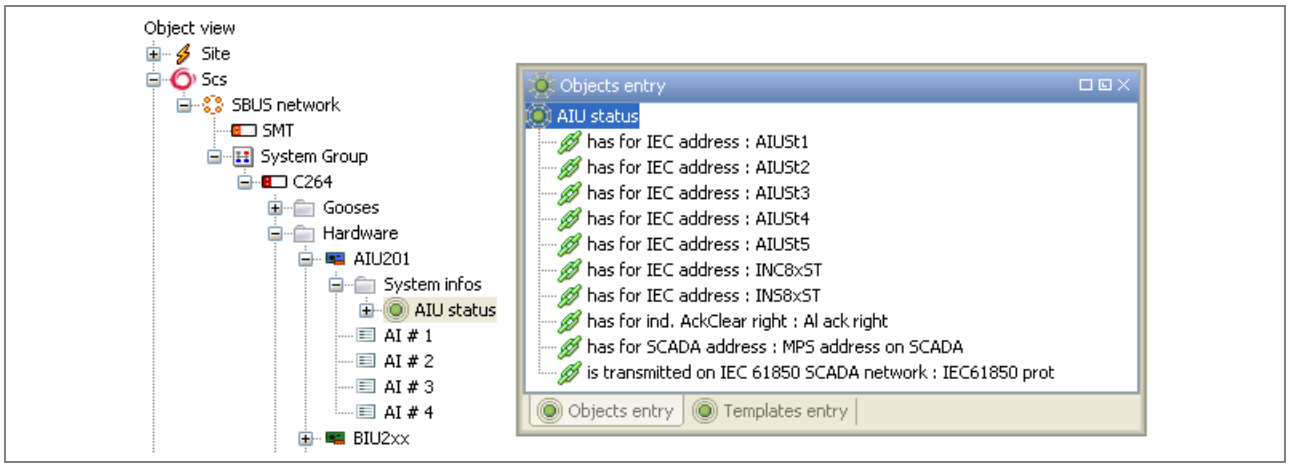


Figure 142: Manual IEC addressing of a board status datapoint

- a pre-defined datapoint profile.
- Fill the mandatory IEC address for this datapoint.

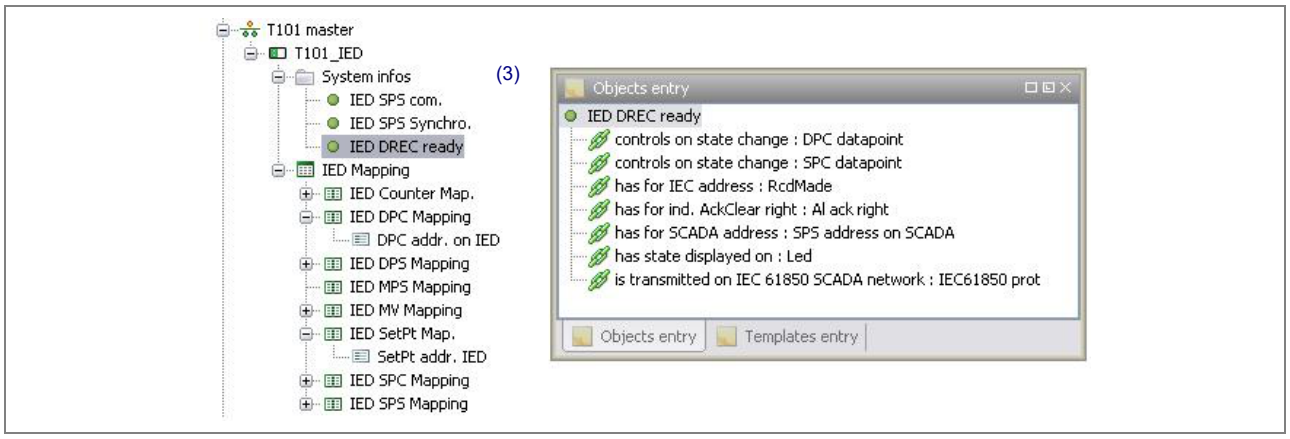


Figure 125: Setting the IEC 61850 address of an IED's DREC Ready datapoint

3.10.3 SETTING SYSTEM INFORMATION OF A SCADA NETWORK

When creating a SCADA network, the following mandatory datapoints are implicitly added.

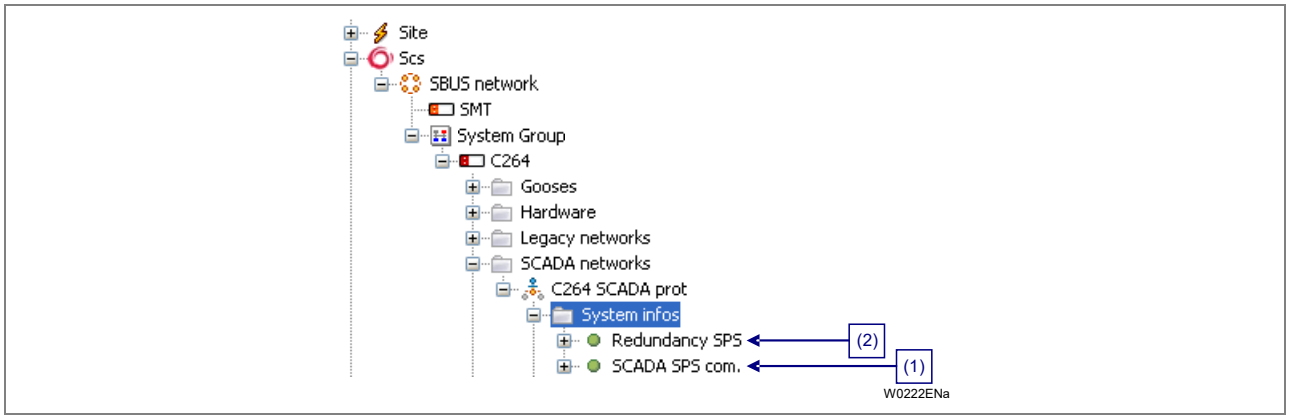


Figure 143: Mandatory System infos datapoint for a SCADA network

- **SCADA communication status SPS** (1): this datapoint is in “SET” state if communication with the SCADA is operational.
  The available states of this datapoint are:
  - RESET for communication with the SCADA not OK
  - SET for communication with the SCADA OK
  - An IEC address for this datapoint is defined using SBUS automatic addressing.
- **SCADA redundancy status SPS** (2): this datapoint is in “SET” state if redundancy with the SCADA is active.
  The available states of this datapoint are:
  - RESET for standby
  - SET for active
  - An IEC address for this datapoint is defined using SBUS automatic addressing.

4 DEFINING A DATAPOINT

4.1 TOPOLOGY

4.1.1 ELECTRICAL AND SYSTEM DATAPOINTS

Electrical and system topologies share entities called datapoints:

- those of the electrical topology are called electrical datapoints
- those belonging to the system topology are called system datapoints

A datapoint corresponds to an atomic object with real-time value, status or control. Moreover, datapoints support extra system functions like forcing, suppression, filtering, and alarms, logging.

Generally, system datapoint creation is automatic when adding system units or sub-components to system units. They are never wired, except for system datapoint used by redundancy and more often correspond to system diagnostics (device, printer board status, control of device mode, …).

Electrical datapoint creation is rarely automatic except when they are required for correct DS Agile system behaviour (for instance, ‘Order running SPS’ at bay level, ‘Computed switchgear position’ at circuit-break level), or relevant to an electrical built-in function that imposes their existence.

4.1.2 INPUT AND OUTPUT DATAPOINTS

Several types of datapoint exist:

- Input datapoints used for supervision:
  - SPS (Single Point Status), DPS (Double Point Status), MPS (Multiple Point Status)
  - MV (Measurement Value), Counter
- Output datapoints used for control:
  - SPC (Single Point Control), DPC (Double Point Control), MPC (Multi Point Control)
  - Setpoint

There are four types of Binary outputs:

- Single Point Status (SPC): derived from one Digital Output
- Double Point Status (DPC): derived from two Digital Outputs
- System output: control information related to the system, meant for configurable and built-in automations or electrical process deprived of acquisition possibilities
- Setpoint (SetPoint): derived from n Digital Outputs

SPC, DPC and SetPoints are mainly controlled via digital output boards (DOU board) or via IEDs connected by a serial link (for details see section *4.5*).

By extension, at SCE level, system outputs are seen as particular SPC or DPC depending on the number of elementary information they represent (for details about system outputs, see section *3.10 Setting system information for C26x components*).

Control sequences are described in chapter C26x/EN FT (Functional Description).

4.2 CREATING A DATAPOINT PROFILE

4.2.1 OVERVIEW

A set of datapoints share often many common characteristics. For instance, all feeder breaker positions have got the same state labels, alarm and logging behaviour. To group these common characteristics, profiles are included in the data modeling. For each type of datapoints (SPS, DPS…) there exists a relevant profile (SPS profile, DPS profile, …). Several datapoints of the same type are linkable to the same profile.

The profile attributes can be seen as the datapoint attributes **as soon as** this datapoint is assigned a profile.

For input datapoints, the following characteristics are set in the profile:

- state labels and eventual unit label for MV and counter
- definition of the archived and logged states
- definition of the alarmed states (gravity, delay, audibility)
- definition of state interlocking values
- definition of forcing/substitution/suppression (FSS) and SBMC facilities

For output datapoints, the following characteristics are set in the profile:

- order labels and eventual unit label for setpoints
- definition of the significant orders for SPC and DPC
- definition of the alarmed order failure (gravity, delay, audibility)
- definition of the archived and logged transitions
- SBO mode facility

Be careful: (See section *3.5.1 Connecting a C26x to other station-bus sub-systems*, for Client / Server definition). In the set of all the C26x units of an Scs:

- the following profile functional characteristics logging, alarm, archiving and FSS, are only useful and given to the C26x that serves the linked DPs because these functions are always done by the server C26x. So, a C26x A using a DP acquired on a C26x B never logs, signals or archives events relevant to this DP
- the profile functional characteristics ‘interlock values’ are given to server and client C26xs using a datapoint, because interlock evaluation is a distributed function done on every C26x that needs it before controlling its own electrical modules
- the profile functional characteristic ‘SBMC’ is given to server or client C26x units using a datapoint exchanged on a SCADA network they manage, because SBMC filtering is a distributed function done on C26x units managing SCADA networks
- the profile characteristics ‘state/order labels’ are given to server or client C26x units using a datapoint but are only used by the server: C26x bay mimics, logging, alarm definitions are reduced to datapoints that the C26x is server of

4.2.2 USING THE PROFILES TABLE

If the **Profiles Table** panel is not displayed, click the icon Reset perspective in the toolbar and the button Profiles Table in the lower part (in Auto Hide mode, move the cursor over the bottom toolbar). To adjust a column width, pass the cursor over the border in the header till the cursor turns to ↔; then drag and drop.

To fill the table:

- Click in a cell to fill out
- Type one character or click two more times; click the button [v] overlaying in the cell and select one value in the drop-down list (it contains all the created datapoint values); ∅ refers to a void value; the type can be changed this way

Note:
For the field 'value', the field SMBC must have been set to Yes *previously*

- To exchange data with a spreadsheet editor like Excel: select **Copy**/**Paste**

Note:
To paste the headers (including the tab labels) into the editor, select any row, right click, select Copy columns header.Null = value in editor of empty cell

- To speed up entry: select a row, copy it and select **Paste and add profile(s)**; this adds a row(s) at the end (regardless of the selected row) with the values in the clipboard
- To delete a profile, which is not linked to any datapoint (brown relation icon), right click and select **Delete**
- To delete the duplication of a profile, select the menu Data/**Indiced profiles merge** (all attributes are taken into account in the comparison, excluding short name and long name)
- After a database migration, to compute the new profile reference of each datapoint (object and template) to the profile table, select the menu Data/**Upgrade to indiced profile**

If you import a library template (.mpl), the source profiles that are referenced by the template are imported into the target profile table.

Assignation can be done in the datapoint attribute table OR in a row, after the datapoints have been defined, in the Profiles table (click the second column link icon). The editor shows these template and object datapoints:

- In Object mode: only object DPs and all instances of template DP (ONLY if 'Profile reference' attribute is set to DOF)
- In Template mode: only template DPs (no instances of template DP). Only the selected template is used to parse the available template DP.

4.2.3 FORBIDDEN CHARACTERS

Caution: The characters ">" and "<" must not be used in the label of datapoint profiles.

4.2.4 DEFINING AN XPS PROFILE

4.2.4.1 OVERVIEW

The binary inputs are described in the **Functional Description** chapter of the C264 user manual.

By extension, in SCE:

- System Inputs (SI) are seen as particular SPS, DPS or MPS depending on the number of elementary information they represent (for details about SI, see section *3.10 Setting system information for C26x components*).
- Group binary input is seen as particular SPS.

4.2.4.2 ADDING AN XPS PROFILE

To create an xPS profile, at any level:

- Select the type tab SPS/DPS/MPS
- Click the icon +
- Set the profile attributes (see following sections). The relation with the datapoints (icon in the second column) will be established, when the datapoints are created

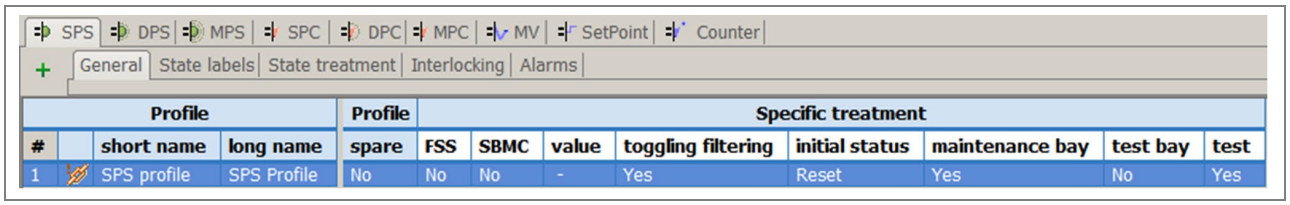


Figure 144: Adding an SPS profile (example given at C26x level)

4.2.4.3 SETTING GENERAL ATTRIBUTES

(1) **short name** and **long name** of the profile only used for profile identification in SCE

And for linked SPS and MPS datapoints:

(2) enable **F**orce/**S**ubst/**S**up (*No* / *Yes*)

(3) **SBMC**-dependent (*No* / *Yes*)

(4) SBMC state substitution **value** (*Suppressed* /…): significant and visible if SBMC-dependent is set to Yes

(5) **test**-mode dependent (*No* / *Yes*)

and, for SPS and DPS:

(6) **toggling filtering** (*No* / *Yes*): useful for a datapoint acquired on a DI board to filter toggling.

(7) **initial status**: used for C26x software initialization especially for system datapoints.

(8) **maintenance bay**: reserved for future use

(9) **test bay**: reserved for future use

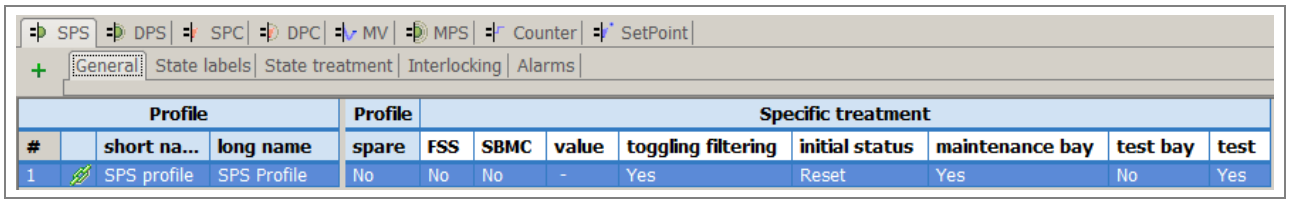


Figure 145: Setting the general attributes of an SPS profile

Configuration rules and checks

The profile of a datapoint of the System topology must have its **F**orce/**S**ubst/**S**up attribute set to *No*.

4.2.4.4 SETTING STATE LABELS ATTRIBUTES

These attributes are used for events/alarm management at C26x level (logging, display).

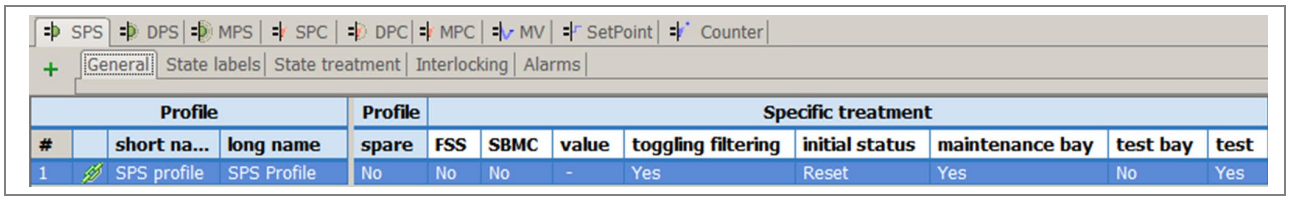


Figure 146: Setting the State labels attributes of an SPS profile

4.2.4.5 SETTING STATE TREATMENT/C26X TREATMENT ON ATTRIBUTES

Available attribute values are:

- no archive, no logging
- archive, logging
- archive, no logging

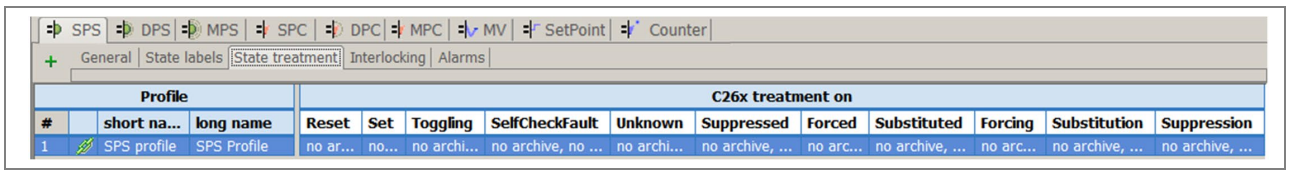


Figure 147: Setting the State treatments attributes of an SPS profile

4.2.4.6 SETTING INTERLOCKING ATTRIBUTES

For each possible state linked to this profile and belonging to an interlocking equation, select among values Invalid, False, True the one used for evaluation of the interlocking equation.

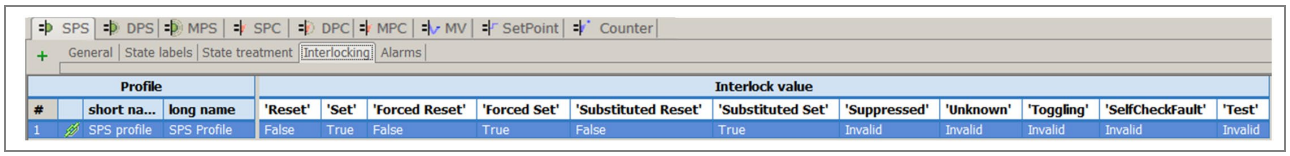


Figure 148: Setting the Interlocking attributes of an SPS profile

4.2.4.7 SETTING ALARMS ATTRIBUTES

(1) **condition** (Appearance/Appearance & disappearance): this attribute is common to all states of each xPS linked to this profile. It defines when alarms are generated.

For each state the following attributes are settable:

(2) **defined** (*No* / *Yes*)

(3) **masking** due to control (*No* / *Yes*): this attribute must be set to Yes to manage correctly discrepancy (alarm appears only in case of spontaneous change of state without previous control)

(4) **delay (s)** (range [0 s, 120 s], step 1 s): to avoid alarm generation if alarm condition disappears within this delay

(5) **gravity** (range [1, 5], step 1)

(6) **audible** (*No* / *Yes*): to activate a klaxon

(7) **clearing**: to precise the way alarm is cleared when alarm condition disappears:

- **Manual**: users must explicitly clear the alarm
- **Automatic**: no user intervention is needed to clear the alarm
- **Cf. Scs – Clearing mode for gravities**: the clearing mode is deduced from the one given at Scs object level for the relevant gravity

For C26x configuration, all attributes are significant for datapoints it is server of.

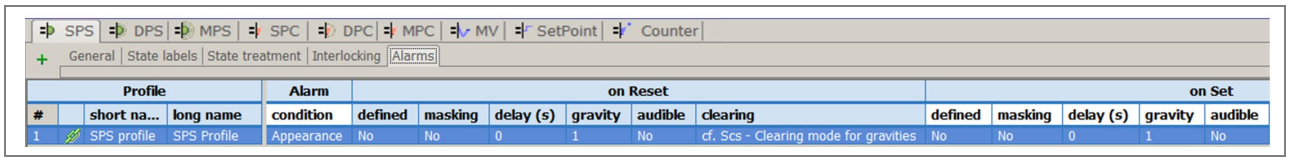


Figure 149: Setting the Alarm attributes of an SPS profile

4.2.5 DEFINING AN MV PROFILE

4.2.5.1 ADDING AN MV PROFILE

To create an MV profile:

- Select the type tab MV
- Click the icon + at any level
- Update the profile attributes (see following sections).

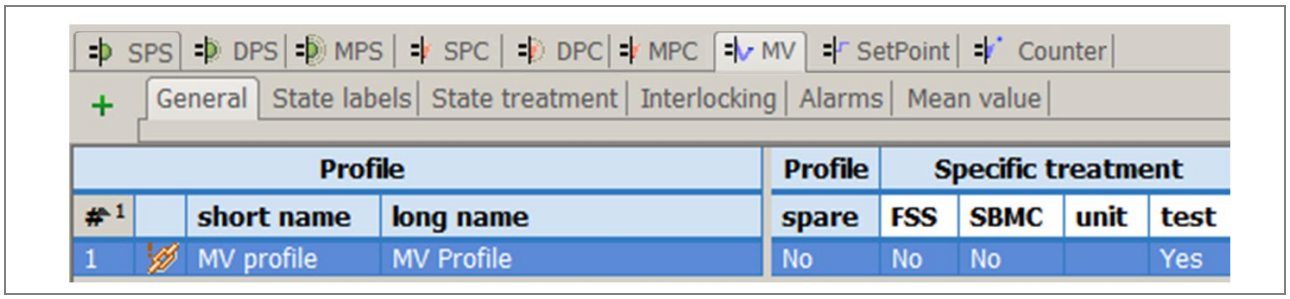


Figure 150: Setting the Interlocking attributes of an MPS profile

4.2.5.2 SETTING GENERAL ATTRIBUTES

When adding an MV profile, some general attributes must be updated:

(1) **short name** and **long name**: only used for profile identification in SCE

and for linked MV datapoints:

(2) enable **F**orce/**S**ubst/**S**up (*No* / *Yes*)

(3) **SBMC**-dependent (*No* / *Yes*)

(4) **unit**: used for display, logging and alarm at C26x, Gateway and system HMI levels. Maximum length: 5 characters.

(5) **test**-mode dependent (*No* / *Yes*)

(6) **default format**: Reserved for Substation control point usage

Default format attribute is a string composed of the following characters:

#	display only significant figures
0	display non-significant zeros
~	suppress sign
%	display in percentage mode
‘’ ‘’	display strings with reserved characters
\	display reserved characters
U	display unit
.	display decimal delimiter

Configuration rules and checks

The profile of a datapoint of the System topology must have its enable **F**orce/**S**ubst/**S**up set to *No*.

4.2.5.3 SETTING STATE LABELS ATTRIBUTES

The **State labels** attributes are used for events and alarm management at C26x level (logging, display).

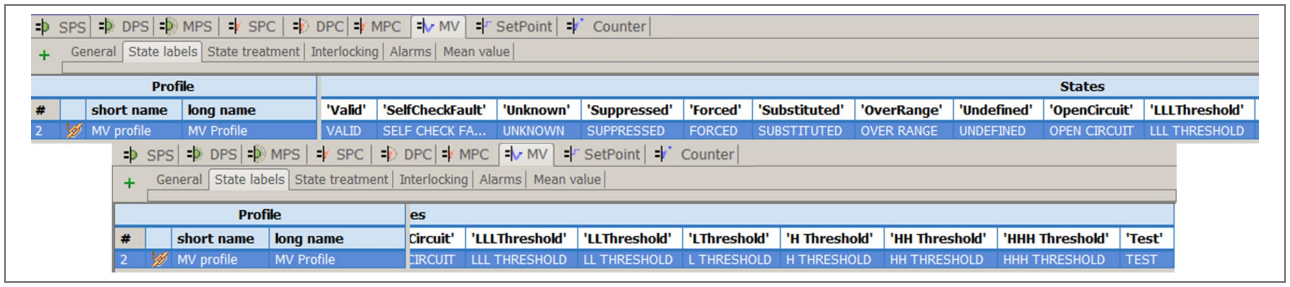


Figure 151: Setting the State labels attributes of an MV profile

4.2.5.4 SETTING STATE TREATMENT ATTRIBUTES

Available attribute values are:

- C26x: no archive, logging
- C26x: archive, logging
- C26x: archive, no logging
- C26x: archive, logging

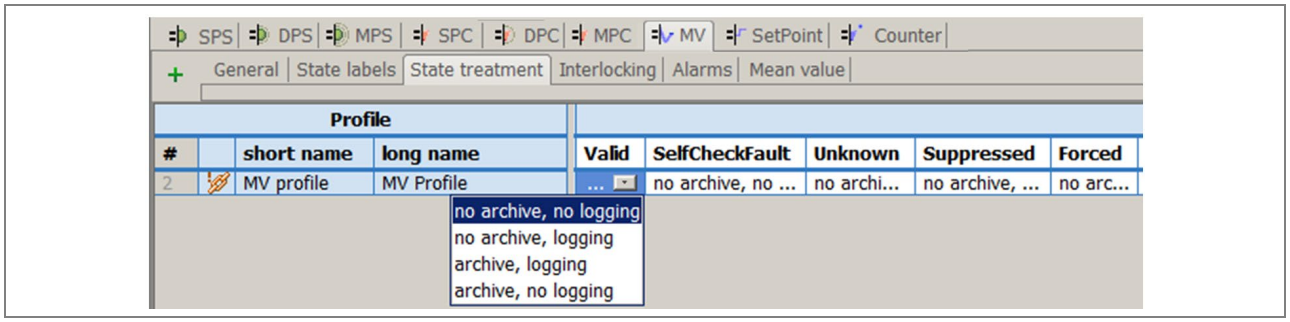


Figure 152: Setting the 'State treatment' attributes of an MV profile

4.2.5.5 SETTING INTERLOCKING ATTRIBUTES

For each possible state of an MV linked to this profile and belonging to an interlocking equation the user chooses among three values (Invalid, False, True) which one will be used for evaluation of the interlocking equation.

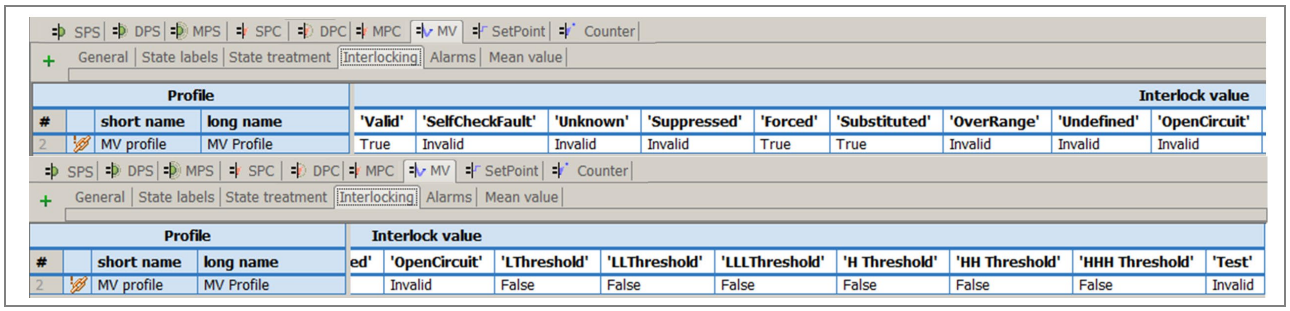


Figure 153: Setting the Interlocking attributes of an MV profile

4.2.5.6 SETTING ALARMS ATTRIBUTES

When adding an MV profile some **Alarms** attributes must be updated, for each available state of the linked datapoints.

For each state, following alarm information are settable:

(1) **generation condition** (*Appearance* / *Appearance and disappearance*): this attribute is common for all the states of each MV linked to this profile. It defines when alarms are generated.

For each state the following attributes are settable:

(2) **defined** (*No* / *Yes*)

(3) **delay** (range [0 s, 120 s], step 1 s): to avoid alarm generation if alarm condition disappears within this delay

(4) **gravity** (range [1, 5], step 1).

(5) **audible** (*No* / *Yes*): to activate a klaxon

(6) **clearing mode**: to precise the way alarm is cleared when alarm condition disappears:

- Manual: users must explicitly clear the alarm
- Automatic: no user intervention is needed to clear the alarm
- Cf. Scs – Clearing mode for gravities: the clearing mode is deduced from the one given at Scs object level for the relevant gravity

For C26x configuration, all attributes are significant for datapoints it is server of.

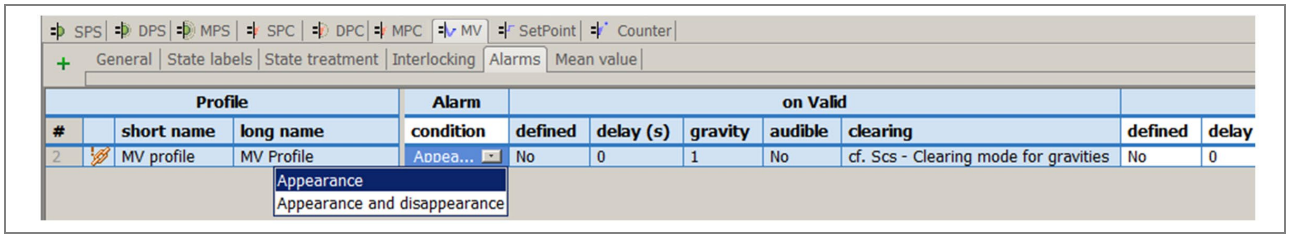


Figure 154: Setting the Alarm attributes of an MV profile

4.2.5.7 SETTING MEAN VALUE ATTRIBUTES

The 'Mean value' attributes are reserved for substation control point usage.

(1) **computation** (*No* / *Yes*)

(2) **reference hour** (range [0, 23], step 1)

(3) **reference day** (range [0, 31], step 1)

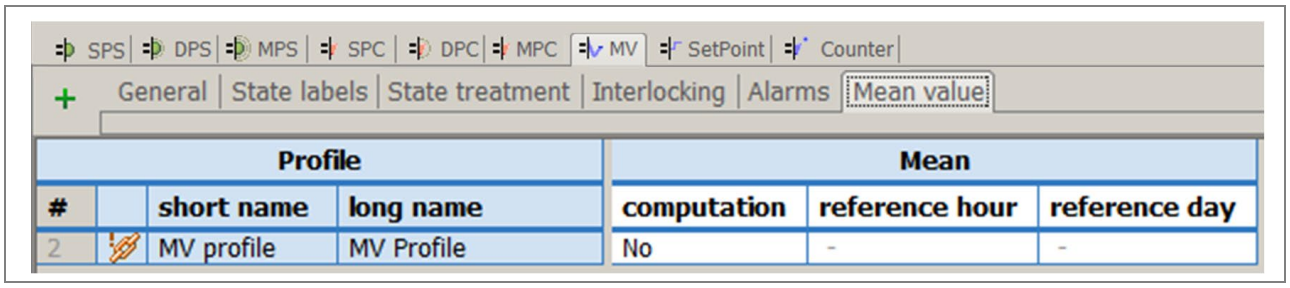


Figure 155: Setting the Mean value attributes of an MV profile

4.2.6 DEFINING A COUNTER PROFILE

4.2.6.1 ADDING A COUNTER PROFILE

To create a Counter profile:

- Select the type tab Counter
- Click the icon + at any level
- Update the profile attributes (see following sections).

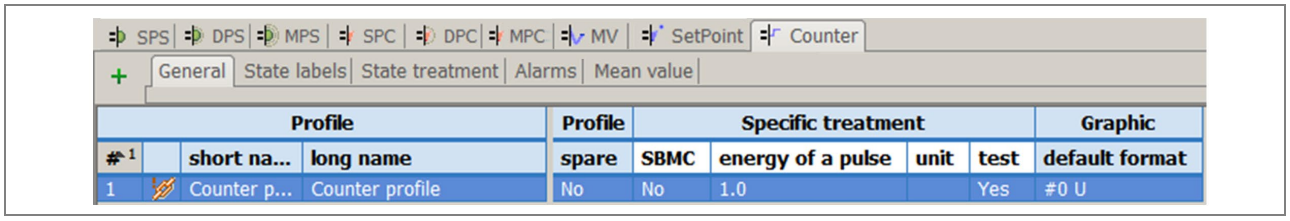


Figure 156: Adding a counter profile

4.2.6.2 SETTING THE GENERAL ATTRIBUTES OF A COUNTER PROFILE

When adding a Counter profile, some general attributes must be updated:

(1) **short name** and **long name**: only used for profile identification in SCE

and for linked Counter datapoints:

(2) **SBMC**-dependent (Yes to suppressed / No)

(3) **energy of a pulse** (range [-3.4E38, +3.4E38]: multiplicative coefficient

(4) **unit** used for display, logging and alarm at C26x level

(5) **test**-mode dependent (*No* / *Yes*)

(6) **default format**: reserved for Substation control point usage

Default format attribute is a string composed of the following characters:

#	display only significant figures
	display non-significant zeros
~	suppress sign
%	display in percentage mode
‘’ ‘’	display strings with reserved characters
\	display reserved characters
U	display unit
.	display decimal delimiter

4.2.6.3 SETTING STATE LABELS ATTRIBUTES

The state of a counter can be:

VALID	Not in one of the states below
SELFCHECK FAULT	Due to the SELFCHECK FAULTY of the DI
UNKNOWN	If the counter is acquired via a transmission link, the information is unknown when the link is disconnected
UNDEFINED	Due to a counting failure of DCT (non-complementarity of the 2 contacts)
OVER RANGE	When the maximum value is reached

The ‘State labels’ attributes are used for C26x events and alarm management (logging, display).

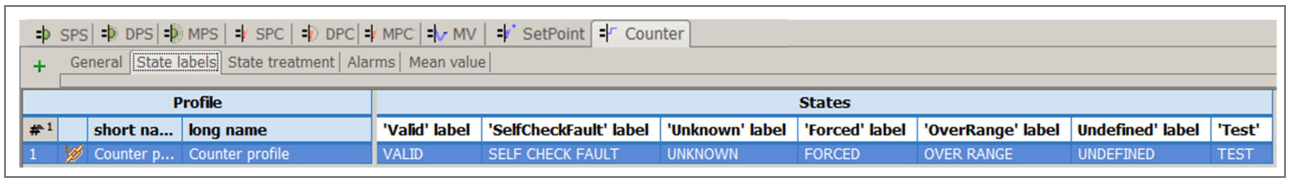


Figure 157: Setting the State labels attributes of a counter profile

4.2.6.4 SETTING STATE TREATMENT ATTRIBUTES

Available attribute values for each available state of the linked datapoints:

- C26x: no archive, logging
- C26x: archive, logging
- C26x: archive, no logging
- C26x: archive, logging

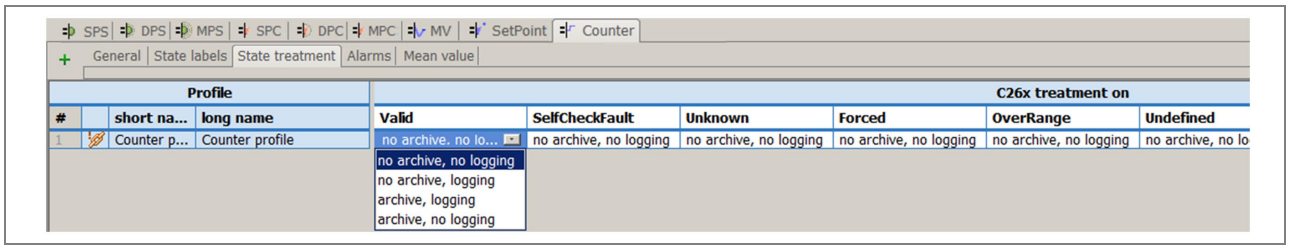


Figure 158: Setting the State treatment attributes of a counter profile

4.2.6.5 SETTING ALARMS ATTRIBUTES

For all Counter states, the attribute General/condition defines when alarms are generated for the datapoint: ‘appearance of the event’ / ‘appearance and disappearance of the event’.

For each state, set the following alarm attributes:

(1) **defined** (*No* / *Yes*)

(2) **delay** (range [0 s, 120 s], step 1 s): to avoid alarm generation if alarm condition disappears within this delay

(3) **gravity** (range [1, 5], step 1)

(4) **audible** (*No* / *Yes*), to activate a klaxon

(5) **clearing mode** (*Manual* / *Automatic* / *Gravity basis*): to precise the way alarm is cleared when alarm condition disappears:

- Manual: users must explicitly clear the alarm
- Automatic: no user intervention is needed to clear the alarm
- Cf. Scs – Clearing mode for gravities: the clearing mode is deduced from the one given at Scs object level for the relevant gravity

For C26x configuration, all attributes are significant for datapoints it is server of.

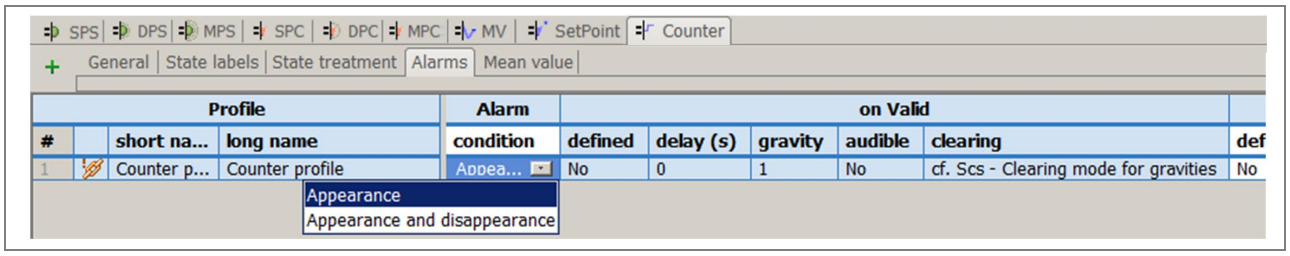


Figure 159: Setting the Alarms attributes of a counter profile

4.2.6.6 SETTING MEAN VALUE ATTRIBUTES

The 'Mean value' attributes are reserved for substation control point usage.

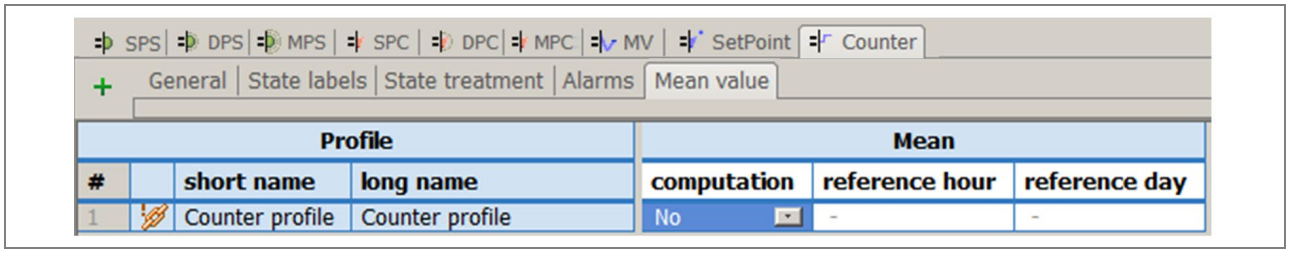


Figure 160: Setting the Mean value attributes of a counter profile

4.2.7 DEFINING AN XPC PROFILE

4.2.7.1 ADDING AN XPC PROFILE

To create an xPC profile:

- Select the type: SPC/DPC/MPC
- Click the icon +
- Set the profile attributes (see following sections)

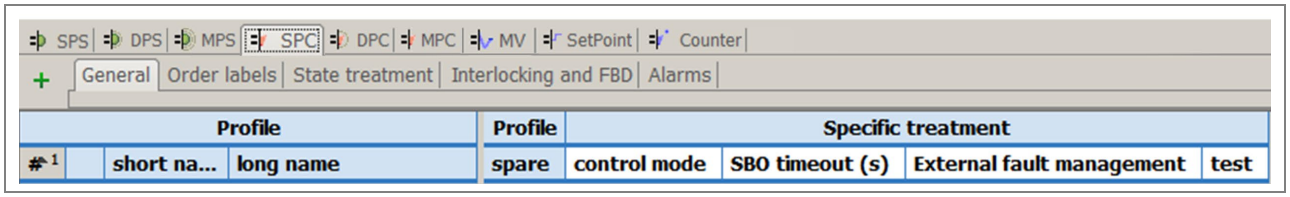


Figure 161: Adding an SPC profile (example given on C26x)

4.2.7.2 SETTING GENERAL ATTRIBUTES

Depending on the type of xPC, some general attributes must be set:

(1) **short name** and **long name** of the profile only used for profile identification in SCE and for linked SPC datapoints:

(2) **Predefined profile** (*No* / *Yes*). This attributes appears for MPC profile.

(3) **control mode** (for details see **Control Mode** description available in the **Functional Description** chapter of the C264 user manual)
Available values are:

- Direct execute
- SBO operate once
- SBO operate many
- Direct execute with SBO popup (reserved to substation control point usage), similar to 'Direct execute' for C26x

(4) **SBO timeout (s)** (range [0, 600 s], step 1s), significant if SBO mode is set to 'SBO operate once' or 'SBO operate many'

(5) **External fault management**

- External fault: the C26x waits for feedback confirming the position change
- OK (special use)

(6) **test-mode dependen** (No / Yes)

4.2.7.3 SETTING ORDER LABELS ATTRIBUTES

The 'Order labels' attributes are used for C26x events and alarm management (logging, display) and for correct xPC order management.

Depending on the type of xPC, some generic attribute must be set:

(1) **Order.. usage** (*No* / *Yes*): if there is a label (*Yes*), the related wording **Order.. label**

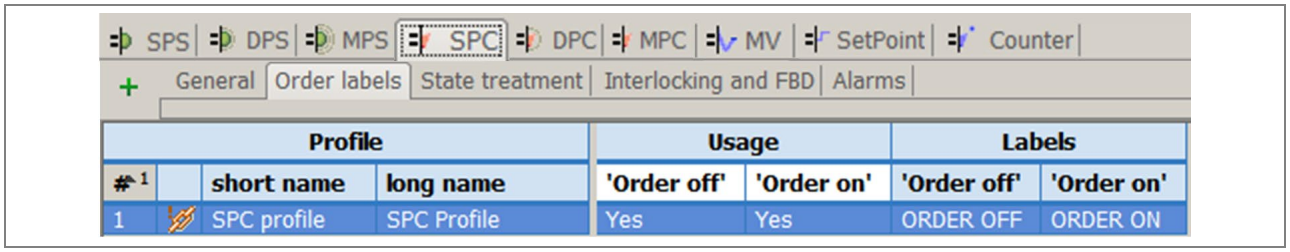


Figure 162: Setting the Order labels attributes of an SPC profile

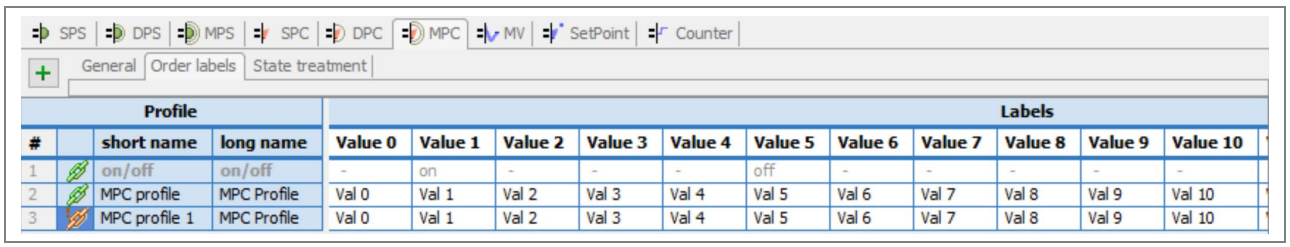


Figure 163: Setting the Order labels attributes of an MPC profile

4.2.7.4 SETTING STATE TREATMENT

The ‘State treatment’ attribute must be updated globally for all available control and acknowledgement steps of the linked datapoints.

The available attribute values are:

- OI/C26x: no archive, no logging
- OI/C26x: archive, logging
- OI/C26x: archive, no logging
- C26x: archive, logging

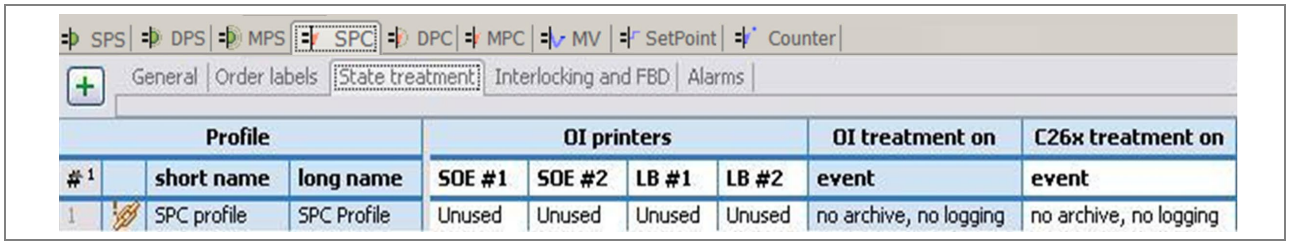


Figure 164: Setting the State treatment attribute of an SPC profile

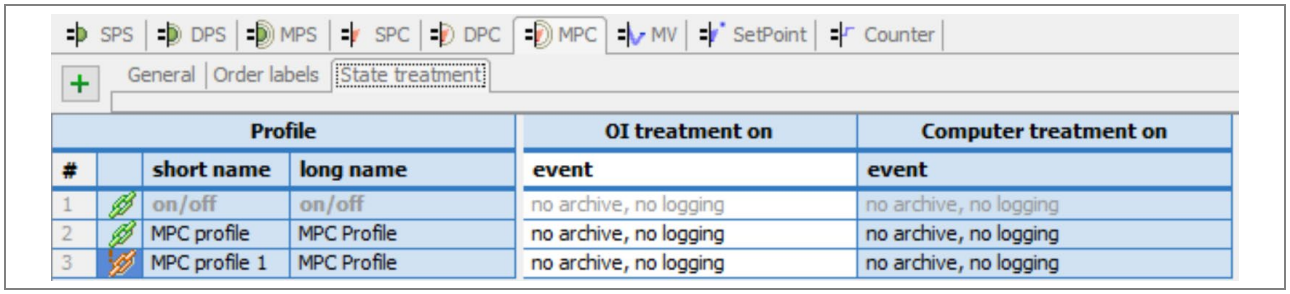


Figure 165: Setting the State treatment attribute of an MPC profile

4.2.7.5 SETTING INTERLOCKING AND FBD ATTRIBUTES

Some 'Interlocking and FBD' attributes can be updated for Boolean evaluation of interlocking equation, if the xPC belongs to an interlock equation or is an input of FBD automation (see sections *5.7.4 Defining an interlock* in this manual and section *Defining an FBD fast automation* in the **Application** chapter of the **SCE** user manual).

Generic settable attribute:

(1) **.. order interlock value** (*Invalid* / *False* / *True*): defines the value affected to the y order state of the xPC for evaluation of an interlock equation or a FBD using this xPC.

For C26x configuration, all attributes are significant for datapoints it is server of.

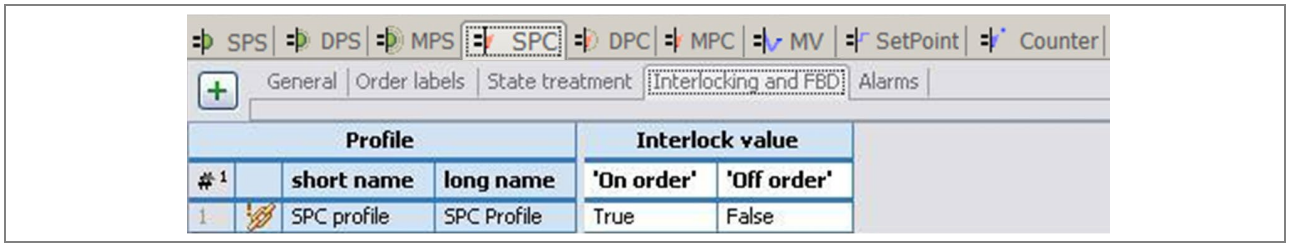


Figure 166: Setting the Interlocking and FBD attributes of an SPC profile

4.2.7.6 SETTING ALARMS ATTRIBUTES

Some 'Alarms' attributes must be set, for the correct alarm management in case of a negative acknowledgement concerning control of the linked datapoints.

The following alarm information is settable:

(1) **defined** (*No* / *Yes*)

(2) **delay (s)** (range [0 s, 120 s], step 1 s): to avoid alarm generation if alarm condition disappears within this delay

(3) **gravity** (range [1, 5], step 1)

(4) **audible** (*No* / *Yes*), to activate a klaxon

(5) **clearing** mode: to define the way alarm is cleared when alarm condition disappears:

- Manual: users must explicitly clear the alarm
- Automatic: no user intervention is needed to clear the alarm
- Cf. Scs – Clearing mode for gravities: the clearing mode is deduced from the one given at Scs object level for the relevant gravity

For C26x configuration, all attributes are significant for datapoints it is server of.

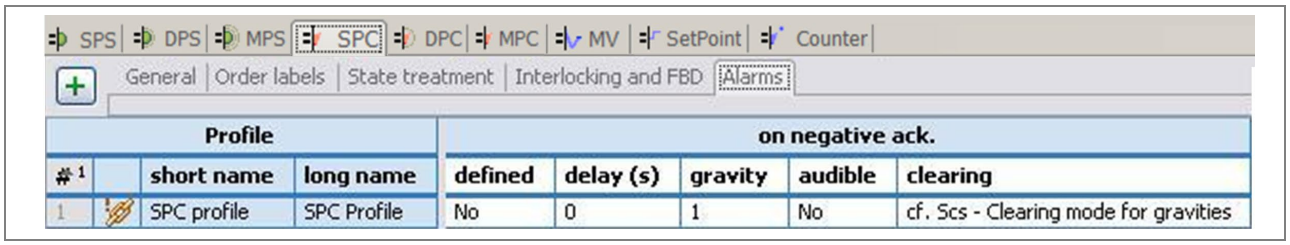


Figure 167: Setting the Alarms attributes of an SPC profile

4.2.8 DEFINING A SETPOINT PROFILE

4.2.8.1 ADDING A SETPOINT PROFILE

To create an SP profile:

- Select the type tab SP
- Click the icon + at any level
- Update the profile attributes (see following sections)

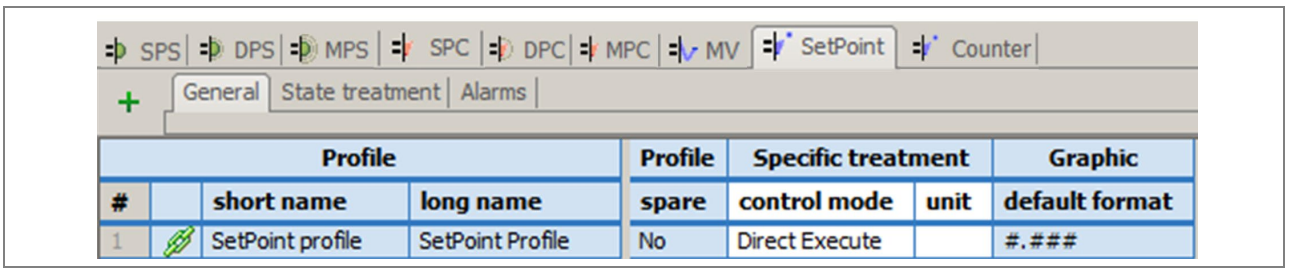


Figure 168: Adding a setpoint profile (example given on C26x)

4.2.8.2 SETTING GENERAL ATTRIBUTES

When adding a SetPoint profile, some general attributes must be updated:

(1) **short name** and **long name** of the profile only used for profile identification in SCE

and, for linked SetPoint datapoints:

(2) **control mode**: The available values are:

- *Direct Execute*
- *Direct Execute* with SBO popup (reserved to substation control point usage), similar to 'Direct execute' for C26x (but it pops up in a window as in SBO mode)

(3) **unit: electrical unit used for display, logging and alarm on C26x.**

(4) **test-mode dependent (No / Yes)**

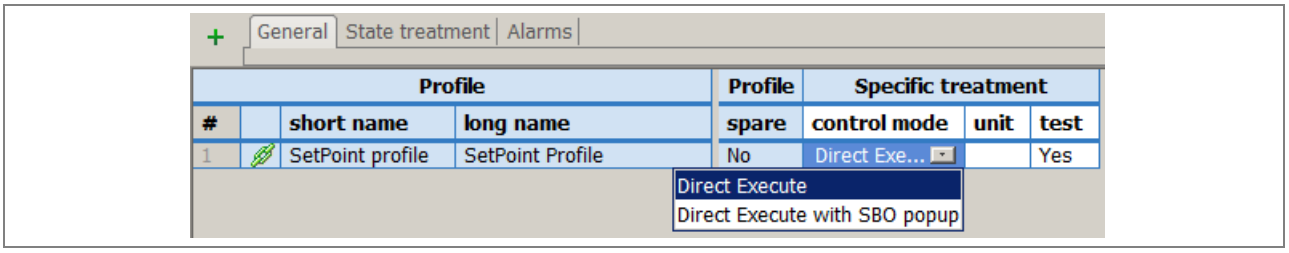


Figure 169: Setting the general attributes of a setpoint profile

4.2.8.3 SETTING TREATMENT ON EVENT ATTRIBUTES

With DS Agile version v7.0.1 the BCU does not manage printers.

However, DS Agile aView uses the “archive” setting for **OI treatment on**: The state changes will be taken into account if set to *archive* (logging or no logging makes no difference). Logging is configured in Blend.

Event logging printers managed by DS Agile aView are not configured in SCE and the settings for **OI printers** have no effect.

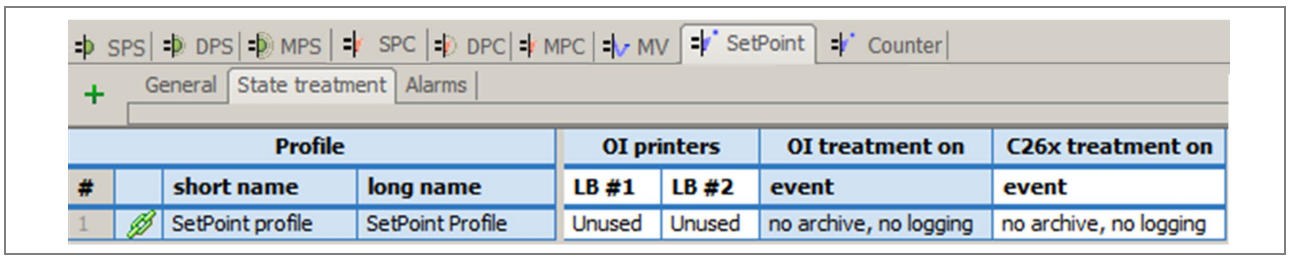


Figure 170: Setting the State treatment attribute of a setpoint profile

4.2.8.4 SETTING ALARMS ATTRIBUTES

Some ‘Alarms’ attributes must be set, for the correct alarm management in case of a negative acknowledgement concerning control of the linked datapoints.

The following alarm information is settable:

(1) **defined** (*No* / *Yes*)

(2) **delay** (range [0 s, 120 s], step 1 s): to avoid alarm generation if alarm condition disappears within this delay

(3) **gravity** (range [1, 5], step 1)

(4) **audible** (*No* / *Yes*), to activate a klaxon

(5) **clearing mode**: to define the way alarm is cleared when alarm condition disappears:

- Manual: users must explicitly clear the alarm
- Automatic: no user intervention is needed to clear the alarm
- Cf. Scs – Clearing mode for gravities: the clearing mode is deduced from the one given at Scs object level for the relevant gravity

For C26x configuration, all attributes are significant for datapoints it is server of.

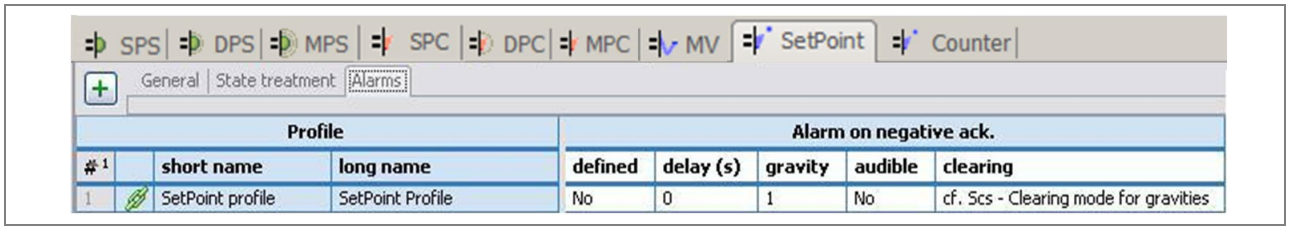


Figure 171: Setting the Alarms attributes of a setpoint profile

4.2.9 LIST OF PREDEFINED PROFILES

Default predefined profiles are present and visible in the Profiles Table. These predefined profiles are not created by user and cannot be modified. They are linked to specific datapoints defined in the configuration.

4.2.9.1 ON/OFF

A default "on/off" MPC profile is used for all MPC used to enable/disable a protection function at any level or stage.

This predefined MPC profile has only two possible values as defined in IEC 61850 Standard (limited usage of Mode):

- 1: sets the protection function to ON
- 5: sets the protection function to OFF

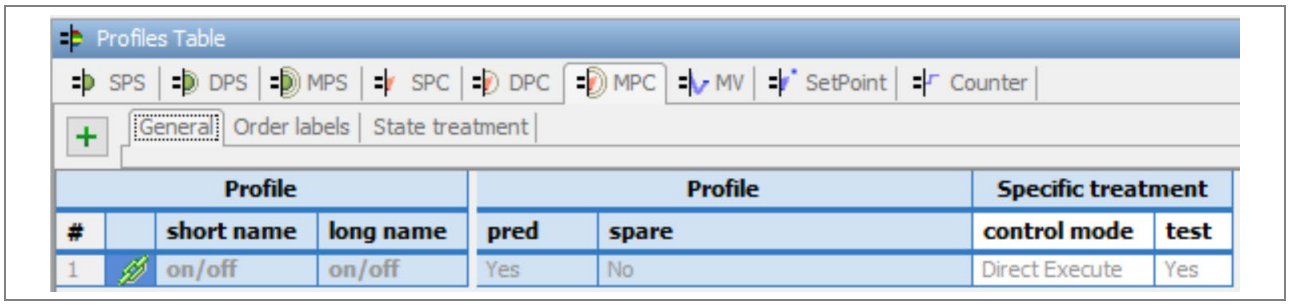


Figure 172: Predefined MPC on/off profile

The attribute values of predefined MPC profile "on/off" are read-only.

General tab:

(1) **short name** and **long name** of the profile only used for profile identification in SCE and for linked datapoints.

(2) **pred**: predefined profile set to Yes.

(3) **control mode**: Direct execute (for details see **Control Mode** description available in the **Functional Description** chapter of the C264 user manual).

(4) **test-mode dependent**: Yes.

Order labels tab:

(1) **value 1**: on

(2) **value 5**: off

State Treatment tab:

(1) **event**: no archive, no logging (OI and C264 treatment)

Note: To control Setting Group by MPC, the predefined MPC profile cannot be used. To change setting grou, the "Setting grp ctrl" MPC must have a generic MPC profile set by user.

4.3 CREATING A DATAPOINT

Be careful

(See section *3.5.1 Connecting a C26x to other station-bus sub-systems*, for Client / Server definition).

In the set of all the C26x units of a Scs, the previous described SPS attributes (except short name and long name) are only useful and given to the C26x that serves the datapoint because the relevant functions are always done at C26x server level.

Limits

For all electrical and system datapoints whatever their type, the maximum length of shortname is 16 characters and the maximum length of longname is 64 characters.

4.3.1 USING AN SPS DATAPOINT

To add an SPS datapoint:

- Select the required system or electrical object level and add an SPS from the contextual **Objects entry** window. Depending on the object level, different pre-defined types of SPS exist. They are used for specific needs at electrical topology level (for details see relevant section in *5 Defining a C26x configuration in the electrical hierarchy*) or system topology level (for details see section *3.10 Setting system information for C26x components*)
- Update the SPS attributes (see following topic); some attributes can be fixed or masked depending on the pre-defined type of SPS
- Update its relation **has for profile** to point to a specific existing profile (2)

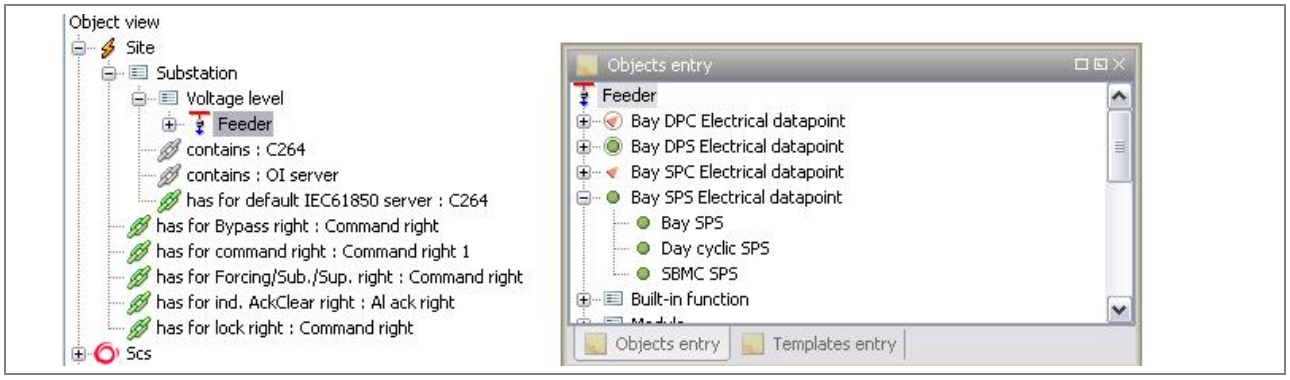
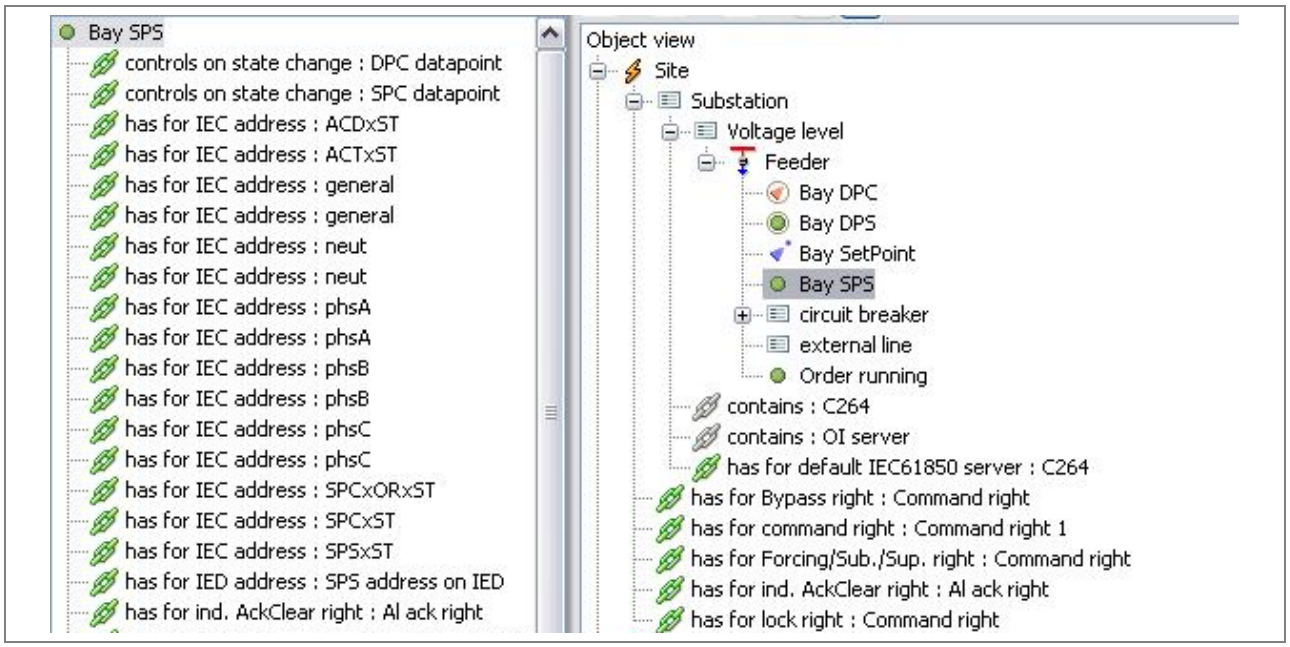


Figure 173: Adding an SPS datapoint (example given at bay level for generic SPS)



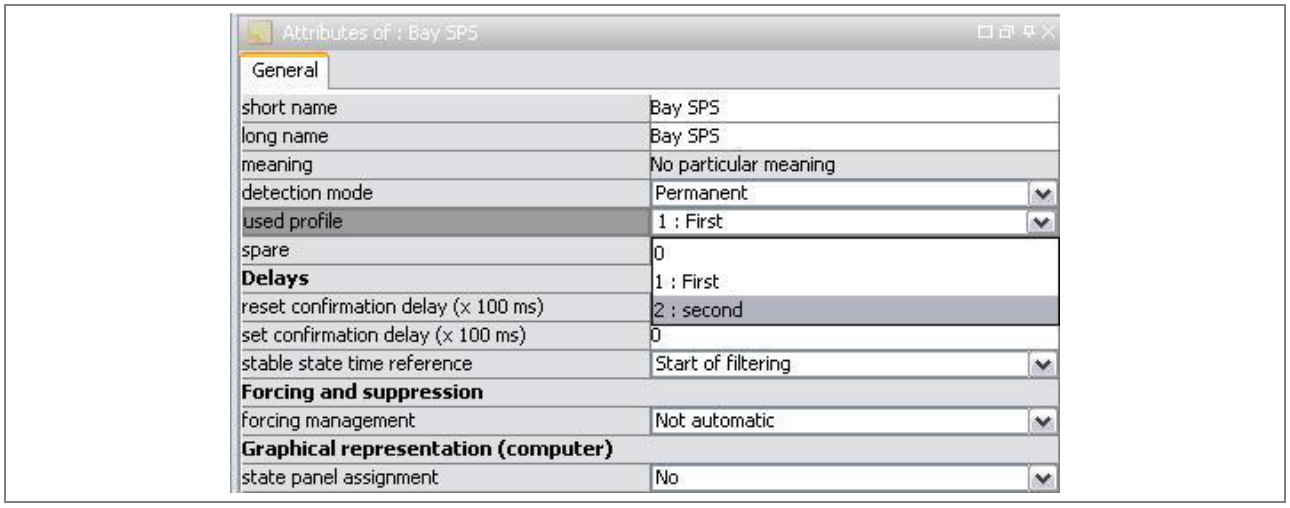


Figure 174: Linking an SPS datapoint to its profile (example for a generic SPS at Bay level)

Updating SPS attributes (description for generic SPS)

When adding a generic SPS datapoint, some general attributes must be updated:

(1) **short name** and **long name** of the datapoint used for logging, alarms ...

(2) **detection mode** (*Permanent* / *Transient* / *Permanent with computer auto-reset*): when this attribute is set to *Permanent with computer auto-reset* the SPS is reset automatically after 1 ms**used profile**: the drop-down list refers to the SPS tab of the Profiles table

(3) **reset confirmation delay** (range [0 s, 300 s], step 100 ms]: confirmation delay for stable ‘reset’ state

(4) **set confirmation delay** (range [0 s, 300 s], step 100 ms]: confirmation delay for stable ‘set’ state

(5) **stable state time reference** (Start of filtering / End of filtering)

(6) **forcing management** (*Not automatic* / *Automatic to reset state* / *Automatic to set state*): when an SPS goes to invalid state, C26x can force or not its status to set or reset state automatically. This attribute defines the way this forcing management is done. Automatic forcing management is independent of the FSS enable facility provided in the SPS profile

(7) **state panel assignment** (*No* / *Yes*): set to *Yes* to enable SPS state display at C26x local HMI level

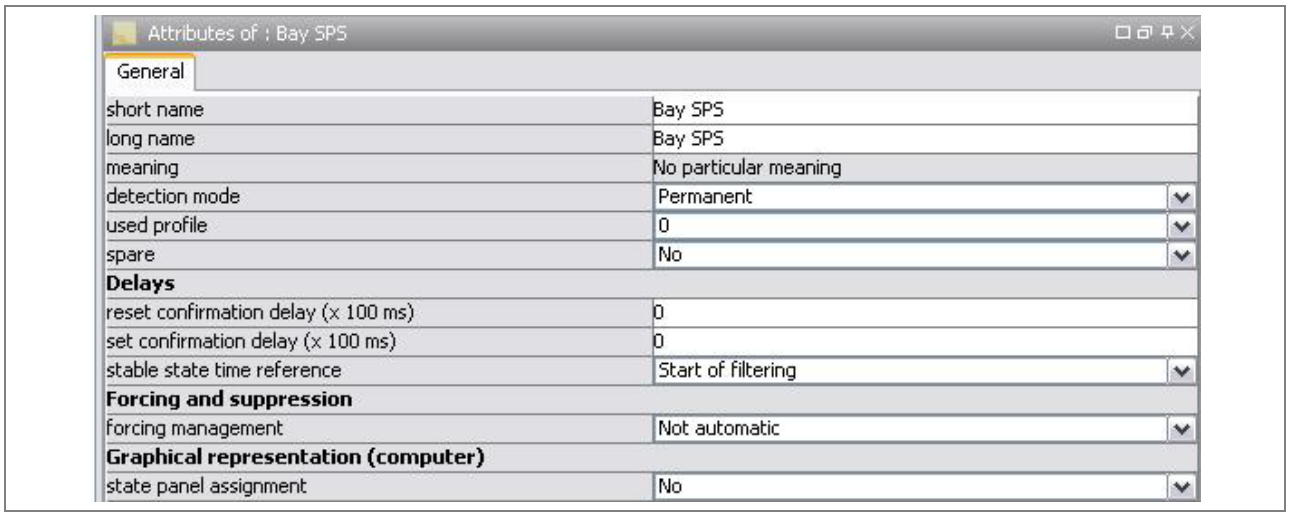


Figure 175: Setting the general attributes of an SPS datapoint (example for a generic SPS at Bay level)

4.3.2 USING A DPS DATAPOINT

DPS means Double Point Status. A Double Point (DP) is derived from two Digital Inputs. One input is the **Close contact** and the other one is the **Open contact**.

A DPS datapoint is electrical type when it is defined in the electrical part, i.e. at Site level. A DPS datapoint is system type when it is defined in the system part, i.e. at Scs level.

When only "DPS datapoint" is notified, information concerns both, electrical and system DPS.

The **DPS datapoint** is represented with graphical icon .

A **DPS datapoint** whether it is object, template or instance of template must reference a DPS profile through its "used profile" attribute.

4.3.2.1 ADDING A DPS DATAPOINT

To add a DPS datapoint:

- Select the required system or electrical object level and add a DPS from the contextual **Objects entry** window. Depending on the object level, different pre-defined types of DPS exist. They are used for specific needs at electrical topology level (for details see relevant section in *5 Defining a C26x configuration in the electrical hierarchy*) or system topology level (for details see section *3.10 Setting system information for C26x components*)
- Update the DPS attributes (see following topic); some attributes can be fixed or masked depending on the pre-defined type of DPS
- Update its relation **has for profile** to point to a specific existing profile

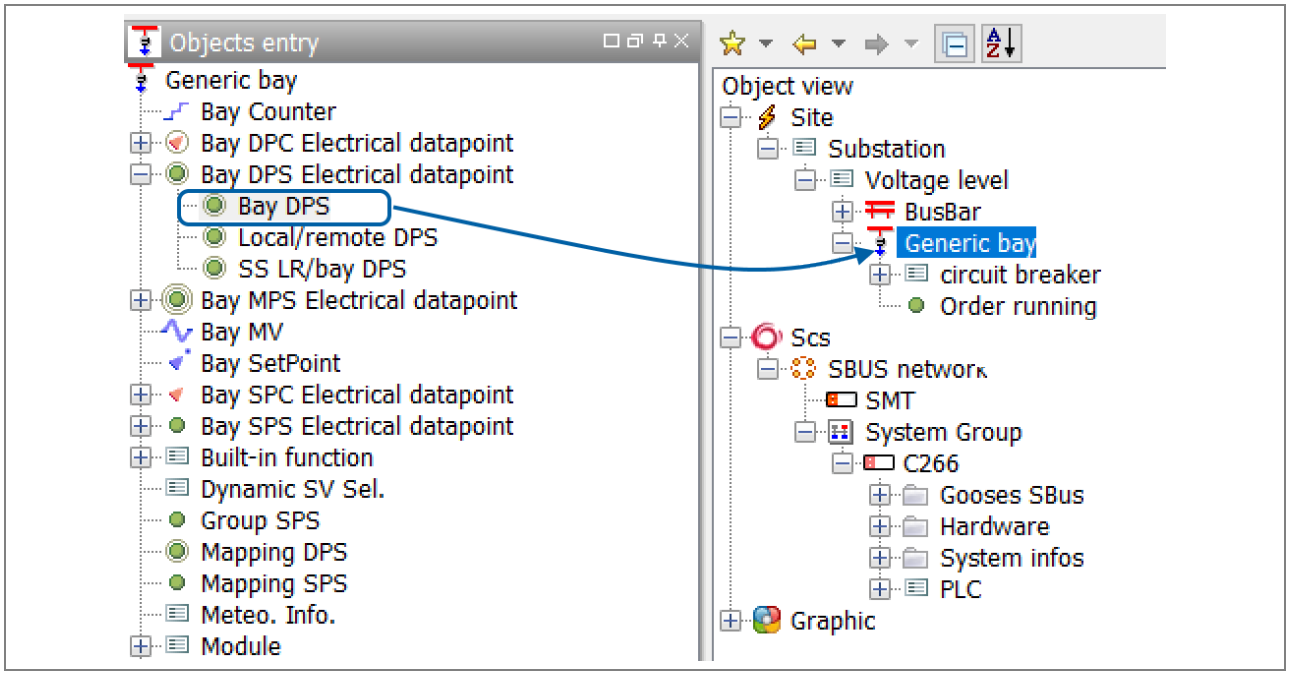


Figure 176: Adding a DPS datapoint (example a generic DPS at Bay level)

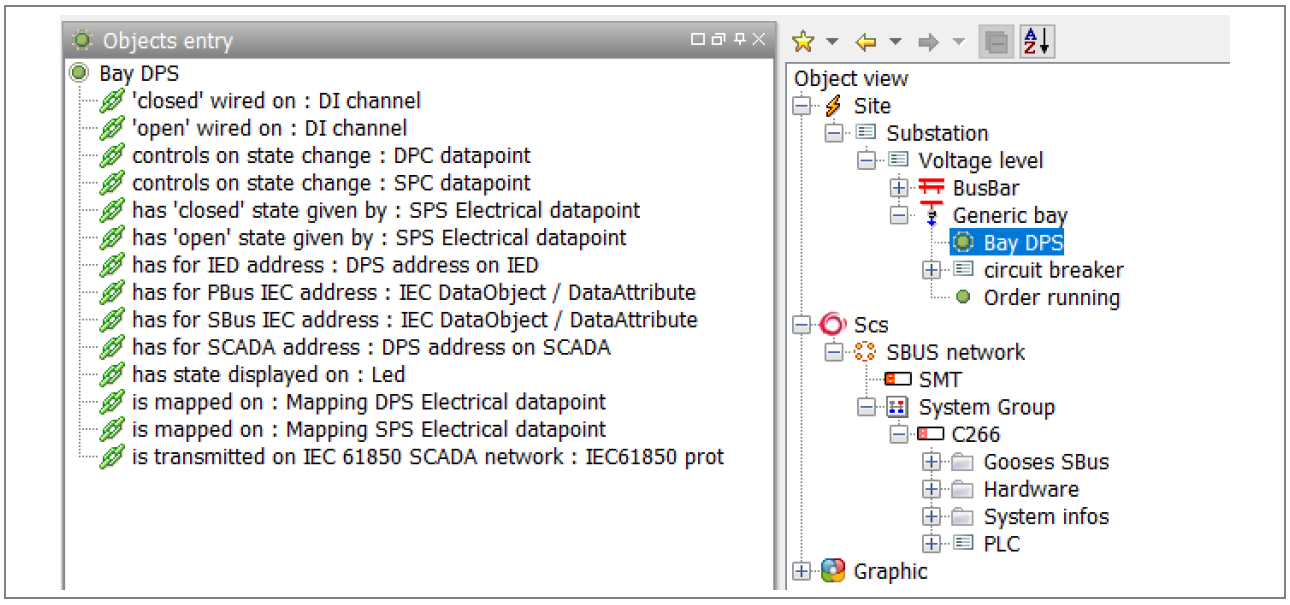


Figure 177: Linking a DPS datapoint to its profile (example for a generic DPS at Bay level)

4.3.2.2 SETTING THE GENERAL ATTRIBUTES OF A DPS DATAPOINT

When adding a generic DPS datapoint, some general attributes must be set:

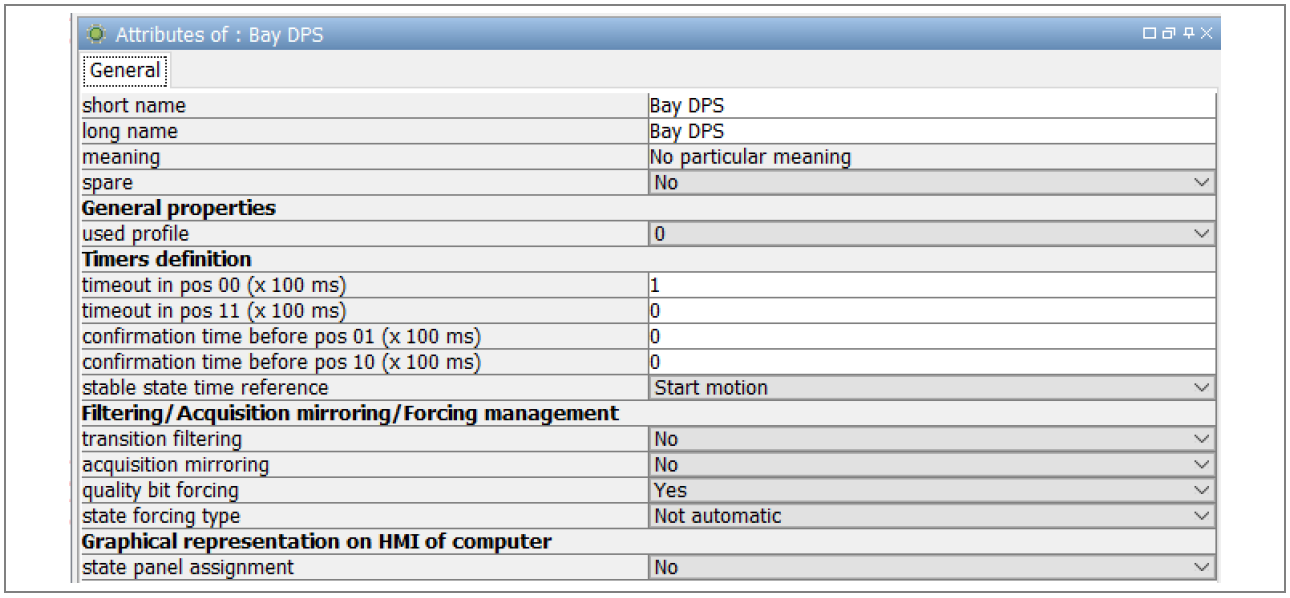


Figure 178: Setting the general attributes of a DPS datapoint (example for a generic DPS at Bay level)

General

(1) **short name** and **long name** of the datapoint used for logging, alarms ...

(2) **used profile**: the drop-down list refers to the DPS tab of the Profiles table

Timer Definition

To configure all possible use cases relative to Status and Quality of DPS in the system, several attributes are available.

DP "Intermediate delay" treatment

Two time-out values can be associated to each DP:

(3) **timeout in pos 00 (x 100 ms**) (range [0, 600]): this attribute defines the delay allowed for temporary state when both inputs are reset (former MOTION00 state) before reaching stable state, i.e. the maximum time passed in not complementary position 00. This parameter is used to filter intermediate state resulting from pos 00 when pos is moving from open to closed and vice versa. It corresponds to parameter T_{00} mentioned in section **Motion Treatment** in the **Functional Description** of the C264 user manual.

(4) **timeout in pos 11 (x 100 ms)** (range [0, 600]): this attribute defines the delay allowed for temporary state when both inputs are set (former MOTION11 state UNDEFINED) before reaching stable state, i.e. the maximum time passed in not complementary position 11. This parameter is used to filter intermediate state resulting from pos 11 when pos is moving from open to closed and vice versa. It is set to 0 when intermediate state is not considered. It corresponds to parameter T_{11} mentioned in section **MOTION TREATMENT** in the **Functional Description** of the C264 user manual.

DP "Persistence filtering" treatment

For some DP, a valid state (OPEN or CLOSE) must be confirmed for a given time period. If a transition occurs before this delay, the state is discarded. This treatment is called "**persistence filtering**".

Two time-out delays can be associated with each DP:

(5) **confirmation time before pos 01 (x 100 ms)** (range [0, 300]): this attribute defines the confirmation delay for the OPEN state. It corresponds to parameter T_0 mentioned in section **DP PERSISTENCE FILTERING** in the Functional Description of the C264 user manual.

(6) **confirmation time before pos 10 (x 100 ms)** (range [0, 300]): this attribute defines the confirmation delay for the CLOSED state. It corresponds to parameter T_C mentioned in section **DP PERSISTENCE FILTERING** in the Functional Description of the C264 user manual.

DP "Intermediate Delay" treatment

On intermediate delay, the time tag is user-selectable at configuration level

(7) **stable state time reference** (*Start motion* / *End motion*): this attribute defines the time reference for a stable state:

- **Start motion**: the valid state (OPEN or CLOSE) is stamped with the time of the beginning of the MOTION state (mode#1)
- **End motion**: the valid state (OPEN or CLOSE) is stamped with the time of this valid transition (mode#2)

Filtering/Acquisition mirroring/Forcing management

(8) **transition filtering** *(Yes / No)*: attribute used to ignore the temporary state when position is moving from open to closed and vice versa. If it is set to 'Yes', intermediate position is filtered at client side.

(9) **acquisition mirroring** *(Yes / No):* attribute used to report the states relative to not complementary positions (00 or 11) as pure acquisition value or not. In that case, the client considers intermediate state at the end of the transition as a stable state. Note: When '**acquisition mirroring**' is set to '**Yes**', '**quality bit forcing**' is forced to '**Yes**'.

(10) **quality bit forcing** *(Yes / No)***:** attribute used to indicate when DPS is in 'Bad State' due to the acquisition of both inputs set to 1 (former undefined state), if the validity of quality is forced to good or not. Setting this attribute to 'Yes' will not differentiate bad state resulting from timeout in pos 00 and acquisition of pos 11.

(11) **state forcing type** [*Not automatic* / *Auto in pos 01 ('Open' state)* / *Auto in pos 10 ('Closed' state)*]: when a DPS is in an invalid state, the C26x can force or not its status to set or reset state automatically. This attribute defines the way this forcing management is done. Automatic forcing management is independent of the FSS enable facility provided in the DPS profile.

Graphical representation on HMI of computer

(12) **state panel assignment** (*No* / *Yes*): set to Yes to enable the display of the DPS state at the C26x local HMI level.

4.3.2.2.1 Configurable implementation

CONFIGURABLE IMPLEMENTATION FOR DPS																
Acquisition (52a and 52b)	SCE Attributes				C264 SERVER APPLICATION			IEC 61850 DATA MODEL			IEC 61850 COM		C264 CLIENT		
	timeout in pos 00 or 11	transition filtering	acquisition mirroring	quality bit forcing	Internal state	Label in SCE profile	Event log	Status value (stVal)	Validity (q.validity)	Transmission (*T)	Status (stVal)	Quality (*Q)	Internal state	Label in SCE profile	Event log
00 Time < timeout in pos 00	timeout in pos 00 > 0	No	N/A	N/A	MOTION00	Intermediate State	INTERMEDIATE	**intermediate-state**	**good**	**YES**	**0x00**	**0x00**	MOTION00	Intermediate State	INTERMEDIATE
		Yes				(NOTHING)		(NOTHING)		NO	(NOTHING)			(NOTHING)	
00 Time >= timeout in pos 00	N/A	N/A	No	N/A	JAMMED	Bad State	BAD STATE	**bad-state**	**good**	**YES**	**0xC0**	**0x00**	JAMMED	Bad State	BAD STATE
	timeout in pos 00 > 0	No	Yes			(NOTHING)*		(NOTHING)*		NO	(NOTHING)*		JAMMED	(NOTHING)*	
	timeout in pos 00 = 0					Intermediate State	INTERMEDIATE	intermediate-state	good	YES	0x00	0x00	JAMMED	Intermediate State	INTERMEDIATE
	N/A	Yes													
01	N/A	N/A	N/A	N/A	OPEN	Open	OPEN	**on**	**good**	**YES**	**0x80**	**0x00**	OPEN	Open	OPEN
10	N/A	N/A	N/A	N/A	CLOSED	Closed	CLOSED	**off**	**good**	**YES**	**0x40**	**0x00**	CLOSED	Closed	CLOSED
11 Time < timeout in pos 11	timeout in pos 11 > 0	No	No	N/A	MOTION11	Intermediate State	INTERMEDIATE	intermediate-state	good	YES	0x00	0x00	MOTION00	Intermediate State	INTERMEDIATE
		Yes				(NOTHING)		(NOTHING)		NO	(NOTHING)			(NOTHING)	
		No	Yes			Bad State	BAD STATE	bad-state	good	YES	0xC0	0x00	MOTION11	Bad State	BAD STATE
		Yes				(NOTHING)		(NOTHING)		NO	(NOTHING)			(NOTHING)	
11 Time >= timeout in pos 11	N/A	N/A	No	No	UNDEFINED	Undefined	UNDEFINED	**bad-state**	invalid	**YES**	**0xC0**	0x80	UNDEFINED	Undefined	UNDEFINED
				Yes		Bad State	BAD STATE		**good**			**0x00**	JAMMED	Bad State	BAD STATE
	timeout in pos 11 > 0	No	Yes	N/A		(NOTHING)*		(NOTHING)*		NO	(NOTHING)*		UNDEFINED	(NOTHING)*	
	timeout in pos 11 = 0					Bad State	BAD STATE	bad-state	good	YES	0xC0	0x00	UNDEFINED	Bad State	BAD STATE
	N/A	Yes													

Notes:

- (*Q): Only 10 first bits for validity and its detailed are considered
- (*T): For GOOSE and reports
- (NOTHING)*: Event is not filtered but it doesn't happen because same state as previous one.

Legend:

- Cell light color for old behavior
- Cell dark color for new behavior
- Bold text for default behavior
- Red text for values different on server and client

Use cases:

Usecase 1									
State	Filter Transition	Mirror aquisition	Quality Bit forcig	C26x Expected	Wireshark Expected		aView Expected	GTW Expected	T101/T104 Expected
					State	Quality			
00<CD	FAUX	FALSE	VRAI	Intermediate	0x00	0x00	Intermediate	Intermediate	0x00 Valid
00>CD	FAUX	FALSE	VRAI	Bad State	0xC0	0x00	Bad State	Bad State	0x03 Valid
11<CD	FAUX	FALSE	VRAI	Intermediate	0x00	0x00	Intermediate	Intermediate	0x00 Valid
11>CD	FAUX	FALSE	VRAI	Bad State	0xC0	0x00	Bad State	Bad State	0x03 Valid

Usecase 2									
State	Filter Transition	Mirror aquisition	Quality Bit forcig	C26x Expected	Wireshark Expected		aView Expected	GTW Expected	T101/T104 Expected
					State	Quality			
00<CD	FAUX	FALSE	VRAI	Intermediate	0x00	0x00	Intermediate	Intermediate	0x00 Valid
00>CD	FAUX	FALSE	VRAI	Bad State	0xC0	0x00	Bad State	Bad State	0x03 Valid
11<CD	FAUX	FALSE	VRAI	Intermediate	0x00	0x00	Intermediate	Intermediate	0x00 Valid
11>CD	FAUX	FALSE	VRAI	undefined	0xC0	0x4000	Bad State with undefined quality	undefined	0x83 InValid

Usecase 3									
State	Filter Transition	Mirror aquisition	Quality Bit forcig	C26x Expected	Wireshark Expected		aView Expected	GTW Expected	T101/T104 Expected
					State	Quality			
00<CD	VRAI	VRAI	VRAI	No event	No event	No event	No event	No event	No event
00>CD	VRAI	VRAI	VRAI	Intermediate	00C0	0x00	Intermediate	Intermediate	0x00 Valid
11<CD	VRAI	VRAI	VRAI	No event	No Event	No event	No event	No event	No event
11>CD	VRAI	VRAI	VRAI	Bad state	0xC0	0x000	Bad State	Bad State	0x03 InValid

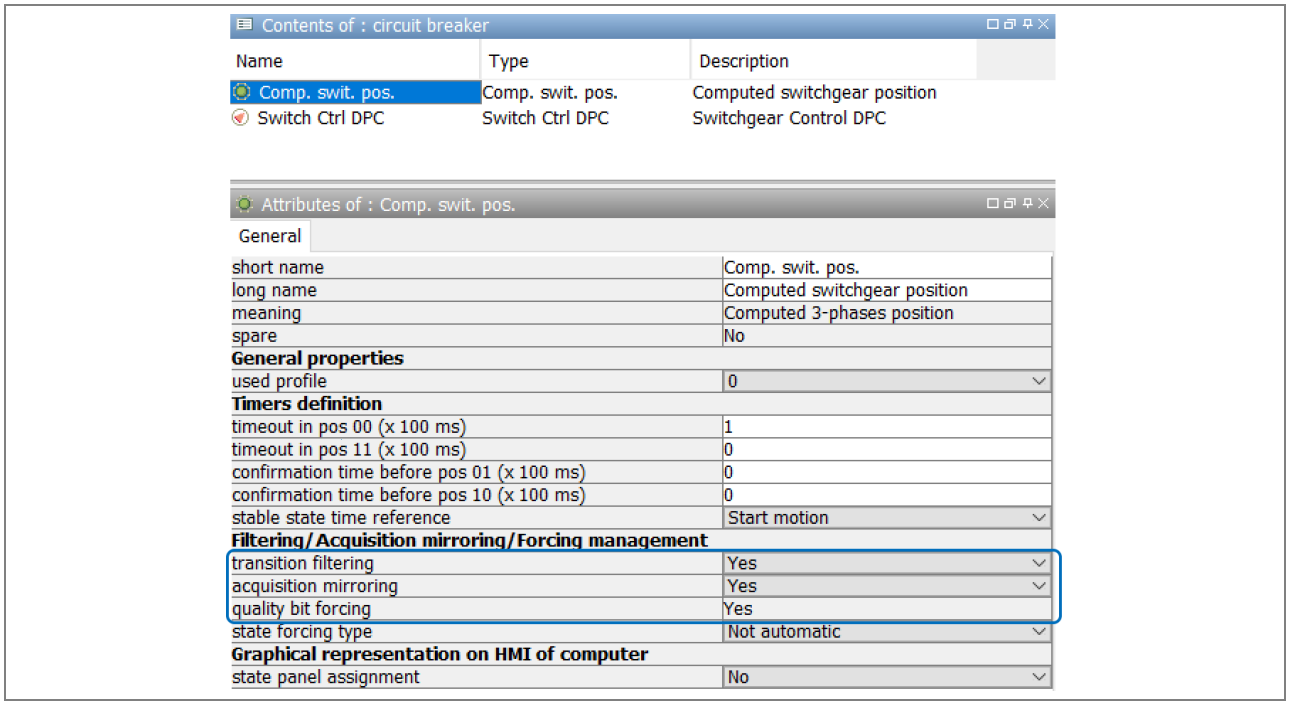
4.3.2.2.2 Configuring DPS intermediate state with transition filtering for CB

To configure a DPS datapoint with transition filtering, follow the steps below:

1 Set the **transition filtering** attribute to **Yes**.

2 Set the **aquisition mirroring** attribute to **Yes**.

3 Set the **quality bit forcing** attribute to **Yes**.



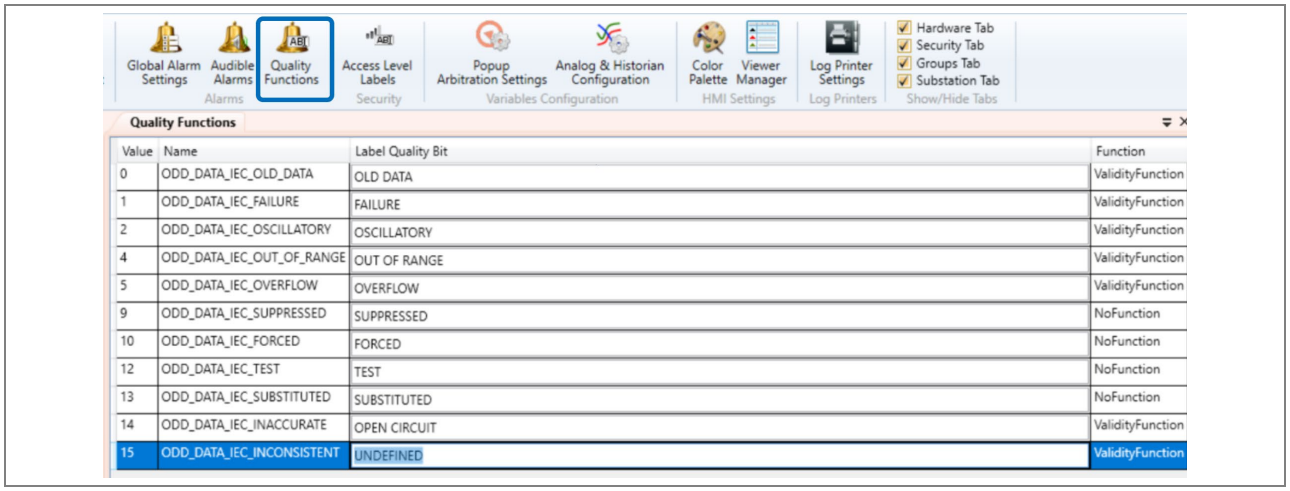
Profile configuration:

1 Enable **FSS profile** for DPS/CB datapoint.

2 Configure Archive logging for the C264 and aView

Blend configuration (for DPS state UNDEFINED):

States for event depend on configurable labels. In the **Quality Functions** window of Blend, set quality to UNDEFINED instead of inconsistent to display proper information on aView:



4.3.2.3 DEFINING THE RELATION LINKS

4.3.2.3.1 For wiring on DI channel

A **DPS electrical datapoint** has two optional relation links with Digital Input (DI) channels of computer board for wiring of 'Open' and 'Closed' signals: “open' wired on” and “closed' wired on”.

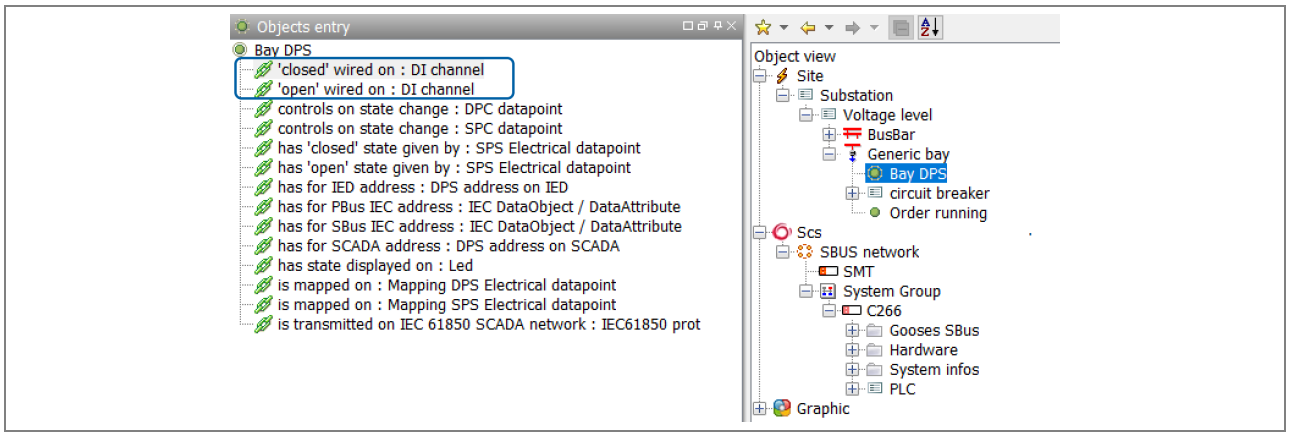


Figure 179: Optional relation links of DPS datapoint for wiring on DI channels

- Add the relation link “open' wired on" or “closed' wired on".
- Fill the relation with the relevant DI channels which vary depending on the DPS datapoint location:
  - If the DPS datapoint is in a bay or its sub-components, only DI channels of the BCU managing the bay are proposed.
  - If the DPS datapoint is at Substation or Voltage Level, DI channels of all BCU belonging to the substation are proposed.

Both relation links have no relation attributes.

4.3.2.3.2 For control on state change

To control a SPC or a DPC on state change, a DPS datapoint can use two optional relation links “controls on state change”:

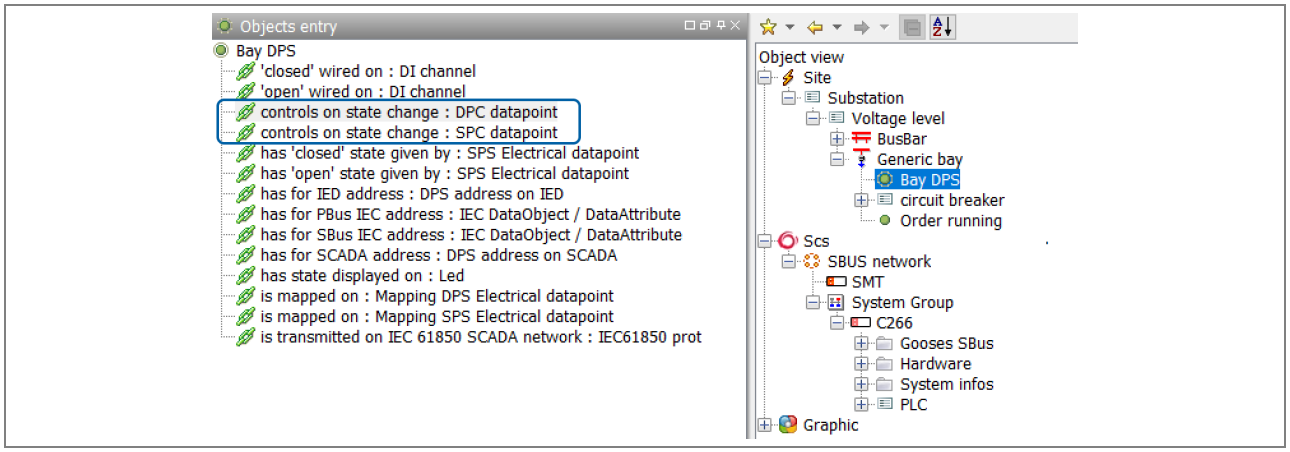


Figure 180: Optional relation links of DPS datapoint for control on state change

- Add the relation link “controls on state change".
- Fill the relation with the relevant DPC or SPC datapoint.
- Set the attributes relative to the relation link:

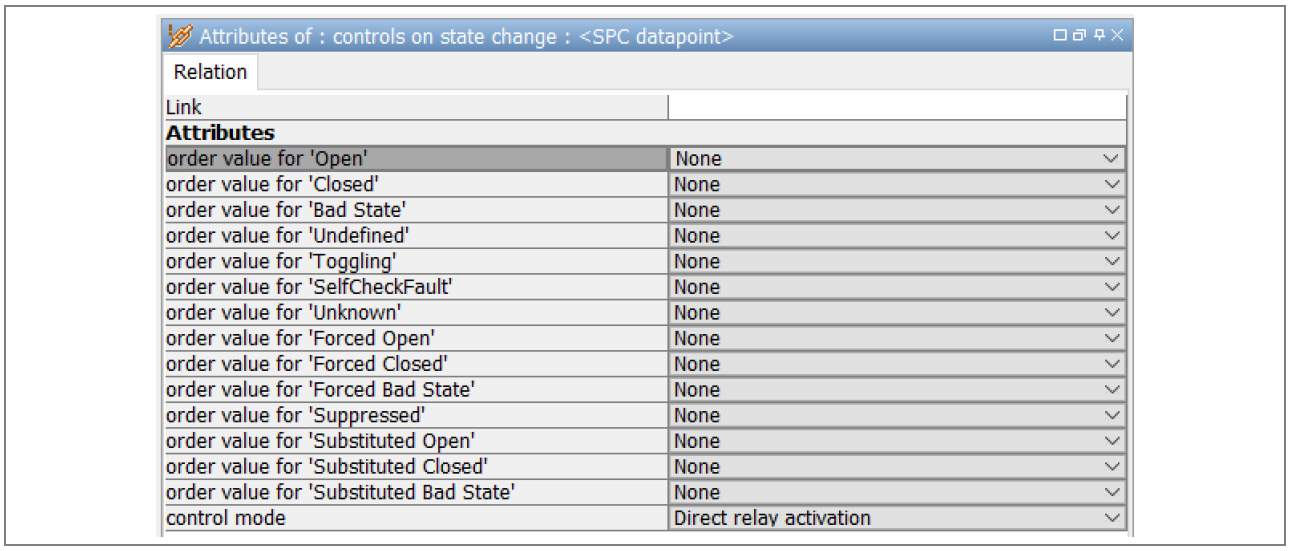


Figure 181: Attributes of the optional relation links “controls on state change”

4.3.2.3.3 For signal assignation

To send 'Open' and 'Closed' signals, a **DPS datapoint** has two optional relation links with any SPS datapoint "**has 'open' state given by**" and "**has 'closed' state given by**":

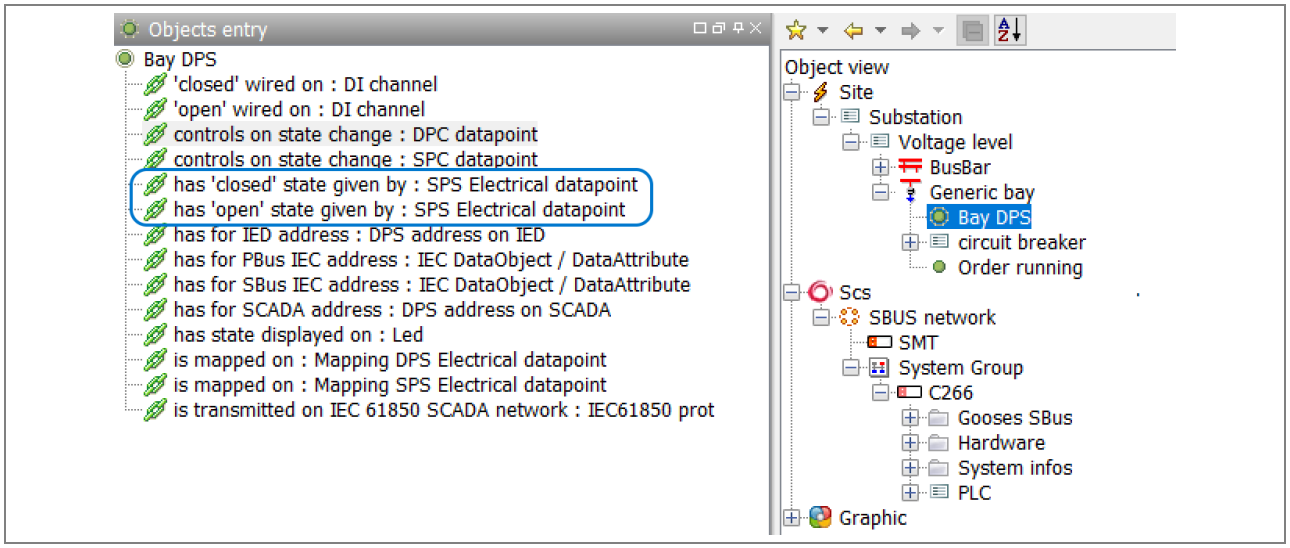


Figure 182: Optional relation links of DPS datapoint for signal assignment

- Add the relation link “**has 'open' state given by**" or “**has 'closed' state given by**".
- Fill the relation with the relevant signal.

Both relation links have no relation attributes.

4.3.2.3.4 For transmission on network

To transmit information over the Station Bus Network or the Process Bus Network, the **DPS datapoint** must have an **IEC DataObject/DataAttribute** set using the relation link “**has for SBus IEC address**” or “**has for PBus IEC address**”.

When the **DPS datapoint** is managed by a generic IED, its address on this IED must be set using the link “**has for IED address**”.

If information must be sent to a SCADA (different from IEC 61850 protocol), set the SCADA DPS address using the relational link has “**for SCADA address**”.

If information must be sent over the IEC 61850 SCADA Network, the **DPS datapoint** needs to be associated with an IEC 61850 SCADA protocol of the Gateway using the relation link “**is transmitted on IEC 61850 SCADA network**”:

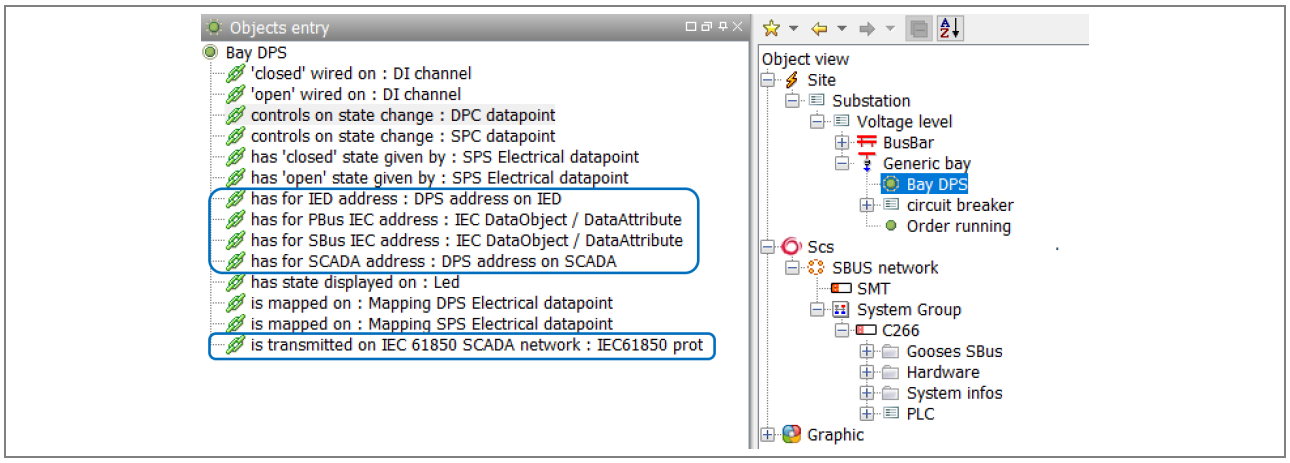


Figure 183: Optional relation links of DPS datapoint for data transmission over the network

These relation links have no attribute.

4.3.2.3.5 For displaying on LED

DPS datapoint status can be displayed via the LEDs of the GHU300 board by adding the relation **has state displayed on** at datapoint level.

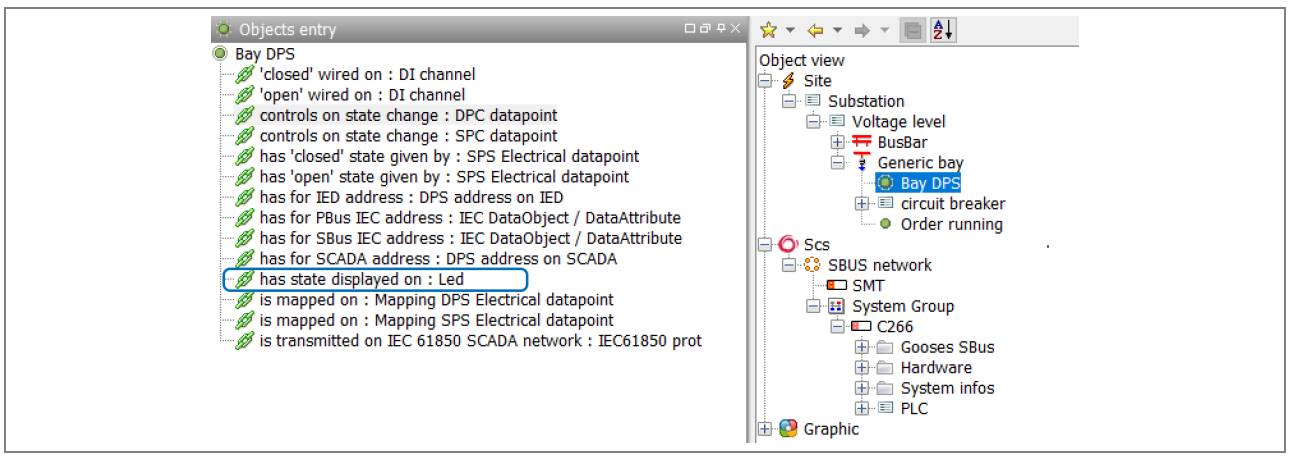
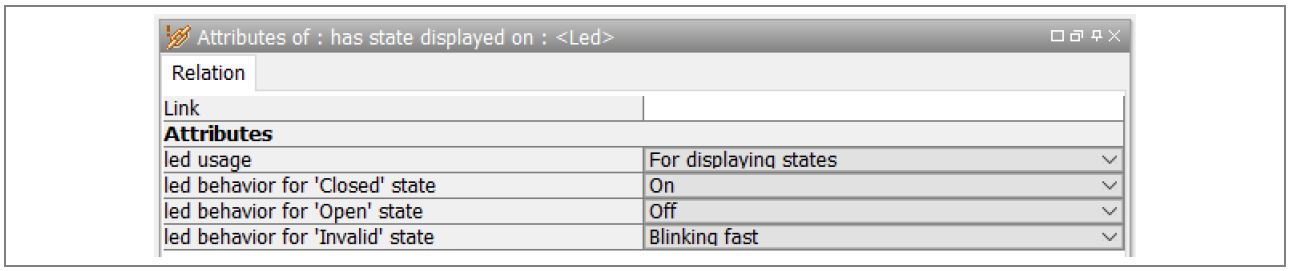


Figure 184: Optional relation links of DPS datapoint for displaying a signal on a LED

- Add the relation link “**has state displayed on**".

- Select the associated led (link) and the set attributes:



- **LED usage**: for displaying alarms / for displaying states

The following attributes depend on the "led usage" value and are shown only if it set to "For displaying states":

- **led behaviour for 'Closed' state**: *Off* / *On* / *Blinking slow* / *Blinking fast.* This attribute depends on the "led usage" attribute value. Only visible if it set to "For displaying states".
- **led behaviour for 'Open' state**: *Off* / *On* / *Blinking slow* / *Blinking fast*
- **led behaviour for 'Invalid' state**: *Off* / *On* / *Blinking slow* / *Blinking fast*

4.3.2.3.6 For mapping on SPS or DPS datapoints

To link each state of the DPS datapoint to a state of a target datapoint (DPS or SPS) a relation '**is mapped on**' must be added to the selected "original" datapoint.

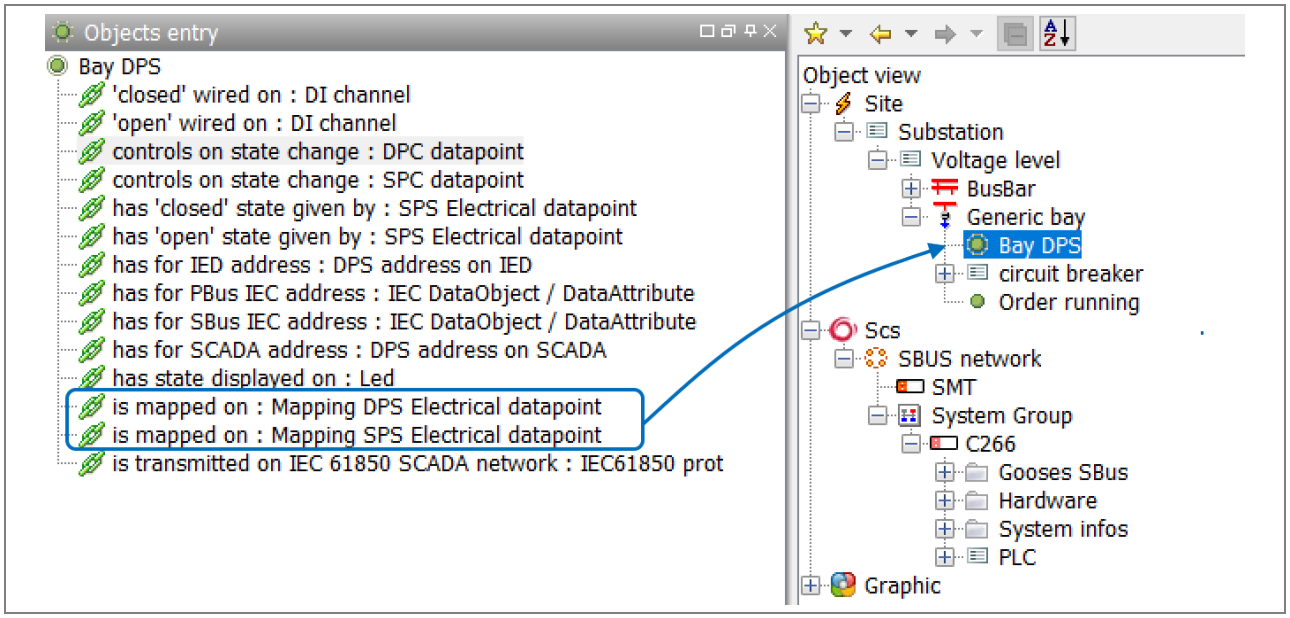


Figure 185: Optional relation links of DPS datapoint for mapping states

- Add the relation link "**is mapped on**" to the running datapoint (Bay DPS in our example). Once added, the relation appears in the "**Contents of**" panel.
- Double-click the relation "**is mapped on**" and select the Mapping DPS or SPS datapoint you want to be associated with the running datapoint then click the OK button.

- Set the attributes for the relation link "**is mapped on**". In the **"Attributes of:"** window associated with this relation are listed all the possible states of the original datapoint (1) and for each one the user has to select the corresponding state of the target datapoint (2).

Note: The attribute labels are the same for target Mapping SPS and taget Mapping DPS. However, the possible values of their attributes differ:

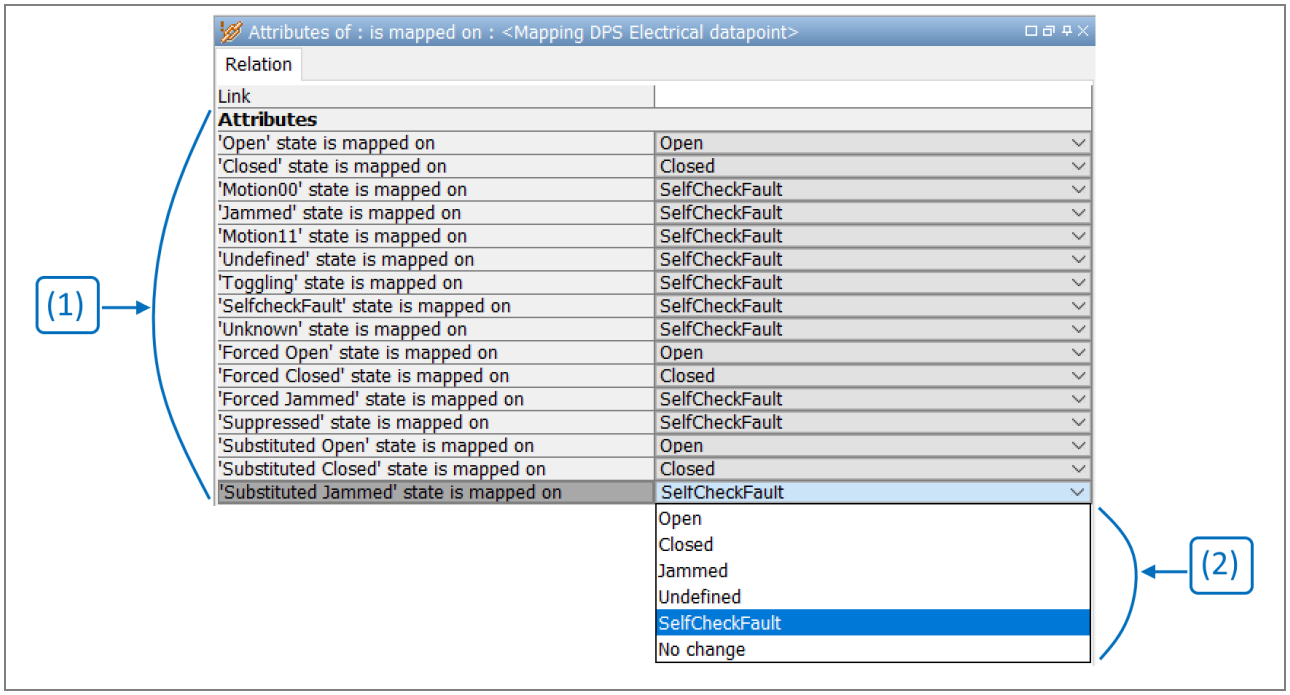


Figure 186: Possible attributes for mapping original and target states

4.3.3 USING AN MPS DATAPOINT

To add an MPS datapoint:

- Select the required system or electrical object level (1) and add an MPS from the contextual **Objects entry** window. Depending on the object level, different pre-defined types of MPS exist. They are used for specific needs at electrical topology level (for details see relevant section in *5 Defining a C26x configuration in the electrical hierarchy*) or system topology level (for details see section *3.10 Setting system information for C26x components*)
- Update the MPS attributes (see following topic); some attributes can be fixed or masked depending on the pre-defined type of MPS
- Update its relation **has for profile** to point to a specific existing profile (2)

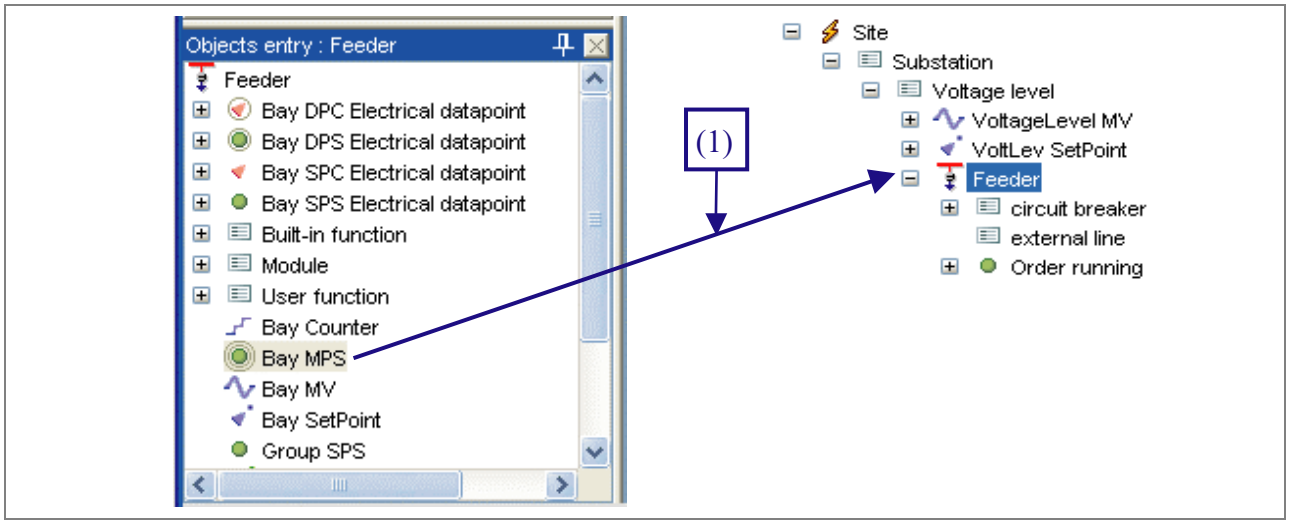


Figure 187: Adding an MPS datapoint (example for a generic MPS at Bay level)

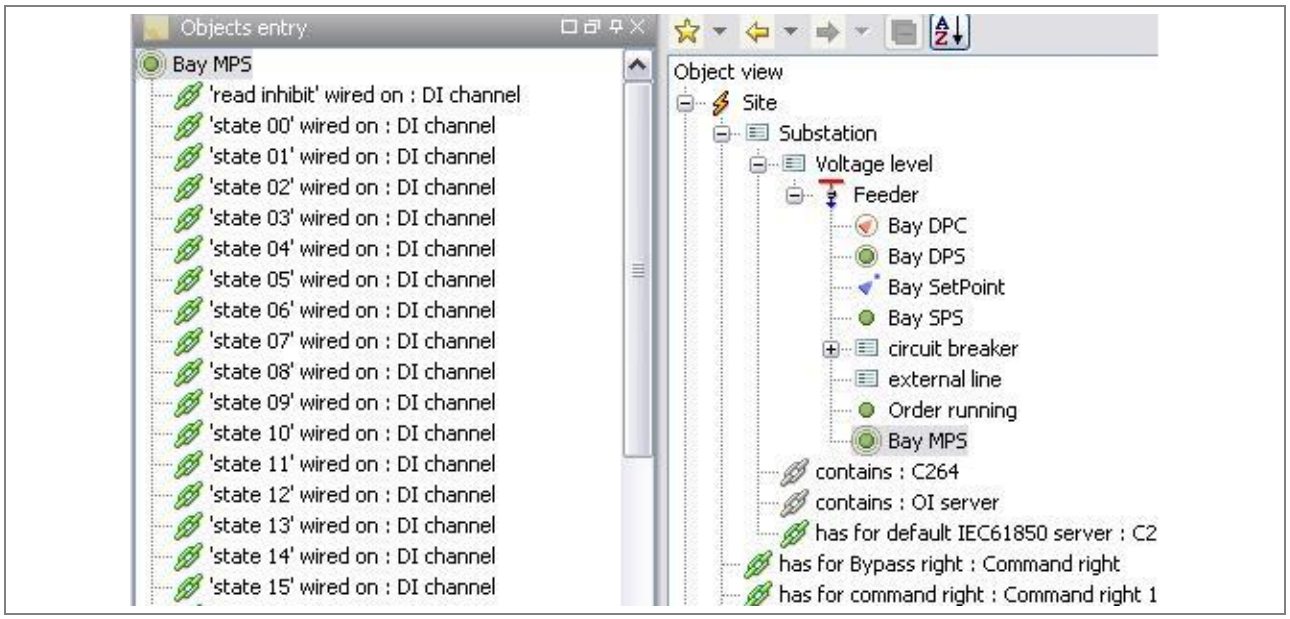


Figure 188: Linking MPS datapoint to its profile (example for a generic MPS at Bay level)

Updating MPS attributes (description for generic MPS)

When adding a generic MPS datapoint, some general attributes must be updated:

(1) **short name** and **long name** of the datapoint used for logging, alarms ...

(2) **used profile**: the drop-down list refers to the MPS tab of the Profiles table

(3) **filtering delay** (range [0 s, 6553.5 s], step 10 ms)

(4) **inhibition delay** (range [0 s, 6553.5 s], step 10 ms)

(5) **forcing management** (*Not automatic* / *Automatic to state* / *Automatic to set state*): when an MPS goes in invalid state, C26x can force or not its status to set or reset state automatically. This attribute defines the way this forcing management is done. Automatic forcing management is independent of the FSS enable facility provided in the MPS profile.

(6) **state panel assignment** (*No* / *Yes*): set to *Yes* to enable MPS state display at C26x local HMI level.

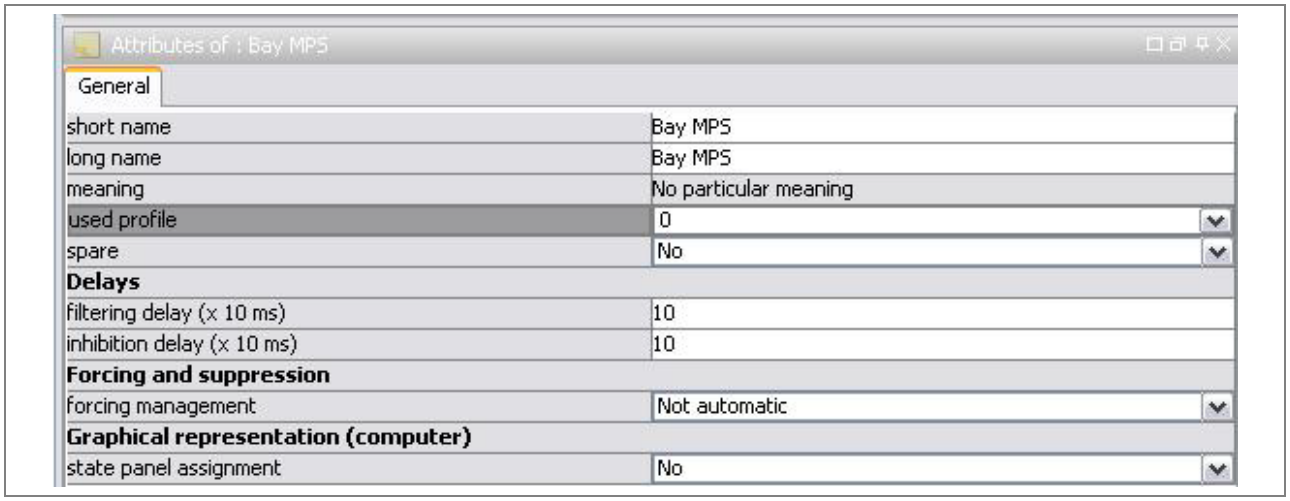


Figure 189: Setting the general attributes of an MPS datapoint (example for a generic MPS at Bay level)

Relation links

An MPS datapoint has an optional relation link "controls on state change" with one **MPC datapoint** in order to allow this feature. This relation link owns no attribute.

4.3.4 USING AN MV DATAPOINT

All electrical MV have several optional relation links with boards able to do computations from acquired Measurement Value.

- TMU210 board
- TMU220 board
- CPU470 board (from IEC 61850-9.2 LE)

To add an MV datapoint:

- Select the required system or electrical object level (1) and add an MV from the contextual **Objects entry** window. Depending on the object level, different pre-defined types of MV exist. They are used for specific needs at electrical topology level (for details see relevant section in *5 Defining a C26x configuration in the electrical hierarchy*) or system topology level (for details see section *3.10 Setting system information for C26x components*)
- Update the MV attributes (see following sections); some attributes can be fixed or masked depending on the pre-defined type of MV
- Update its relation **has for profile** to point to a specific existing profile (2)

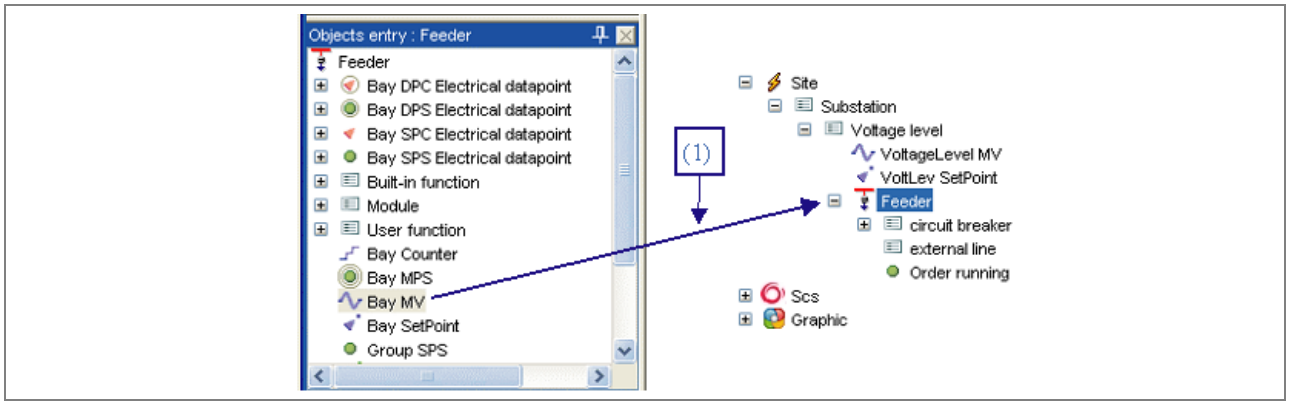


Figure 190: Adding an MV datapoint (example for a generic MV at Bay level)

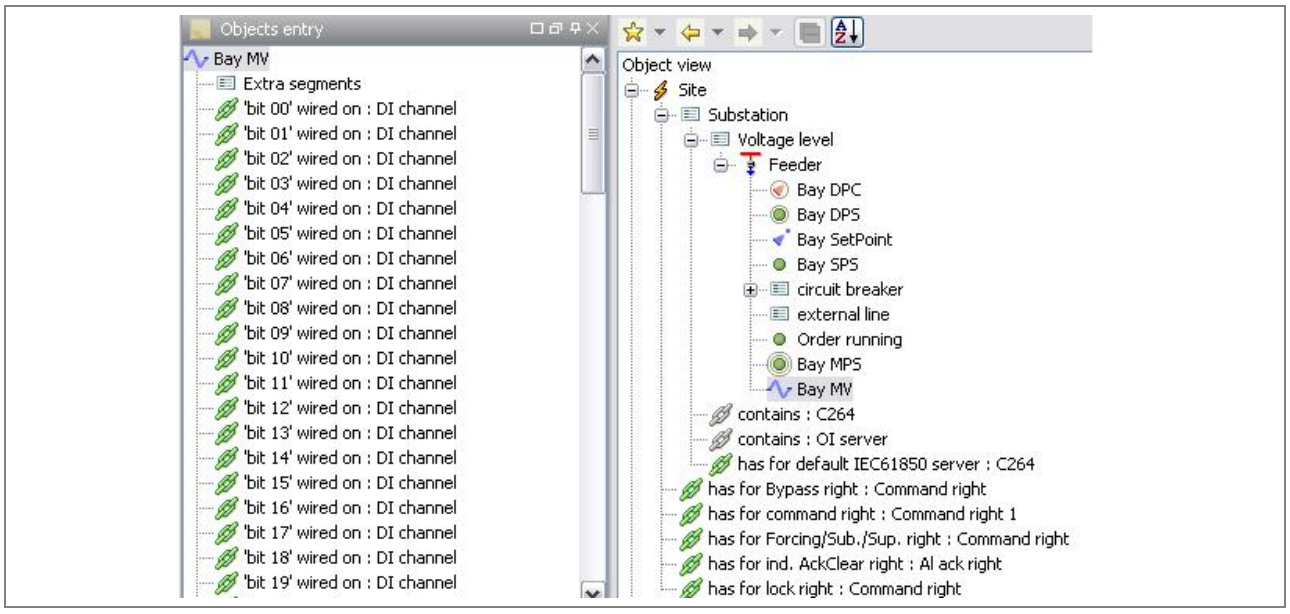


Figure 191: Linking an MV datapoint to its profile (example for a generic MV at Bay level)

Note:
To create a Computed MV, select the window Wiring and the board TMU2xx, then click Insert.

4.3.4.1 SETTING THE GENERAL ATTRIBUTES OF AN MV DATAPOINT

When adding a generic MV datapoint, some general attributes must be updated:

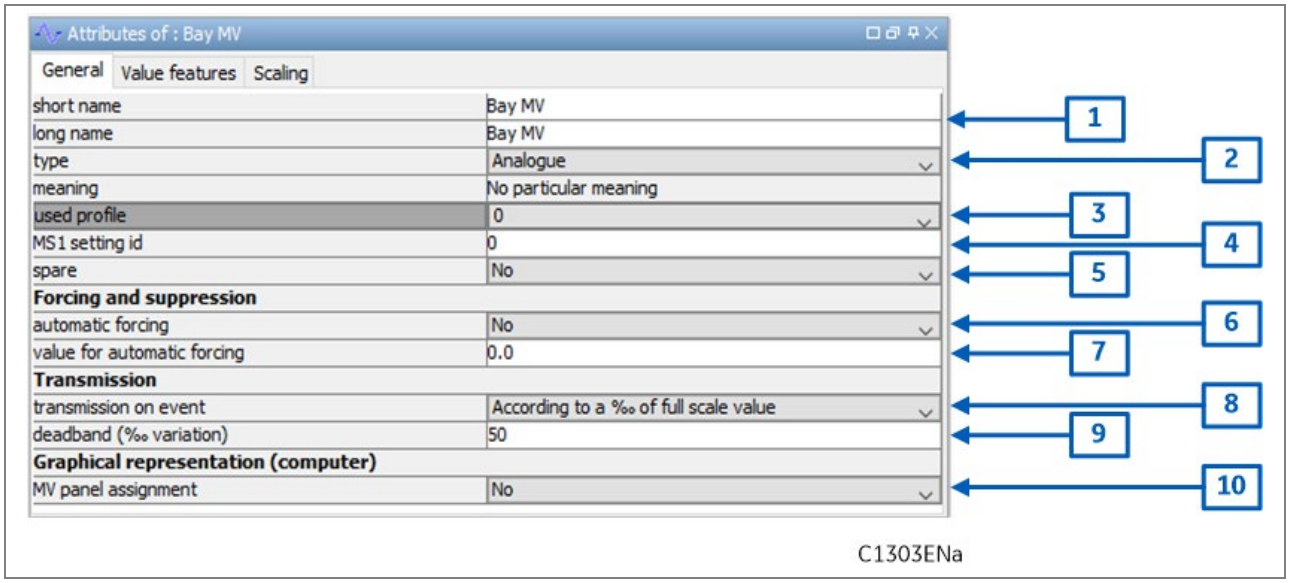


Figure 192: Setting the General attributes of an MV datapoint

(1) **short name** and **long name**: used for logging, alarms ...

(2) **type**: available values are:

- Analogue (used for analogue acquisition, IED acquisition, CT/VT calculation or system input)
- Digital coded ‘BCD’ (only used for digital acquisition)
- Digital coded ‘pure binary’ (only used for digital acquisition)
- Digital coded ‘gray’ (only used for digital acquisition)
- Digital coded ‘1 among n’ (only used for digital acquisition)
- Digital coded ‘decimal’ (only used for digital acquisition)
- For details about digital encoding refer to the Functional Description chapter of the C264 user manual.

(3) **used profile**: the drop-down list refers to the MV tab of the Profiles table

(4) **MS1 setting id**: This attribute is self-managed (the default value is 0) and can be modified by the user. This attribute is dependent on the use of thresholds which are manageable by MS1. When at least one MV threshold is set to 'Yes with setting MS1' then this attribute is set to a valid value (between 1 and 16) and inversely if no threshold is set to'Yes with setting MS1' then the value is automatically set to 0.

(5) **Spare** (Yes/No)

(6) **automatic forcing** (No / Yes): when an MV goes in invalid state, C26x can force or not its value automatically. Automatic forcing management is independent of the FSS enable facility provided in the MV profile.

(7) **value for automatic forcing**: MV value when automatic forcing

(8) **transmission on event** (Cyclic long period / Cyclic short period / According to a ‰ of full scale value / According to a ‰ of current value): see section 4.3.4.5 Setting the transmission interval of an MV datapoint below.

(9) **deadband** (‰ variation) (range [0, 255], step 1): this attribute is significant only if the previous parameter is set to ‘According to a ‰ of ...’: this attribute corresponds to the ‘p’ parameter described in the Transmission section in the Functional Description chapter of the C264 user manual.

(10) **MV panel assignment** (No / Yes): set to Yes to enable MV value displayed at C26x local HMI level.

Note: In case of configuration issues, MV datapoints defined as ALARM in the MV profile may appear on the "M" panel of BCU LHMI even if the "MV panel assignment" setting is is set to NO.

*To not display MVs displayed on the BCU LHMI, make sure to set the "**ALARM**" MV datapoint **profile** to "**No**" AND the MV datapoint attribute "**MV panel assignment**" to "**No**".*

4.3.4.2 SETTING THE VALUE FEATURES ATTRIBUTES OF AN MV DATAPOINT

When adding a generic MV datapoint, some 'Value features' attributes must be updated:

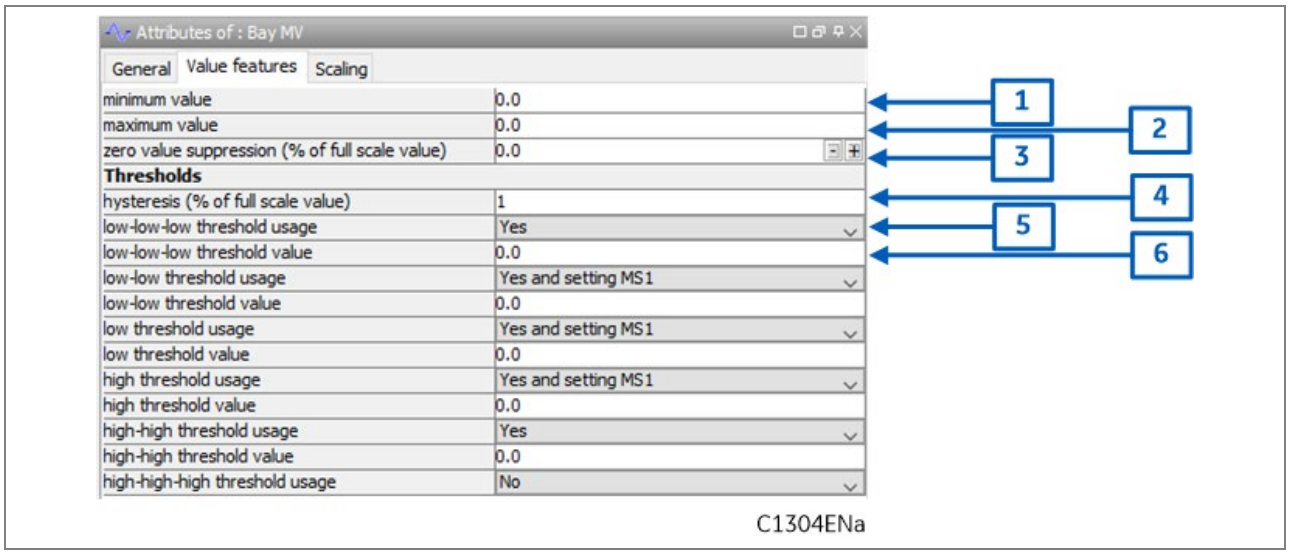


Figure 193: Setting the value features attributes to MV datapoint (example for a generic MV at Bay level)

(1) **minimum value** (range [-3.4E38, 3.4E38]: minimum value of the process range (in volts, amps, degrees…), used for full scale calculation and scaling.

(2) **maximum value** (range [-3.4E38, 3.4E38]: maximum value of the process range (in volts, amps, degrees…), used for full scale calculation and scaling.
(Full scale = maximum value - minimum value)

(3) **zero value suppression** (% of full scale value) (range [0,10], step 0.1): this parameter is used to define the zero suppression area (deadband) for zero value suppression processing (see section ZERO VALUE SUPPRESSION in the Functional Description of the C264 user manual for details)

(4) **Hysteresis** used for threshold detection (see *Functional Description chapter C26x/EN FT* for details)

(5) **… threshold usage** (*No / Yes / Yes and setting MS1*):

- **Yes**: threshold is actived
- **No**: threshold is deactived
- **Yes and setting MS1***:* threshold is active and editable from MiCOM S1. Threshold values low-low, low, high and high-high are editable from MiCOM S1 tool for all MV datapoints of a bay.

(6) **… threshold**: value of threshold (the value is in range of the MV, and the threshold is activated). If the threshold usage is "**Yes and setting MS1**" then, this threshold value is visible and modifiable from MiCOM S1 tool. When a threshold value is modified from MiCOM S1, the new value is taken into account by the C264 as the new parameter value.

Note 1: The number of MV datapoints with at least one threshold defined as "MS1 setting" shall not exceed 16 per bay.

*Note 2: MV datapoints that are feedbacks of setpoints (via the relation **is feedback of :**) do not support thresholds. If thresholds are nonetheless configured, they will not be transmitted over the IEC 61850 network.*

4.3.4.3 SETTING THE SCALING ATTRIBUTES OF AN MV DATAPOINT

When adding a generic MV datapoint, some 'Scaling' attributes must be updated:

(1) **scaling rule**: available values are (see *Functional Description chapter C26x/EN FT* for calculation details): *Linear*/*Quadratic*/*Quadratic with offset*.

Note:
For MVs received from external IEDs, only linear scaling is available. Any other settings will be ignored.

(2) **minimum acq. value** (used for scaling)

(3) **maximum acq. value** (used for scaling)

In case of multi-segment scaling (see below):

(4) **A (or A1) coefficient: multiplication factor of transformation**

(5) **B (or B1) offset: offset of transformation**

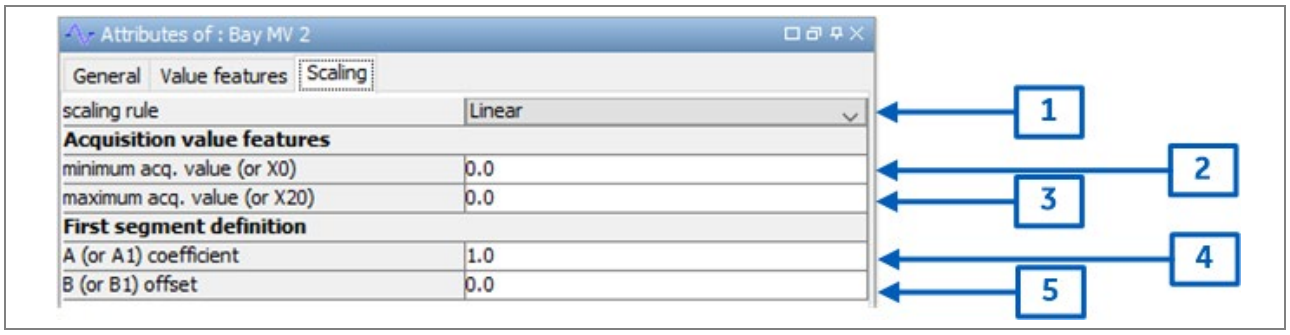


Figure 194: Setting the scaling attributes of an MV datapoint (example for a generic MV at Bay level)

Note: For measurement values (MV) acquired through an analogue input, the minimum and maximum values can be different from the minimum and maximum process values.

Multi-segment scaling configuration

1 In the MV's own attributes (see above):

a Select the "linear" scaling rule

b Define the coefficients multiplicator (A) and the offset (B) of the first segment [X0-X1[

2 Configure multi-segment scaling on a measurement (MV) by additing the optional object **Extra segments** underneath it. Then set its attributes:

a the diffferent boundaries of each segment of the non-linear curve ([X0-X1[, [X1-X2[, ...)

b the coefficients multiplicator (Ai) and the offset (Bi) of each segment

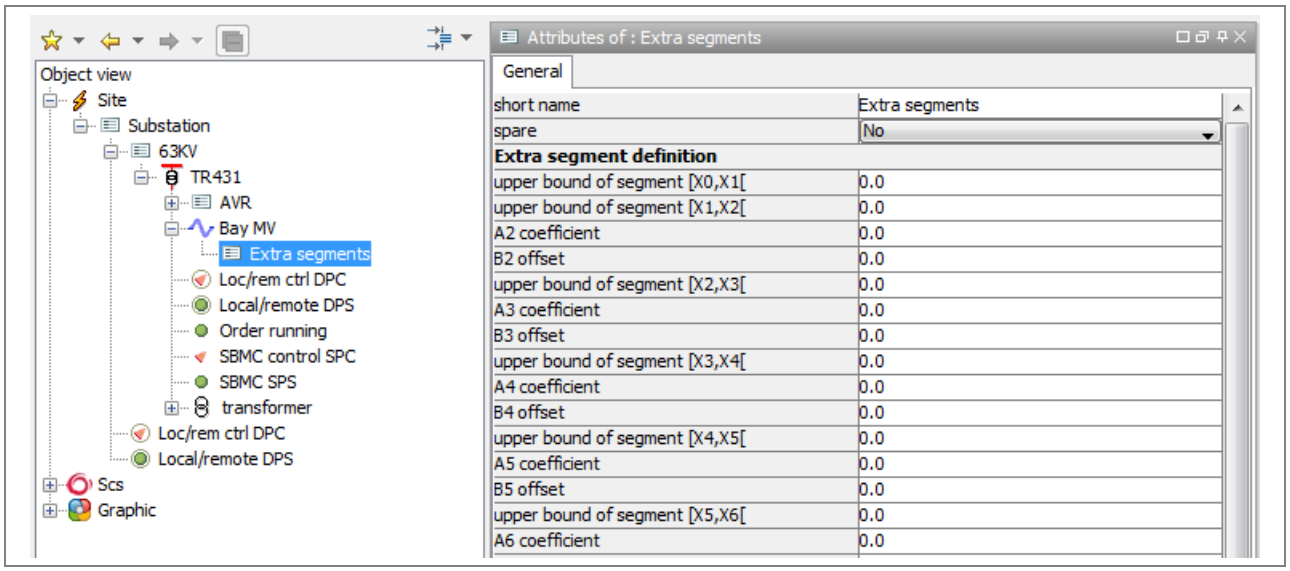


Figure 195: Setting the scaling attributes for the extra segments of an MV datapoint

4.3.4.4 SETTING THE TRANSMISSION INTERVAL OF AN MV DATAPOINT

4.3.4.4.1 Cyclic transmission

To transmit the current value of an MV datapoint at set intervals:

1 Set its general attribute **transmission on event** to either *Cyclic long period* or *Cyclic short period*

2 Include this datapoint into an MMS report (see *SCE manual, Application chapter* for MMS reports configuration).

*Note: **Report settings** are automatically configured to transmit MV upon cyclic data acquisition. Attributes of the report instance are set as follows:*

*- **Data update (dupd)** = Yes*
*- **Periodic (period)** = No*

4.3.4.4.2 Transmission upon variation

To transmit the current value of an MV datapoint only when its value varies from the previously transmitted value by more than a specified amount **ΔV**:

Set its general attribute **transmission on event** to either

- *According to a ‰ of full scale value*:

  $\Delta V = (p/1000) * |V_t|$
  where
  - **p** is the deadband, with a value in the range 0 .. 255
  - $\mathbf{V_t}$ is the last transmitted measurement value.

- *According to a ‰ of current value*:

  $\Delta V = (p/1000) * |V_t|$
  where
  - **p** is the deadband, with a value in the range 0 .. 255
  - $\mathbf{V_t}$ is the last transmitted measurement value.

4.3.4.4.3 Transmission upon trigger

In addition to the above transmission modes (cyclic or upon variation), transmission can be triggered by an SPS or DPS datapoint.

The trigger is defined for each measurement (MV) by adding a relation:

- **is sent on set state of :** if a SPS is used as trigger,
- **is sent on closed state of :** if a DPS is used as trigger.

It is possible to link several measurements to the same trigger datapoint in order transmit them in the same group, as shown below.

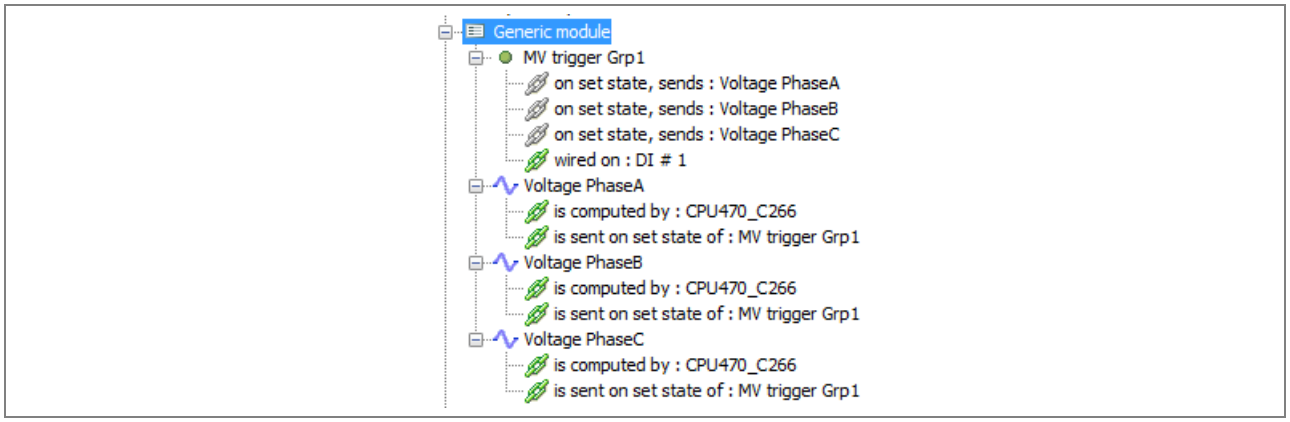


Figure 196: Assigning a trigger to the transmission of MV datapoints

4.3.5 USING A TPI DATAPOINT

Tap Position Indicator (TPI) is an MV with specific features:

- Its value is an integer in the range [1..64]
- Acquisition can be done via AI channel of AIU board
- Acquisition can be done on digital channels of DIU board (up to 64 DI channels). In this case, available digital MV type are: Decimal, Gray, BCD or ‘1 among n’

4.3.5.1 ADDING A TPI DATAPOINT

TPI datapoint is automatically created when adding a tap changer built-in function under a mandatory transformer module of a transformer bay. For details about transformer bay, module or tap changer function creation see section *5 Defining a C26x configuration in the electrical hierarchy*.

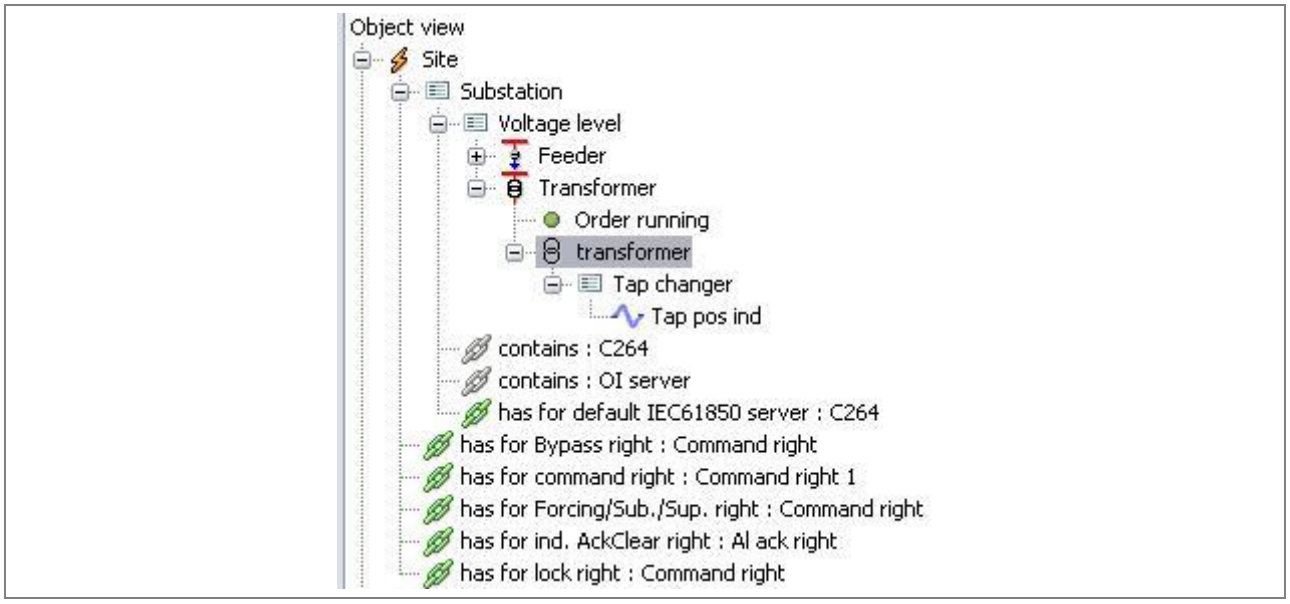


Figure 197: Automatic TPI creation for the tap-changer built-in function

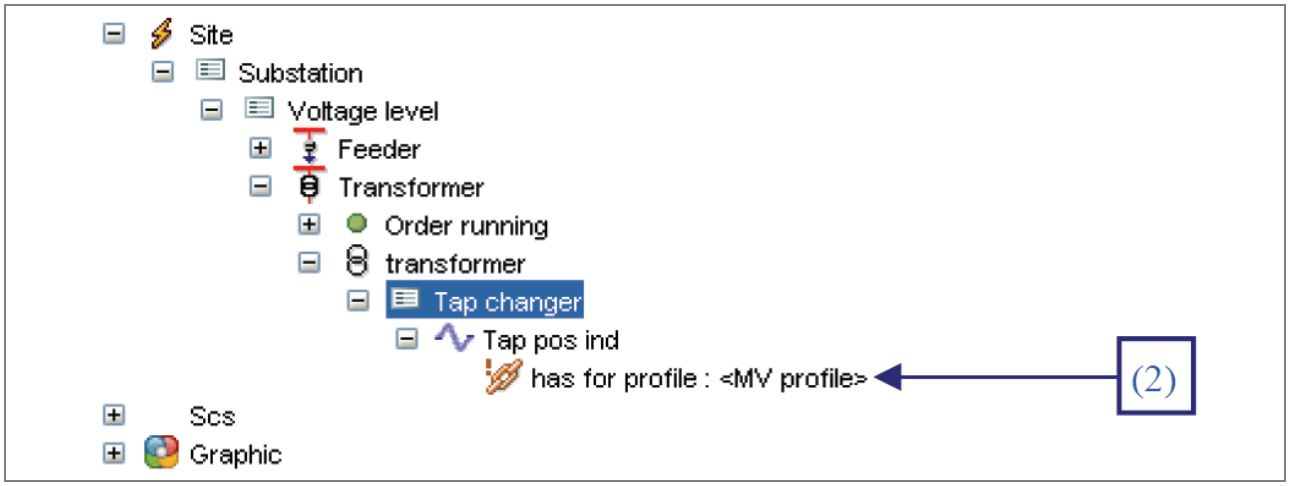


Figure 198: Linking a TPI datapoint to its profile

4.3.5.2 SETTING THE GENERAL ATTRIBUTES OF A TPI DATAPOINT

Some general attributes, similar to MV attributes, must be set:

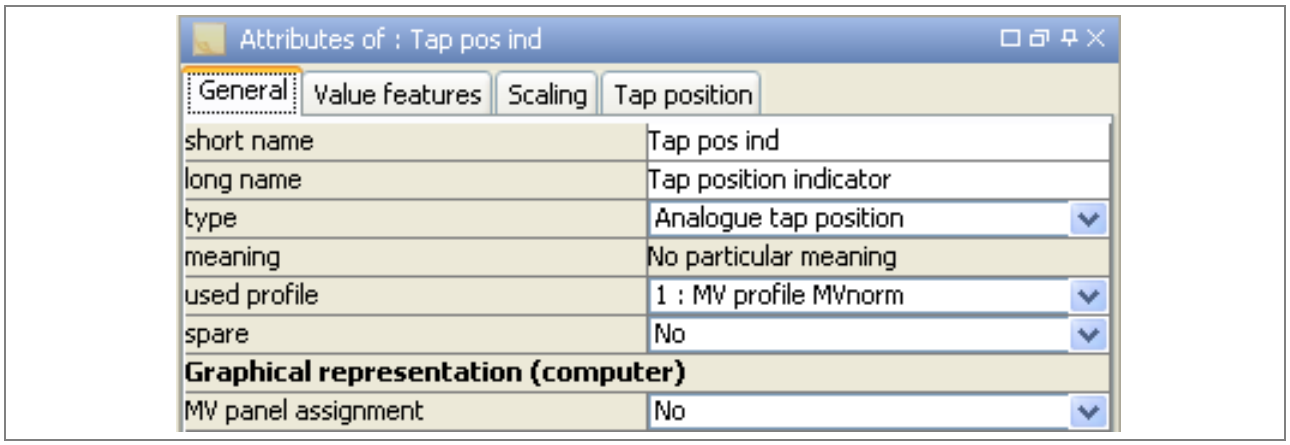


Figure 199: Setting the general attributes of a TPI datapoint

(1) **short name** and **long name** of the datapoint used for logging, alarms ...

(2) **type**: available values are:

- *Analogue tap positio*n (not available in Process Bus configuration)
- *Digital tap position coded '1 among N'* (only used for digital acquisition)
- *Digital tap position coded 'decimal'* (only used for digital acquisition)
- *Digital tap position coded 'gray'* (only used for digital acquisition)
- *Digital tap position coded 'BCD'* (only used for digital acquisition)

For details about digital encoding refer to te Functional Description chapter of the C264 user manual.

(3) **used profile**: the drop-down list refers to the MV tab of the Profiles table

(4) **MV panel assignment** (No / Yes): set to 'yes' to enable MV value display at C26x local HMI level.

4.3.5.3 SETTING THE VALUE FEATURES ATTRIBUTES OF A TPI DATAPOINT

See section *4.3.4.3 Setting the Value features attributes of an MV datapoint*.

Configuration rules and checks

The following constraint between the two attributes must be respected:
("maximum value" – "minimum value" + 1) ∈ [1..64]

4.3.5.4 SETTING THE TAP POSITION ATTRIBUTES OF A TPI DATAPOINT

For a TPI datapoint, some specific attributes must be updated:

(1) **filtering delay** (range [0 , 655,35 s], step 10 ms):

- for digital TPI, corresponds to T_{stab} of digital measurement
  (For attribute description, see section DIGITAL MEASUREMENT in the Functional chapter of the C264 user manual.
- for analog TPI, corresponds to a delay to filter transient UNDEFINED state (delay to confirm UNDEFINED state).

(2) **current valid range (% maximum value)** (range [0 , 20 %], step 1 %): only used for analogue TPI, corresponds to N parameter described in section 5.3 of chapter C26x/EN FT.

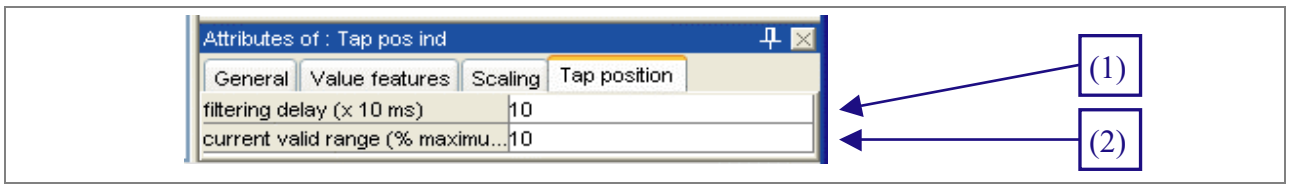


Figure 200: Setting the tap position attributes of a TPI datapoint

4.3.5.5 SETTING THE SCALING ATTRIBUTES OF A TPI DATAPOINT

For an analogue TPI datapoint, some 'Scaling' attributes appear and must be updated:

(1) **minimum acq. value**: corresponds to Imin parameter described in section TAP POSITION INDICATION (TPI) MEASUREMENT PROCESSING, in the Functional chapter of the C264 user manual.

(2) **maximum acq. value**: corresponds to Imax parameter described in section TAP POSITION INDICATION (TPI) MEASUREMENT PROCESSING, in the Functional chapter of the C264 user manual.

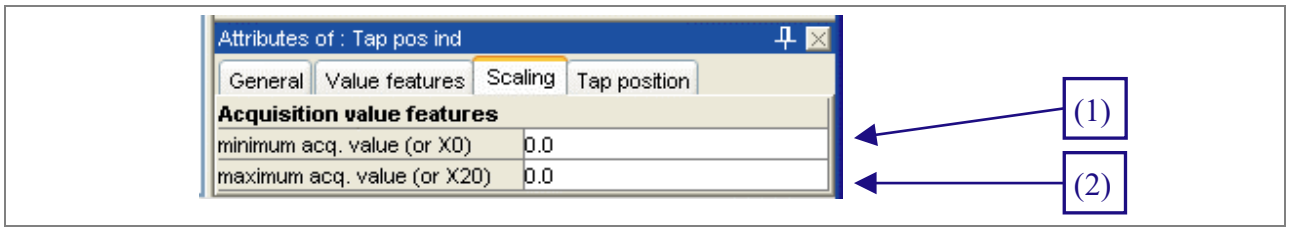


Figure 201: Setting the scaling attributes of a TPI datapoint

4.3.6 USING A COUNTER DATAPOINT

Single counters and double counters are described in section COUNTERS ACQUISITION (CT) in the Functional chapter of the C24 user manual.

Scaling is used for printing or displaying a counter. EPI is a parameter giving the amount of energy in kW-h or kVAR-h equivalent to a pulse. The displayed value is:

N x EPI kW-h (N = value of a counter)

4.3.6.1 ADDING A COUNTER DATAPOINT

Select the required system or electrical object level (1) and add a Counter from the contextual **Objects entry** window. Depending on the object level, different pre-defined types of counter exist. They are used for specific needs at electrical topology level (for details see relevant section in *5 Defining a C26x configuration in the electrical hierarchy*) or system topology level (for details see section *3.10 Setting system information for C26x components*).

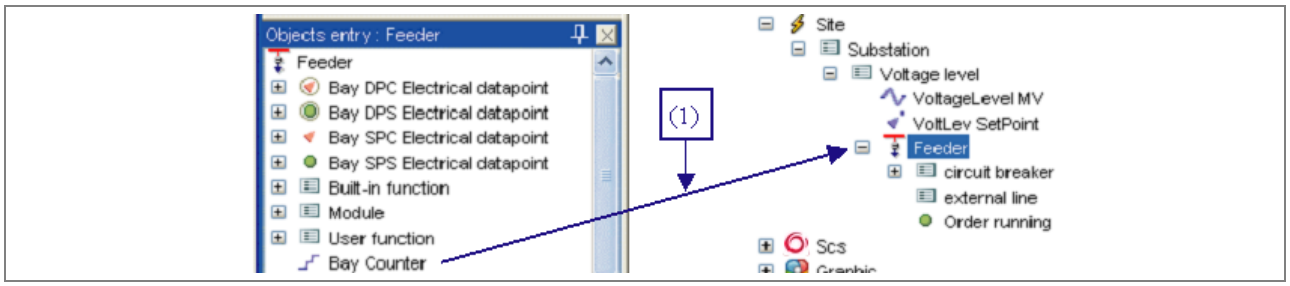


Figure 202: Adding a counter datapoint (example for generic counter at Bay level)

4.3.6.2 SETTING GENERAL ATTRIBUTES OF A COUNTER DATAPOINT

When adding a generic Counter datapoint, some general attributes must be updated:

(1) **short name** and **long name** of the datapoint used for logging, alarms ...

(2) **used profile**: the drop-down list refers to the Counter tab of the Profiles table

(3) **counter type** (*Standard* / *Energy import* / *Energy export*): when this attribute is set to "Standard" associated attributes are Validation duration (3), Invalidity duration (4), IED value already totaled (5), Cumul period (6) and Reset at cumulative period (7). When this attribute is set to *Energy import* or *Energy export*, the associated attributes are energy type (9), Scale factor (10), Transmission period (11) and reset after transmission (12)

(4) **validation duration** (range [0, 10 s], step 1 ms): corresponds to T_{count} parameter described in section 4.5 of chapter C26x/EN FT

(5) **invalidity duration** (range [5, 10 s], step 1 ms): corresponds to T_{def} parameter described in section COUNTERS ACQUISITION (CT) in the Functional chapter of the C24 user manual.

(6) **IED value already totalized** (*No* / *Yes*): attribute must be set to Yes if counter value acquired on IED must not be totaled periodically (total done at IED level)

(7) **cumul period** (*10 mn* / *15 mn* / *30 mn* / *N h (N ∈ [1, 24])*): corresponds to period length of internal clock parameter just described

(8) **reset at cumulative period** (*No* / *Yes*): when set to Yes that the way to transmit the periodic register, if not the cumulative register is transmitted

(9) **MV panel assignment** (*No* / *Yes*): set to Yes to enable Counter value display at C26x local HMI level

(10) **energy type** (*Active energy* / *Reactive energy*)

(11) **scale factor**

(12) **transmission period** (10 mn / 15 mn / 30 mn / N h (N ∈ [1, 24]))

(13) **reset after transmission** (No / Yes)

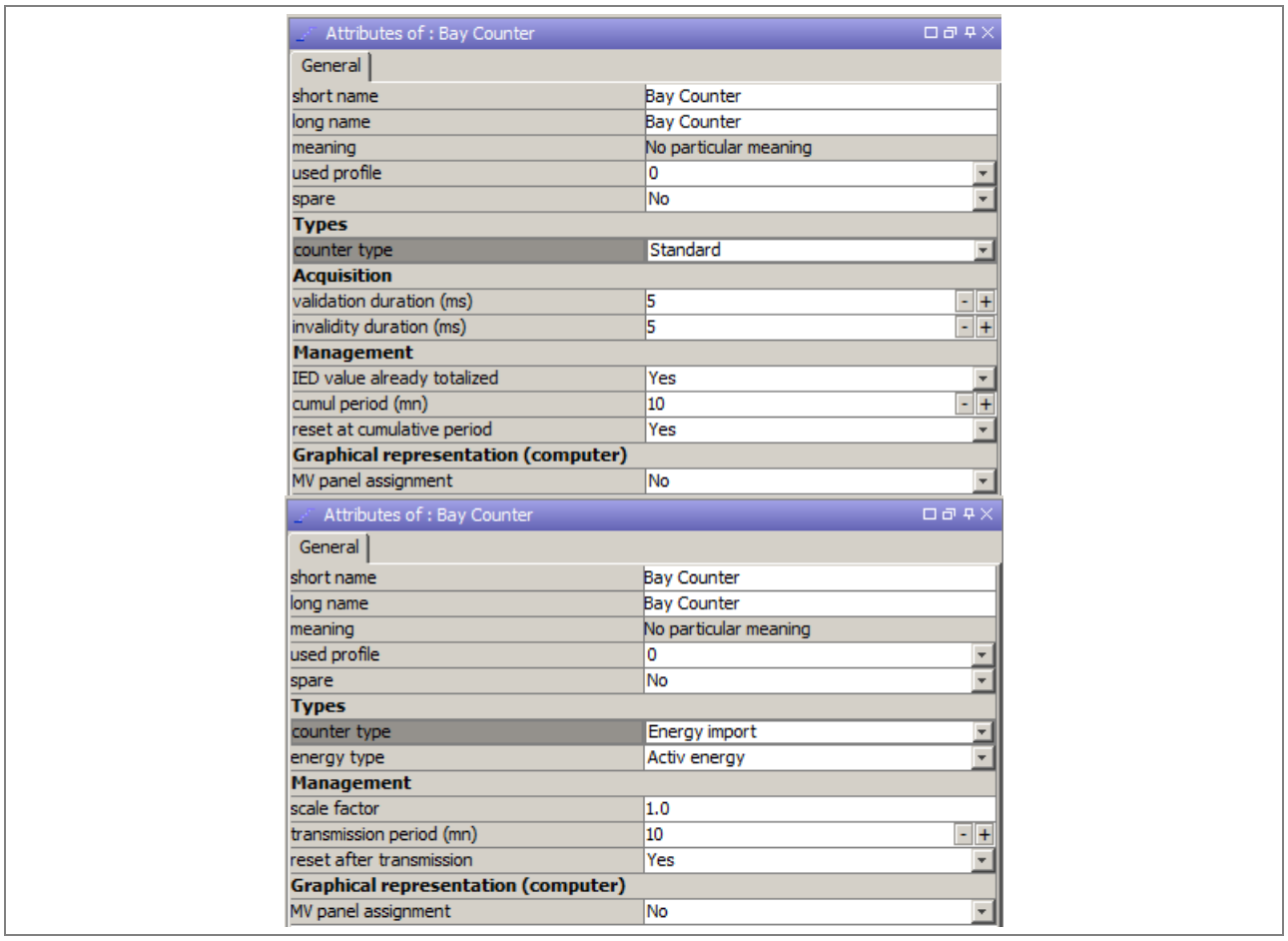


Figure 203: Setting the general attributes of a counter datapoint (example for a generic counter at Bay level)

4.3.6.3 TRANSMISSION UPON IEC 61850 REPORTS

*Note: **Report settings** are automatically configured to transmit counter value when it is refreshed/computed". Attributes of the report instance are set as follows:*

*- **Data update (dupd)** = Yes*
*- **Periodic (period)** = No*

4.3.7 USING AN SPC DATAPOINT

Select the required system or electrical object level and add an SPC from the contextual **Objects entry** window. Depending on the object level, different pre-defined types of SPC exist. They are used for specific needs at electrical topology level (for details see relevant section in *5 Defining a C26x configuration in the electrical hierarchy*) or system topology level (for details see section *3.10 Setting system information for C26x components*).

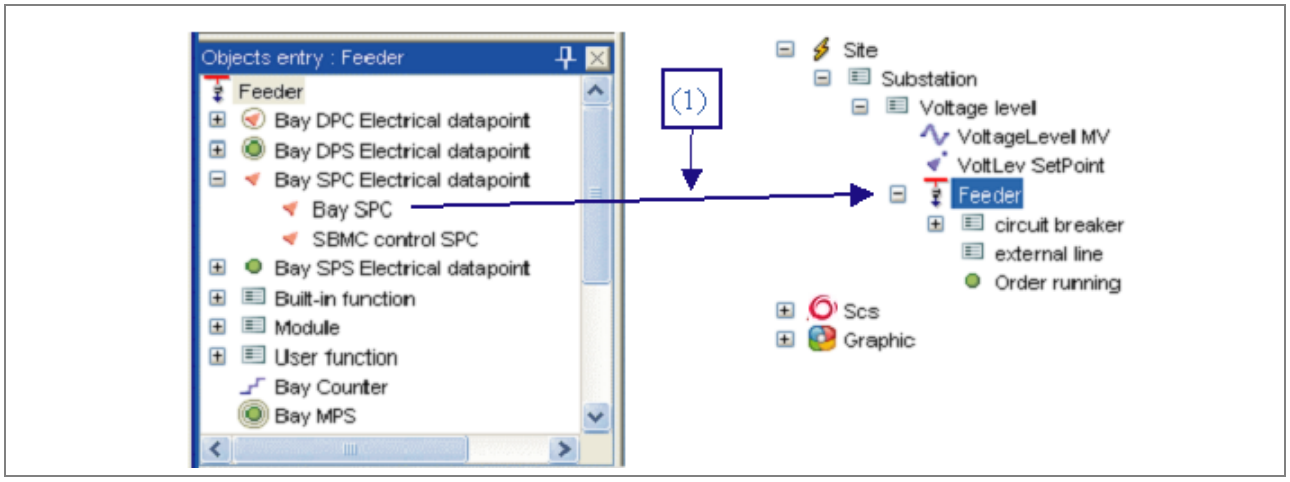


Figure 204: Adding an SPC datapoint (example for a generic SPC at Bay level)

4.3.7.1 SETTING THE GENERAL ATTRIBUTES OF AN SPC DATAPOINT

When adding a generic SPC datapoint, some general attributes must be updated:

(1) **short name** and **long name**: used for logging, alarms ...

(2) **used profile**: the drop-down list refers to the SPC tab of the Profiles table

(3) **activation mode** (*Permanent* / *Transient* / *Permanent until feedback*)

(4) **order on duration** (range [0, 15 s], step 10ms): this attribute is only available if the activation mode is set to *Transient*. It defines the time while the contact is closed before re-opening.

(5) **hold duration** (range [0, 10 s], step 10ms): this attribute is only available if the activation mode is set to *Permanent until feedback*. It defines the time while the contact is held in the requested position after reception of the confirmation of the position of the device.

(6) **time between two orders** (range [0, 10 s], step 100ms): this attribute corresponds to the inter-control delay

(7) **command panel assignment** (*No* / *Yes*): set to *Yes* to enable SPC control at C26x local HMI level

(8) **bay mode dependency:** *Yes* / *No*

(9) **SBMC mode dependency**: *Yes* / *No*

(10) **bay control uniqueness**: (*No* / *Yes*): only significant if control uniqueness is set to bay at substation level

(11) **Local substation dependency**: *Command from SCADA is refused* / *Allowed*

(12) **Remote substation dependency**: *Command from OI* (OI = substation control point, i.e. aView) *is refused* / *Allowed*

(13) **Remote alarm substation dependency:** Customer-specific, not used in system versions V7.0.0. It should be set to its default value: *Command always accepted*.

(14) **Backup alarm substation dependency:** Customer-specific, not used in system versions V7.0.1. It should be set to its default value: *Command always accepted*.

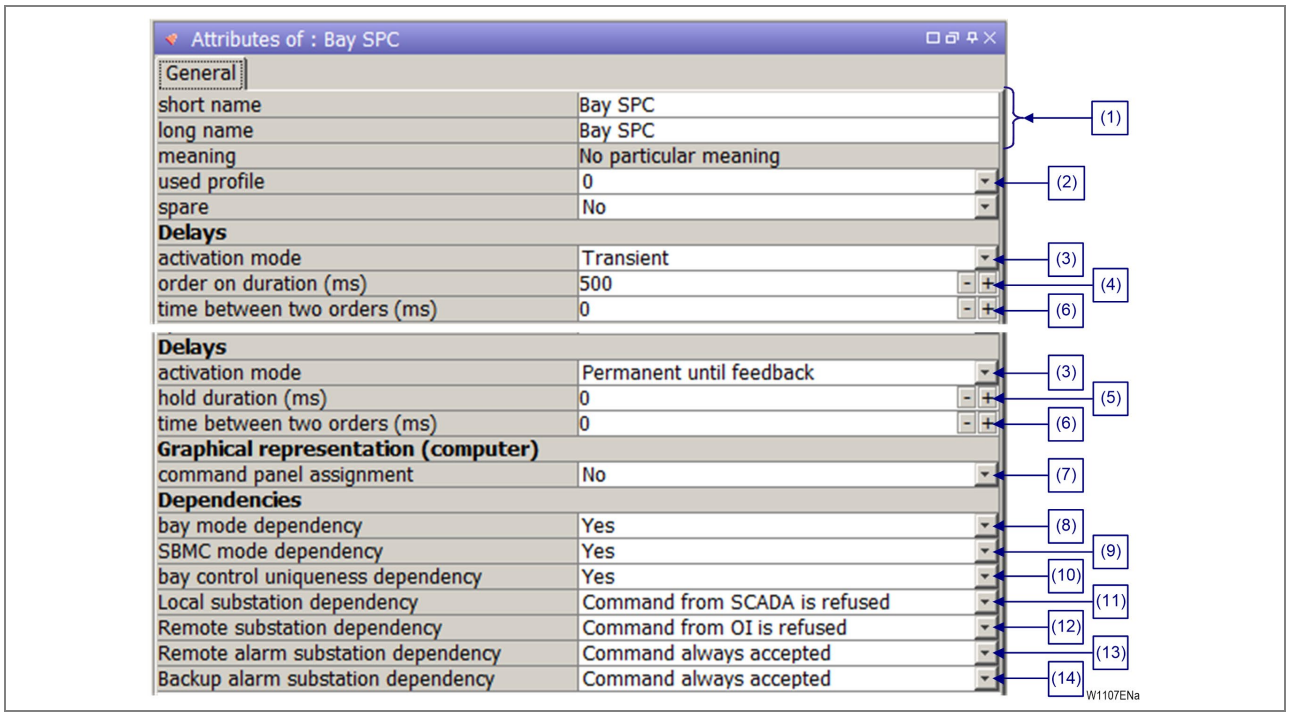


Figure 205: Setting the general attributes of an SPC datapoint (example for a generic SPC at Bay level)

4.3.7.2 DEFINING AN SPC FEEDBACK

For correct execution behaviour and control acknowledgement, an SPC datapoint can be linked to an SPS or DPS datapoint that corresponds to a feedback. For instance a circuit-breaker control SPC is linked to the circuit-breaker status DPS.

To define an SPC feedback:

- Add the relation **has for feedback** at SPC level: choose exclusively one of the two relations **has for feedback: SPS datapoint** (1) or **has for feedback: DPS datapoint** (2) depending on the type of feedback datapoint.
- Fill the relation with the relevant SPS or DPS datapoint.
- If necessary, set the relation attributes:

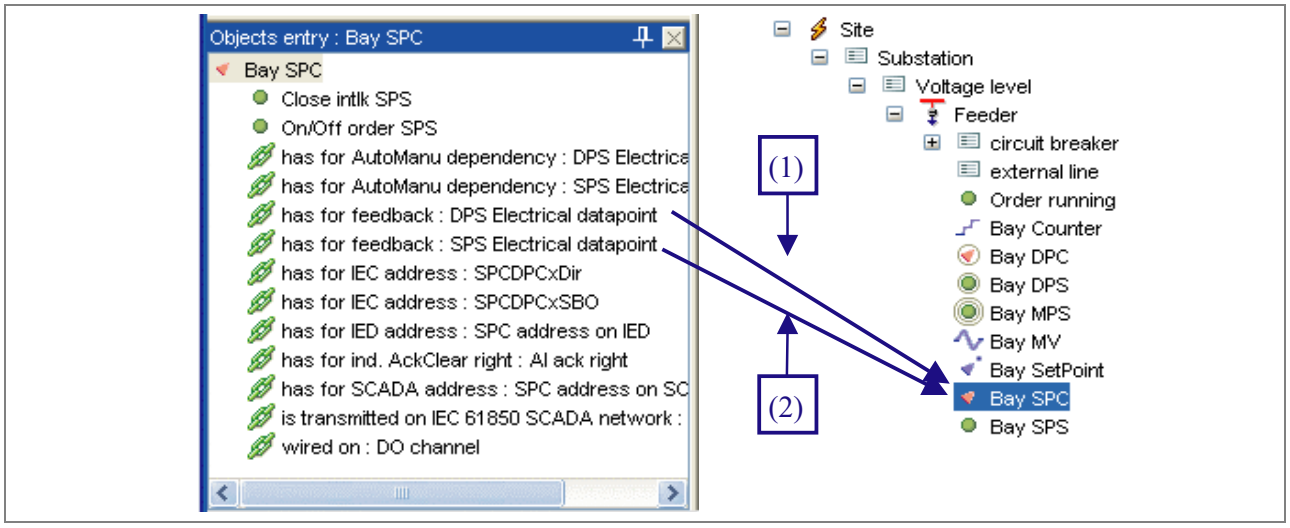


Figure 206: Defining an SPC feedback

(1) **execution time-out** (range [0, 6000 s], step 100 ms): in this given delay, feedback must change relatively to the control. If not, a negative acknowledgement is sent for the control.

(2) **status check for command** (*No check* / *Control authorized only if the device is in the opposite state* / *Control authorized only if the device is in the opposite state, jammed or undefined* / *Control refused if the device is in the same state*): this attribute corresponds to the 'current status check for the device' described in the Functional Description chapter of the C264 user manual (section 10.1.6.8) and used also for execution checks (see section 10.1.8 in the Functional Description).

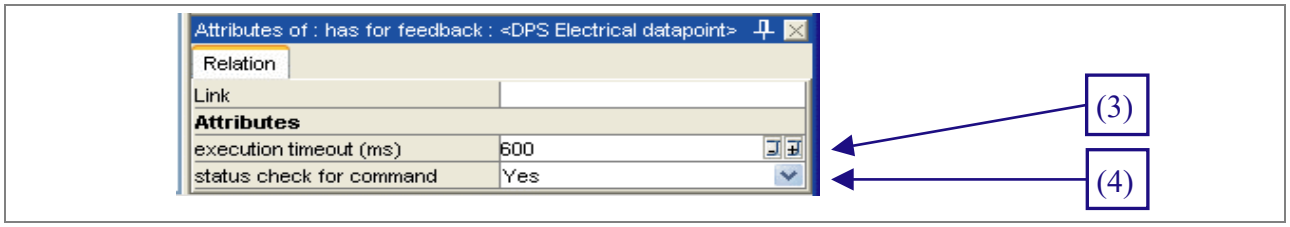


Figure 207: Setting the attributes of an SPC feedback relation

Configuration rules and checks

- For each "SPC", two relations **has for feedback** are available, but they are mutually exclusive
- A datapoint and its feedback datapoint must comply with the following rules:
  - both must have the same Server device
  - if one of them is a "Wired" datapoint, the other one must be "Wired" too (Here, the term "Wired" means that the datapoint is linked to a digital or analog channel of a C26x, or linked to an IED address, else it's "System")
  - if one of them is a "System" datapoint, the other one must be "System" too.
  - if one of them is linked to an " IEC61850 gen IED" through the relation **has for IEC61850 address**, this relation must also be defined for the other one
- For an "SPC" datapoint, if its attribute "activation mode" is set to the "Transient" value, respect the rule: "execution timeout" > "order on duration"

4.3.8 USING A DPC DATAPOINT

To create a DPC datapoint:

- Select the required system or electrical object level (1) and add a DPC from the contextual **Objects entry** window. Depending on the object level, different pre-defined types of DPC exist. They are used for specific needs at electrical topology level (for details see relevant section in *5 Defining a C26x configuration in the electrical hierarchy*) or system topology level (for details see section *3.10 Setting system information for C26x components*).
- Update the DPC attributes (see following topic); some attributes can be fixed or hidden depending on the pre-defined type of DPC.

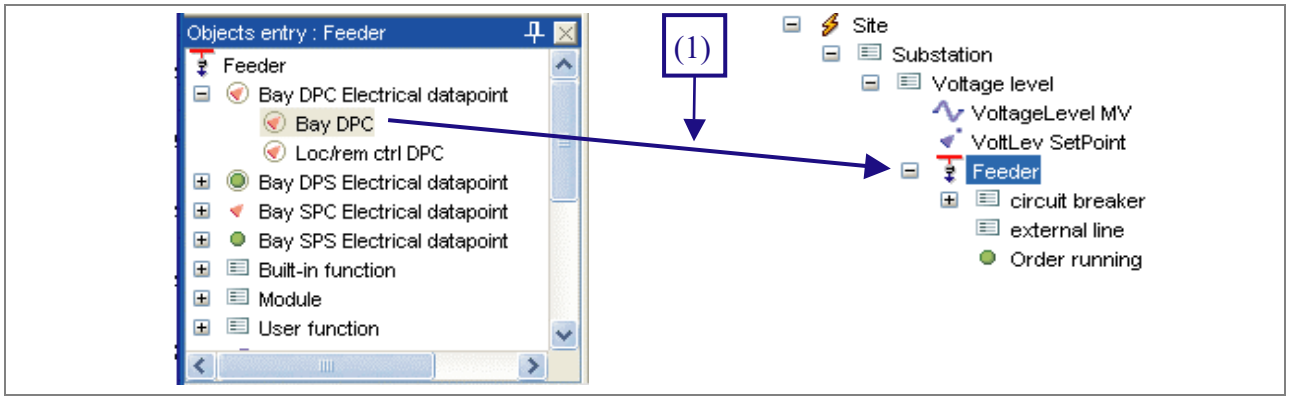


Figure 208: Adding a DPC datapoint

4.3.8.1 SETTING THE GENERAL ATTRIBUTES OF A DPC DATAPOINT

When adding a generic DPC datapoint, some general attributes must be updated:

(1) **short name** and **long name**: used for logging, alarms ...

(2) **used profile**: the drop-down list refers to the DPC tab of the Profiles table

(3) **activation mode** (*Permanent* / *Transient* / *Permanent until feedback*)

(4) **close duration** (range [0, 15 s], step 10ms): this attribute is only available if the activation mode is set to **Transient**. It defines the time while the DPC is held in the "closed" state before returning to the "open" state.

(5) **open duration** (range [0, 15 s], step 10ms): this attribute is only available if the activation mode is set to *Transient*. It defines the time while the DPC is held in the "open" state before returning to the "closed" state.

(6) **hold duration** (range [0, 10 s], step 10ms): this attribute is only available if the activation mode is set to *Permanent until feedback*. It defines the time while the contact is held in the requested state after reception of the confirmation of the position of the device.

(7) **time between two orders** (range [0, 10 s], step 100ms): this attribute corresponds to the inter-control delay defined in section INTER-CONTROL DELAY in the Functional Description chapter of the C264 user manual and also used for execution checks (see section GENERIC SELECTION CHECKS in the Functional Description chapter of the C264 user manual).

(8) **command panel assignment** (*No* / *Yes*): set to *Yes* to enable SPC control at C26x local HMI level.

(9) **bay mode dependency**: *Yes* / *No*

(10) **SBMC mode dependency**: *Yes* / *No*

(11) **bay control uniqueness dependency**: *Yes* / *No* (only significant if control uniqueness is set to bay at substation level)

(12) **Local substation dependency**: *Command from SCADA is refused* / *Allowed*

(13) **Remote substation dependency**: *Command from OI* (OI = substation control point, i.e. aView) *is refused* / *Allowed*

(14) **Remote alarm substation dependency:** Customer-specific, not used in system versions V7.0.0. It should be set to its default value: *Command always accepted*.

(15) **Backup alarm substation dependency:** Customer-specific, not used in system versions V7.0.0. It should be set to its default value: *Command always accepted*.

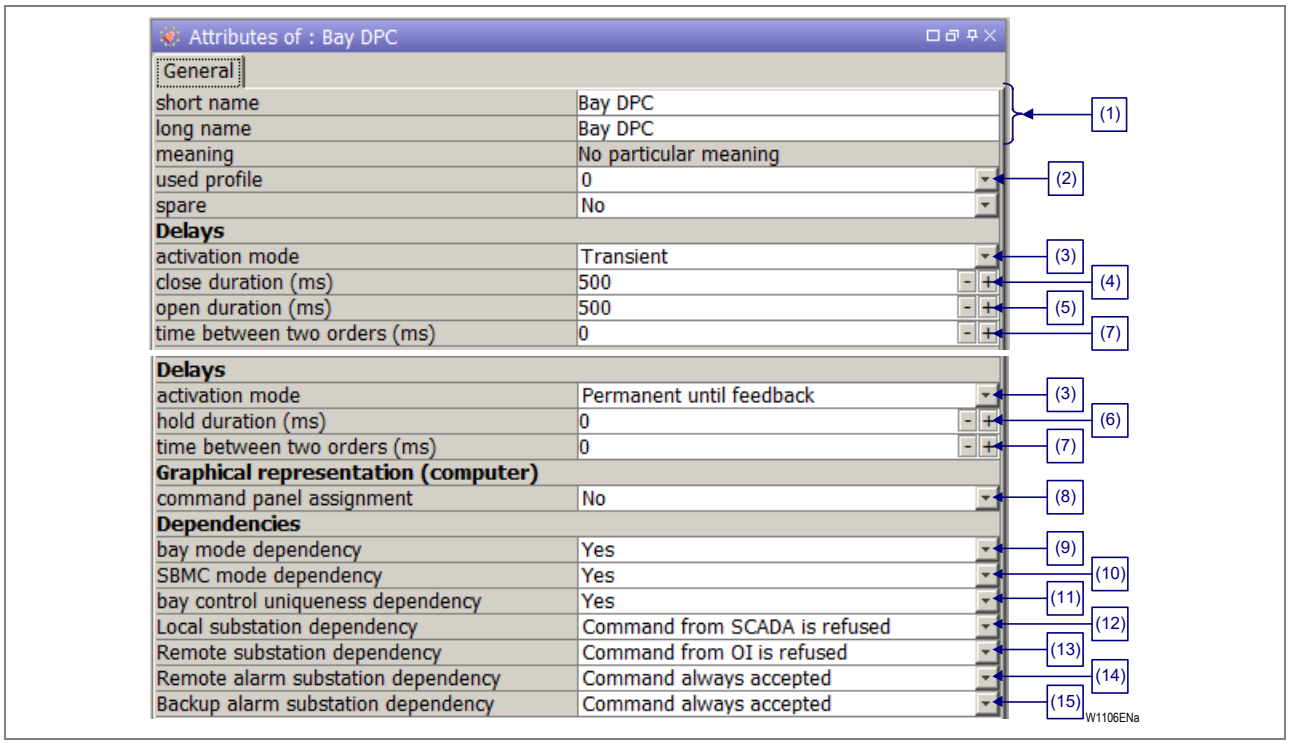


Figure 209: Setting the general attributes of a DPC datapoint (example for a generic DPC at Bay level)

4.3.8.2 DEFINING A DPC FEEDBACK

For correct execution behaviour and control acknowledgement, a DPC datapoint can be linked to an SPS or DPS datapoint that corresponds to a feedback. For instance, a circuit-breaker control DPC is linked to the circuit-breaker status DPS.

To define a DPC feedback:

- Add the relation **has for feedback** at DPC level: choose exclusively one of the two relations **has for feedback: SPS datapoint** (1) or **has for feedback: DPS datapoint** (2) depending on the type of feedback datapoint.
- Fill the relation with the relevant SPS or DPS datapoint.
- If necessary, update the relation attributes:
  - **execution timeout** (range [0, 6000 s] step 100 ms): in this given delay, feedback must change relatively to the control. If not, a negative acknowledgement is sent for the control
  - **status check for command**: this attribute corresponds to the 'current status check for the device' described in the Functional Description chapter of the C264 and also used for execution checks. Values:

No check

Control authorized only if the device is in the opposite state

Control authorized only if the device is in the opposite state, jammed or undefined

  - Control refused if the device is in the same state

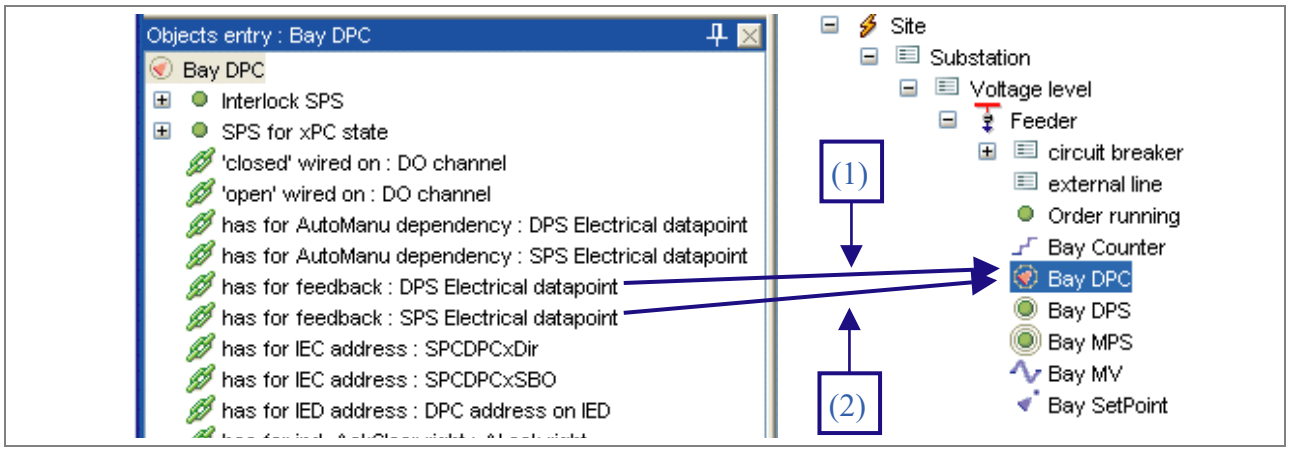


Figure 210: Defining a DPC feedback

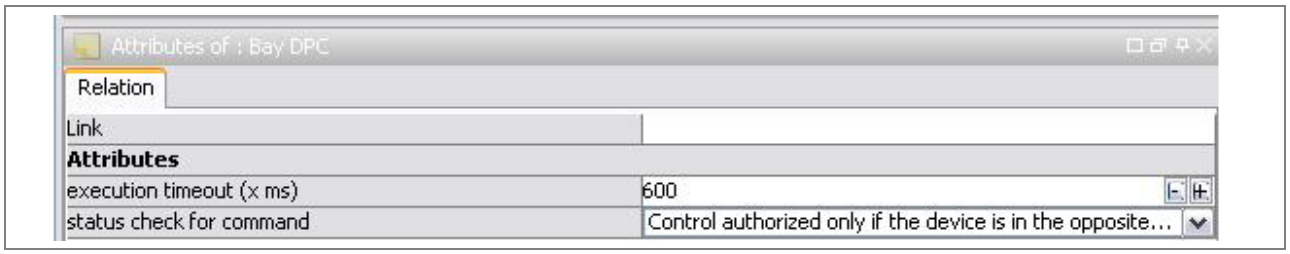


Figure 211: Setting the attributes of a DPC feedback relation

Configuration rules and checks

- For each "DPC", two relations **has for feedback** are available, but they are mutually exclusive
- A datapoint and its feedback datapoint must comply with the following rules:
  - both must have the same Server device
  - if one of them is a "Wired" datapoint, the other one must be "Wired" too (here, Wired" means that the datapoint is linked to a digital or analog channel of a C26x, or linked to an IED address, else it is referred to as "System")
  - if one of them is a "System" datapoint, the other one must be "System" too
  - if one of them is linked to an " IEC61850 gen IED" through the relation **has for IEC61850 address**, this relation must also be defined for the other one
- For a "DPC" datapoint, if its attribute "activation mode" is set to the "Transient" value, then the following rule must be respected: "execution timeout"> max ["open duration", "close duration"]

4.3.9 USING AN MPC DATAPOINT

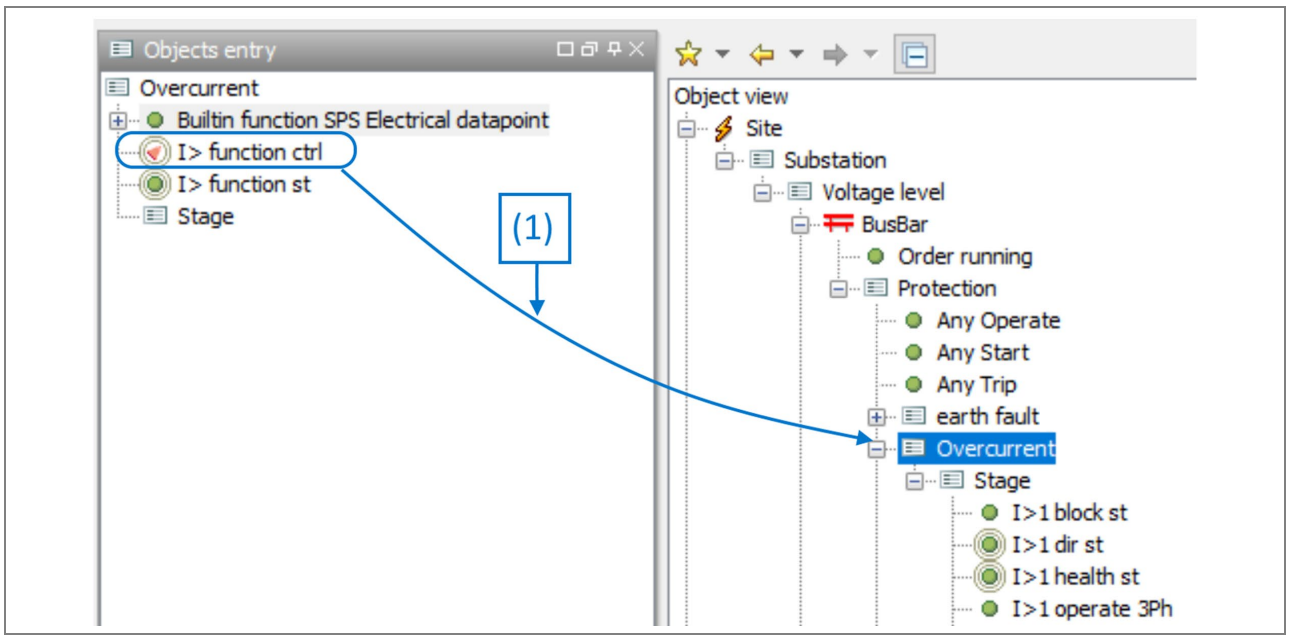
MPC datapoints are used to:

- Enable/Disable built-in protection functions in the C264
- Enable/Disable protection functions stages or initiate built-in protection functions in the C264
- Switch settings groups

MPC datapoints are represented with the graphical icon  .

To add an MPC datapoint:

- Select the required electrical object level (1) and add the MPC from the contextual **Objects entry** window. MPC are used for specific needs at electrical topology level (for details see relevant section in *5 Defining a C26x configuration in the electrical hierarchy*).
- Update the MPC attributes (see following topic).



4.3.9.1 SETTING THE GENERAL ATTRIBUTES OF AN MPC DATAPOINT

When adding a generic MPC datapoint, some general attributes must be updated:

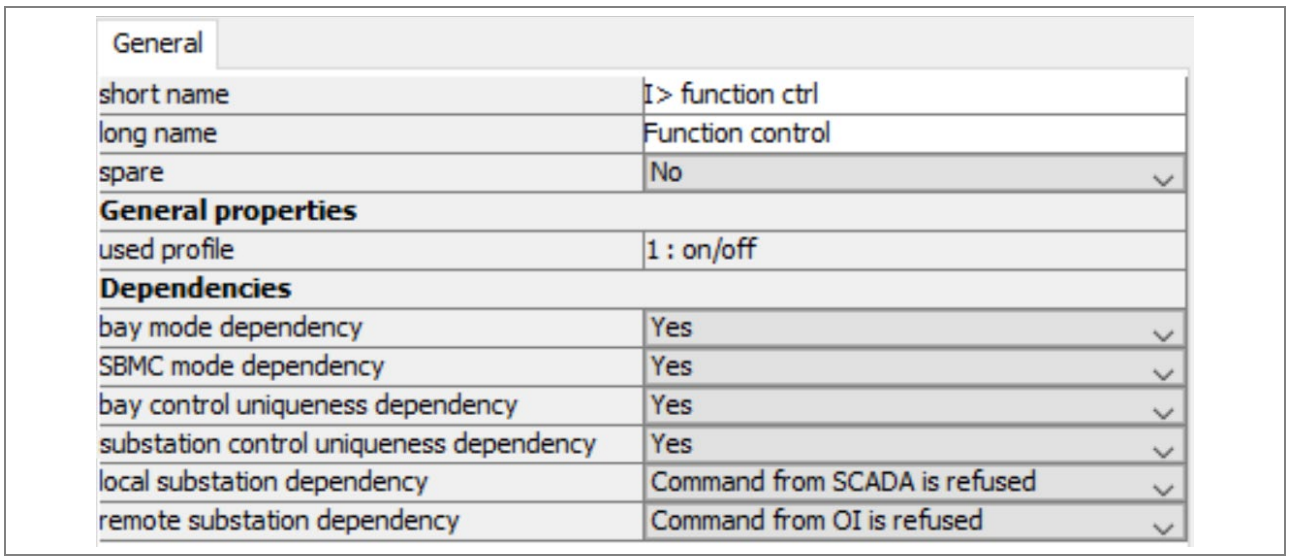


Figure 212: Setting the general attributes of an MPC datapoint

(1) **short name** and **long name**: used for logging, alarms ...

(2) **spare**

(3) **used profile**: select the number of the profile to be used from the MPC tab in the Profiles table

(4) **bay mode dependency** (*Yes* / *No).* flag indicating the dependency on bay mode. Only visible when the MPC datapoint is hierarchically under an electrical bay or its children.

(5) **SBMC mode dependency** (*Yes* / *No).* flag ndicating the dependency on SBMC mode. Only visible when the MPC datapoint is under an electrical bay or its children.

(6) **bay control uniqueness dependency** *(Yes* / *No).* flag indicating the dependency on bay control uniqueness. Only visible when MPC datapoint is under an electrical bay or its children.

(7) **substation control uniqueness dependency** *(Yes* / *No).* flag indicating the dependency on substation control uniqueness. Only visible when MPC datapoint is above an electrical bay.

(8) **Local substation dependency** (*Command from SCADA is refused* / *Allowed):* flag indicating the dependency when substation is in local mode.

(9) **Remote substation dependency**: *Command from OI* (OI = substation control point, i.e. aView) *is refused* / *Allowed.* This flag indicates the dependency when substation is in remote mode.

4.3.9.2 DEFINING AN MPC FEEDBACK

For correct execution behaviour and control acknowledgement, an MPC datapoint can be linked to one MPS datapoint that corresponds to a feedback.

To define an MPC feedback:

- Add the relation **has for feedback** at MPC level: choose exclusively one **has for feedback: MPS datapoint**.
- Fill the relation with the relevant MPS datapoint.
- Update the relation attributes:
  - **execution timeout** (range [0, 6000 s] step 100 ms): in this given delay, feedback must change relatively to the control. If not, a negative acknowledgement is sent for the control
  - **command acceptation**: this attribute allows to define conditions for accepting the command (*Always accepted / Refused if always in same state /Refused if MPS feedback is not valid / Refused in both cases*).

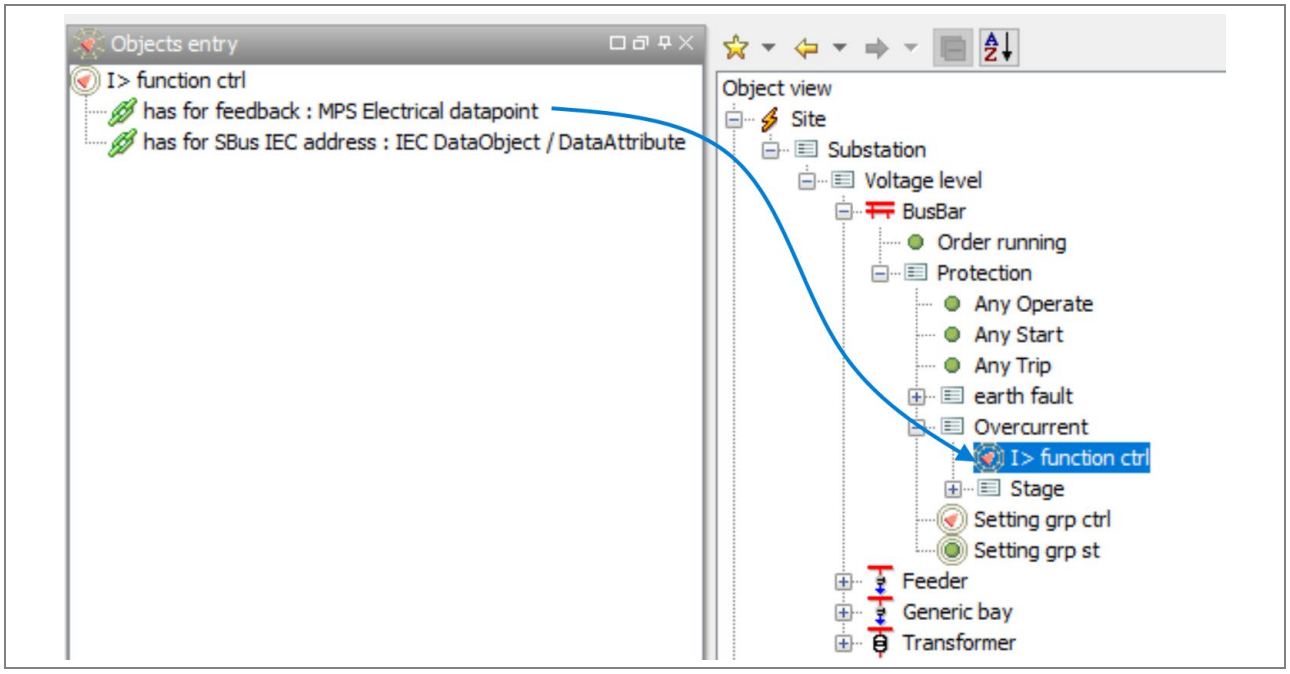


Figure 213: Defining an MPC feedback

Limits

- The link of feedback between MPC datapoint and MPS datapoint is only available for electrical datapoints and not for system datapoints.
- MPC datapoint does not support:
  - SBO mode (Select Before Operate).
  - interlocking functionality.
  - wiring on physical board.
  - alarm management.
  - control from Local HMI of Cx66.
  - usage as input or output of automatism.
  - SCADA addressing.
  - addressing on legacy IED.
- MPC datapoint usage domain is limited to:
  - activeation/deactivation of built-in protection function in C264.
  - activation/deactivation of stage or initiation for built-in protection function in C264.
  - switch of settings groups.

4.3.10 USING A SETPOINT DATAPOINT

Digital setpoints are described in section DIGITAL SETPOINTS in the Functional Description of the C264 user manual.

SetPoints are used to send instruction values to the process or to ancillary units. DS Agile C26x units manage four types of SetPoints:

- Digital SetPoints
- SetPoints to IEDs
- System SetPoints
- Analog Setpoints

Digital SetPoints

Digital SetPoints are executed via DO channels of Digital Output boards. This type of controls is managed in “Direct Execute mode” only.

The checks performed during execution phase for SetPoints are:

- Substation and bay modes: check user selectable.
- Uniqueness: check user selectable.
- Device Locked: check user selectable.
- Automatism running control: check user selectable.

Digital SetPoints may be configured with digital “refresh DO” (see following topic).

The configuration also allows to define two methods of activation of the SetPoint relays:

- Raw activation: all activated relays which must be open are deactivated, all relays which must be closed are activated. If a “read inhibit DO” is configured this one must be deactivated during the relay positioning (see following topic).
- Incremental activation: the restitution of the SetPoint and relays can be done by successive increments from the initial value to the final one. The value of increments and the duration of the activation are user selectable. If a “read inhibit DO” is configured this one must be deactivated during every incremental activation (see following topic).

SetPoints to IEDs

SetPoints controls towards IEDs are managed in “Direct execute mode”. Execution phase is identical to the digital SetPoints. The execution is performed via the communication protocol of the concerned IED.

System SetPoint

SetPoints can be locally managed by C26x as a system control for automation for instance. Execution phase is identical to the digital SetPoints.

Analog Setpoints

Analog setpoints are measurement values sent on the Analog Output board.

These setpoints commands (with analog indication) are received from the Remote Control Point (RCP) or from the local HMI (with LCD).

Analog Setpoints are used to interface auxiliary units requiring analog inputs (ex: measurement viewers, generator).

The AO values are secured with an external power supply which allows keeping the analog output value in case of C26x shutdown or power off. A quality indication is available with the additional Read Inhibit output relays (NO) associated with each AO.

4.3.10.1 ADDING A SETPOINT DATAPOINT

To create a SetPoint datapoint:

- Select the required system or electrical object level (1) and add a SetPoint from the contextual **Objects entry** window. Depending on the object level, different pre-defined types of SetPoint exist. They are used for specific needs at electrical topology level (for details see relevant section in *5 Defining a C26x configuration in the electrical hierarchy*) or system topology level (for details see section *3.10 Setting system information for C26x components*).
- set the SetPoint attributes (see following section); some attributes can be fixed or masked depending on the pre-defined type of SetPoint.

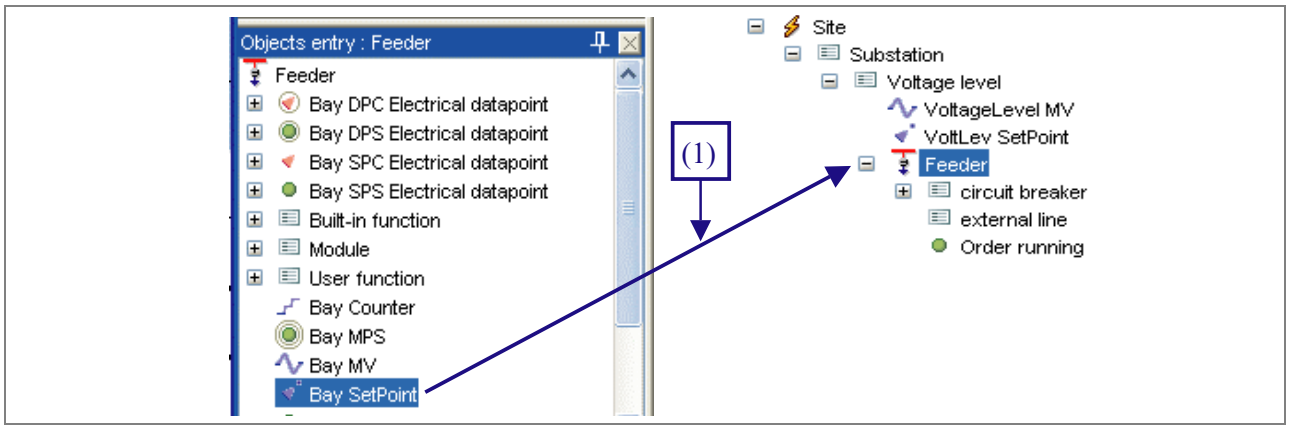


Figure 214: Adding a SetPoint datapoint

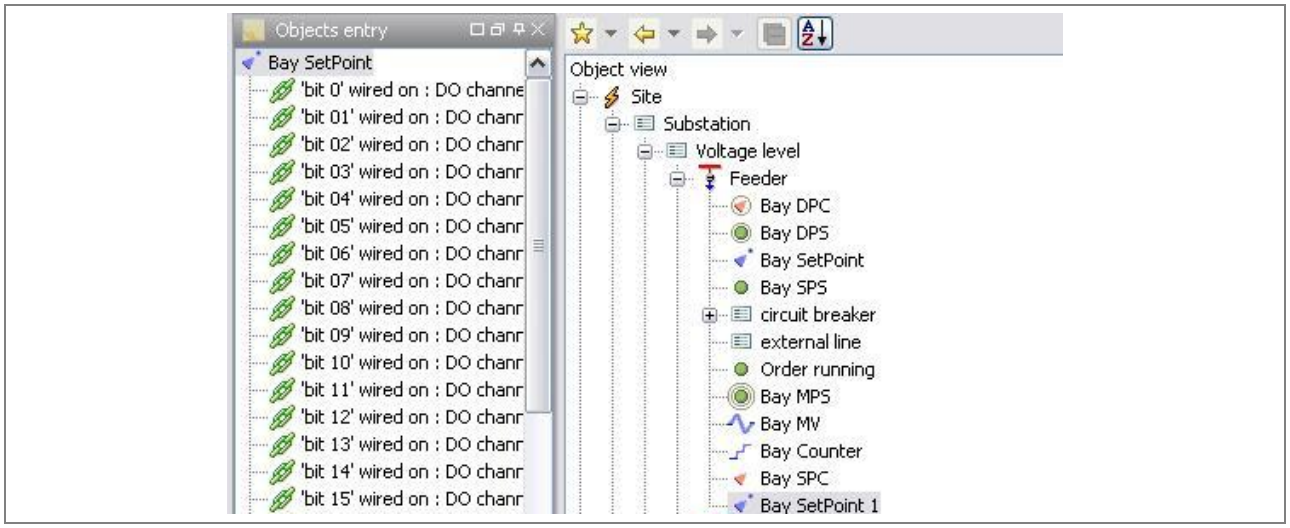


Figure 215: Linking a SetPoint datapoint to its profile

4.3.10.2 SETTING GENERAL ATTRIBUTES OF A SETPOINT DATAPOINT

When adding a generic SetPoint datapoint, some general attributes must be set:

(1) **short name** and **long name** of the datapoint used for logging, alarms ...

(2) **type**:

- *Analogue*: SetPoint is managed by system output or by AOU board output
- *Digital coded BCD*
- *Digital coded 'Pure binary'*
- *Digital coded 'Gray'*
- *Digital coded '1 among N'*
- *Digital coded 'decimal'*

(3) **used profile**: the drop-down list refers to the SetPoint tab of the Profiles table

(4) **progressive step usage**: only used for digital SetPoint. No corresponds to Raw activation, Yes to Incremental Activation, as described in section Defining a SetPoint datapoint.

(5) **minimum value (range [-3.4E38, 3.4E38])**: used for value control and scaling

(6) **increment value (range [1, 24], step 1)**: used for incremental activation only

(7) **maximum value (range [-3.4E38, 3.4E38])**: used for value control and scaling

(8) **increment duration (range [1 s, 999 s], step 1 s)**: used for incremental activation only

(9) **command panel assignment** (Yes / No): set to Yes to enable SetPoint control at C26x local HMI level

(10) **bay mode dependency**: Yes / No

(11) **SBMC mode dependency**: Yes / No

(12) **bay control uniqueness dependency**: Yes / No (only significant if control uniqueness is set to bay at substation level)

(13) **Local substation dependency**: SetPoint from SCADA is refused / Allowed

(14) **Remote substation dependency**: SetPoint from OI (OI = substation control point, i.e. aView) is refused / Allowed

(15) **Remote alarm substation dependency**: Customer-specific feature, not used in system versions. It should be set to its default value: Command always accepted.

(16) **Backup alarm substation dependency:** Customer-specific, not used in system versions V6.1.x. It should be set to its default value: *Command always accepted*.

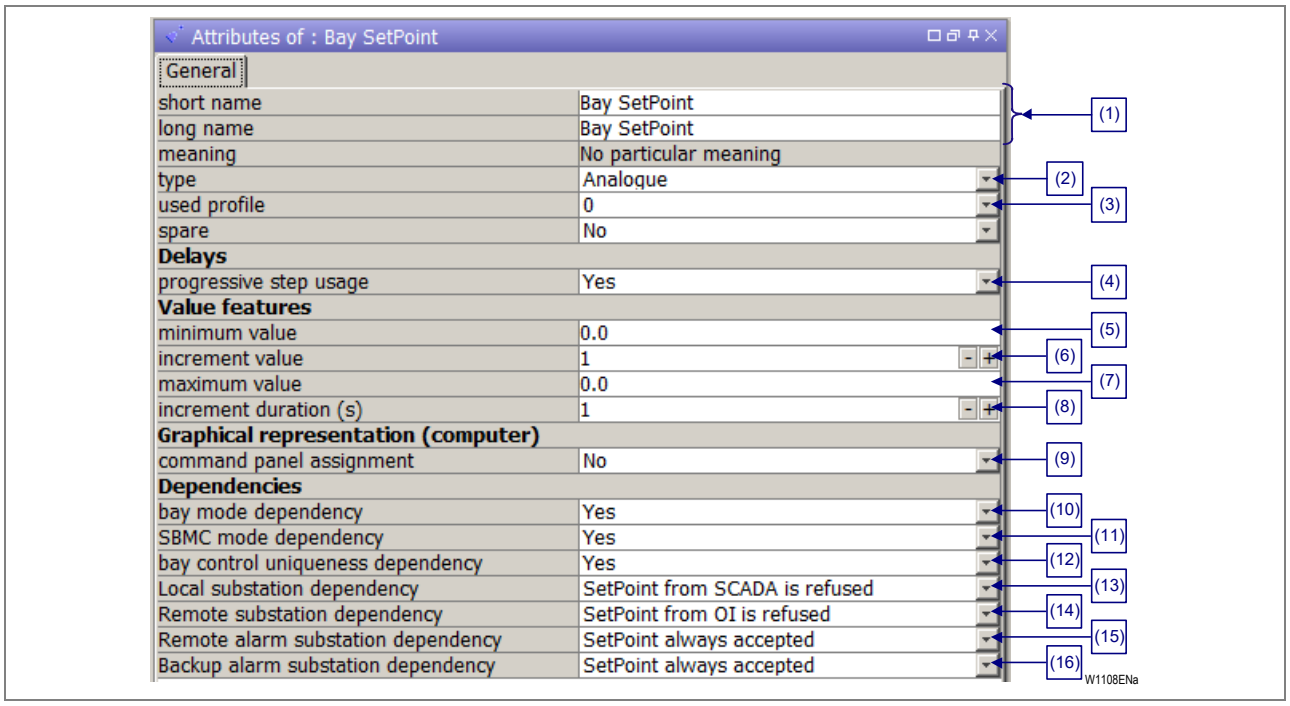


Figure 216: Setting the general attributes of a SetPoint datapoint

Configuration rules and checks

A Setpoint datapoint wired on DO channels of a C26x must be digital and have a profile with attribute “SBO mode” set to "Direct Execute" or “Direct Execute with SBO popup”.

4.3.10.3 DEFINING A SETPOINT FEEDBACK

For correct execution behaviour and control acknowledgement, a SetPoint datapoint can be linked to an MV datapoint that corresponds to a feedback.

To define SetPoint feedback:

- Add the relation **has for feedback** (1) at SetPoint level by tapping into the Object entry window
- Double click the relation in the browser and select the relevant MV datapoint in the Relation link editor
- If necessary, set the relation attribute:

(1) **execution timeout** (range [0, 999 s], step 1 s): within this delay, the feedback must change relatively to the control. Otherwise, a negative acknowledgement is sent for the control

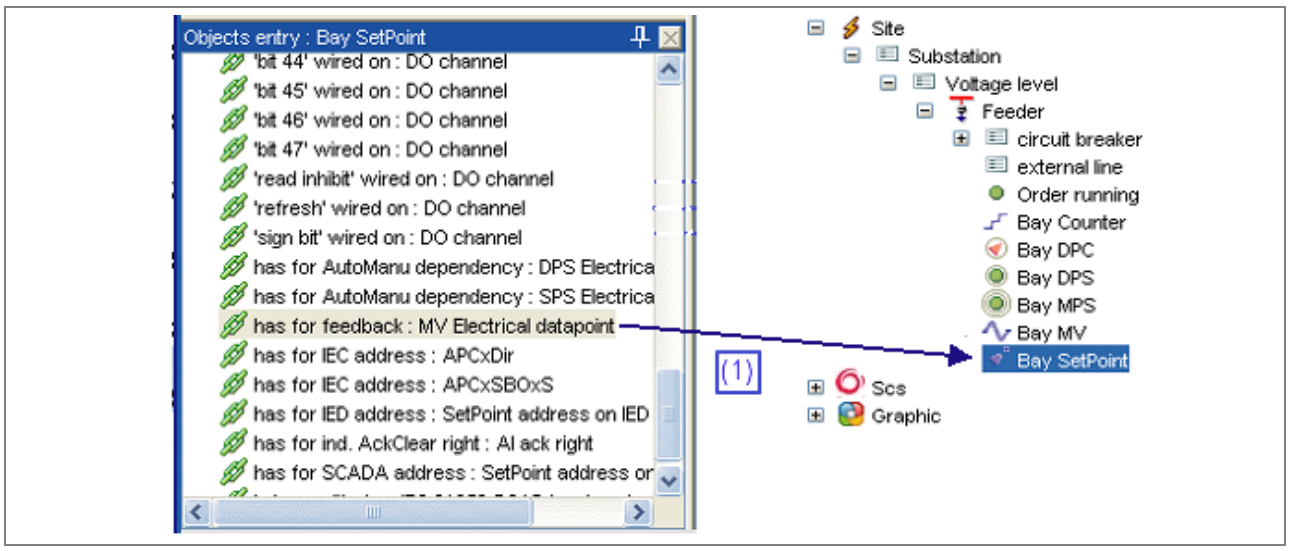


Figure 217: Defining SetPoint feedback

Configuration rules and checks

- A datapoint and its feedback datapoint must comply with the following rules:
- both must have the same Server device
- if one of them is a "Wired" datapoint, the other one must be "Wired" too (here "Wired" means that the datapoint is linked to a digital or analog channel of a C26x, or linked to an IED address, otherwise it is referred to as "System")
- if one of them is a "System" datapoint, the other one must be "System" too
- if one of them is linked to an "IEC61850 gen IED" through the relation has for IEC61850 address, this relation must also be defined for the other one.

4.4 DEFINING LOCAL ARCHIVING OF DATAPOINT EVENTS AND ALARMS BY THE C26X

A C26x manages only archiving of the datapoints it is server of (see section *3.5.1 Connecting a C26x to other station-bus sub-systems*, for Client/Server definition).

For C26x, archiving is available or not for all the EVENTS appearing on a given datapoint. Archiving is activated as soon as one ‘state treatment’ attribute is set to ‘Archive and logging’ or ‘archive only’ at datapoint profile level

ALARM archiving at C26x level is defined globally for all the C26x units at Scs object level.

4.5 DEFINING THE ACQUISITION SOURCE FOR INPUT DATAPOINTS

4.5.1 OVERVIEW

Input datapoints have real-time values, fed by several ways excluding each other:

- acquisition via input channel(s)
- acquisition via non-DS Agile IEC61850-communicating IED

(Virtual) acquisition via software production:

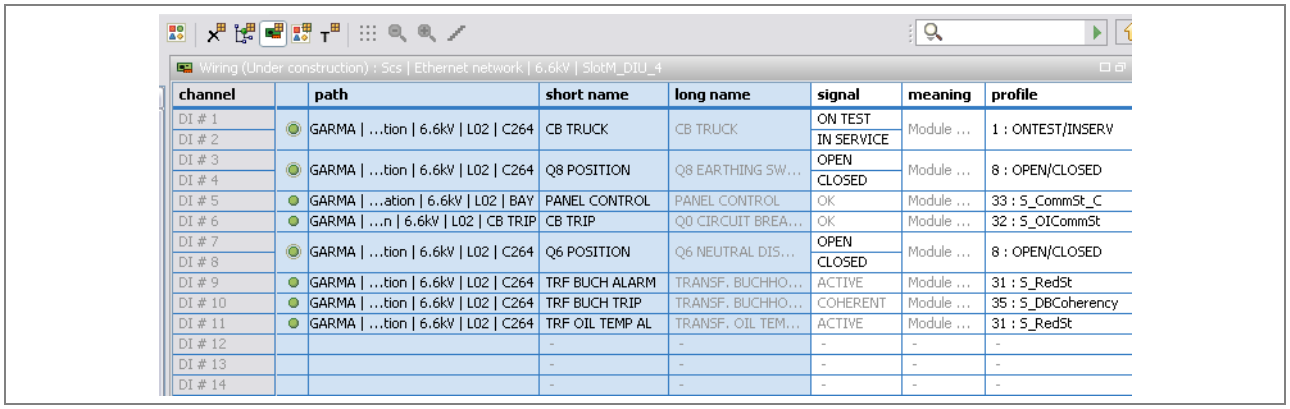
- diagnostic and control of system components
- datapoints relevant to built-in function and user's function
- MV or counter datapoint relevant to CT/VT board computation

The wiring is based on some best practices:

- first channel of DPS wired in an ODD channel
- two channels of a DPS contiguous
- channels of an MPS contiguous
- digital MV wired into 4 channels at least

4.5.2 SMART TABLES

Select in the browser a board (other than BIU or CPU) as in this screenshot:



Select, in the menu Window, Wiring editor. If it is grayed out, click the Wiring button in the lower part. If there is no button, click the icon Reset perspective in the toolbar (like in the screenshot). The window Wiring features a table:

- the channel number
- the variants (pictograms) and the attributes (path of DP parent, short name, profile, long name); copy/paste is enabled; the long name is editable
- the read-only attributes (meaning, signal); copy is enabled
- the profiles; copy/paste is enabled

To adjust a column width, pass the cursor over the border in the header till the cursor turns to ↔; then drag and drop.

Procedure to fill the table (this must be done from left to right)

- Click in a cell to fill out
- Type one character or click two more times; click the button [v] overlaying in the cell and select one value in the drop-down list (it contains all the created datapoint values); ∅ refers to a void value; the type can be changed this way
- The 'short name' prompted in the list depend on the DP available at the path level; to create a new DP, enter its short name (see sketch in section 2).
- The 'meaning' prompted in the list depends on the level reflected in the path and is the one found in the Objects entry pane; it includes among others:
  - at substation level, Substation <DP type>
  - at voltage level, VoltageLevel <DP type>
  - at bay level, Bay <DP type>
  - at module level, Module <DP type>

The same value is repeated for the long name, but it can be fixed manually. The relation **wired on** gets created under the DP with the short name.

- To export the table to a spreadsheet editor like Excel, select the rows and copy/paste them; the empty cells are filled with the word 'null' (for the headers, use the menu item **Copy columns header**)
- To break the relation **wired on**, select ∅ as short name; only path is retained
- To clear a row information, select the row(s), right-click and select **Unwire**. Unwiring channels linked to DPs inside the unity of templates is ineffective.

Notes:
*For the datapoints without automatic addressing it is possible to add the relation **has for IEC address** and define it.*
A channel cannot be edited if it is already wired in a used template.
In template mode, the available objects (as paths) are:
- unified template if DPs are defined directly as root
- all the electric elements with DP, if board not defined under C26x
- objects in local templates (inside same unified template)

Multi-channel DP: when the meaning is selected, the SCE allocates automatically the required number of channels. For example, A TPI acquired by a DIU board on 4 bits (a fifth bit, a sign bit, a refresh bit, or a read inhibit can be added via the attribute 'signal'):



Copying / pasting to another board's table works if both boards are of the same type.

4.5.3 SMART TABLES FOR TMU BOARDS

For TMU boards, the channel column is replaced by a **measure type** column and a button Insert allows to create a DP.

When a row is selected, the insertion results in computing the next measure type (e.g. 'IA value of the current phase A' is followed by 'IB value of the current phase B'); if the type is already used, the new row has no type.

When no row is selected, a row is inserted at the table beginning and the list for measure type is limited to the items not yet used.

Note:
Vr and Ir are the residual values, ADC stands for Analog/Digital Conversion.

There are two ways to delete the DP relation **is computed by: <board name>**; right click and select:

- **Suppress measure type**: the whole row is erased
- **Clear datapoint**: short name, meaning, profile, long name are erased

To export the table to a spreadsheet editor, select any cell, right click and select

- **Copy all measure types** and paste them in editor's first column; the empty cells are filled with the word 'null'
- **Copy columns header** and paste them in editor's heading row
- **Copy** the cells by row or group of rows and paste them in editor's rows (an empty cell produces the value Null; in a path, the objects are separated with |)

To import a sheet from a spreadsheet editor like Excel, copy the rows in the editor; in SCE, select a row, right click and select **Insert & paste**; the pasted row takes precedence over the older ones:

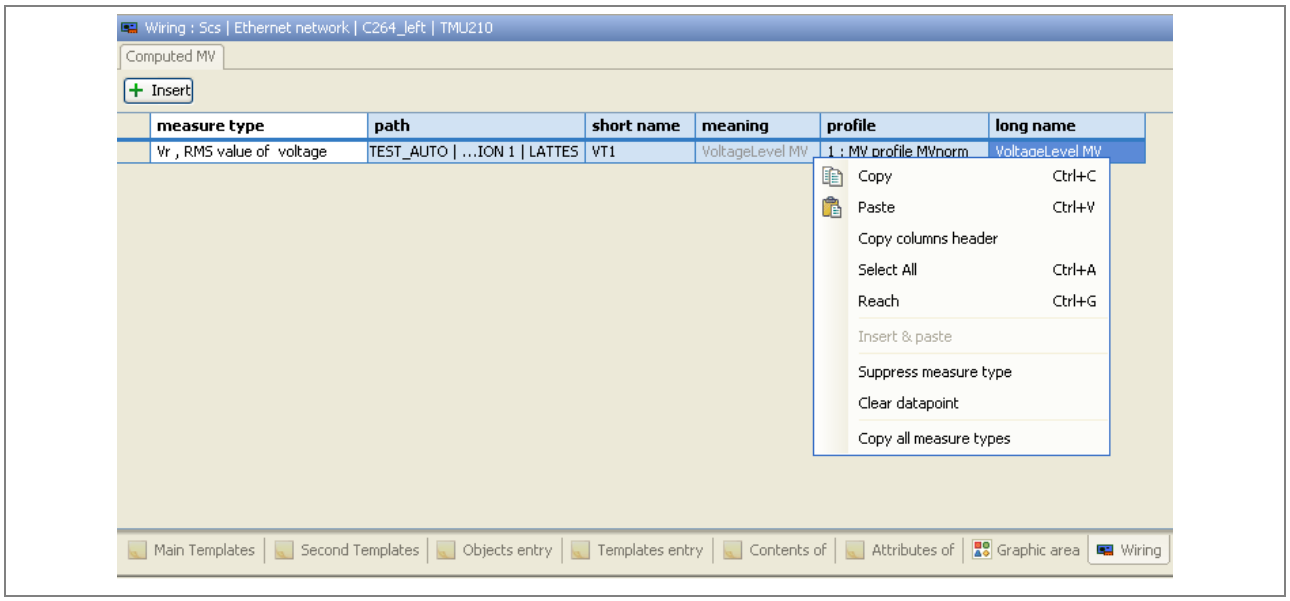
- If a measure type was all ready used, the new data point used this measure type and the old DP remains in the table but the measure type is deleted
- if the copied path and short name are already used in one row, the path and short name are stripped away from this row

On a paste action if the clipboard content inconsistent data a message box is displayed with error message and the error details:



List of possible errors

- Invalid path
- MV Type of datapoint not compatible to compute on the current board, not analog.
- Invalid MV type for current TMU
- Profile attribute is read-only
- Datapoint creation impossible under specified path
- Datapoint has many acquisition sources
- Datapoint meaning is invalid for datapoint creation
- Relation for wiring are not compatible with current datapoint
- Relation attribute measure type is read-only



A red row denotes a wrong input; this can result from these situations:

- the same measure type is used for more than one computed MV on the TMU
- the MV is computed by more than one TMU board
- the MV is computed AND issued from an IED
- the MV is computed AND physically wired on a board
- the MV is not analog

To erase the row, select it, right click and select Reach, then delete the relation at the DP level.

4.5.4 ACQUIRING INPUT DATAPOINTS VIA INPUT CHANNELS

At SCE level, linking datapoint to specific channels (DI or AI channels) belonging to the DIU200-210-211, CCU200, AIU2xx boards of the C26x is called input datapoint wiring.

4.5.4.1 WIRING AN SPS DATAPOINT VIA ONE DI CHANNEL

A wired SPS is in the SET or in the RESET state, depending on the state of the associated Digital Input and of the mode, normal or inverted (defined in configuration), of the SPS.

DI state	Mode	SPS state
ON	Normal	SET
OFF	Normal	RESET
ON	Inverted	RESET
OFF	Inverted	SET
Faulty	*	SELFCHECK FAULTY

To wire an SPS datapoint on a DI channel:

- Add the relation **wired on** (1) at SPS datapoint level
- Fill the relation with the relevant DI channel:
  When datapoint level is lower than or equal to bay level, only DI channels from DIU boards belonging to the C26x BCU that manages the bay are available. To define the control unit that manages a bay, see section *5.1.4 Defining a Bay*.
- If necessary, update the relation attribute **inverted value** (2): If you select *Yes*, the corresponding SPS will be *RESET* when the DI is energised and *SET* when it is not (see above table).

Note:
The inverted value attribute is ineffective when the the corresponding DI channel is in an SCU on the Process Bus. In that case, whether it is set to Yes or No, the SPS will always be SET when the DI is energised, and vice-versa.

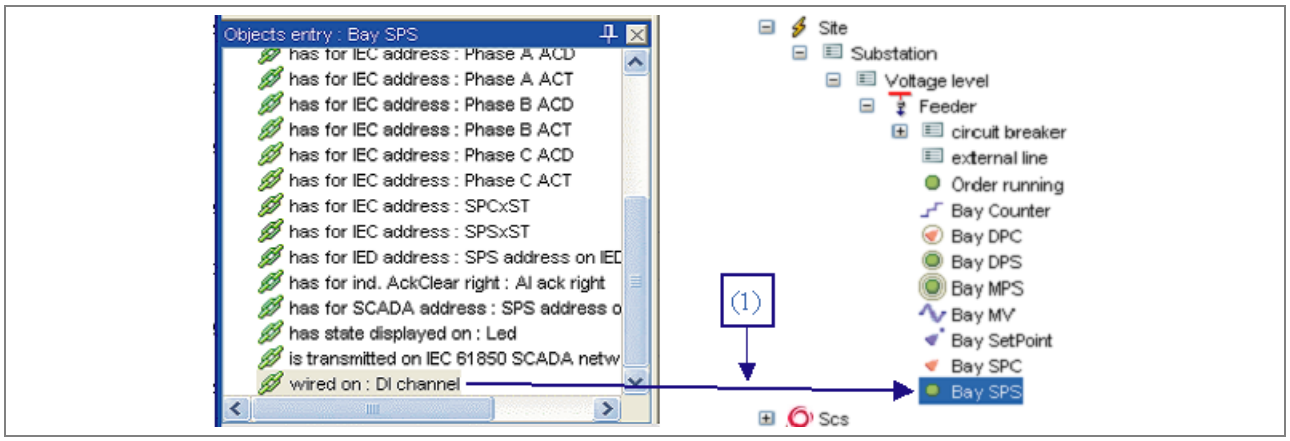


Figure 218: Wiring an SPS datapoint via one DI channel

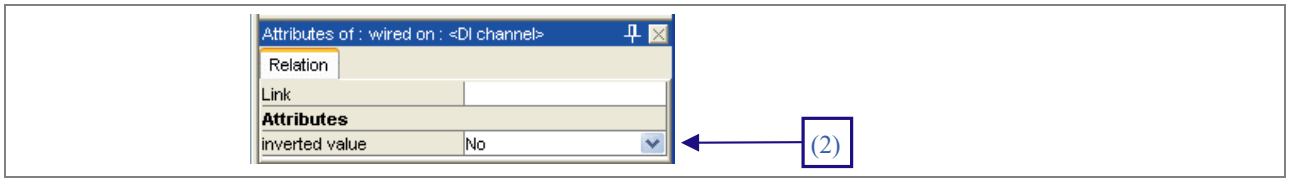


Figure 219: Updating the wiring of an SPS datapoint

4.5.4.2 WIRING A DPS DATAPOINT VIA TWO DI CHANNELS

To wire a DPS datapoint on two DI channels:

- Add the relations **closed' wired on** (1) and **'open' wired on** (2) at DPS level.
- Fill the relations with the relevant DI channels:
  When datapoint level is lower than or equal to bay level, only DI channels from local or remote DIU boards belonging to the C26x that manages the bay are available. To define the C26x that manages a bay, see section *5.1.4 Defining a Bay*.

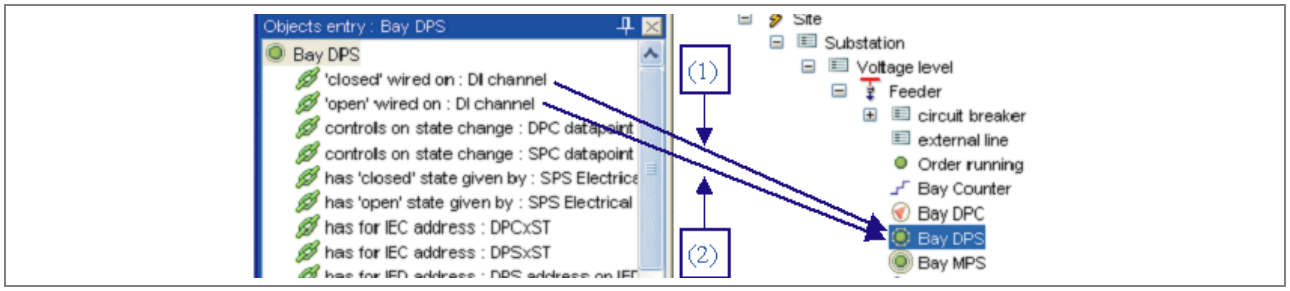


Figure 220: Wiring a DPS datapoint via two DI channels

4.5.4.3 WIRING AN MPS DATAPOINT VIA N DI CHANNELS

MPS datapoint wiring is done via 3 or more DI channels (up to 16) for each state, and an optional DI channel for ‘read inhibit’ indication.

To wire an MPS datapoint on n DI channels (n <=16):

- Add the relations **state <i> wired on** (1) at MPS datapoint level, for each available state of the MPS (i begins from 0).
- Fill the relations with the relevant DI channels: when datapoint level is lower than or equal to bay level, only DI channels from local DIU boards belonging to the C26x that manages the bay, are available. To define the C26x that manages a bay, see section *5.1.4 Defining a Bay*.
- If a read inhibit signal exists for the MPS, add the relations **read inhibit wired on** (2) at MPS datapoint level.

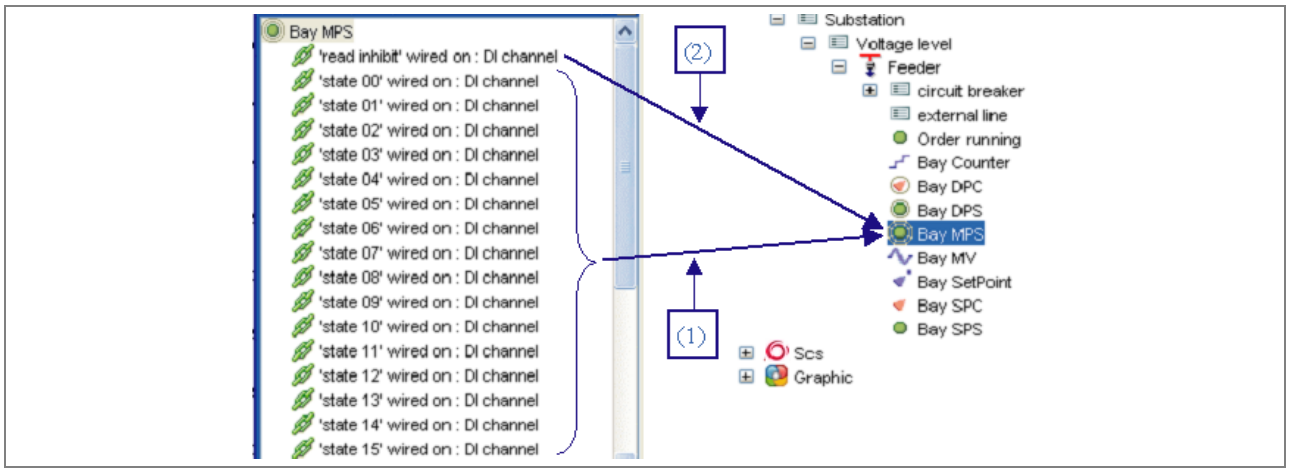


Figure 221: Wiring an MPS datapoint via n DI channels

4.5.4.4 WIRING MV AND TPI DATAPOINTS

MV and TPI datapoint wiring is done via 1 AI channel (analogue measurement) or via up to 64 DI channels (for digital measurements) and two optional DI channels for 'read inhibit' indication and sign bit.

To wire an MV or TPI datapoint on AI channel:

- Add the relation **wired on** (1) at MV or TPI datapoint level.
- Fill the relation with the relevant AI channel: when datapoint level is lower than or equal to bay level, only AI channels from AIU boards belonging to the C26x that manages the bay, are available. To define the C26x that manages a bay, see section *5.1.4 Defining a Bay*.
- To define sensor range of the AI channel, see section *3.3.6 Configuring an AI channel.*

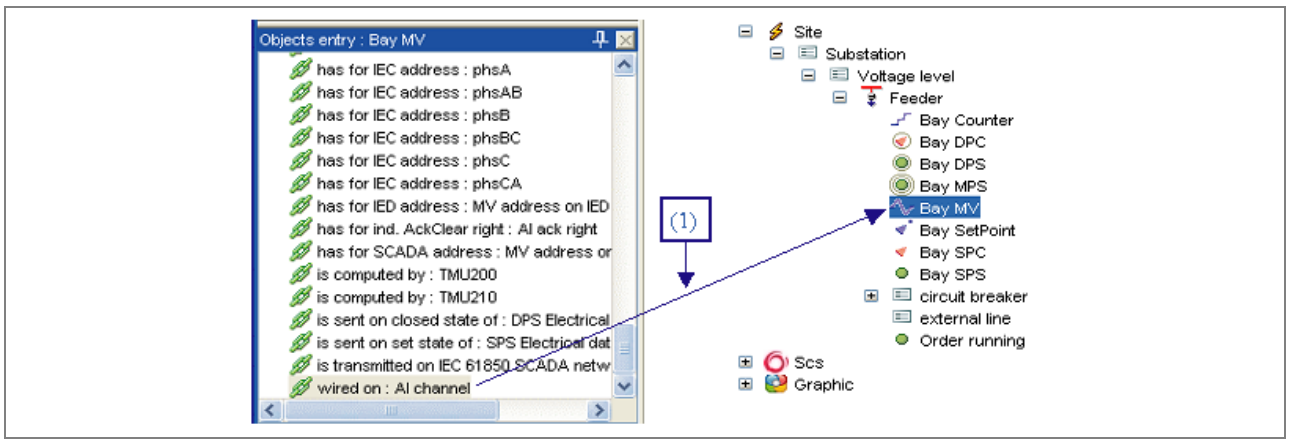


Figure 222: Wiring an MV datapoint or a TPI datapoint via one AI channel

To wire an MV or TPI datapoint on n DI channels (n <=64):

- Add the relations **bit <i> wired on** (1) at MV or TPI datapoint level, for each available bit channel of the MV or TPI (i begins from 0).
- Fill the relations with the relevant DI channels: when datapoint level is lower than or equal to bay level, only DI channels from local DIU boards belonging to the C26x that manages the bay, are available. To define the C26x that manages a bay, see section *5.1.4 Defining a Bay*.
- If a read inhibit signal exists for the MV or TPI, add the relations **read inhibit wired on** (2) at MV or TPI datapoint level.
- If a sign bit exists for the MV, add the relations **sign bit wired on** (3) at MV datapoint level.

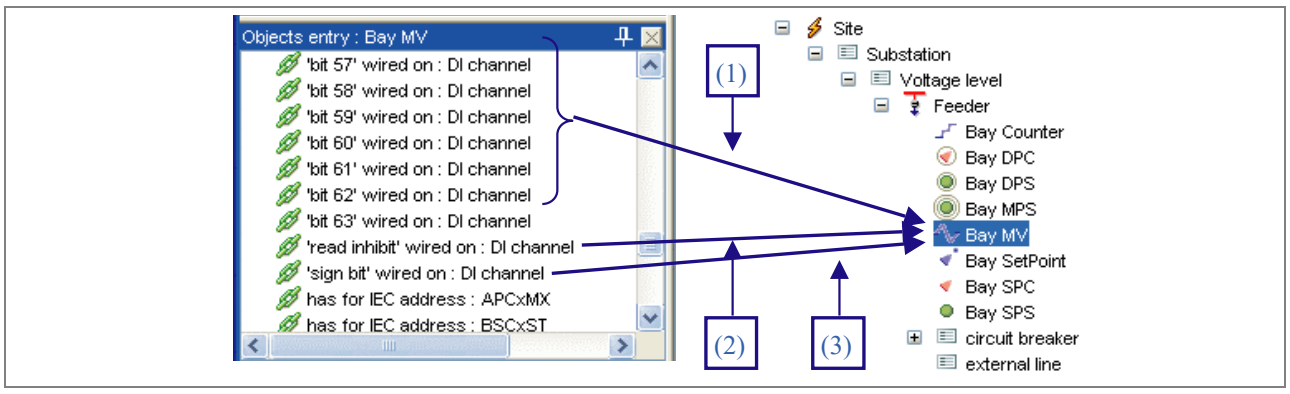


Figure 223: Wiring an MV or TPI datapoint via n DI channels

4.5.4.5 WIRING A COUNTER DATAPOINT

A "standard" Counter datapoint ("counter type" attribute set to "standard") wiring is done via one DI channel (simple standard counter) or two DI channels (double standard counter).

To wire a Counter datapoint on DI channel:

- Add the relation **primary input wired on** (1) at Counter datapoint level.
- If it is a double counter, add the extra relation **secondary input wired on** (2) at Counter datapoint level.
- Fill the relations with the relevant DI channel: when datapoint level is lower than or equal to bay level, only DI channels from local DIU boards belonging to the C26x that manages the bay, are available. To define the C26x that manages a bay, see section *5.1.4 Defining a Bay*.
- When the counter is used as an energy counter ("counter type" attribute set to "Energy import" or "Energy Export") no wiring is needed but the relation **integrate: MV electrical datapoint** (3) must be added to define the input of the counter. This relation must be filled with the relevant MV datapoint.

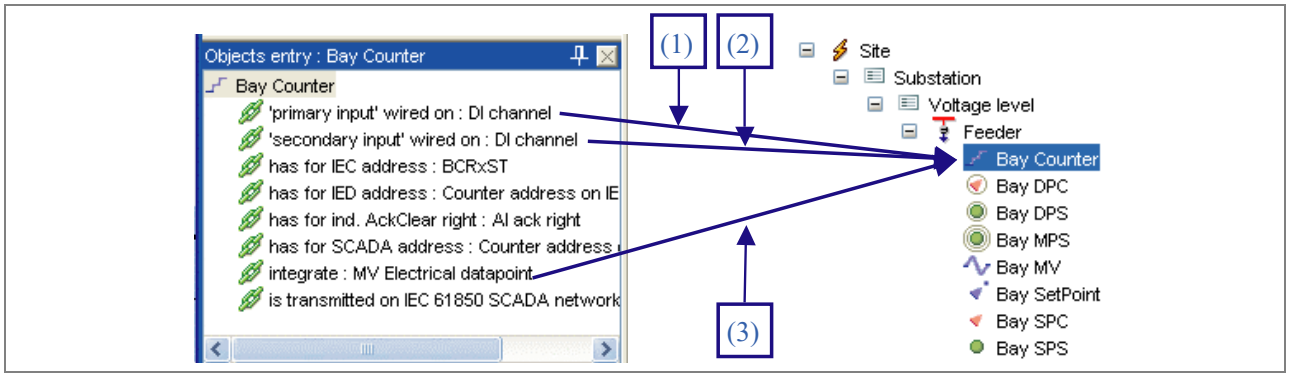


Figure 224: Wiring a Counter datapoint via a DI channel

4.5.5 ACQUIRING AN INPUT DATAPOINT VIA A NON-DS AGILE IEC61850-COMMUNICATING IED

At SCE level, IED wiring is not described. Acquiring input datapoint issued from IEC 61850 IED is done by giving it a communication address in the relay's IEC 61850 mapping. This addressing can be seen as a virtual wiring regardless to channel wiring (implicit association is done at IED level).

See relevant application guide for further details about IED creation and corresponding IEC 61850 address mapping definition (nevertheless, a similar IEC 61850 address mapping is described in section *1.1.1 Defining the address map of a station-bus network of the present guide*).

To link an input datapoint to an existing IEC 61850 IED address in the IED mapping:

- Add the relation **has for IED address** (1) at datapoint level
- Fill the relation with the relevant IEC61850 address

Do not confuse:

- Give an IEC 61850 address to a datapoint, still wired on a C26x, via **has for IEC address** relation adding.
- Give an IEC address to a datapoint on an IEC IED. In that case the datapoint can not be wired, because it is seen as produced or managed by the IEC IED.

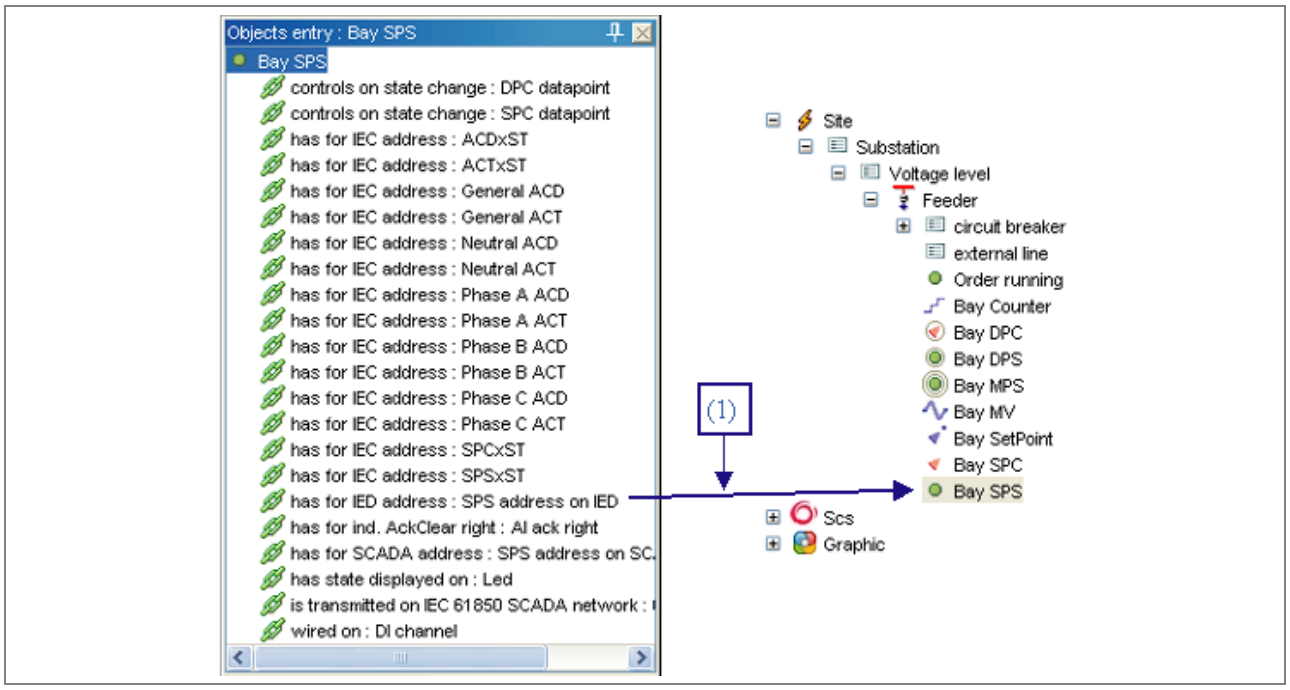


Figure 225: Acquiring an input datapoint via a non-DS Agile IED (example for an SPS datapoint)

4.5.6 PRODUCING AN INPUT DATAPOINT

Another way to produce input datapoint real-time values is to allow software functions to generate them.

This is done at several software levels:

- Supervision of an IEC 61850 DS Agile system device, where system datapoints are produced to indicate the device mode, synchronisation device, database status..
- Supervision of IEC61850 DS Agile system device board (board status diagnostics).
- Supervision of redundancy between two DS Agile C26x units (redundancy status diagnostics).
- Supervision of logging printers managed by aView server (printer status diagnostics).
- Supervision of archiving managed by aView server (archiving status diagnostics).
- Facilities given by built-in electrical and grouping functions or user's function, in DS Agile C26x units.

4.5.6.1 IMPLICIT SYSTEM INPUT DATAPOINT VIA SYSTEM DECOMPOSITION

In data modeling many components of the system topology own input datapoints. Their creation is generally implicit when creating the component: they belong to its hierarchy.

Most of system input datapoints when transmitted on station bus network are addressed in IEC 61850 diagnostics bricks.

The list of such system datapoints are given in section *3.10 Setting system information for C26x components*.

4.5.6.2 IMPLICIT ELECTRICAL INPUT DATAPOINT VIA A BUILT-IN FUNCTION

Implicit input datapoints can be embedded in built-in function creation. For details refer to the following sections:

- *5.2 Defining Synchrocheck function,*
- *5.4 Defining an Auto-recloser built-in function,*
- *5.5 Defining a Tap changer built-in function.*

4.5.6.3 DEFINING AN ISAGRAF SLOW AUTOMATION

By setting output plug, fast automation can produce real-time value for electrical input datapoint (see section *4.5 Defining an FBD fast automation* of SCE/EN AP).

So can slow automation when it manages electrical datapoints or owns management input datapoints (see section *5.5 Defining an ISaGRAF slow automation* of SCE/EN AP).

For group needs, an electrical SPS containing the group result must be created (see section *5.7.1 Datapoint Grouping*).

For SPS-DPS association, the resulting DPS is the product of the two SPS associations (see section *5.7.3 Producing a DPS*).

To define (open or close) interlocking equation on SPC or DPC datapoint, an extra (open or close) SPS should be produced, whose result is interlocking equation computation (see section *5.7.4 Defining an interlock*).

4.5.6.4 EXPLICIT ELECTRICAL INPUT DATAPOINT VIA CT/VT COMPUTATION

Another way to produce an MV electrical datapoint is to link it to a CT/VT C26x board. Then, a specific link attribute must be filled to precise which MV computation is concerned (power, harmonic ...).

Data produced by CT/VT board computation concern:

- RMS Values of phase voltage
- RMS values of busbar voltage
- RMS values of phase current
- RMS values of residual voltage and current
- Fundamental sequence components
- Active Power
- Reactive Power
- Apparent Power
- Frequency
- Harmonics levels (expressed as a ratio of the magnitude of the fundamental voltage or fundamental current)

To link an MV datapoint to a CT/VT computation:

- Add the relation **is computed by** (1) at datapoint level.
- Fill the relation with the relevant CT/VT board. When datapoint level is lower than or equal to bay level, only the CT/VT board belonging to the C26x that manages the bay, is available. To define the C26x that manages a bay, see section *5.1.4 Defining a Bay*.
- Select in the relation attribute **measurement type** (2) the computation type and the harmonics/fundamental taken in account.

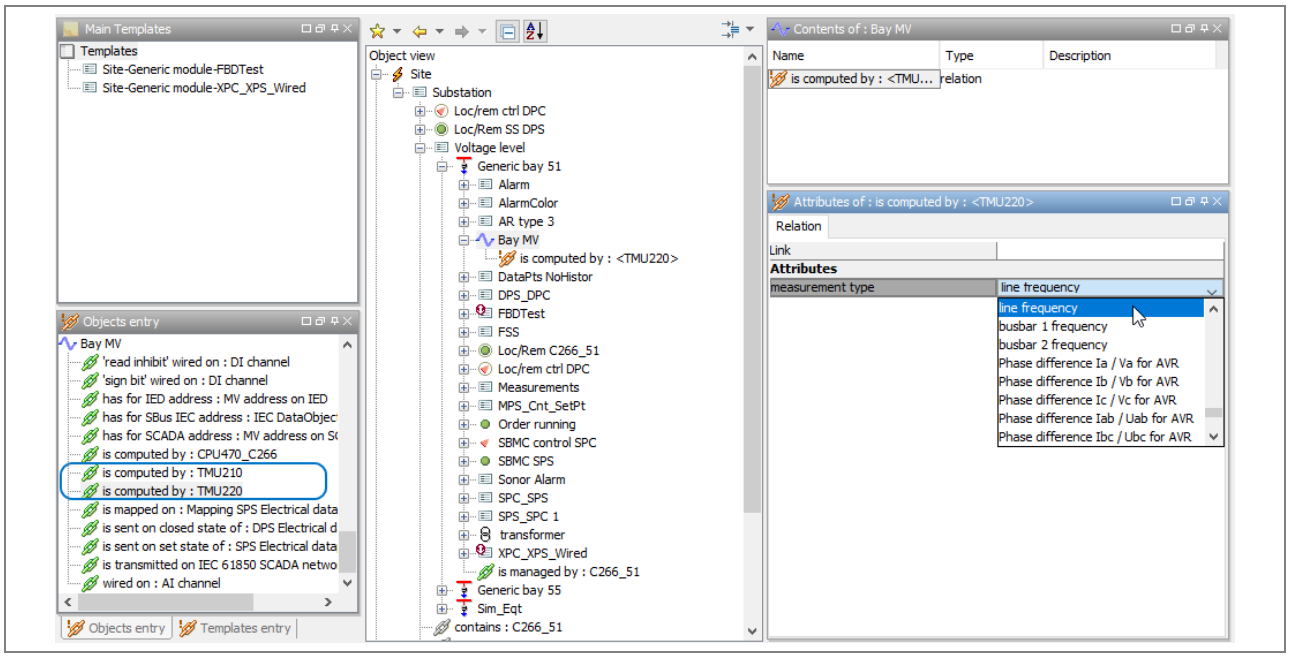


Figure 226: Defining CT/VT computation for an MV datapoint

4.6 DEFINING THE CONTROL SOURCE FOR OUTPUT DATAPOINTS

4.6.1 OVERVIEW

Output datapoints have real-time control values, managed by several ways excluding each other:

- control via output channel(s)
- control via non-DS Agile IEC 61850-communicating IED
- (virtual) control via software production:
  - control of system components
  - datapoints relevant to built-in function and user's function

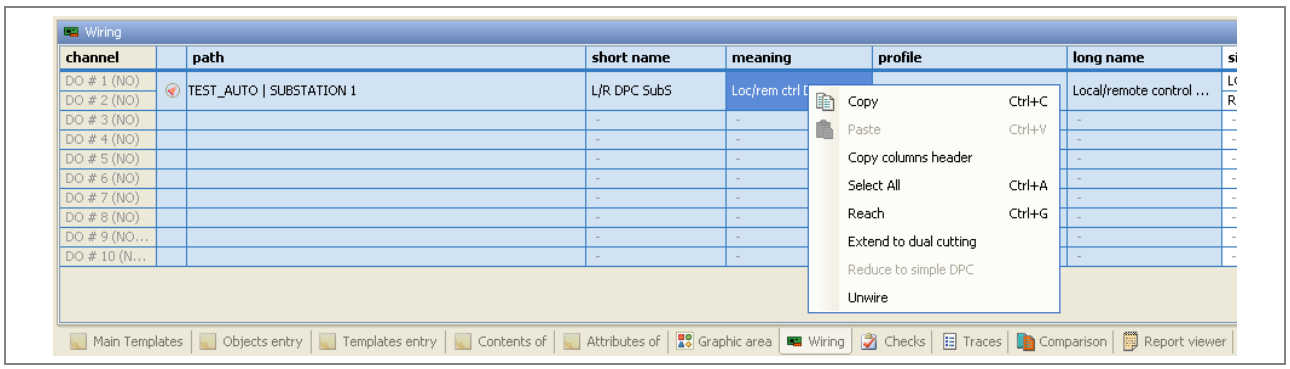
The wiring is based on some best practices:

- first channel of DPC wired in an ODD channel
- two channels of a DPC contiguous

4.6.2 SMART TABLES

See section *4.5.2 Smart tables*.

For double DP, creating a channel results in automatic creation of the associated channel with the same attributes:



To extend to 4 channels, select **Extend to dual cutting**.

To undo this, select **Reduce to simple DPC**.

4.6.3 CONTROLLING AN OUTPUT DATAPOINT VIA OUTPUT CHANNELS

At SCE level, linking datapoint to specific channels (DO channels) belonging to DS Agile C26x's DOU200, DOU201, HBU200 or CCU2xx boards is called output datapoint wiring.

4.6.3.1 WIRING AN SPC DATAPOINT VIA ONE OR TWO DO CHANNEL(S)

To wire an SPC datapoint on one or two DO channel(s):

- Add the relation **wired on** (1) at SPC datapoint level (this relation is added twice if 2 DO channels are used).
- Fill the relation with the relevant DO channel(s): when the datapoint level is lower than or equal to bay level, only DO channels from output boards belonging to the C26x that manages the bay are available. To define the C26x that manages a bay, see section *5.1.4 Defining a Bay*.

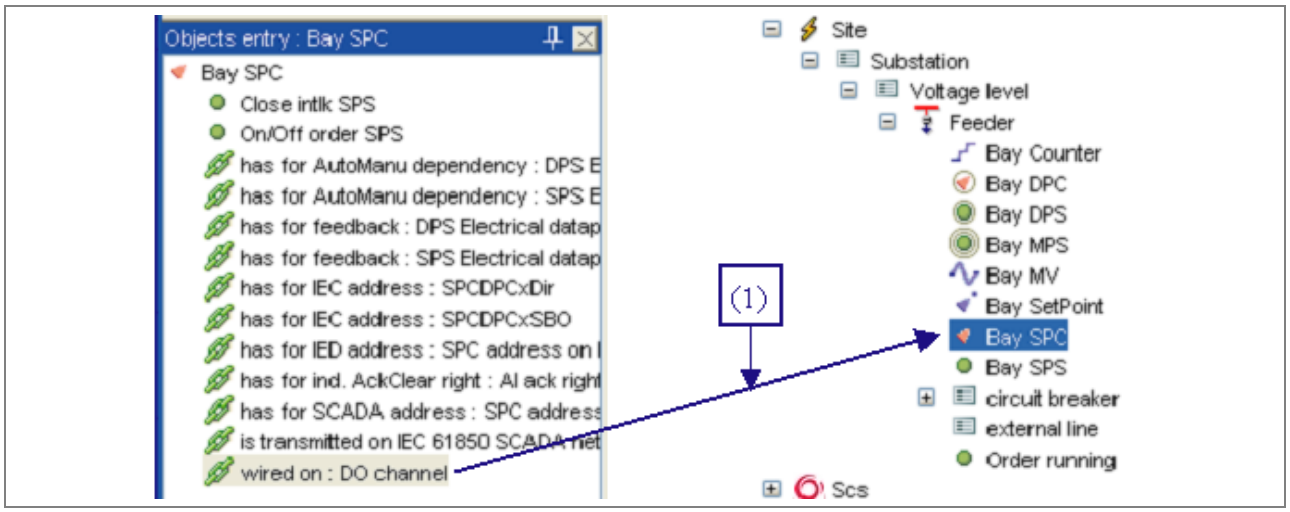


Figure 227: Wiring an SPC datapoint via one DO channel

4.6.3.2 WIRING A DPC DATAPOINT VIA TWO OR FOUR DO CHANNELS

To wire a DPC datapoint on two or four DO channels:

- Add the relations **closed wired on** (1) and **open wired on** (2) at DPC datapoint level (these relations are added twice if 4 DO channels are used)
- Fill the relations with the relevant DO channels: when the datapoint level is lower than or equal to bay level, only DO channels from output boards belonging to the C26x that manages the bay are available. To define the C26x that manages a bay, see section *5.1.4 Defining a Bay*

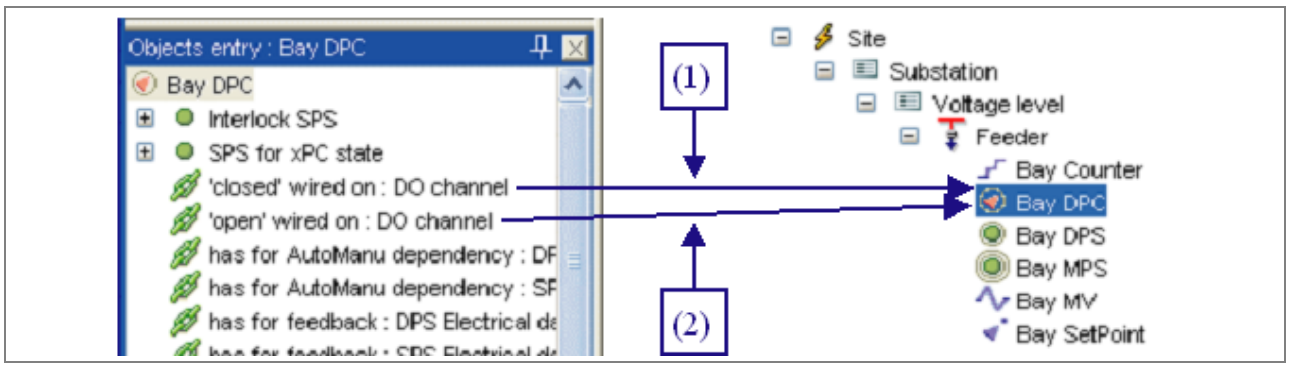


Figure 228: Wiring a DPC datapoint via two DO channels

4.6.3.3 WIRING A SETPOINT DATAPOINT

SetPoint datapoints can only be wired on digital channels (up to 48 DO channels) and two optional DO channels for 'read inhibit' indication and sign bit and can also be wired on 1 Analogue channel.

To wire a SetPoint datapoint on n DO channels (n <=48):

- Add the relations **bit <i> wired on** (1) at SetPoint datapoint level, for each available bit channel of the SetPoint (i begins from 0)
- Fill the relations with the relevant DO channels: when datapoint level is lower than or equal to bay level, only DO channels from DOU boards belonging to the C26x that manages the bay, are available. To define the C26x that manages a bay, see section *5.1.4 Defining a Bay.*

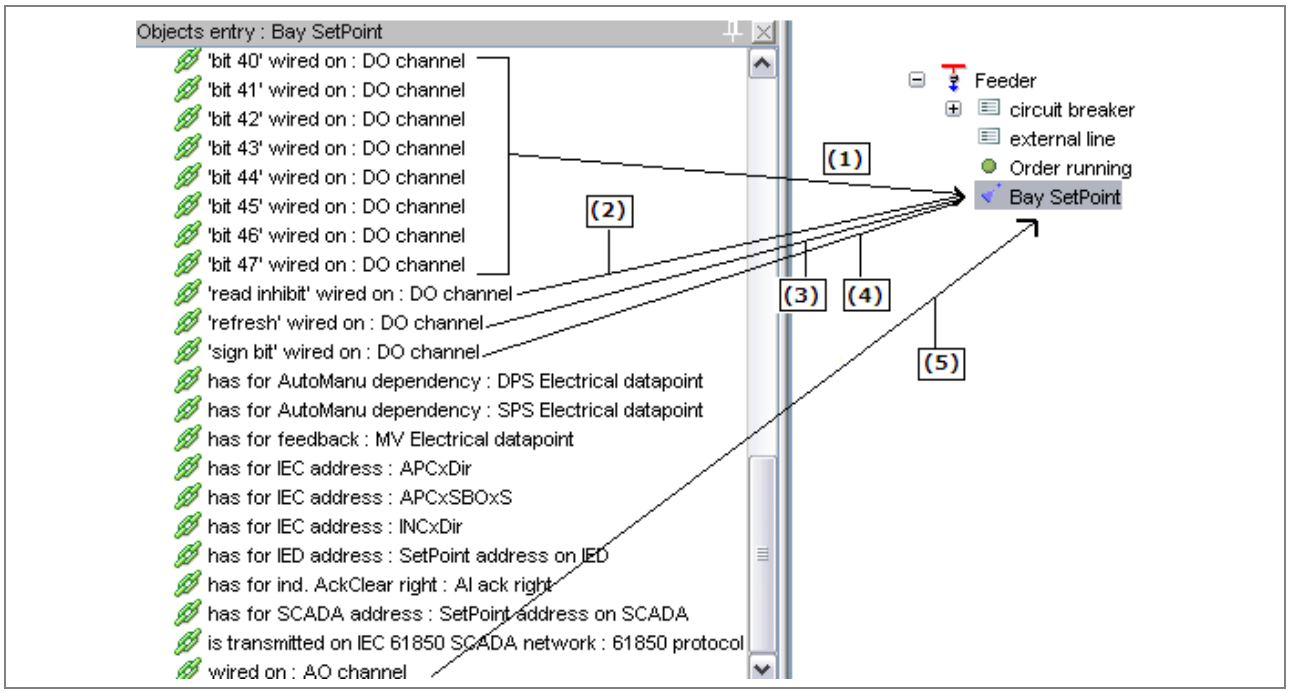


Figure 229: Wiring a setpoint datapoint via a DO channel and an AO channel

Configuration rules and checks

A Setpoint datapoint wired on DO channels of C26x must be digital and have a profile with attribute “SBO mode” set to "Direct Execute" or “Direct Execute with SBO popup”.

To define the optional relations 2 to 4:

- Add the relation at SetPoint level by tapping into the Object entry window
- Double click the relation in the browser and select the target in the Relation link editor
- If necessary, set the relation attribute

Mark	Relation	Attribute 0..999 s	At expiry
2	‘read inhibit’ wired on: DO channel	inhibition duration	setpoint is allowed
3	‘refresh’ wired on: DO channel	Refresh duration	alarm not refreshed, but last received SetPoint is maintained
4	‘sign bit’ wired on: DO channel	–	–

4.6.3.4 WIRING FROM A CCU DATAPOINT

SPC, DPC datapoint can also use digital outputs of CCU boards.

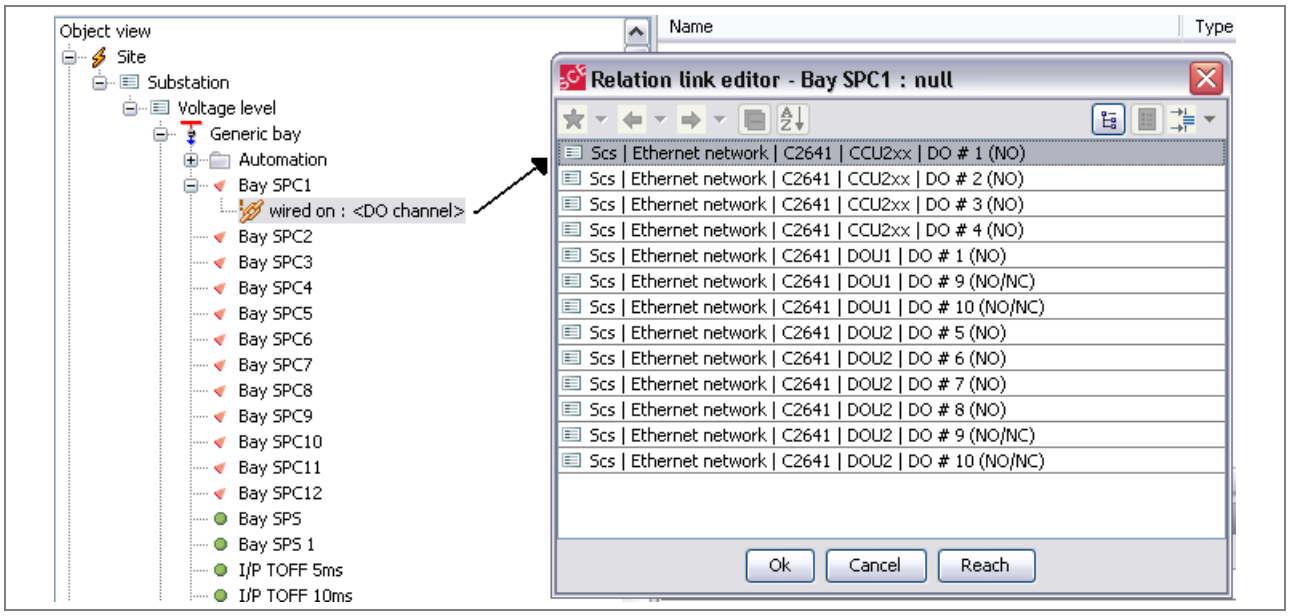


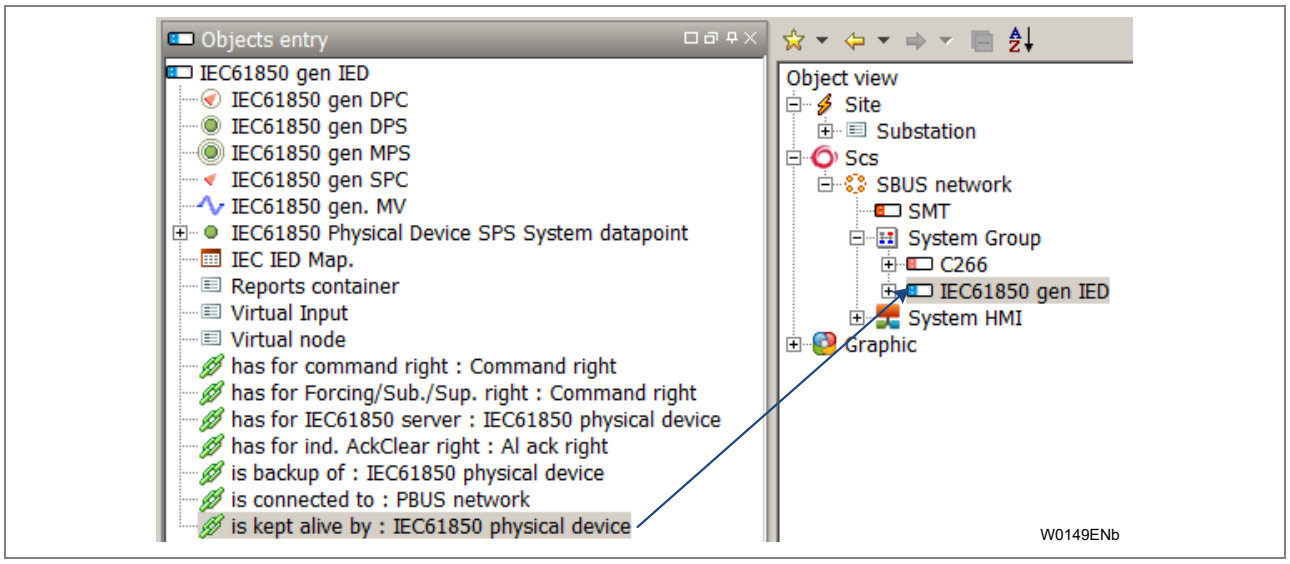
Figure 230: Acquiring an output datapoint using the CCU Card

4.6.4 CONTROLLING AN OUTPUT DATAPOINT VIA A NON-DS AGILE IEC 61850-COMMUNICATING IED

At SCE level, IED wiring is not described. Controlling output datapoint issued from IED is done by giving it a communication address in the relay's IEC 61850 mapping. This addressing can be seen as a virtual wiring regardless to channel wiring.

See relevant application guide for further details about the creation of IEC 61850 IEDs and corresponding address mapping definition (nevertheless, similar IEC address mapping is described in section *1.1.1 "Keep-Alive" function.*

Some older generation IEDs automatically disconnect from their clients on the station bus when they are not polled for a certain amount of time. A relation is kept alive by : IEC61850 device was used in previous system versions to poll these IEDs at settable intervals to prevent that disconnection. This function is no longer used and the relation has no effect (it will be deleted in the next SCE release).



To link an output datapoint to an existing IED address in the IED IEC mapping:

- Add the relation **has for IED address** (1) at datapoint level
- Fill the relation with the relevant IED address

Do not confuse:

- Give an IEC address to a datapoint, still wired on a C26x, via **has for IEC address** relation adding.
- Give an IEC address to a datapoint on an IEC IED. In that case the datapoint can not be wired, because it is seen as produced or managed by the IEC IED.

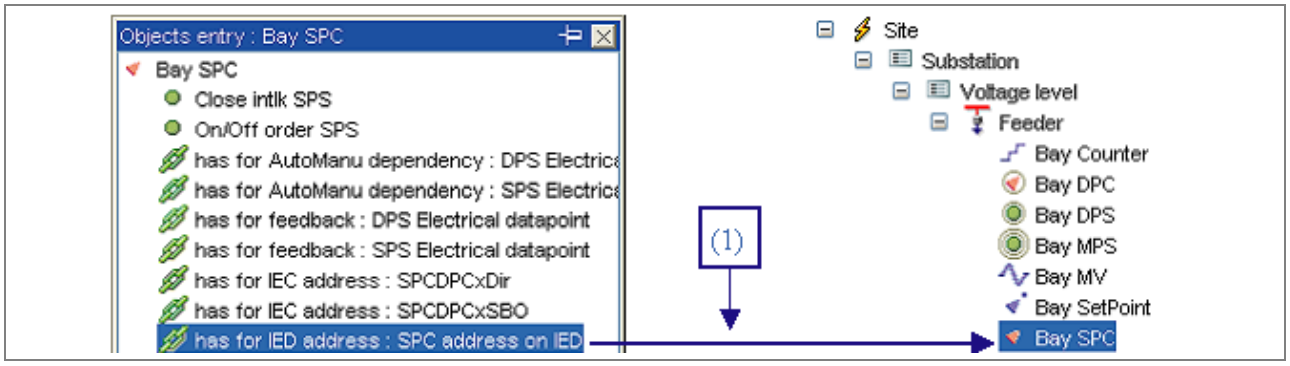


Figure 231: Acquiring output datapoint via non-DS Agile IEC IED

4.6.5 PRODUCING AN OUTPUT DATAPOINT

Another way to produce output datapoint real-time control values is to allow software functions to generate them.

This is done at several software levels:

- Supervision of IEC 61850 DS Agile system device, where system datapoints are produced to control mode device, database switch. These output system datapoints are only used by System Management Tool.
- Supervision of redundancy between two DS Agile C26x units (redundancy controls).
- Facilities given by built-in electrical and grouping functions or user's function, in DS Agile C26x units.

4.6.5.1 IMPLICIT SYSTEM OUTPUT DATAPOINT VIA SYSTEM DECOMPOSITION

In data modeling, only DS Agile units of the system topology own output datapoints for device mode management and database switch. Their creation is implicit when creating the device: they belong to its hierarchy.

C26x redundancy needs specific output typed datapoints that must be manually added in C26x's hierarchy.

Most of system output datapoints when transmitted on station bus network are addressed in IEC 61850 diagnostics bricks.

The list of such system datapoints are given in section *3.10 Setting system information for C26x components*.

4.6.5.2 IMPLICIT ELECTRICAL OUTPUT DATAPOINT VIA A BUILT-IN FUNCTION

Implicit output datapoints can be embedded in built-in function creation. For details see the following sections:

- *5.2 Defining a Synchrocheck function*
- *5.4 Defining an Auto-recloser built-in function*
- *5.5 Defining a Tap changer built-in function*

4.6.5.3 DEFINING AN ISAGRAF SLOW AUTOMATION

By setting output plug, fast automation can produce real-time order value for electrical output datapoint. So can slow automation when it manages electrical output datapoints or owns management output datapoints (see section *5.5 Defining an ISaGRAF slow automation* in the **Application** chapter of the SCE user manual).

For xPS-xPC association, an electrical output SPC or DPC linked to the SPS or DPS must exist and sometimes be created (see section *5.7.2 Controlling an xPC*).

4.6.6 ACKNOWLEDGEMENT DEFINITION IN CASE OF SIMULTANEOUS ORDERS

When two opposite orders (Open/Close or Close/Open) are simultaneous and from different origins, the acknowledgment management is described on the following table:

Cmd1	Cmd2	Action	Ack
PSL	PSL	Cmd 1 cancelled	NA
PSL	Operator	Cmd 1 cancelled	NA
Operator	PSL	Cmd 1 cancelled	CO_ACK_FAILED_ORDER (ACK 19)
Operator	Operator	Cmd 2 ignored	CO_REQUEST_IN_PROGRESS (ACK 6)

When two identical orders (Open/Open or Close/Close) are simultaneous and from different origins, the acknowledgment management is described on the following table:

Cmd1	Cmd2	Action	Ack
PSL	PSL	Cmd 2 Ignored	NA
PSL	Operator	Cmd 2 Ignored	CO_REQUEST_IN_PROGRESS (ACK 6)
Operator	PSL	Cmd 2 Ignored	NA
Operator	Operator	Cmd 2 ignored	CO_REQUEST_IN_PROGRESS (ACK 6)

4.7 DEFINING A DATAPOINT ASSOCIATION

This functionality is used to create a link between two datapoints so that the state of one datapoint (called the target datapoint) is defined by the state of the other datapoint (called the original datapoint).

Target datapoints can be one of the following types: SPS or DPS. They are available with default name **Mapping SPS** and **Mapping DPS** at each level of the Electrical topology. In the example given here after these two "target" datapoints are shown at the Substation level (1).

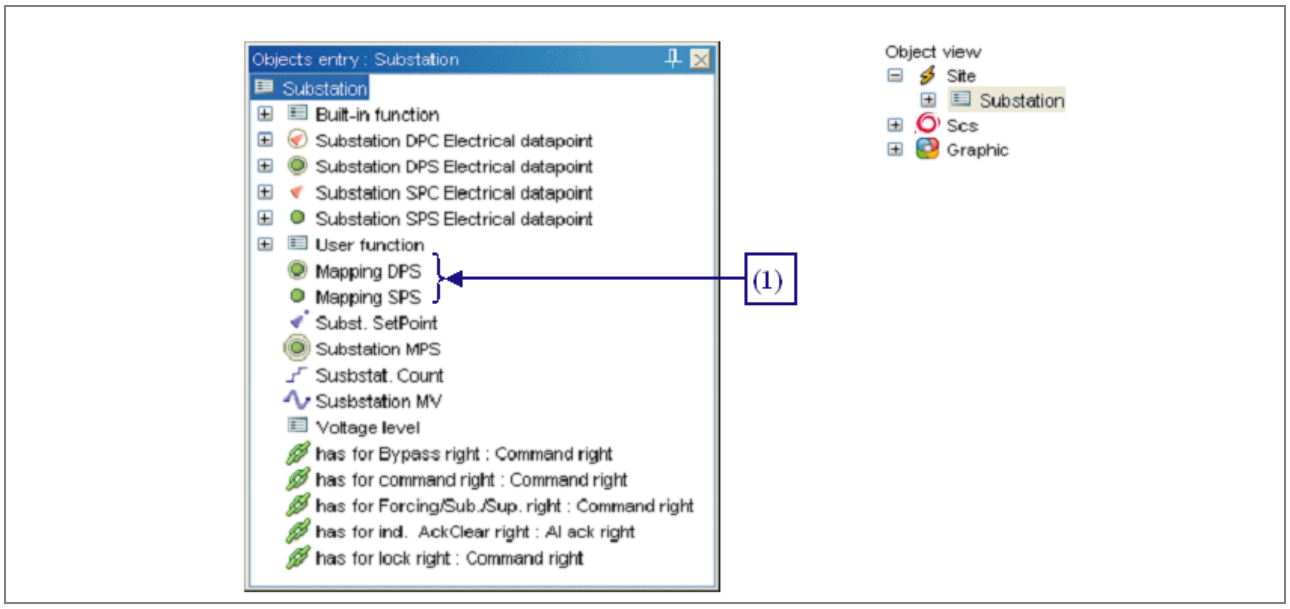


Figure 232: The two target datapoints of the substation level

Original datapoints can be one of the following types: SPS, DPS, MPS, and MV.

4.7.1 ADDING A TARGET DATAPOINT

To add a target datapoint, select the required electrical level (Substation in our example) and add the Mapping xPS from the contextual **Objects entry** window.

4.7.2 LINKING THE TARGET DATAPOINT TO THE ORIGINAL DATAPOINT

To link the target datapoint to the original datapoint a relation **'is mapped on'** (1) must be added to the selected "original" datapoint (**order running** at generic bay level in our example). Once added, the undefined relation is present in the "**Contents of**" window associated with the order running datapoint (2).

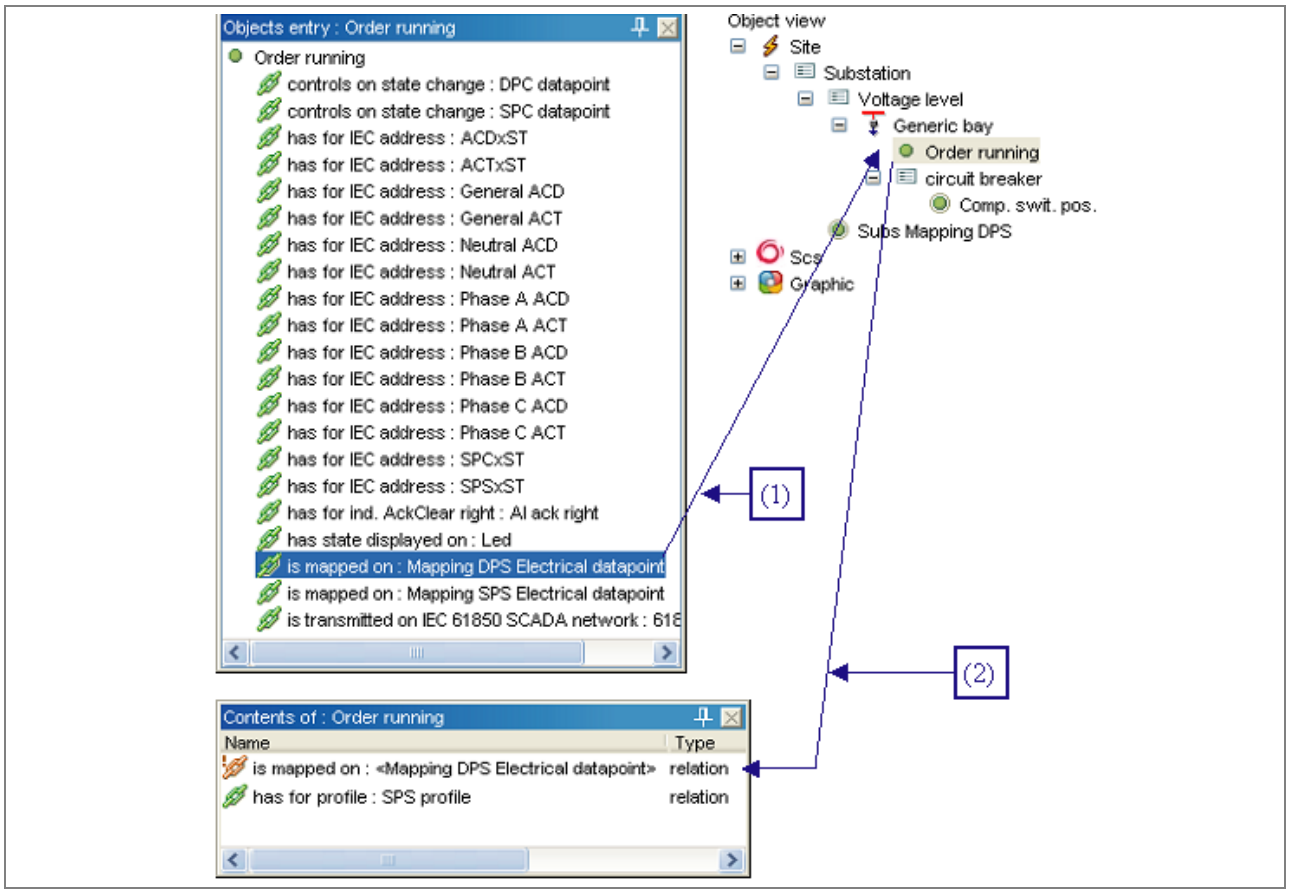


Figure 233: Linking the target datapoint to the original datapoint

To select the target datapoint double-click the undefined relation **is mapped on:** (3). In the **Relation link editor** dialog box are displayed all the available Mapping DPS datapoints (4). Click the Mapping DPS datapoint you want to be associated with the **order running** datapoint (**Subs Mapping DPS** in our example) then click the **OK** button.

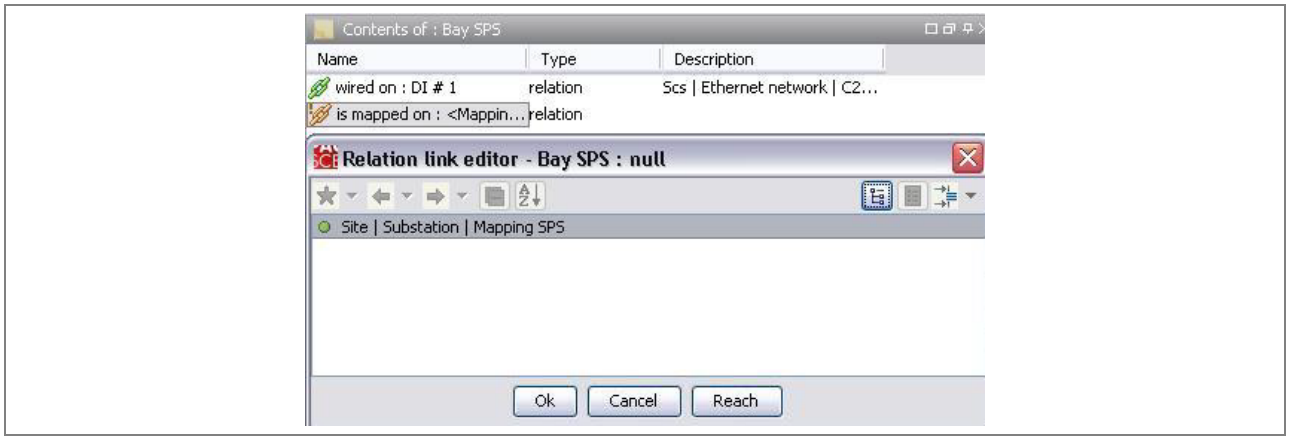


Figure 234: Selecting the target datapoint

4.7.3 DEFINING THE STATES ASSOCIATIONS

For every possible state of the original datapoint the user can define the corresponding state of the target datapoint. To perform this association, click the now defined relation **is mapped on:** (5) in the **"Contents of:"** window associated with the "**order running**" datapoint. In the **"Attributes of:"** window associated with this relation are listed all the possible states of the original datapoint (6) and for each one the user has to select the corresponding state of the target datapoint (7).

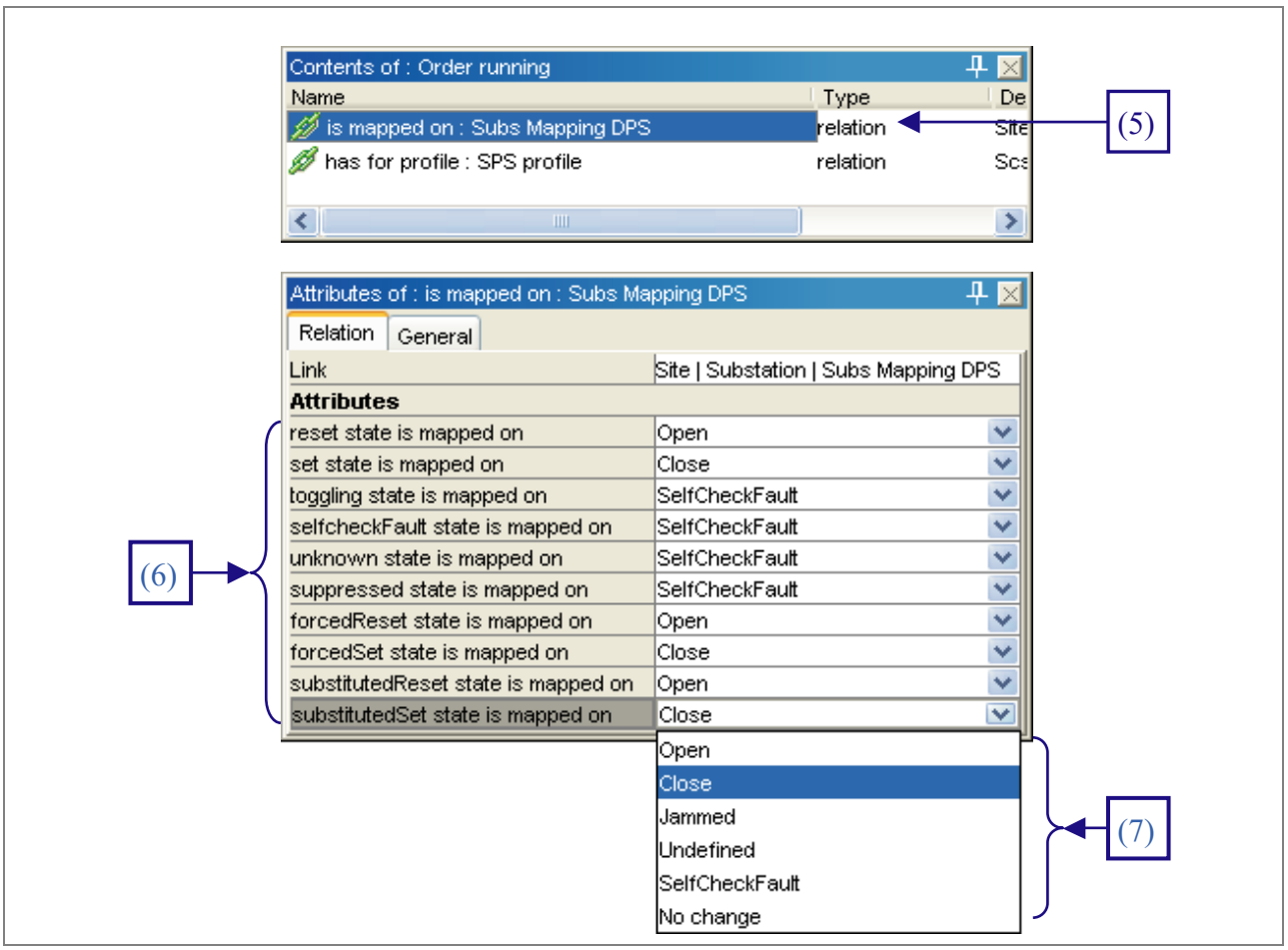


Figure 235: Defining the states associations

Configuration rules and checks

- Up to 10 target datapoints can be associated with an original datapoint
- Up to 100 datapoints can be defined as original datapoints
- The original datapoint and the target datapoint can belong to different C26x units. In this case the states of the original datapoints are transmitted through GOOSE messages
- A target datapoint is managed as any other datapoint: transmission, used in automation, alarms, …
- An SPS original datapoint can be associated with an SPS or a DPS
- A DPS original datapoint can be associated with an SPS or a DPS
- An MPS original datapoint can only be associated with an SPS (the relation **is mapped on: Mapping DPS Electrical datapoint** is not available in the **"Objects entry"** window associated with an MPS)
- An MV original datapoint can only be associated with an SPS (the relation **is mapped on: Mapping DPS Electrical datapoint** is not available in the **"Objects entry"** window associated with an MV)

5 DEFINING A C26X CONFIGURATION IN THE ELECTRICAL HIERARCHY

5.1 DEFINING AN ELECTRICAL TOPOLOGY

At SCE data modeling level, the entry point of electrical topology is the ‘Site’ object. At the moment, a ‘Site object’ (1) can be composed of only one ‘Substation’ object.

A substation (2) is constituted of ‘Voltage level’ objects, each of them corresponding to an electrical partitioning of the substation by voltage level value (in kV).

A voltage level (3) is an aggregation of ‘Bay’ object (4), grouping of electrical units, called module (5). Generally, this grouping is electrically self-safety, i.e. can be isolated from other bays by switchgears for maintenance and managed by only one DS Agil C26x. There are different types of bays: feeder, transformer, busbar, bus coupler, bus section, capacitor bank and generic bay.

Coupling two voltage levels is commonly done via transformer. To respect SCE data modeling electrical partitioning, this transformer must belong to a transformer bay (6) arbitrary put in one of both voltage levels (generally its primary). An extra relation on transformer defines to which voltage level its secondary (or primary) belongs.

Final electrical components are modules composing bays. There are different types of modules: circuit breaker, switchgear, transformer, motor, generator, battery, capacitor, inductor, converter and generic module. An extra module exists to describe substation external connection (external line).

Every level of the electrical topology, except Site level, can own datapoints whose features and configuration are described in section *4 Defining a datapoint*.

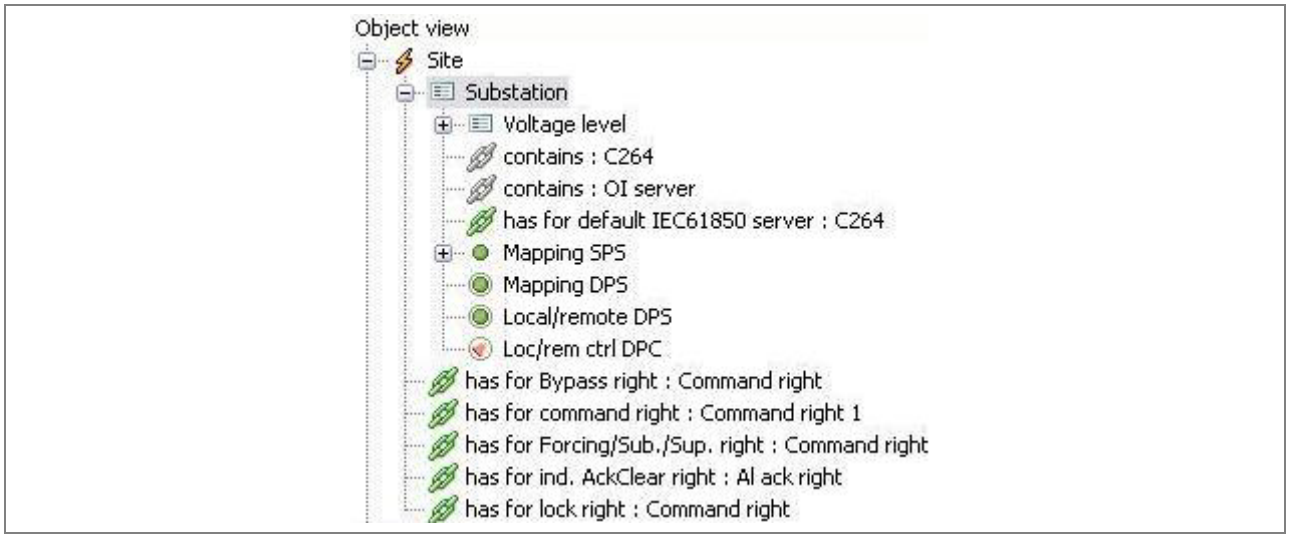


Figure 236: Electrical topology definition (example)

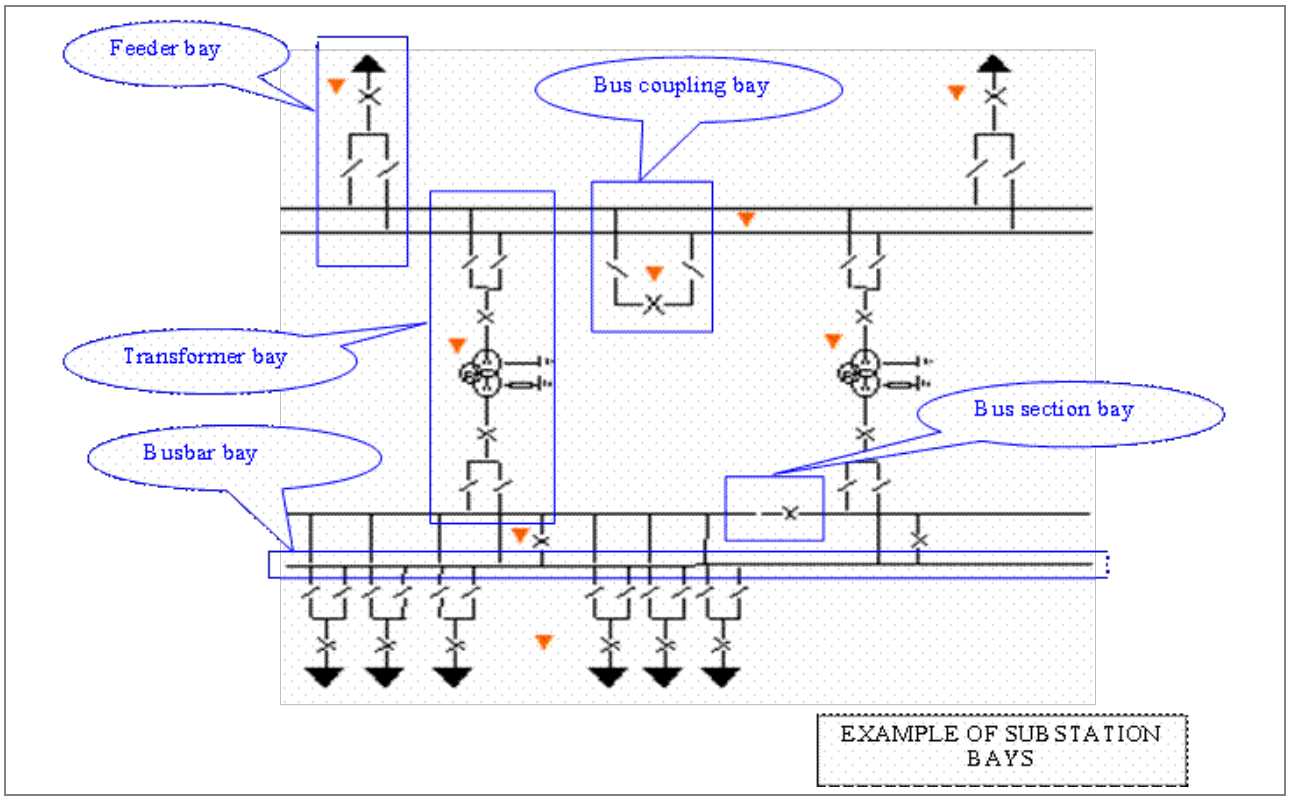


Figure 237: Bay examples

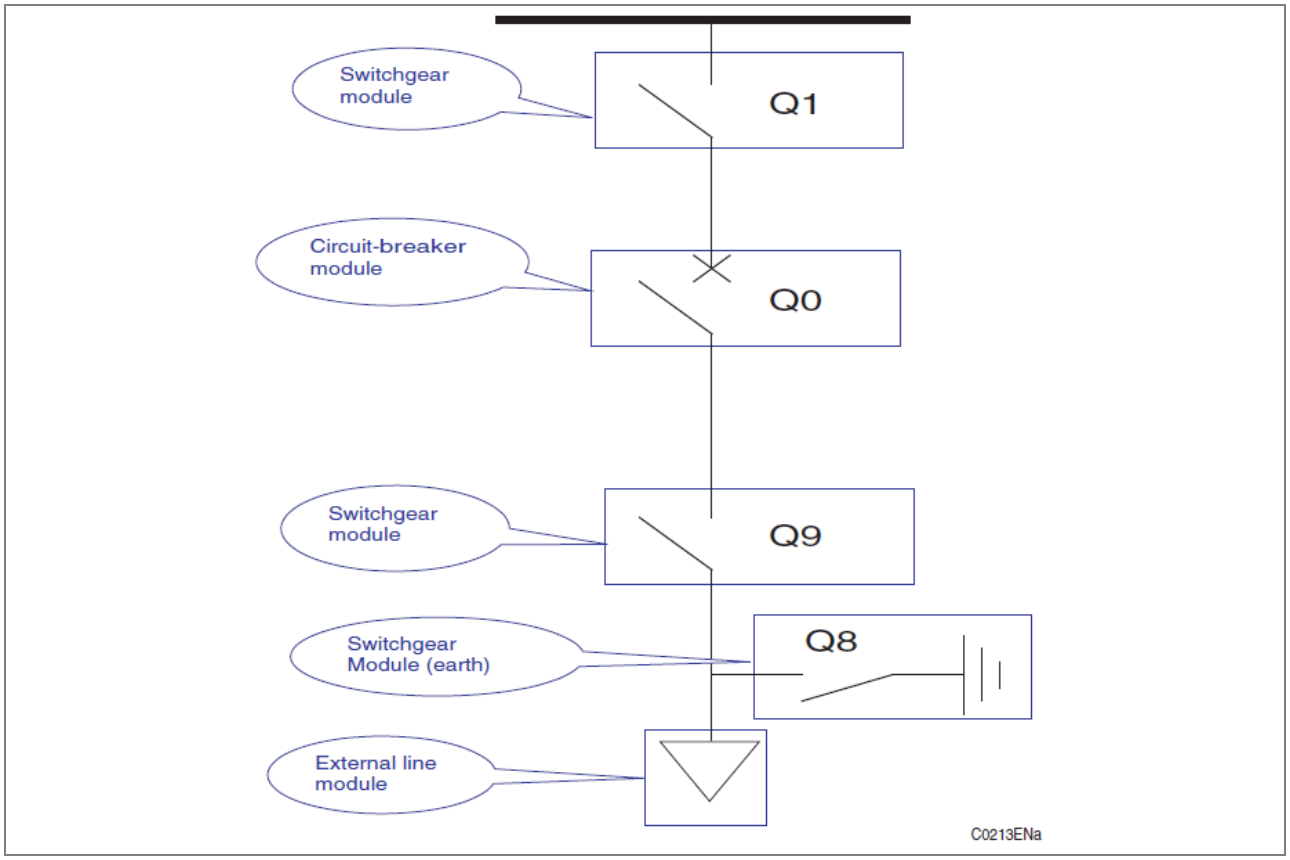


Figure 238: Module examples

5.1.1 DEFINING A SITE

When creating a new configuration with the SCE, the electrical topology is automatically instantiated via a 'Site' root object, containing a mandatory 'Substation' object.

A **Site** object corresponds to customer project identification: its attributes **short name** and **long name** (1) can be entered at SCE level. Currently, these attributes are not used.

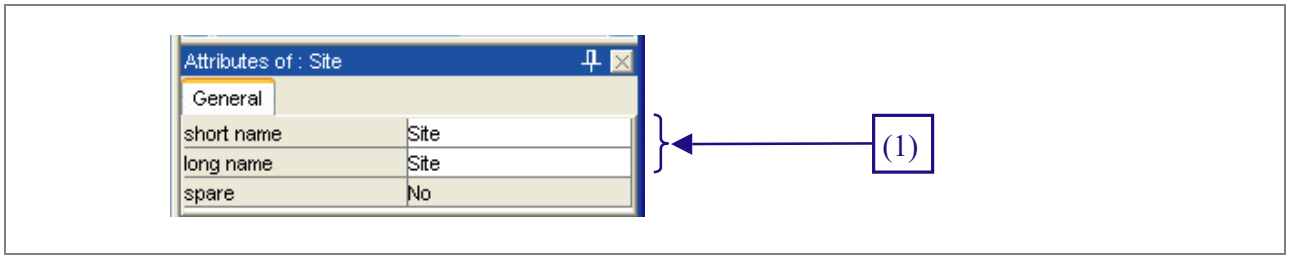


Figure 239: Setting the attributes of a site

5.1.2 DEFINING A SUBSTATION

When creating a new configuration using SCE, the electrical topology is automatically instantiated via 'Site' root object, containing a mandatory 'Substation' object.

A **Substation** object corresponds to customer substation identification: its attributes **short name** and **long name** (1) must be entered at SCE level, for proper logging formatting and datapoint identification, at C26x and system HMI (aView) levels.

At substation level, the attribute 'default uniqueness' (2) defines the way control uniqueness of physically wired controls is managed for the whole substation. The available values are:

- None: no control uniqueness is provided by the DS Agile system for the substation.
- Substation level: control uniqueness is provided by the DS Agile system for the whole substation, i.e. 2 simultaneous controls are refused within the substation, except for control datapoints configured as independent of substation uniqueness (see sections *4.3.7.1, 4.3.8.1* and *4.3.9.3*),
- Bay level: control uniqueness is provided by the DS Agile system for an entire bay, i.e. 2 simultaneous controls are refused within the same bay, except for control datapoints configured as independent of bay uniqueness (see sections *4.3.7.1, 4.3.8.1* and *4.3.9.3*).

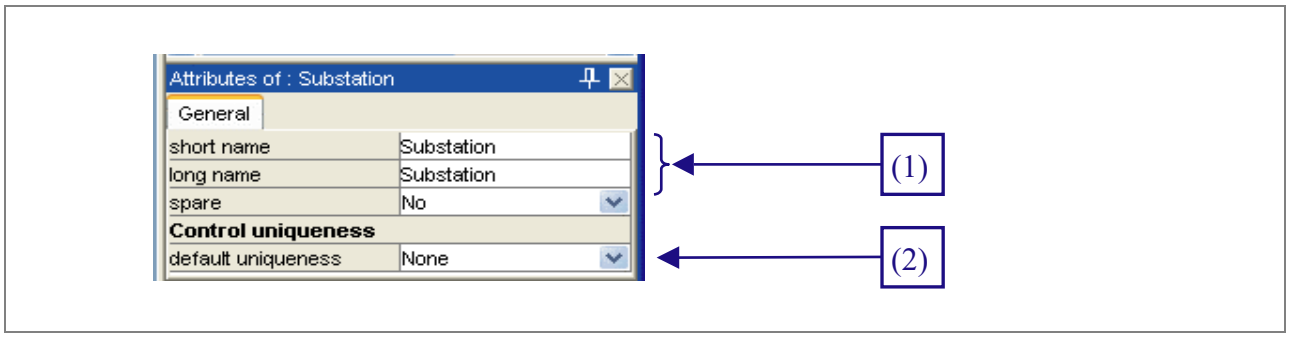


Figure 240: Setting the attributes of a substation

Bay and substation uniqueness are managed by C26x by synthesis of mandatory SPS datapoints 'Order running', automatically added under a bay at its creation (see section *5.1.4 Defining a Bay*).

Configuration rules and checks

- When control uniqueness is set for a substation, all the C26x units in the substation must be IEC 61850 clients of all 'order running' SPS datapoints defined for all the bays. So, a correct IEC 61850 configuration must be done for all C26x units to support that feature. For details about IEC 61850 configuration, see section *3.5* Networking a C26x on the station-bus network.

5.1.2.1 ADDING A SUBSTATION GENERIC DATAPOINT

To add a typed datapoint to a substation, select the substation level and add the typed datapoint from the contextual **Objects entry** window. The following generic datapoints (standard usage) are out of the specific substation functions scope:

- Local/remote for substation (see section *5.1.2.2 Defining a Local/Remote datapoint)*
- Taking Control for substation and SCADA links (see section *5.1.2.3 Defining a Taking Control datapoint for substation and SCADA links*)

For more details about datapoints and their configuration, see section *4 Defining a datapoint*.

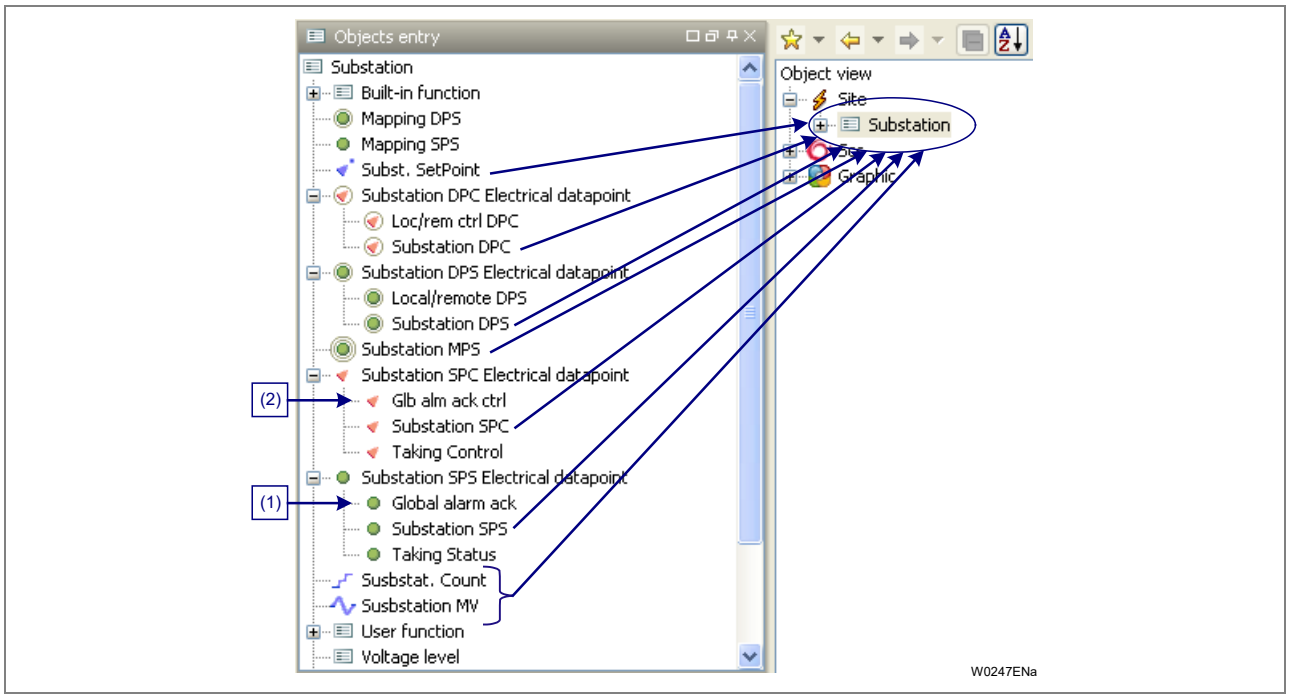


Figure 241: Adding a substation generic datapoint

Note:
A Global alarm ack SPS (1) can be added to the substation level in order to automatically acknowledge the new alarms in the *C26x*. The detection mode attribute of this SPS must be set to "Permanent" or "Permanent with *C26x* auto-reset". This SPS may be any wired SPS or SPS activated by a control (using the Glb alm ack ctrl SPC(2)) from the SCADA or generated by any PSL. It is also possible to launch a global alarm acknowledgment at a fixed time using a cyclic SPS (described in section *5.1.4.1 Adding a bay generic datapoint)*

5.1.2.2 DEFINING A LOCAL/REMOTE DATAPOINT AT STATION BUS LEVEL

A substation can be in remote or local control mode.

Remote mode means that the substation/bay is controlled from the Remote-Control Point (RCP) through the gateway. No controls can be sent from the Substation Control Point level (except if the concerned bay is in SBMC mode, see section *5.1.4.3 Defining the SBMC mode for a bay)*

Local mode means that the substation/bay is controlled from the DS Agile system HMI (aView at the Substation Control Point). The controls issued from the RCP (SCADA or upper level DS Agile aView) are not taken into account by the system and rejected.

Some control commands, defined during the configuration stage, can be independent of the local/remote control mode: it means that they can be issued from the SCP or RCP whatever the current control mode. Control commands from a configurable automation (see section *5.7 Defining an electrical regulation by user function*) are accepted in both modes. For details about the configuration of this dependency attribute, refer to sections:

- SPC: see section *4.3.7.1*,
- DPC: see section *4.3.8.1*,
- SetPoint: see section *4.3.9.3*.

In Local or Remote mode, the information acquired by C26x units and IEDs is always sent to the RCP and the SCP.

The automatic “Forcing of Invalid BI” function is used to avoid processing invalid states of the substation mode (the local or remote substitution state is defined in configuration). The “Forced Local” state is processed as “Local” state. The “Forced Remote” state is processed as “Remote” state.

Moreover, any IEC 61850 client (i.e. system HMI, gateway, C26x units) will automatically force the substation mode to “Forced Local” or “Forced Remote” if it takes the UNKNOWN state (due for example to the loss of communication between the C26x that manages the substation mode and the IEC 61850-8-1 clients).

5.1.2.2.1 Global substation L/R datapoint

To enable the Substation Local/Remote feature for the whole substation, a DPS and/or MPS datapoint can be used depending on the application and the expected datapoint statuses.

5.1.2.2.1.1 Substation DPS Electric Datapoint

- add the optional datapoints Local/remote DPS’ (1) and/or Loc/rem ctrl DPC’ (2) from the contextual **Objects entry** window at substation level,
- configure them (see section *4 Defining a datapoint*),
- if necessary, do not forget to link Loc/rem ctrl DPC’ to Local/remote DPS’ via the **has for feedback** relation.

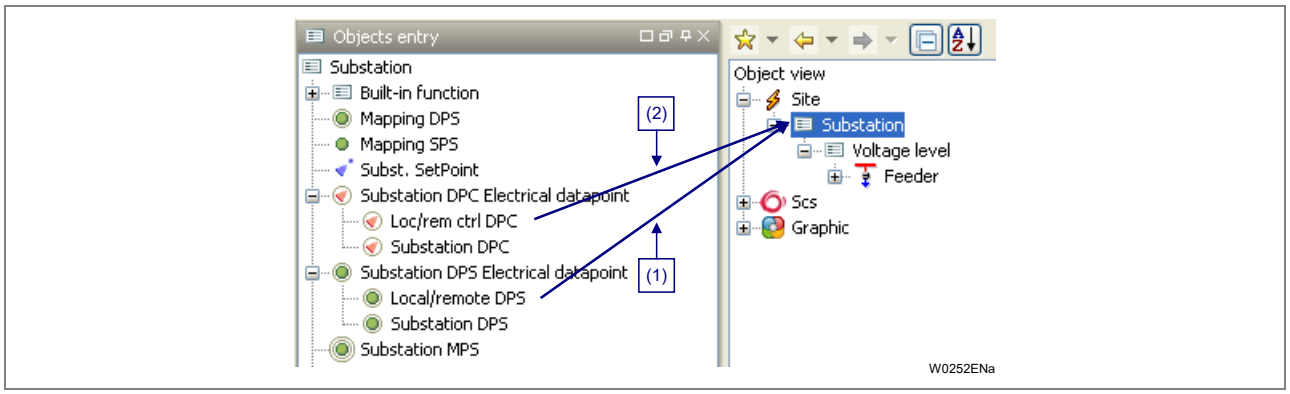


Figure 242: Defining a Local/Remote datapoint for a substation

Configuration rules and checks

Note:
Here the term "wired" means that the datapoint must be wired to (a) digital channel(s) of a C26x (C266 or C066).

- If *Loc/rem ctrl DPC* is present, then *Local/remote DPS* must be present (it is its feedback).
- If *Local/remote DPS* is not wired, then *Loc/rem ctrl DPC* is mandatory.
- If *Local/remote DPS* is wired, then *Loc/rem ctrl DPC* is optional but, if it is present, it must be wired.
- If, under a Substation, a "DPC" or "SPC" datapoint is configured to be dependent on the L/R mode, then the Substation's *Local/remote DPS* datapoint must be present.
- If the two datapoints *Local/remote DPS* and *Loc/rem ctrl DPC* are present, they must have the same Server device.
- The *Loc/rem ctrl DPC* datapoint must have its profile attribute **SBO mode** set to *Direct Execute* or *Direct Execute with SBO popup*.

Initial state configuration

The initial state of the Local/remote DPS is selected in its profile, in the **General** tab-pane.
Setting for **Specific treatment|Inital status**: *Local = SET (1) or CLOSE* and *Remote = RESET (0) or OPEN*.

5.1.2.2.1.2 Substation MPS Electric Datapoint

- add the optional datapoint **Operating mode MPS** (1) from the contextual **Objects entry** window at substation level,
- configure the MPS datapoint with the relevant attribues and states (see section *4 Defining a datapoint*).

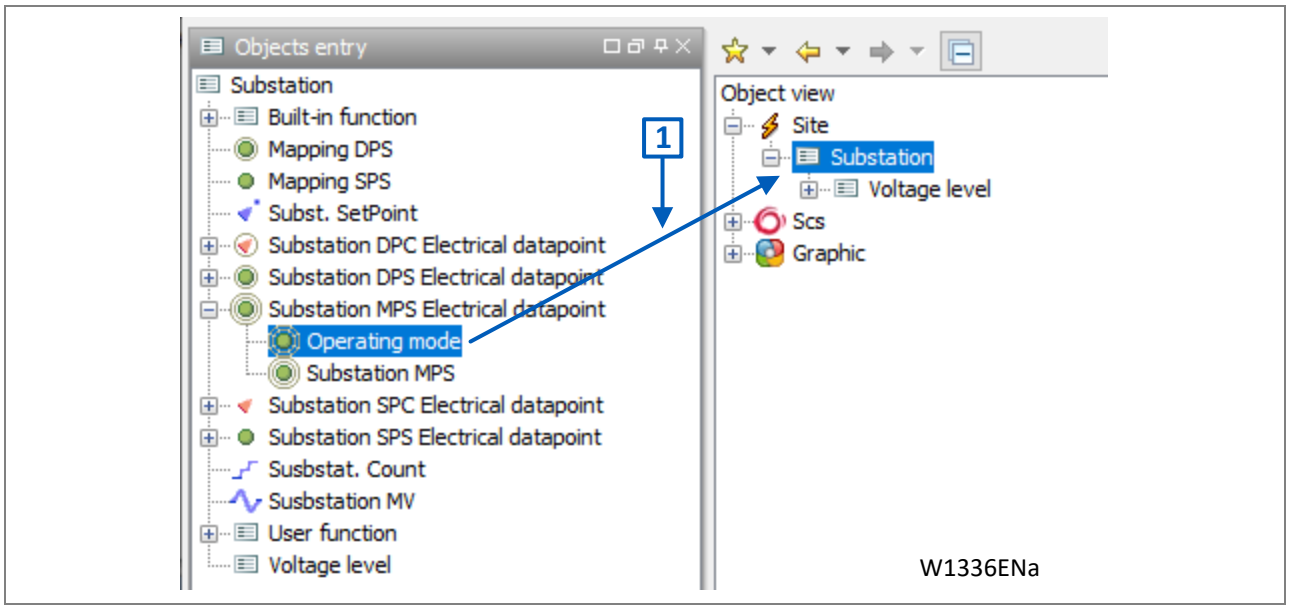


Figure 243: Defining a Local/Remote MPS datapoint for a substation

Note: When both DPS and MPS Substation L/R datapoints exist in the same configuration, the Substation MPS Electric datapoint (Operating mode) takes precedence over the Local/remote DPS datapoint.

5.1.2.2.2 Substation L/R datapoint per Bay

Note:
This feature can only be used in single ring Station Bus networks; it cannot be used in an IEC 61850/IEC 61850 architecture.

Caution:
In order to use the Substation L/R mode per bay, the initial state of the global substation L/R mode must be set to Remote in the Local/remote DPS's profile (i.e. Specific treatment|Inital status = Closed).
It must remain in that state: Do not give users any means of changing that setting (buttons, etc...).

To enable the Substation Local/Remote feature independently for each bay:

- add the optional datapoints SS LR/bay DPS (1) and/or SS LR/bay DPC (2) from the contextual Objects entry window at bay level,
- configure them (see section 4 Defining a datapoint),
- if necessary, do not forget to link SS LR/bay DPC to SS LR/bay DPS via the has for feedback relation.

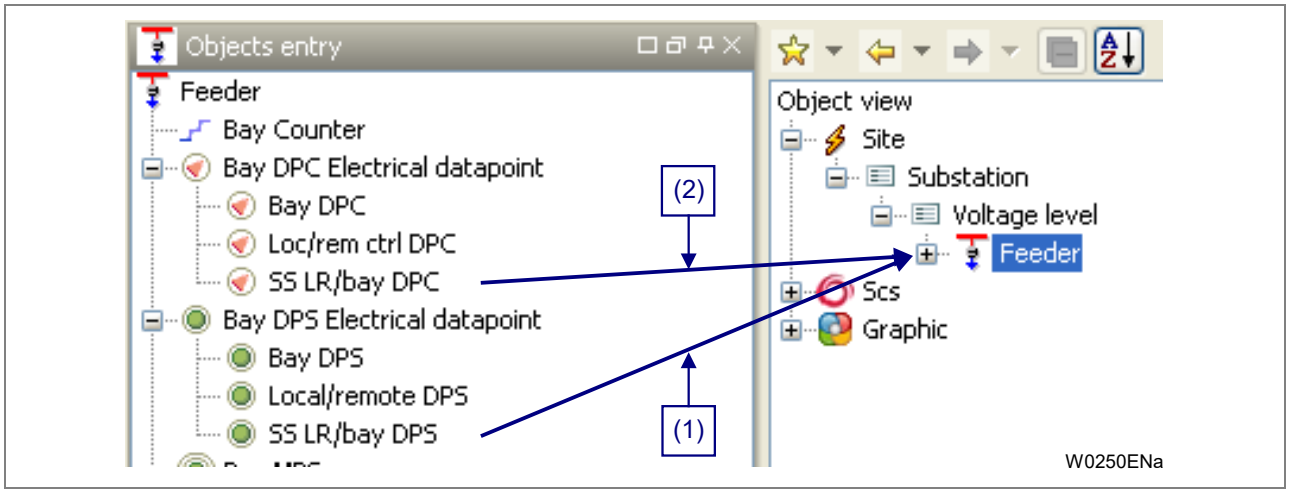


Figure 244: Defining a substation Local/Remote datapoint for a bay

Caution:
If the Substation L/R mode per bay is used, it must be defined for ALL the bays in the database that are managed by a C26x.

Configuration rules and checks

Note:
The term "wired" means that the datapoint must be wired to (a) digital channel(s) of a C26x.

- If SS LR/bay DPC is present, then SS LR/bay DPS must be present (it is its feedback).
- If SS LR/bay DPS is not wired, then SS LR/bay DPC is mandatory.
- If SS LR/bay DPS is wired, then SS LR/bay DPC is optional but, if it is present, it must be wired.
- If, under a bay, a "DPC" or "SPC" datapoint has its attribute Substation mode dependency set to Yes, then the bay's SS LR/bay DPS datapoint must be present.
- If the two datapoints SS LR/bay DPS and SS LR/bay DPC are present, they must have the same Server device.
- The SS LR/bay DPC datapoint must have its profile attribute SBO mode set to Direct Execute or Direct Execute with SBO popup.

Initial state configuration

The initial state of the SS LR/bay DPS is selected in its profile, in the General tab-pane.
Setting for Specific treatment|Inital status: Closed = Remote and Open = Local.

5.1.2.3 DEFINING A TAKING CONTROL DATAPOINT FOR SUBSTATION AND SCADA LINKS

This facility allows a Remote-Control Point (RCP) to force the mode of the substation from LOCAL to REMOTE and to define on which link the SCADA controls must be accepted.

To activate Taking control facilities for a given SCADA network:

- add the optional datapoints 'Taking Control' (2) and 'Taking status' (1), via the **Objects entry** window at substation level by clicking on mouse's right button.
- configure them (see section *4 Defining a datapoint*).
- add the relation **is taken control of** at 'Taking status' datapoint level (3) and fill it with the relevant given SCADA network.
- do not forget to link via **has for feedback** relation, the control with the status datapoint.

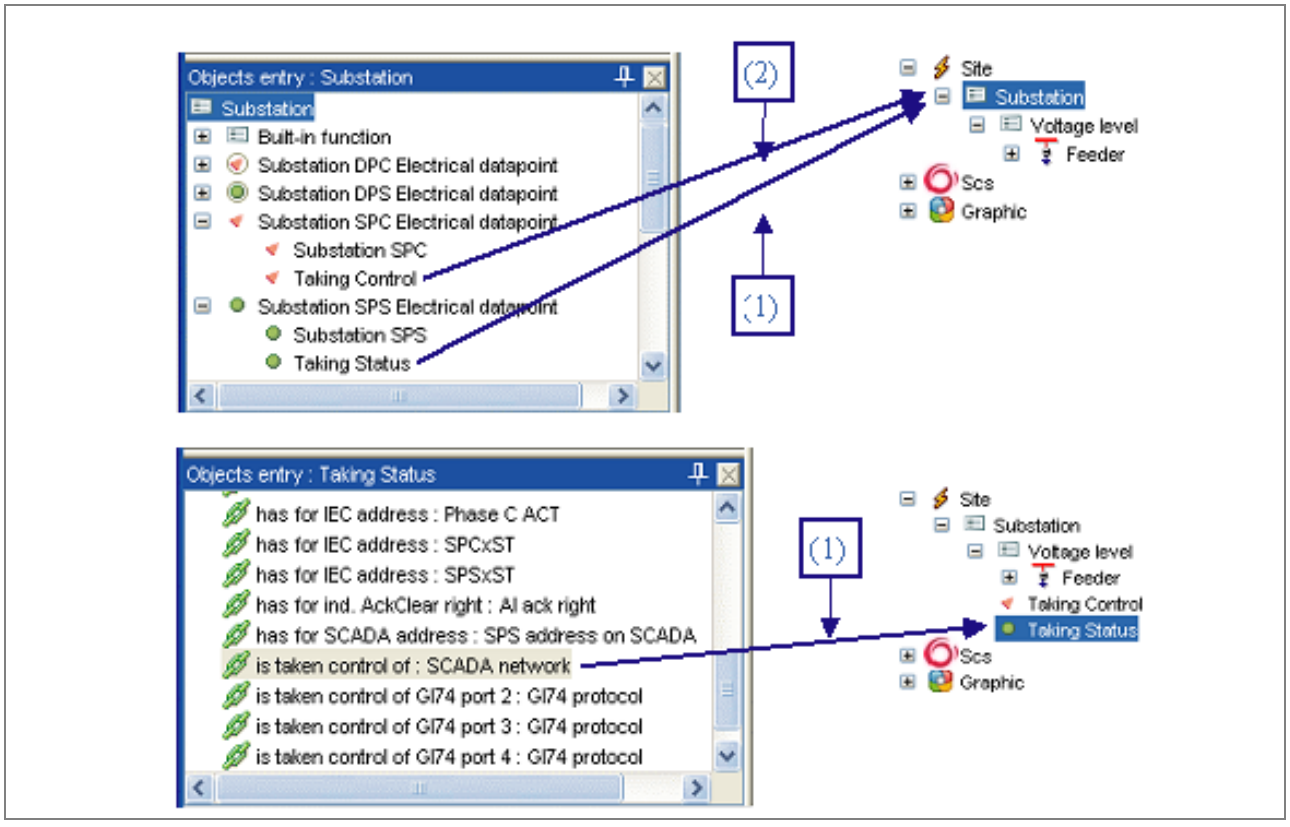


Figure 245: Defining a Taking Control datapoint for a substation and SCADA link

Configuration rules and checks

- If, at least, one SCADA network is linked to a Taking Control function, all the SCADA Networks of the system must be linked to a Taking Control function.
- If a "Taking Status" datapoint is linked to a SCADA Network, it must also be linked to a "Taking Control" datapoint through the relation **has for feedback**.
- A "Taking Control" datapoint must be linked to a "Taking Status" datapoint through the relation **has for feedback**.
- The "Taking Control" datapoint must have its **activation mode** attribute set to a "Permanent…" value. The "Taking Status" datapoint must have its **detection mode** attribute set to the "Permanent" value.
- Both "Taking Control" and "Taking Status" datapoints must be linked to a SCADA address in the mapping of their SCADA network.
- If a Taking-Control function is defined then, the "Loc/rem ctrl DPC" for substation must be present and not wired.
- The Server of the Local/Remote datapoints is the **Server** of each datapoint pair "Taking Status" / "Taking Control".
- All the units having a SCADA network linked to a Taking-Control function are:
  - **Clients** of each datapoint pair "Taking Status" / "Taking Control".
  - **Clients** of the datapoint pair "Local/remote DPS" / "Loc/rem ctrl DPC".

5.1.2.4 ADDING A USER FUNCTION TO A SUBSTATION

To add a user function to a substation, select the substation level and add the user function from the contextual **Objects entry** window.

For more details about user functions usage and configuration, see section *5.7 Defining an electrical regulation by user function*.

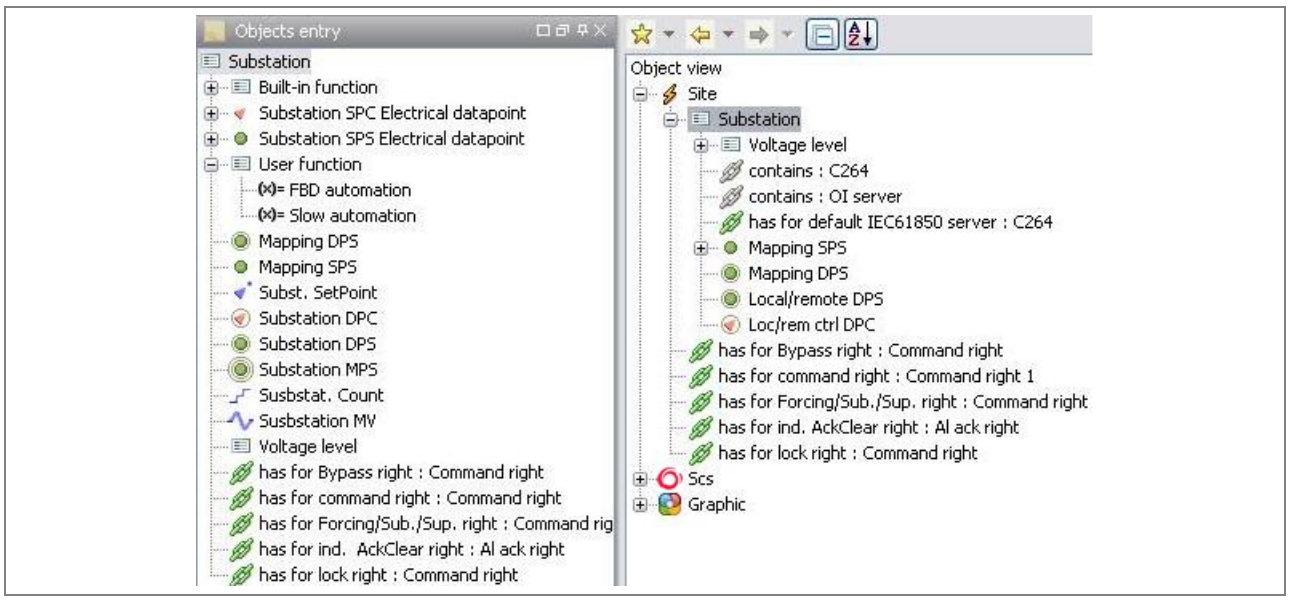


Figure 246: Adding a user function to a substation

5.1.3 DEFINING A VOLTAGE LEVEL

At substation level, several 'voltage level' objects can be added. A voltage level corresponds to a substation area whose electrical bays and sub-modules refer to the same nominal voltage. There is an exception for transformer bay, coupling 2 different voltage levels, that must be arbitrary located on one of the both.

To create a voltage level, select the substation level and add the voltage level from the contextual **Objects entry** window, as follows:

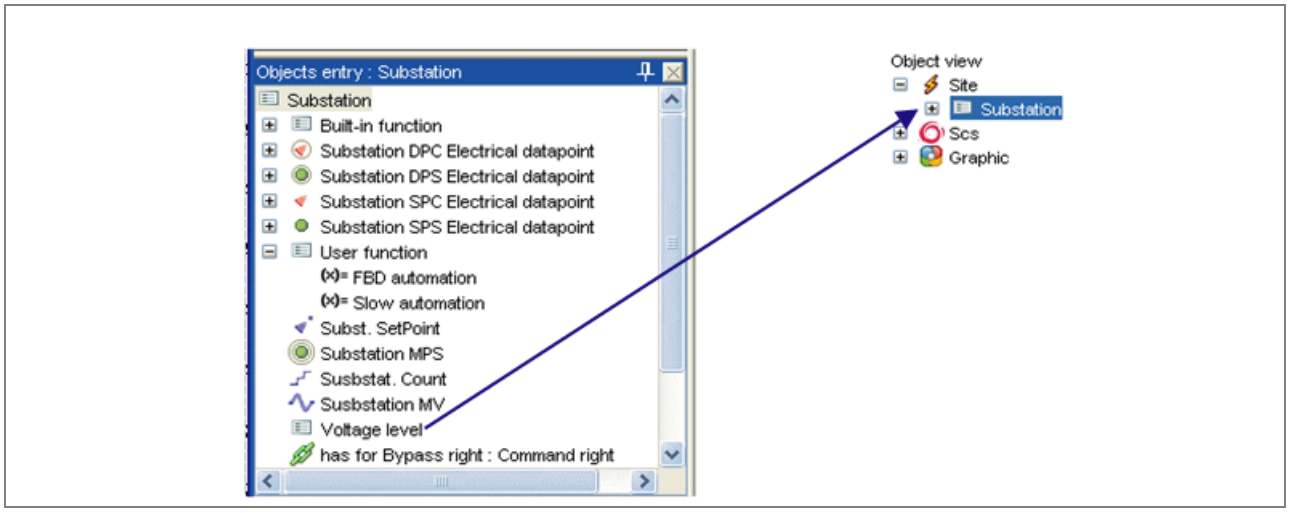


Figure 247: Adding a Voltage Level

When adding a voltage level, some general attributes must be updated:

- **short name** and **long name**: used for logging, alarms ...
- **nominal value** in kV
- **ATCC existence** (*No* / *Yes*): Not used with system version v7.x.

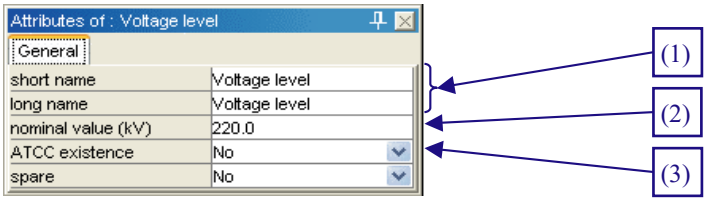


Figure 248: Setting the general attributes of an MV datapoint (example for a generic MV at Bay level)

5.1.3.1 ADDING A VOLTAGE LEVEL GENERIC DATAPOINT

To add a typed datapoint to a voltage level, select the voltage level and add the typed datapoint from the contextual **Objects entry** window. The available generic datapoints (standard usage) are listed in the figure below.

For more details about datapoints and their configuration, see section *4 Defining a datapoint*.

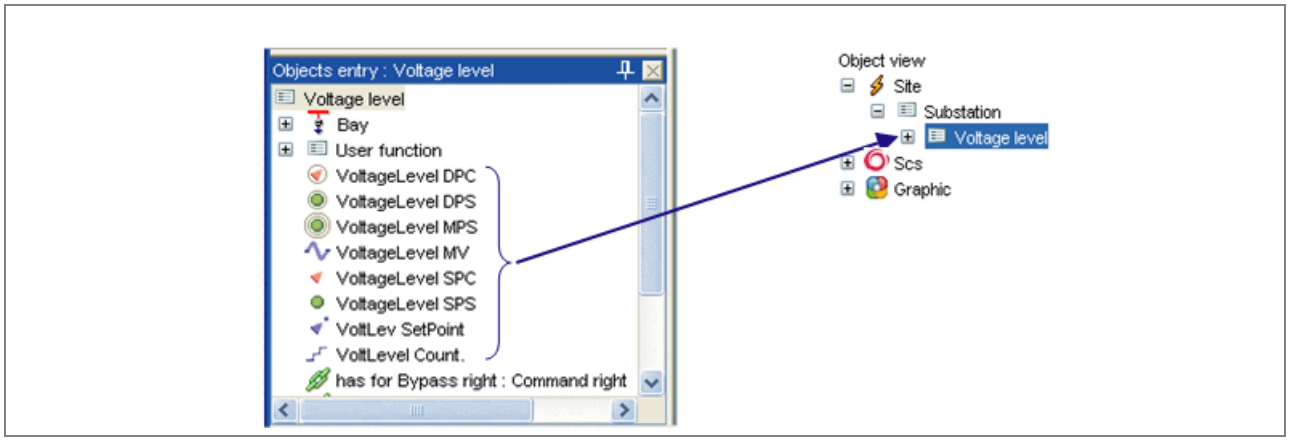


Figure 249: Adding a Voltage Level generic datapoint

5.1.3.2 ADDING A USER FUNCTION TO A VOLTAGE LEVEL

To add a user function to a voltage level, select the voltage level and add the user function from the contextual **Objects entry** window.

For more details about user functions' usage and configuration, see section *5.7 Defining an electrical regulation by user function*.

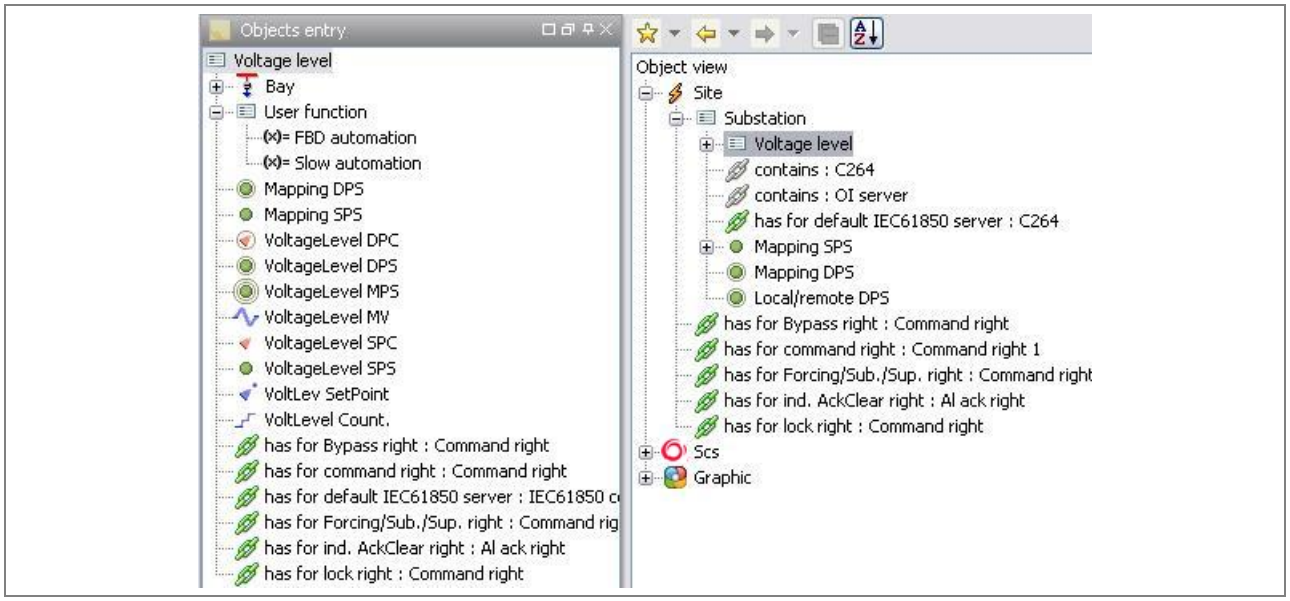


Figure 250: Adding a user function to a Voltage Level

5.1.4 DEFINING A BAY

At ‘voltage level’ level, several ‘bay’ objects can be added. A voltage level corresponds to a substation area whose electrical bays and sub-modules refer to the same nominal voltage. There is an exception for transformer bay, coupling two different voltage levels that must be arbitrary located on one of the both.

To create a bay:

- Select the voltage level (1) and add a typed bay from the contextual **Objects entry** window.
- Update the bay attributes.
- Update its **is managed by** relation, to define which C26x manages the bay (2).

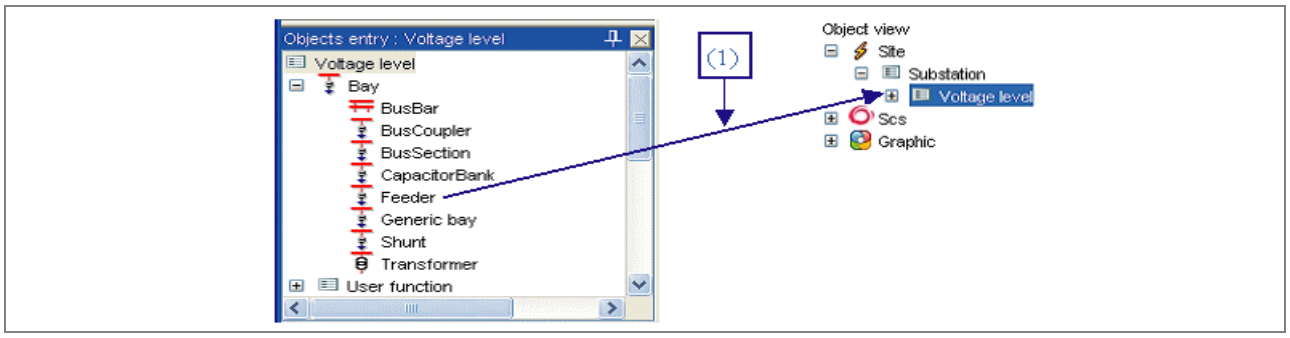


Figure 251: Adding a typed bay

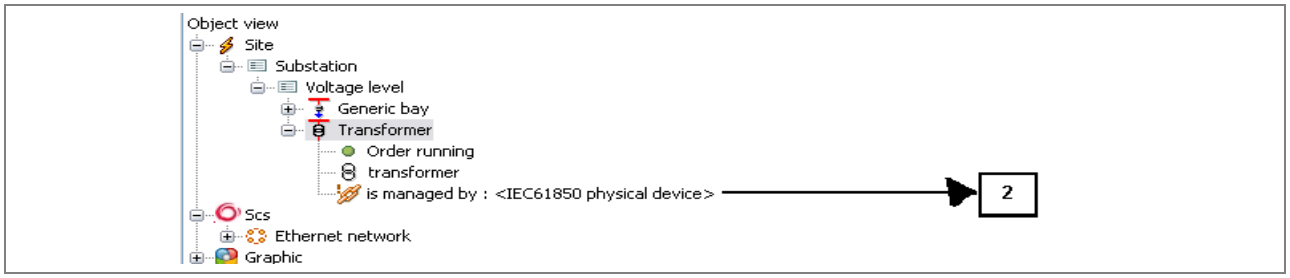


Figure 252: Defining the C26x that manages a bay

When adding a bay, some general attributes must be updated:

(1) **short name** and **long name** of the bay used for logging, alarms ...

(2) **control uniqueness** used for output datapoints under the bay.
The available values are:

- *None*: no control uniqueness is provided by the DS Agile system for output datapoints under the bay.
- *See substation definition*: control uniqueness is inherited from the attribute ‘default uniqueness’ at substation level (see section *5.1.2 Defining a Substation*).

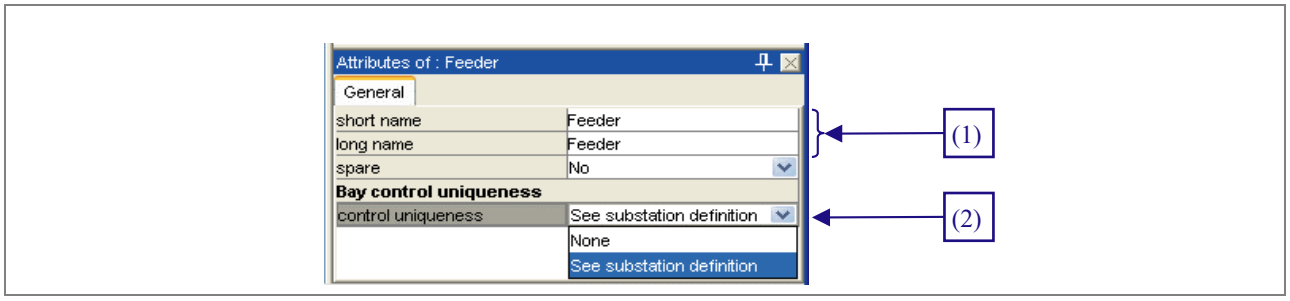


Figure 253: Setting the general attributes of a bay (example for a Feeder Bay type)

When adding a bay, a mandatory SPS datapoint ‘order running’ is automatically created at bay level. This datapoint allows DS Agile system to manage control uniqueness at substation and bay level: it is set when a control is in progress on a bay.

Configuration rules and checks

When control uniqueness is set to substation, all the C26x units of a substation must be IEC 61850 clients of all ‘order running’ SPS datapoints defined for all the bays. So, proper IEC 61850 configuration must be done for all C26x units to support that feature. For details about IEC 61850 configuration, see section *3.5*

Networking a C26x on the station-bus network.

Typed bay features

Using typed bay allows implicit sub-component creation. All the typed bays are listed below, with their sub-component features:

- Feeder: a circuit-breaker and external line modules are mandatory and implicitly created,
- Transformer: a transformer module is mandatory and implicitly created,
- Bus coupler: a circuit-breaker module is mandatory and implicitly created,
- Bus section: a circuit-breaker module is mandatory and implicitly created,
- Capacitor bank: a capacitor module is mandatory and implicitly created,
- Shunt: a circuit-breaker module is mandatory and implicitly created,
- Busbar: no module is available. This typed bay must be seen as a single electrical node.
- Generic bay: no sub-component constraint. Used for general usage outside the scope of other previous typed bays.

5.1.4.1 ADDING A BAY GENERIC DATAPOINT

To add a typed datapoint to a bay, select the bay level and add the typed datapoint from the contextual **Objects entry** window. The generic datapoints (standard usage) out of the specific bay functions' scope are listed below:

- Local/remote for bay (see section *5.1.4.2 Defining a bay Local/Remote datapoint*)
- SBMC for bay (see section *5.1.4.3 Defining the SBMC mode for a bay)*
- Group computation (see section *5.7.1 Datapoint Grouping*)

For more details about datapoints and their configuration, see section *4 Defining a datapoint*.

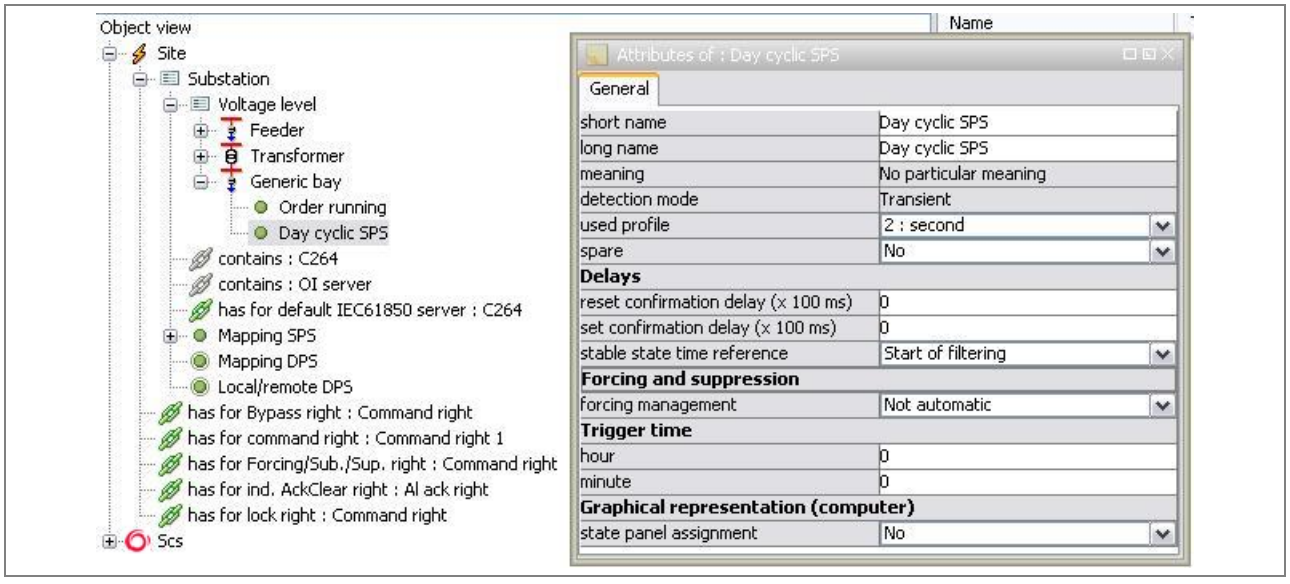


Figure 254: Adding a generic datapoint to a bay

Note:
In the C26x, up to 8 transient SPS datapoints (1) can be defined as cyclic (day cycle). They can be used to activate a periodic treatment. In addition to the usual attributes of SPS datapoints, these require the configuration of an extra two specific attributes (2) that define their time of activation.

5.1.4.2 DEFINING A BAY LOCAL/REMOTE DATAPOINT

Each bay can be independently switched to Remote or Local mode.

Remote mode means that the bay is controlled from the upper level, i.e. the Remote Control Point (RCP) or the Substation Control Point (SCP), depending on the current substation control mode. No control commands can be sent from the Bay Control Point (BCP) level, i.e. the front panel LHMI of the C26x unit that manages the bay.

Local mode means that the bay is controlled from the BCP. Control commands issued from the upper level are ignored.

Some control commands, defined during the configuration stage, can be independent of the bay control mode: it means that they can be issued from any control points whatever was the current control mode. Controls from configurable automation (ISaGRAF) are accepted in remote mode. For details about the configuration of this dependency attribute, refer to sections:

- SPC: see section *4.3.7.1*
- DPC: see section *4.3.8.1*
- SetPoint: see section *4.3.9.3*

Note:
- A control command sent from an ISaGRAF automation that uses only datapoints coming from the ***C26x unit on which the Isagraf automation is running*** *has an* orCat value = 4 (AUTOMATIC_BAY_CONTROL).
It means that all the datapoints (command and status) are managed by the C26x unit that manages the automation. In this case, ***the check is done at bay level****.*
- A control command sent from an ISaGRAF automation that uses datapoints coming from ***several C26x units in the substation*** *has an* orCat value = 5 (AUTOMATIC_STATION_CONTROL).
It means that the datapoints (command and status) belong to several C26x units. In this case, ***the check is done at the substation level****.*



Caution:
A control command linked to an ISaGRAF automation with an *orCat value = 4 (AUTOMATIC_BAY_CONTROL)* is always sent with that *orCat value = 4*, even when it is activated by another automation that needs an *orCat value = 5 (AUTOMATIC_STATION_CONTROL*).
This means that a system's set of ISaGRAF automations can only provide one *orCat value.*

Whether in Local or Remote mode, the indications transmitted by the bay are always sent to both the SCP and the RCP.

The function automatic "Forcing of Invalid BI" is used to avoid processing the invalid states of the bay mode (the local or remote substituted state is defined in configuration). The "Forced Local" state is processed as the "Local" state. The "Forced Remote" state is processed as the "Remote" state.

To enable Local/Remote bay facilities:

1 add the optional datapoints **Local/remote DPS** (1) and/or **Loc/rem ctrl DPC** (2), at bay level from the contextual **Objects entry** window

2 configure them (see section *4 Defining a datapoint*),

3 if necessary, do not forget to link the control of the Local/remote with the Local/remote status datapoint using the **has for feedback** relation.

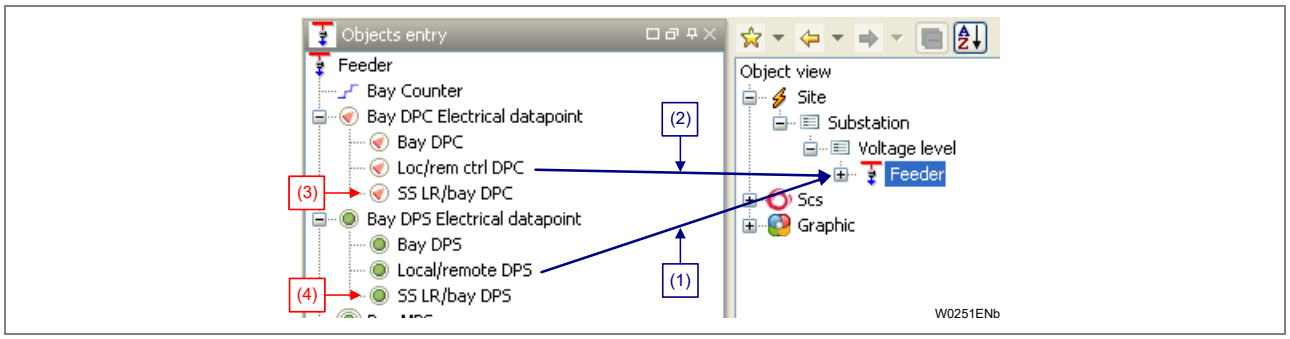


Figure 255: Defining a Local/Remote datapoint for a bay

Note:
The datapoints SS LR/bay DPC *(3) and* SS LR/bay DPS *(4) are not used in DS Agile version* v7.0.2.
They are present for database migration purposes only.

Configuration rules and checks

Note:
Here, the term "wired" means that the datapoint must be linked to a C26x's digital input(s) (C066 or C266).

- If **Loc/rem ctrl DPC** is present, then **Local/remote DPS** must be present (it is its feedback).
- If **Local/remote DPS** is not wired, then **Loc/rem ctrl DPC** is not required but, if it is nevertheless present, it must NOT be wired.
- If **Local/remote DPS** is wired, then **Loc/rem ctrl DPC** is not required but, if it is nevertheless present, it MUST be wired.
- If, under a Bay, a "DPC" or "SPC" datapoint has its attribute **bay mode dependency** set to *Yes*, then the Bay **Local/remote DPS** datapoint must be present.
- The **Loc/rem ctrl DPC** datapoint must have its profile attribute **SBO mode** set to *Direct Execute* or *Direct Execute with SBO popup*.

If a C26x's "GHU300" board has its attribute **HMI type** set to *Simple*, then the **Local/remote DPS** datapoints of the bays managed by the same C26x must be all be "Wired" or all "System".

5.1.4.3 DEFINING THE SBMC MODE FOR A BAY

Any electrical bay can be separately switched to SBMC mode (Site Based Maintenance Control mode) using a dedicated control datapoint (*SBMC control SPC*). While the bay is in SBMC mode, its datapoints that have been defined as SBMC-dependent are processed according to different rules:

- While in SBMC mode, an electrical bay does not receive, and therefore does not execute, SBMC-dependent xPC commands received from the Remote Control Point (RCP), even if the substation is in remote mode and whatever device manages them.
  It is possible, however, to configure some xPC datapoints to be independent of the SBMC mode.
- Whatever the device that manages it, if an indication datapoint belonging to a bay that is in SBMC mode is configured as SBMC-dependent (in its profile), the Gateway sends the SBMC state defined in its profile to the RCP. It is, however, still processed normally at the substation control system level (i.e. none of the processes inside the system are impacted by the state alteration of an indication at the RCP interface).

For details about the configuration of the dependency attribute, refer to sections:

- SPC: see section *4.3.7.1*
- DPC: see section *4.3.8.1*
- SetPoint: see section *4.3.9.3*

Note:
The SBMC Control SPC/SBMC SPS *datapoints only affect SBMC-dependent datapoints attached to the same electrical bay.*

The states of indication datapoints sent to the RCP in SBMC mode are configured in their profile. The available SBMC states vary depending on the type of datapoint:

SPS	SUPPRESSED, SET, RESET
DPS	SUPPRESSED, OPEN, CLOSE, JAMMED
MPS	SUPPRESSED, UNDEFINED
MV, TPI and Counter	SUPPRESSED

To enable the SBMC function at bay level:

- add the optional datapoints ‘SBMC SPS’ (1) and ‘SBMC control SPC’ (2), from the contextual **Objects entry** window at bay level,
- configure them (see section *4 Defining a datapoint*),
- do not forget to link the control of the SBMC with the SBMC status datapoint using a **has for feedback** relation,

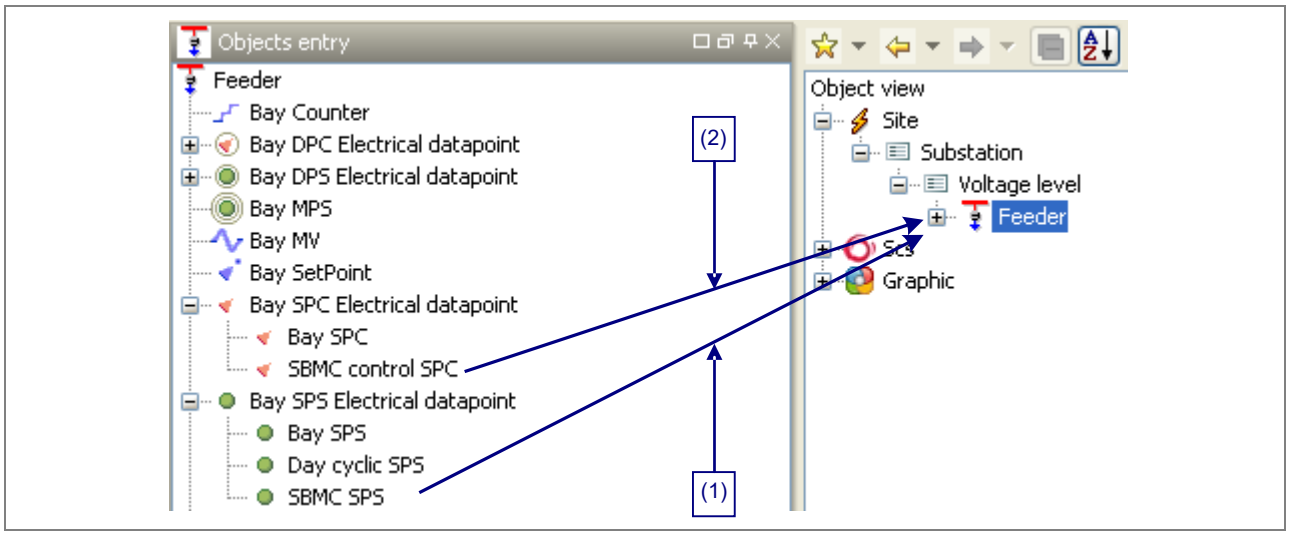


Figure 256: Defining the SBMC mode for a bay

Configuration rules and checks

- If **SBMC SPS** is present, then **SBMC control SPC** must be present
- If **SBMC control SPC** is present, then **SBMC SPS** must be present
- If **SBMC control SPC** is present, then its attribute **bay mode dependency** must be set to "No"
- If a "DPC" or "SPC" datapoint has its attribute **SBMC mode dependency** set to *Yes*, then the **SBMC SPS** datapoint must be present
- If a "DPS" or "SPS" datapoint has the attribute **SBMC dependent** of its profile set to *Yes*, then the "SBMC SPS" datapoint must be present

5.1.4.4 ADDING A USER FUNCTION TO A BAY

To add a user function to a bay, select the bay level and add the user function from the contextual **Objects entry** window.

For more details about user functions usage and configuration, see section *5.7 Defining an electrical regulation by user function*.

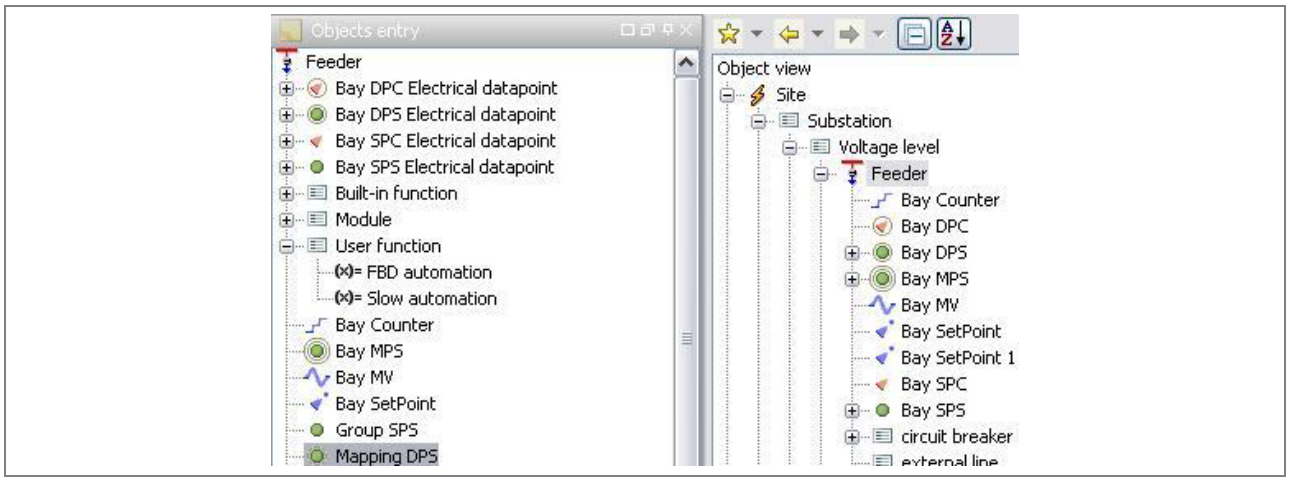


Figure 257: Adding a user function to bay

5.1.5 DEFINING A MODULE

This section covers general module configuration. The configuration of specific module types is described in the relevant sections further down.

At 'bay' level, several 'module' objects can be implicitly or explicitly added. A module generally corresponds to a substation electrical plant: transformer, circuit-breaker, etc. It can have its own **Order running SPS**.

To explicitly create a module:

- Select the bay level (1) and add a typed module from the contextual **Objects entry** window

For an implicit or explicit module:

- Update the module attributes (see the following sections)

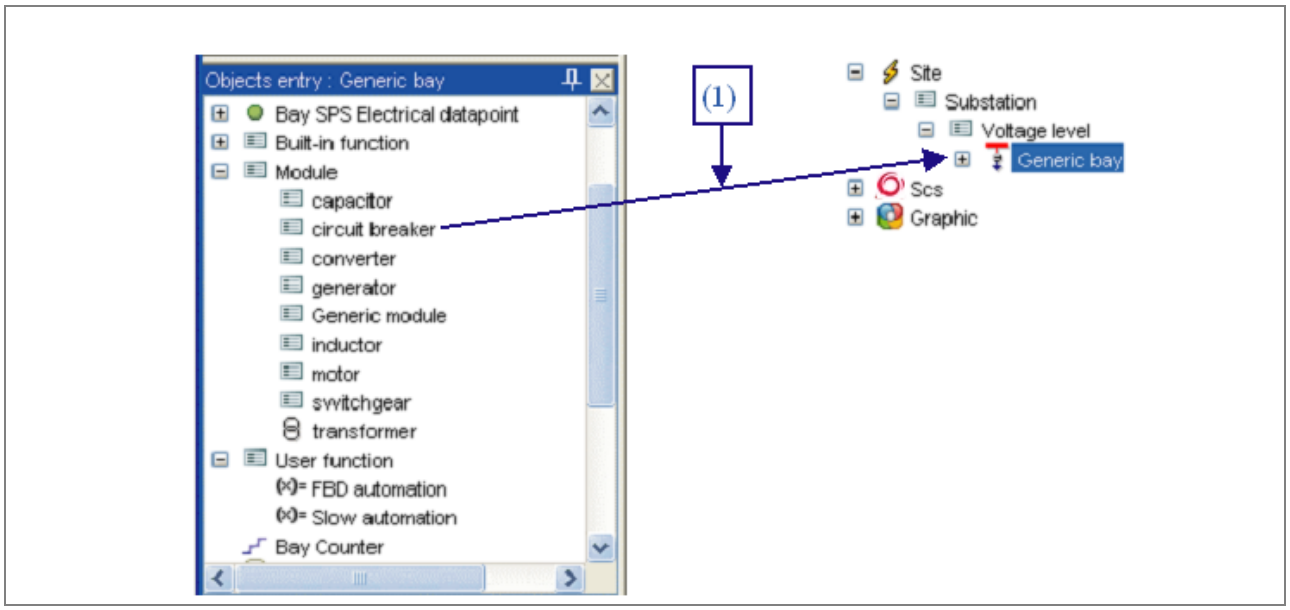


Figure 258: Explicitly adding a typed module

When adding a module, some general attributes must be updated:

(1) **short name** and **long name** of the module used for logging, alarms ...

(2) **node reference**, used for electrical topology definition.

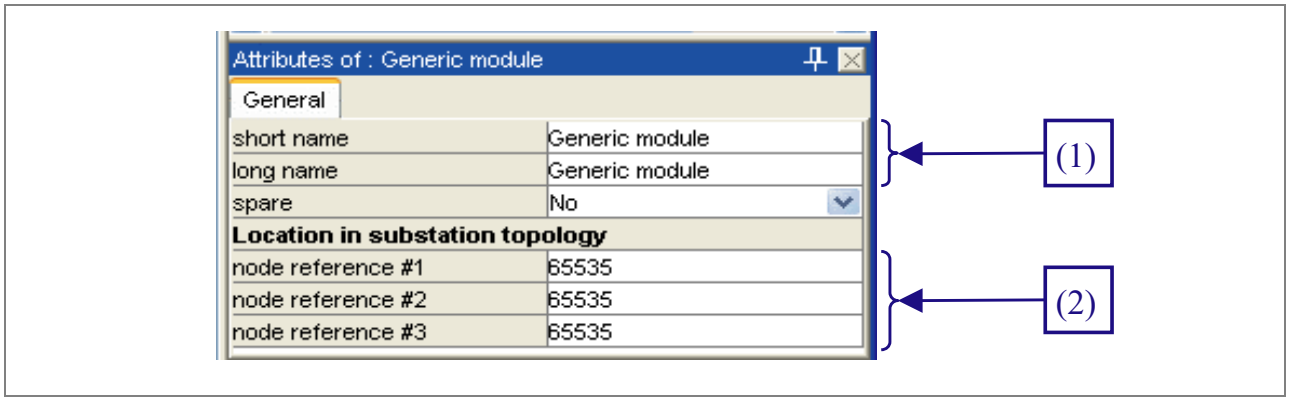


Figure 259: Setting the general attributes of a generic module

Typed module features

Using a typed module narrows down the configuration of the module. All the available typed modules with their main configuration features are listed below:

- Capacitor, Inductor:
  - Specific attribute ‘reactive power value’ (in MVA).
  - Non-lockable module
- Converter, generator, motor:
  - Non-lockable module
- Transformer:
  - Lockable module
  - Supports the Tap changer built-in function
- Circuit-breaker module:
  - Lockable module
  - Supports synchrocheck and auto-recloser built-in functions
  - Supports withdrawing if the circuit-breaker is withdrawable
- Switchgear module
  - Lockable module
  - Supports withdrawing if the switchgear is withdrawable
- External line:
  - Only support SPS and DPS assignment
- Generic module:
  - Lockable module
  - Used for plant items other than the above typed modules

Some modules (three-pole circuit-breaker, switchgear, converter) support the Operating MV datapoint in addition to the Module MV datapoint. This is used to represent a state (operation) counter from a third-party IED.

5.1.5.1 ADDING A MODULE GENERIC DATAPOINT

To add a typed datapoint to a module, select the module level and add the typed datapoint from the contextual **Objects entry** window. The generic datapoints (standard use) out of the specific module functions' scope are listed below:

- Group computation (see section *5.7.1 Datapoint Grouping)*.
- Locking module (see section *5.1.5.3 Defining a lockable module)*.
- Specific features and configuration of typed modules (see following sections).

For more details about datapoints and their configuration, see section *4 Defining a datapoint.*

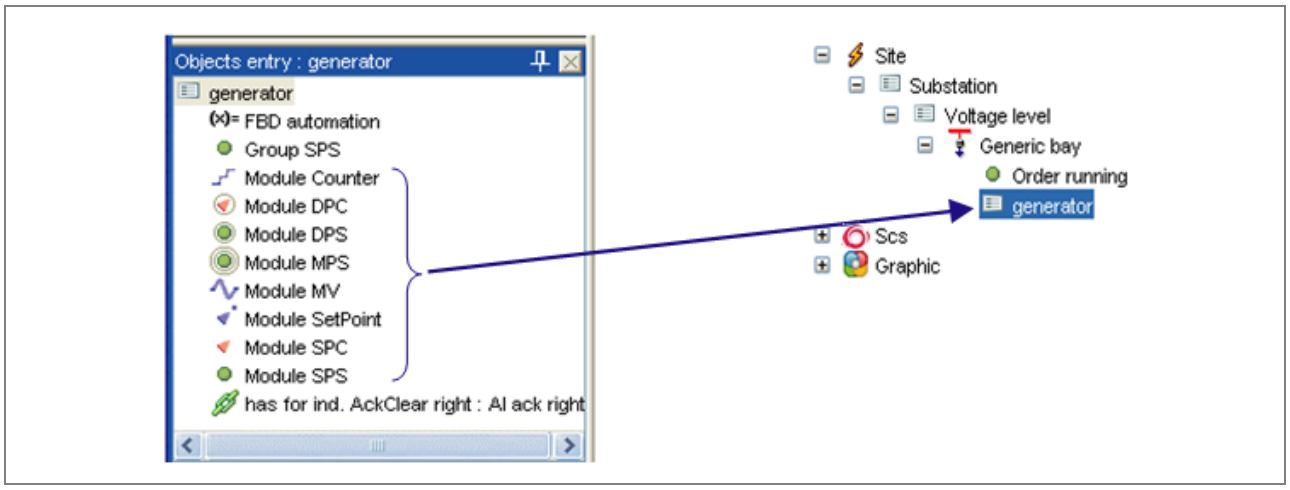


Figure 260: Adding a module generic datapoint (example for a generator module)

5.1.5.2 ADDING A USER FUNCTION TO A MODULE

To add a user function to a module, select the module level and add the user function from the contextual **Objects entry** window.

For more details about user function use and configuration, see section *5.7 Defining an electrical regulation by user function.*

Modules do not support the ISaGRAF function.

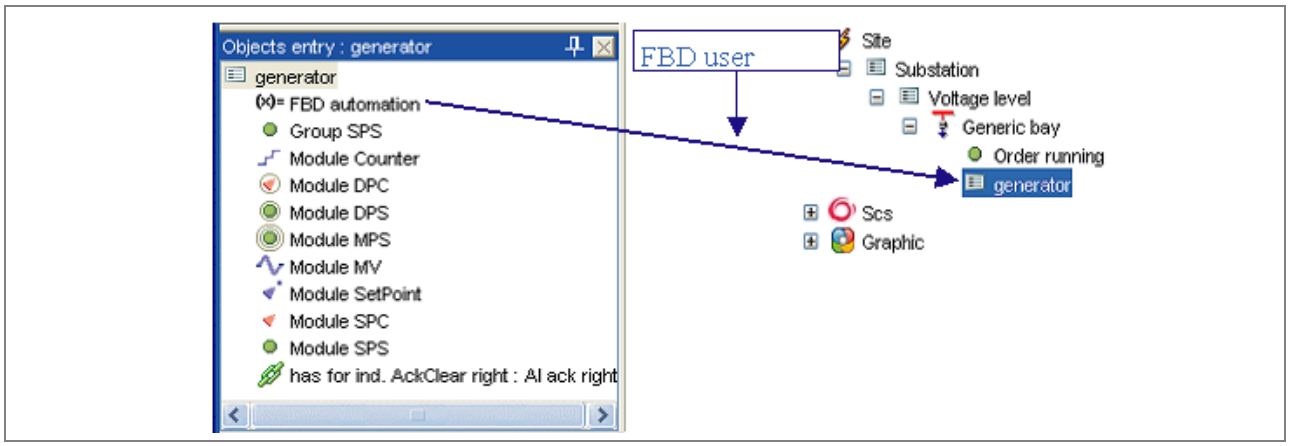


Figure 261: Assigning a user function to a module (example for generator module)

5.1.5.3 DEFINING A LOCKABLE MODULE

In the DS Agile system, module locking is a system function running on the C26x that manages the bay containing the module.

After a module has been locked, any subsequent control command it receives is denied. Locking is checked during control sequence processing at C26x level.

Only the following module types are lockable:

- Circuit-breaker,
- Switchgear,
- Transformer,
- Generic module.

To set such a module as lockable:

- Add the pre-defined SPS datapoint **Lock SPS** at module level (1) and configure it (see section *4 Defining a datapoint*),
- Add the pre-defined SPC datapoint **Lock control SPC** at module level (2) and configure it (see section *4 Defining a datapoint*),
- Define **Lock SPS** as feedback for **Lock control SPC** by adding and filling in the **has for feedback** relation at the SPC level (see section *4.3.7.2 Defining an SPC feedback*).

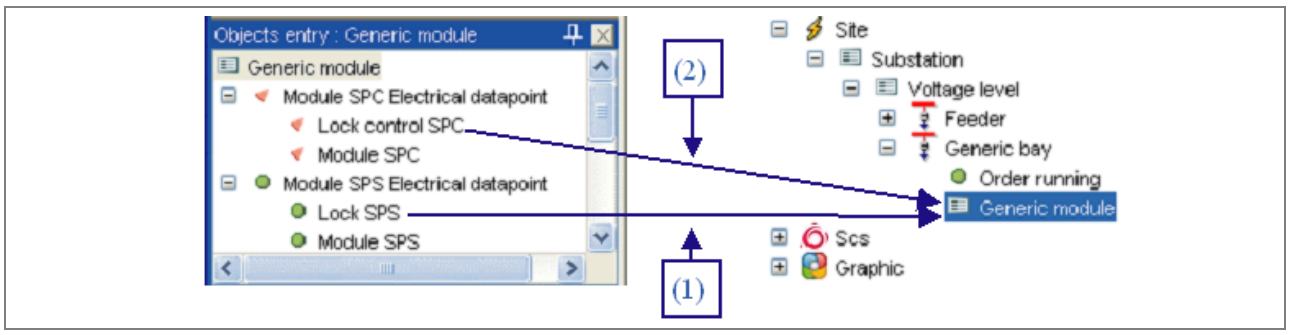


Figure 262: Defining a lockable module

Lock SPS and **Lock control SPC** are datapoints fed and controlled directly by the C26x that manages the module. They cannot be wired.

Configuration rules and checks

Lock control SPC must have **Lock SPS** for feedback.

5.1.5.4 DEFINING A WITHDRAWABLE CIRCUIT-BREAKER OR SWITCHGEAR

To define a withdrawable circuit-breaker or switchgear:

- add the pre-defined SPS 'Withdrawn' at module level
- configure it (see section *4 Defining a datapoint*)

The Withdrawn state information is useful for bay mimic animation on the C26x front panel LCD. For more details, see section *7.2.3 Defining a C26x Bay mimic*.

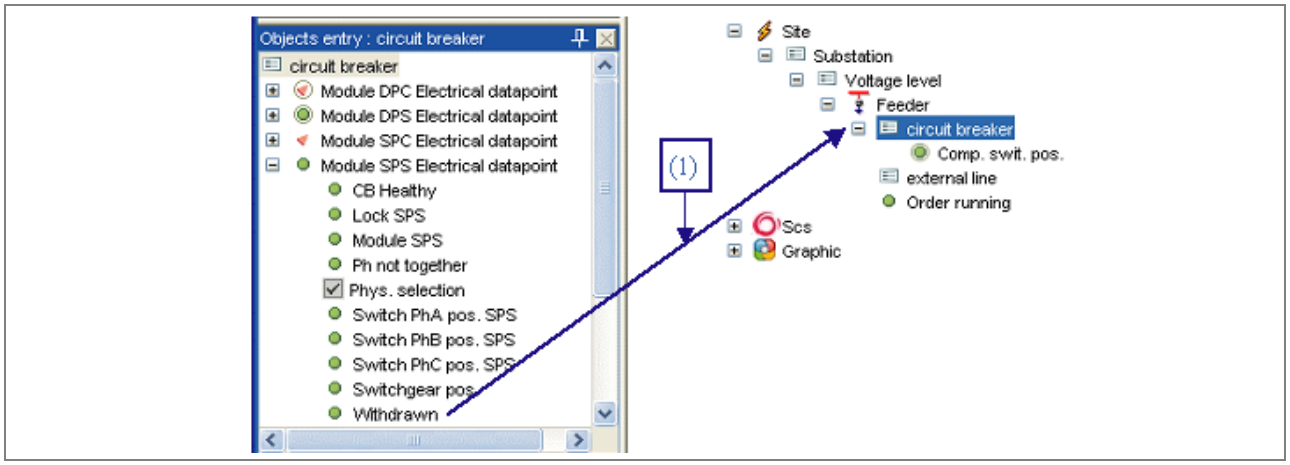


Figure 263: Defining a withdrawable module (example for a circuit-breaker)

5.1.5.5 DEFINING A CIRCUIT-BREAKER

This section covers the general features of circuit-breakers and their associated input and output datapoints at the C26x level.

If the circuit-breaker is synchronized by an internal or external synchrocheck, there are extra datapoints. For more details see section *5.2 Defining a Synchrocheck function.*

The general features of modules are described in section *5.1.5 Defining a Module.* They are applicable to the circuit-breaker module and not discussed here.

After having created a circuit-breaker module (or automatically added it as part of a bay), either one of the following objects must be added from the contextual **Objects entry** window:

- *Single-pole*: this will create the datapoints compulsory for a **single pole circuit-breader** according to IEC 60870-7-4
- *Three-pole*: this will create the datapoints compulsory for a **three-pole circuit-breader** according to IEC 60870-7-4

Circuit-breaker type

Single-pole CB	Three-pole CB
The 3 poles can be operated independently. 	The 3 poles can only be operated together. 

If the circuit-breaker is to be synchronised in a breaker-and-a-half arrangement (diameter topology "type 3" internal synchrocheck function), its rank attribute must be set:

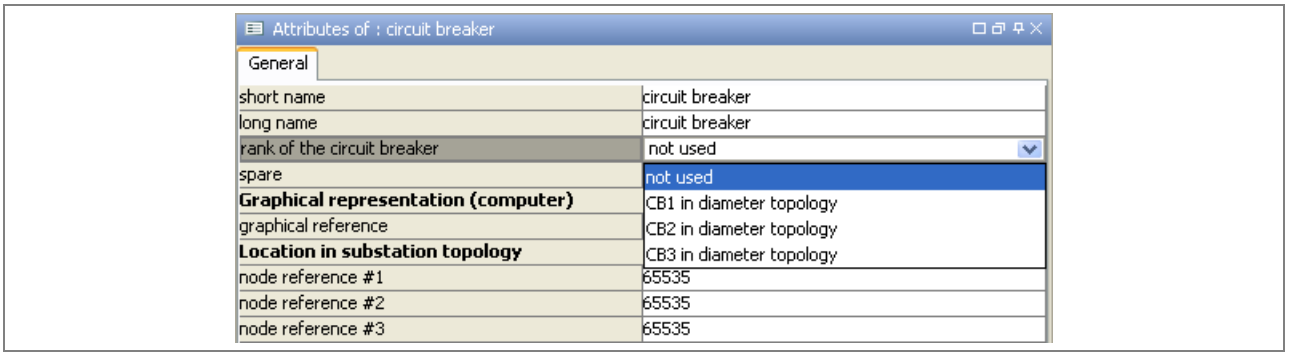


Figure 264: Circuit-breaker rank definition in diameter topology

The tables further down give the inputs and outputs of the circuit breaker functions controlled by the C26x for three-pole and single pole circuit-breakers. The SCE label for each datapoint is assigned a reference number in the figure below.

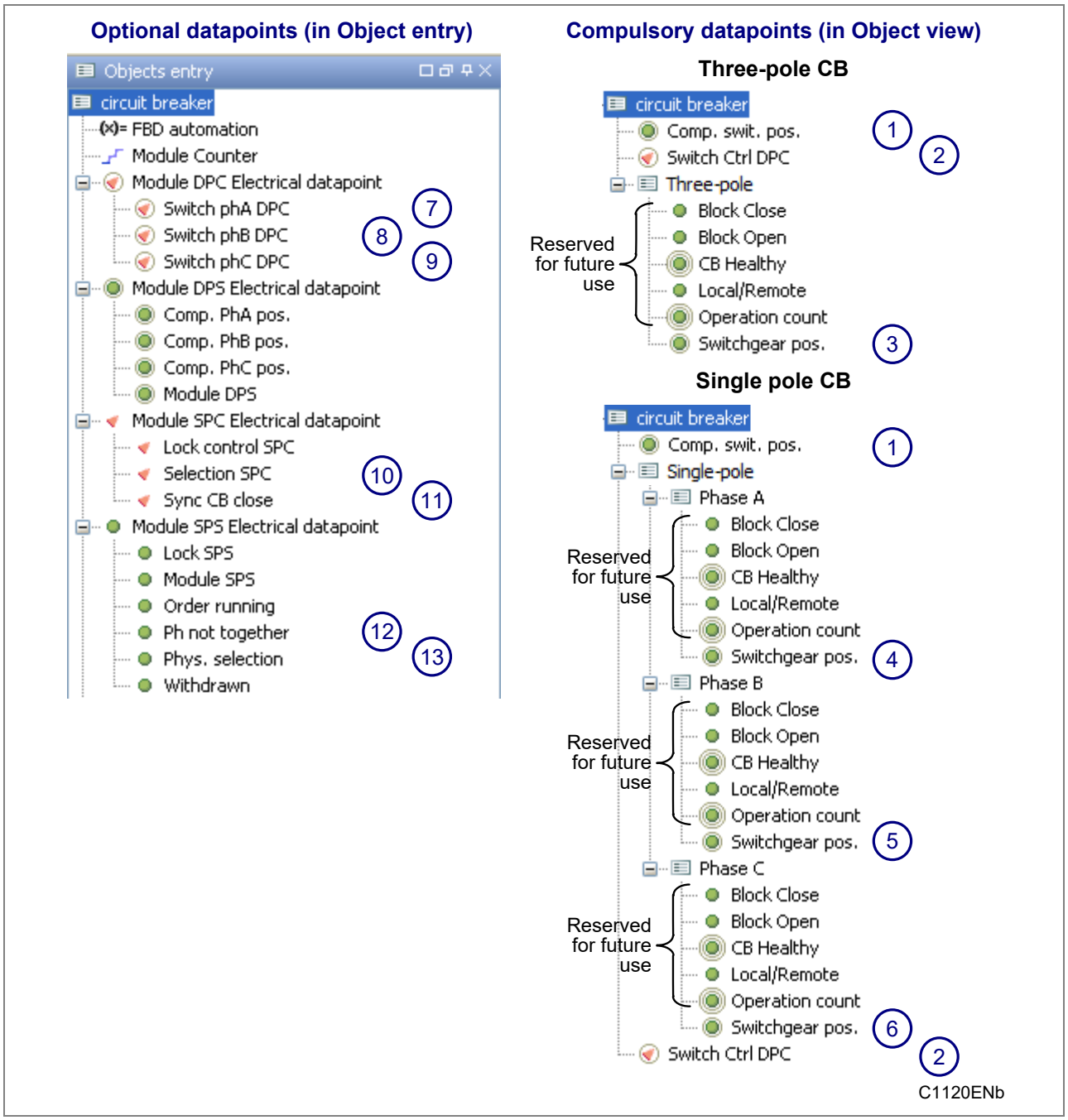


Figure 265: Pre-defined datapoints available for a circuit-breaker module

When creating a circuit breaker module, either implicitly or explicitly (section *5.1.4 Defining a Bay*), the mandatory pre-defined DPS **computed switch position** (1) is automatically created.

To correctly configure a circuit-breaker module:

- add the relevant datapoints according to the tables below,
- configure them (see section *4 Defining a datapoint*),
- do not forget to link the control (2) of the circuit breaker to the **computed switch position** (1) datapoint with the **has for feedback** relation.

Three-pole circuit-breaker (conventional wiring or process bus wiring)		
	Outputs to CB	**Inputs from CB**
Device control	(2) DPC, device open/close control	(3) DPS, physical position of the device (1 pole) (12) SPS (optional), pole discrepancy (ph not together) indication (1) System DPS, feedback of the control (i)
Device selection (hardware)	(10) SPC (optional), device selection control	(13) SPS (optional), device selection position indication

Single pole circuit-breaker (conventional wiring only)			
	Outputs to CB 3-p operations	**Outputs to CB 1-p operations**	**Inputs from CB**
Device control	(2) DPC, device open/close control	(7) DPC, control to open phase A (8) DPC, control to open phase B (9) DPC, control to open phase C (2) DPC, control to close the device	(4) DPS, physical position of pole A (5) DPS, physical position of pole B (6) DPS, physical position of pole C (12) System SPS, "ph not together" indication (ii) (1) System DPS, control feedback (iii)
Device selection (hardware)	(10) SPC (optional), device selection control	(10) SPC (optional), device selection control	(13) SPS (optional), device selection position indication

(i) The computed value matches the state of the CB's auxiliary contacts when there is no pole discrepancy, i.e. if the value of **ph not together** is *false*, otherwise the computed value is *jammed*.

(ii) The computed **ph not together** value is *false* if all the CB poles are in the same open or closed position. It is *true* when a pole discrepancy is detected.

(iii) The computed value matches the state of phase A if the state of **ph not together** is equal to *false* (i.e. no pole discrepancy is detected), otherwise the computed value is *jammed*.

Configuration rules and checks

- If the circuit-breaker sub-group "Single-pole" is selected, and that the datapoint(s) *Switch phx DPC* (7/8/9) and/or *Switchgear pos.* (6/7/8) have been added to a "Phase x", they must also be added to the other two.
- A single-pole circuit breaker can only be wired directly to the BCU (“conventional” wiring). It cannot be wired to an SCU on the process bus.
- The **Selection SPC** datapoint must have its profile attribute **SBO mode** set to *Direct Execute* or *Direct execute with SBO popup*

Control sequence for non-synchronized circuit breakers

Circuit breakers units are managed in “direct execute mode” and in “SBO once mode”. Refer to the generic description.

Control sequence for synchronized circuit breakers

See section *5.2 Defining a Synchrocheck function*.

5.1.5.6 DEFINING A SWITCHING DEVICE

This section covers the general features of switchgear and their associated input and output datapoints at the C26x level.

The general features of modules are described in section *5.1.5 Defining a Module*. They are applicable to switchgear modules and not discussed here.

When adding a switchgear module, the following specific general attribute must be updated:

- **Switchgear type**:

  The available values are:

  - Busbar disconnector (e.g. S3, S4, S7, S8)
  - Disconnector (e.g. S11)
  - Bypass disconnector (e.g. S18 to S20)
  - Transfer busbar disconnector (e.g. S13)
  - Earth switch (e.g. S5, S6, S9, S10, S12, S14, S17)

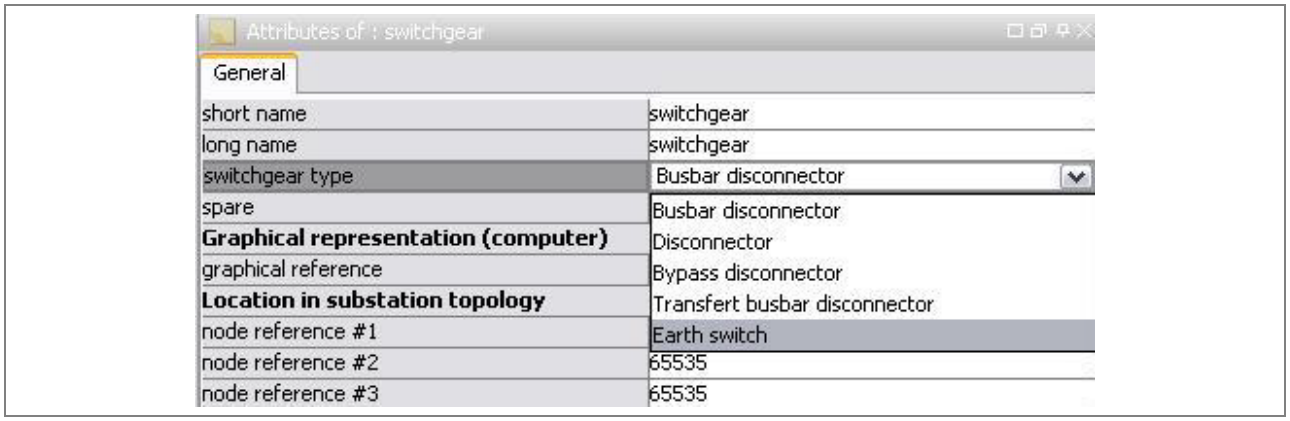


Figure 266: Setting the type of switchgear

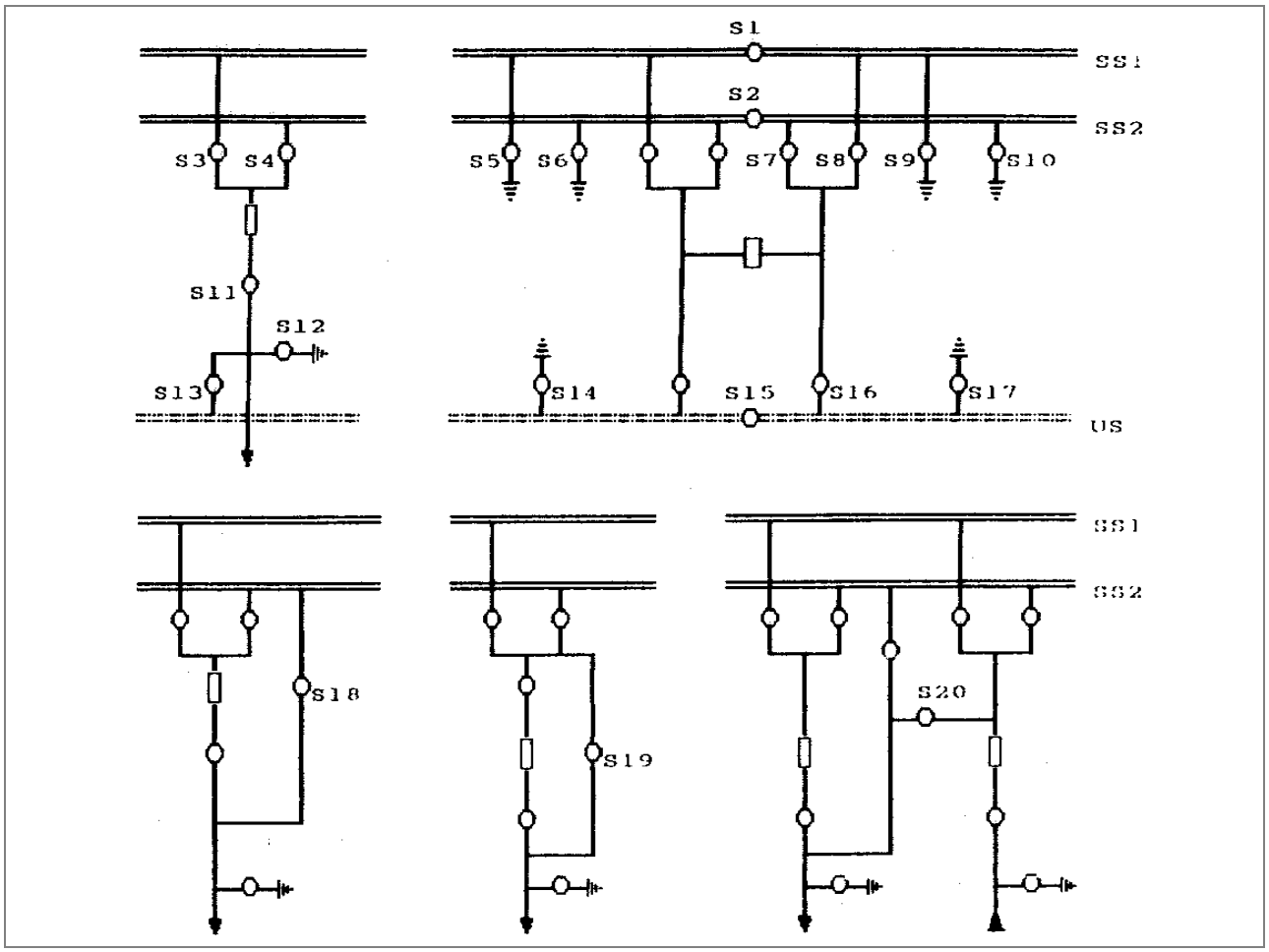


Figure 267: Types of switchgear in various substation architectures

The table below gives the inputs and outputs of the switchgear functions controlled by the C26x. The SCE label of each datapoint is assigned a number for reference in the figure below.

To correctly configure a switchgear module:

- add the relevant datapoints, according to the table below,
- configure them (see section *4 Defining a datapoint*),
- do not forget to link the control (3) of the switchgear (if it exists) to the switch position datapoint (1) or (5) with the **has for feedback** relation.

Switchgear		
	Outputs to switchgear	**Inputs from switchgear**
Device control	(3) DPC, control for open/close of device	(1) DPS, physical position of the device (1 phase)
Device selection (hardware)	(2) SPC, (optional) control of device selection	(4) SPS (optional), device selection position information

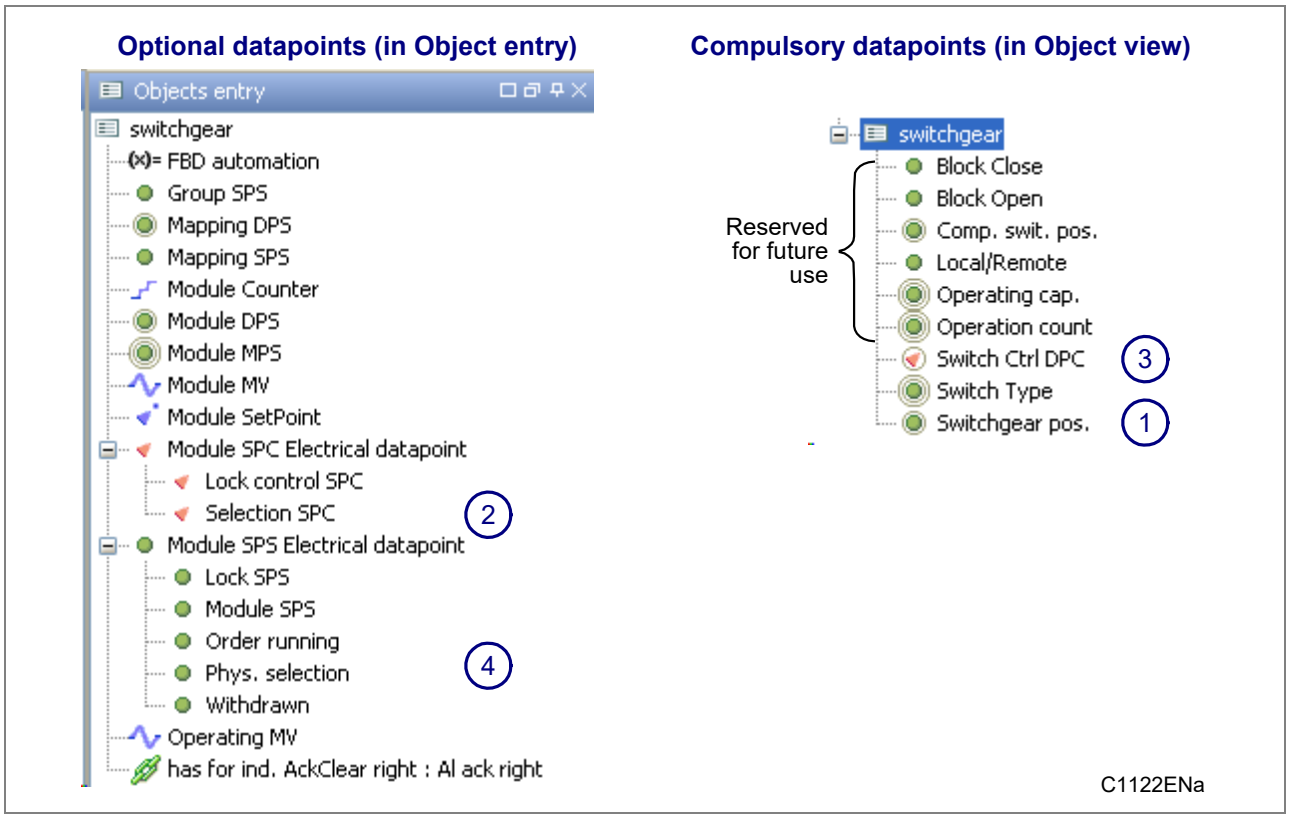


Figure 268: Pre-defined datapoints available for a switching device

Control sequence for switchgear

Switchgear units are managed in “direct execute mode” and in “SBO once mode”. Refer to the relevant generic description.

5.1.5.7 DEFINING A TRANSFORMER

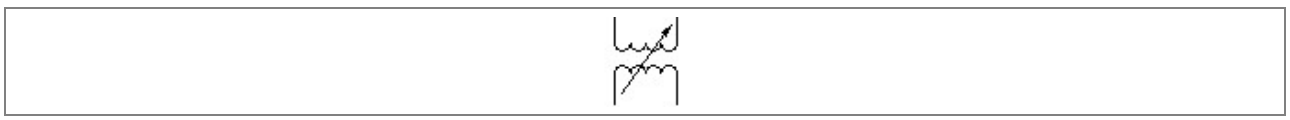
This section covers the general features of transformers and their associated input and output datapoints at the C26x level.

The general features of modules are described in section *5.1.5 Defining a Module*. They are applicable to transformer modules and not discussed here.

When a transformer bay is created (see section *5.1.4 Defining a Bay*), a a transformer module is implicitly added and the following general attribute must be updated:

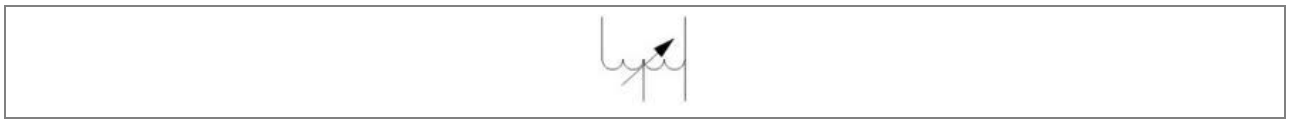
(1) **transformer type**:

- *Double wound*: a double wound (or two-winding) transformer is a transformer with galvanic isolation between its primary and secondary coils. The Tap Changer (with additional winding) is usually located at the HV-neutral side for economic reasons. Tapping-up (raise command) reduces the width of the primary winding and increases the LV voltage.



- *Auto transformer*: an auto transformer (or auto-wound, or single wound) is a transformer without galvanic isolation between its primary and secondary windings. The secondary winding follows the primary winding (windings are linked in series). The Tap Changer (with the tap on a separate winding) is mounted in series. Increasing the tap position (raise command) acts simultaneously on

the primary and secondary windings, it reduces the transformer ratio and therefore the voltage on the LV side. Thus, the raise order must be inverted (considered as a lower command) for this type of transformers.



power value (range [1 to 300 MVA), used for ATCC regulation (not available with system version v7.x)

impedance, whose unit is a percentage of the value for S=100 MVA (range [0.01 to 24.99 in steps of 0.01) , used for ATCC regulation (not available with system version v7.x)

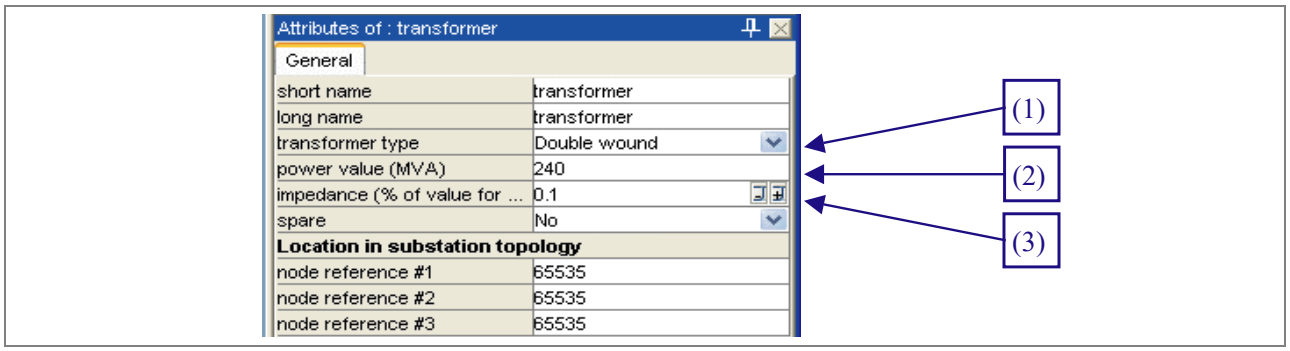


Figure 269: Setting the type of transformer

The transformer is used for coupling two voltage levels. Because the SCE's data modeling is based on electrical partitioning, this transformer must belong to a transformer bay arbitrarily placed in either voltage level (usually the primary voltage level). An extra relation must be defined on the transformer to indicate which voltage level its other side (secondary or primary) belongs to.

To create such a relation:

- Add the correct relation at transformer level
- Fill in the relation with the relevant voltage level

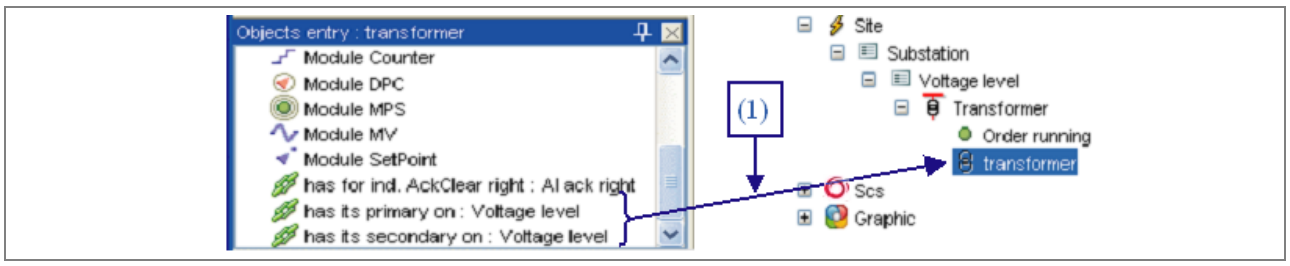


Figure 270: Linking the primary/secondary sides of a transformer

When adding a transformer, some optional datapoints can be created at module level and they must be configured (see section *4 Defining a datapoint*):

(1) **MCB position DPS**: used for the ATCC function (see section *5.6*) to give the position of the Mini Circuit-Breaker associated with the tap-changer, using a DPS datapoint (not available with system version v7.x)

(2) **MCB position SPS**: used for the ATCC function (see section *5.6*) (not available with system version v7.x)

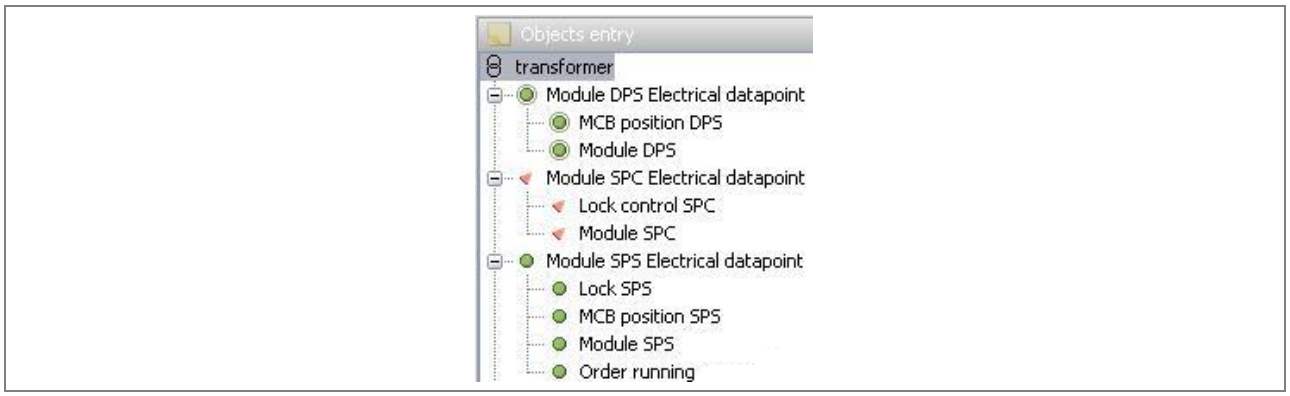


Figure 271: Optional datapoints for a transformer

When it exists, the tap position of a transformer is controlled by a specific built-in **Tap changer** function available at transformer module level. For details about transformer control using the tap changer function, see section *5.5 Defining a Tap changer built-in function*.

The "phase reference" vector argument is equal to **0°** in the Fresnel representation. The full-scale values depend on the measurement device type being used. Refer to the Human Interface chapter of Blend user manual for information on how to configure Fresnels widgets.

5.2 DEFINING CONDITION MONITORING FUNCTIONS

Condition monitoring includes the following monitoring functions:

- Circuit breaker monitoring
- Switchgear monitoring
- Tap Changer monitoring and Diverter Switch monitoring
- Low voltage monitoring and Residual lifetime monitoring

5.2.1 CONFIGURING THE CIRCUIT BREAKER MONITORING FUNCTION

The Circuit Breaker monitoring function can be added under Single-pole and Three-pole circuit breakers module, within the electrical topology.

To add a Circuit Breaker monitoring function:

1 Select the **Substation level** and then, click the appropriate **Voltage level**.

2 From the **Object entry** panel, expand the **Bay** folder. Select and add the desired electrical device.

3 In the **Object entry** panel, expand the **Module** group and add a **Circuit Breaker** module.

4 In the **Object view** panel, click the **Circuit Breaker** and add an option “**Single-pole**” or “**Three-pole**”:

5 In the **Object view** panel, click “**Single-pole**” or “**Three-pole**” and add a **CB monitoring** option

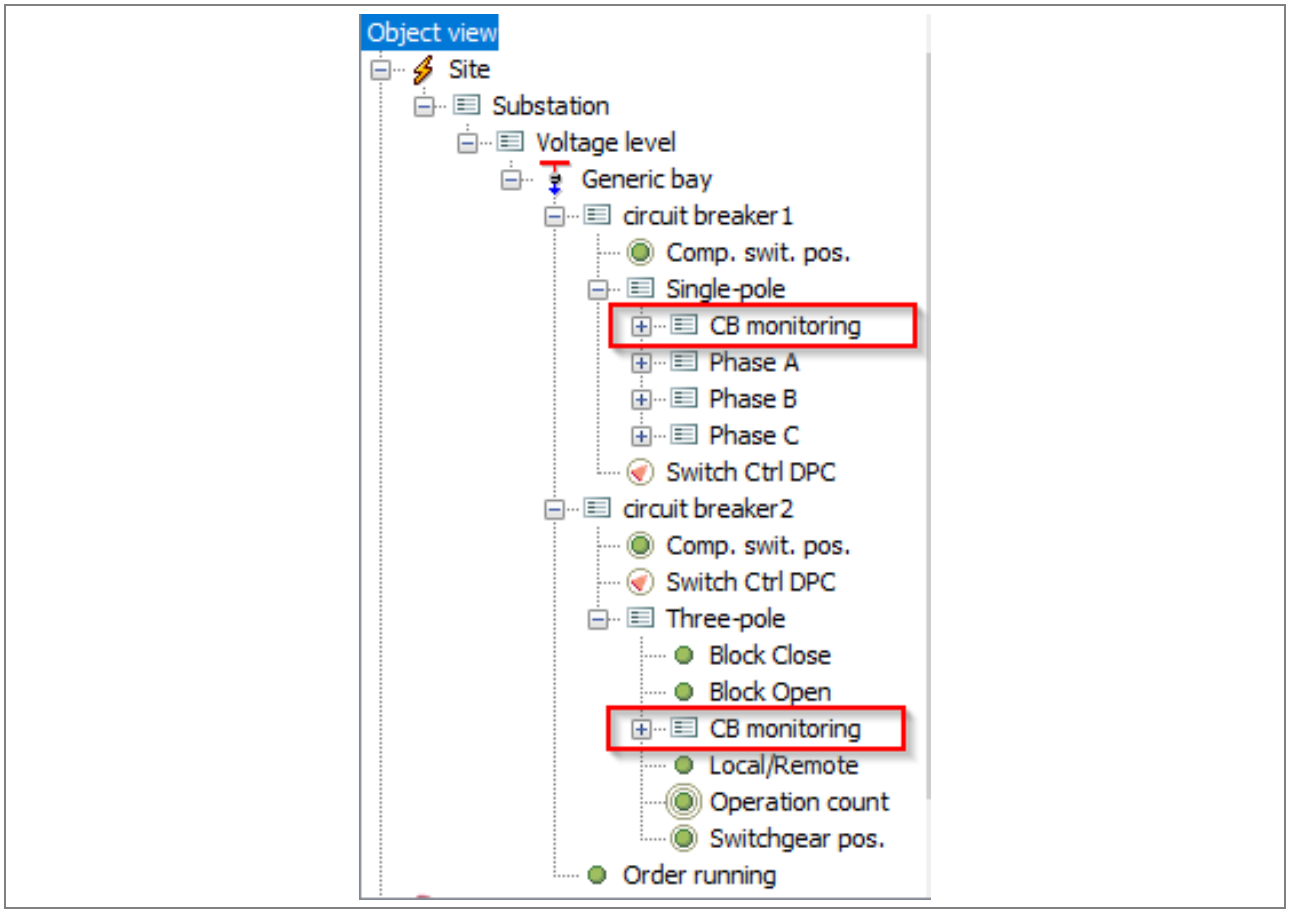


Figure 272: Adding a CB monitoring feature

5.2.1.1 DATAPOINTS

When adding a switchgear monitoring function, a number of mandatory datapoints are automatically created at function level and must be configured (see section *4 Defining a datapoint*):

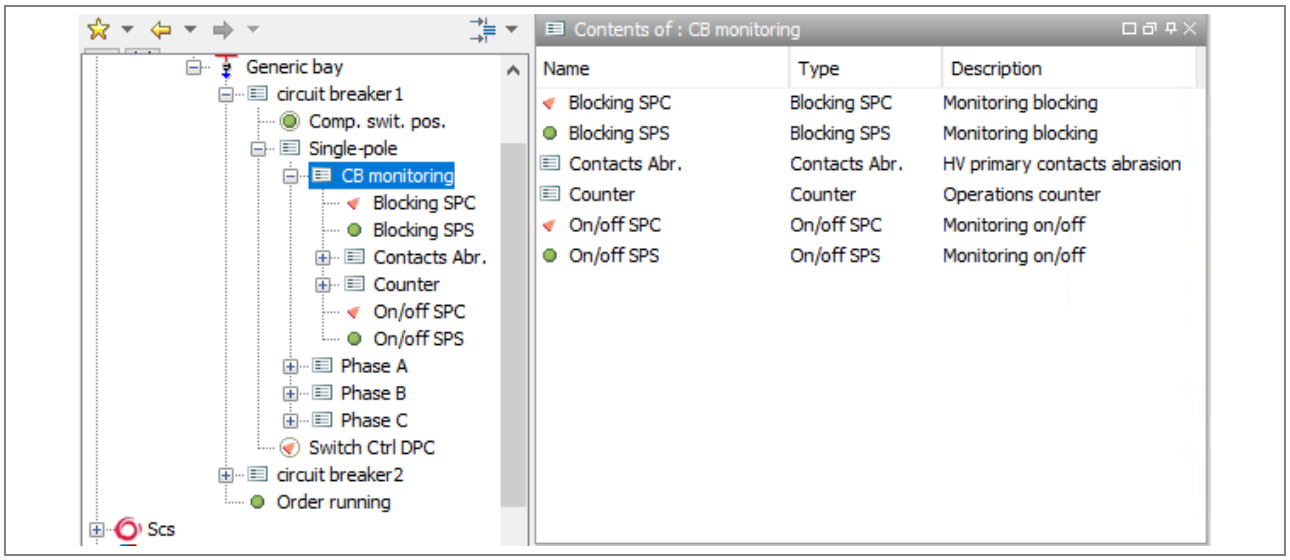


Figure 273: CB monitoring function datapoints

Datapoint	Description
Blocking SPC	Blocks/Unblocks the CB monitoring function
Blocking SPS	Blocking state of the CB monitoring function
on/off SPC	Starts/stops the CB monitoring function
on/off SPS	Start/stop state of the CB monitoring function

5.2.1.2 OPTIONAL DATAPOINTS

The following optional datapoints can also be defined:

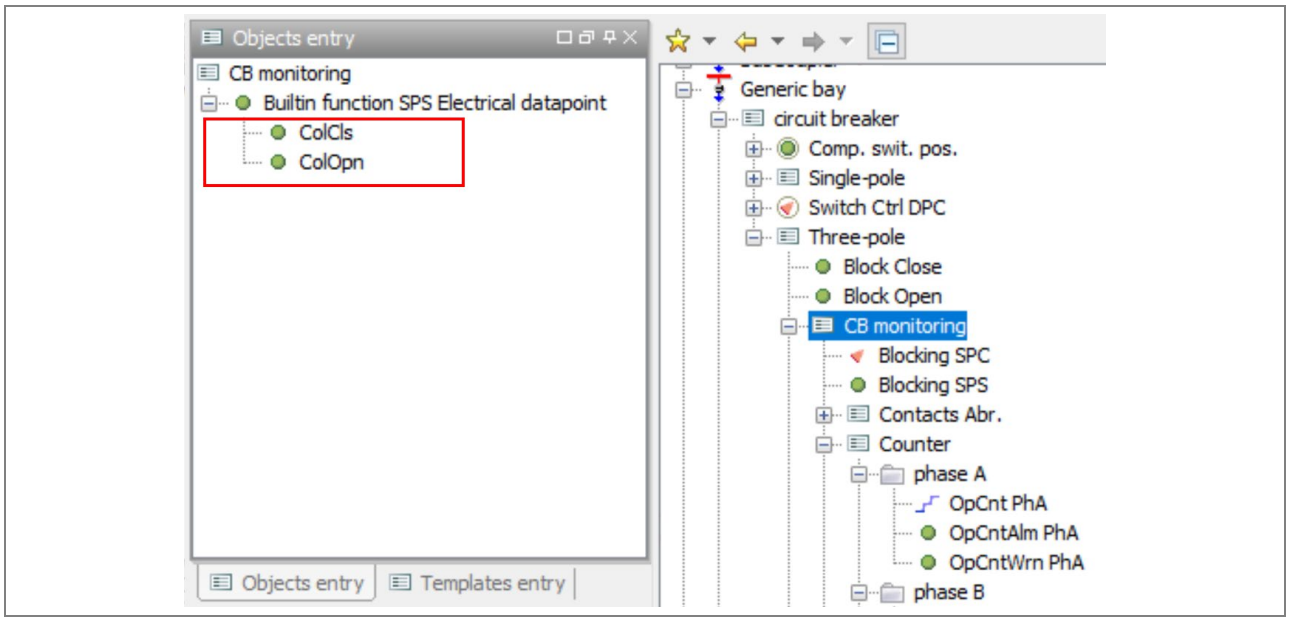


Figure 274: CB monitoring optional datapoints

Datapoint	Description
ColOpn	Energizing of opening coil release. This datapoint is SET when the "trip" coil has been energized through the "open" command.
ColCls	Energizing of closing coil release. This datapoint is SET when the "close" coil has been energized through the "close" command.

When adding additional SPS datapoints, some general attributes must be updated:

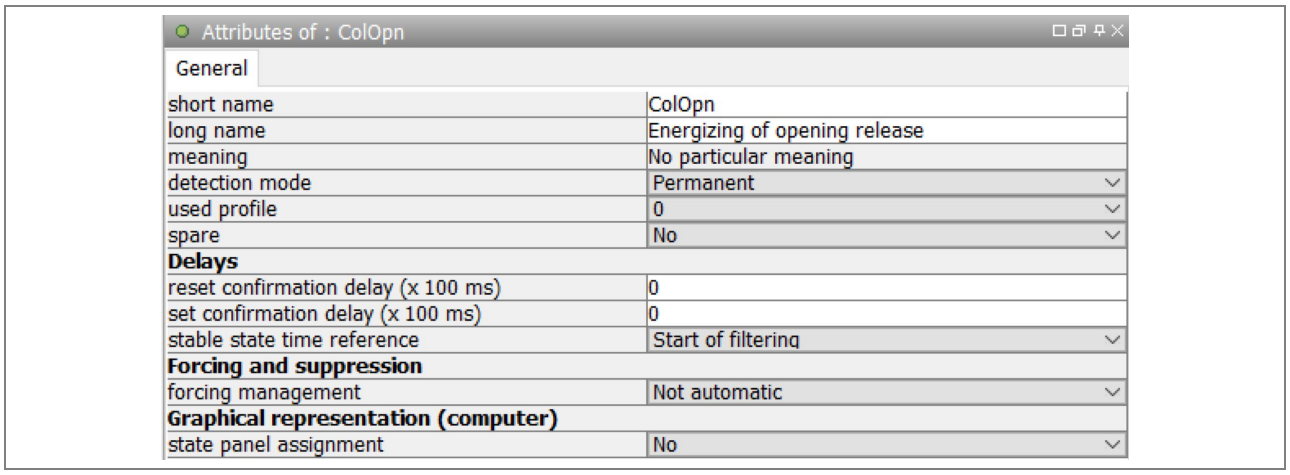


Figure 275: Setting the general attributes of the ColOpn or ColCls SPS datapoint

(1) **short name** and **long name** of the datapoint used for logging, alarms ...

(2) **detection mode** (*Permanent* / *Transient* / *Permanent with computer auto-reset*): when this attribute is set to *Permanent with computer auto-reset* the SPS is reset automatically after 1 ms

(3) **used profile**: the drop-down list refers to the SPS tab of the **Profiles** table

(4) **reset confirmation delay** (range [0 s, 300 s], step 100 ms]: confirmation delay for stable ‘reset’ state

(5) **set confirmation delay** (range [0 s, 300 s], step 100 ms]: confirmation delay for stable ‘set’ state

(6) **stable state time reference** (Start of filtering / End of filtering)

(7) **forcing management**: *Not automatic* / *Automatic to reset state* / *Automatic to set state*): when an SPS goes to invalid state, C26x can force or not its status to set or reset state automatically. This attribute defines the way this forcing management is done. Automatic forcing management is independent of the FSS enable facility provided in the SPS profile

(8) **state panel assignment** (*No* / *Yes*): set to *Yes* to enable SPS state display at local HMI level

5.2.1.3 ATTRIBUTE PARAMETERS

The CB Monitoring function can be configured by using the following attributes.

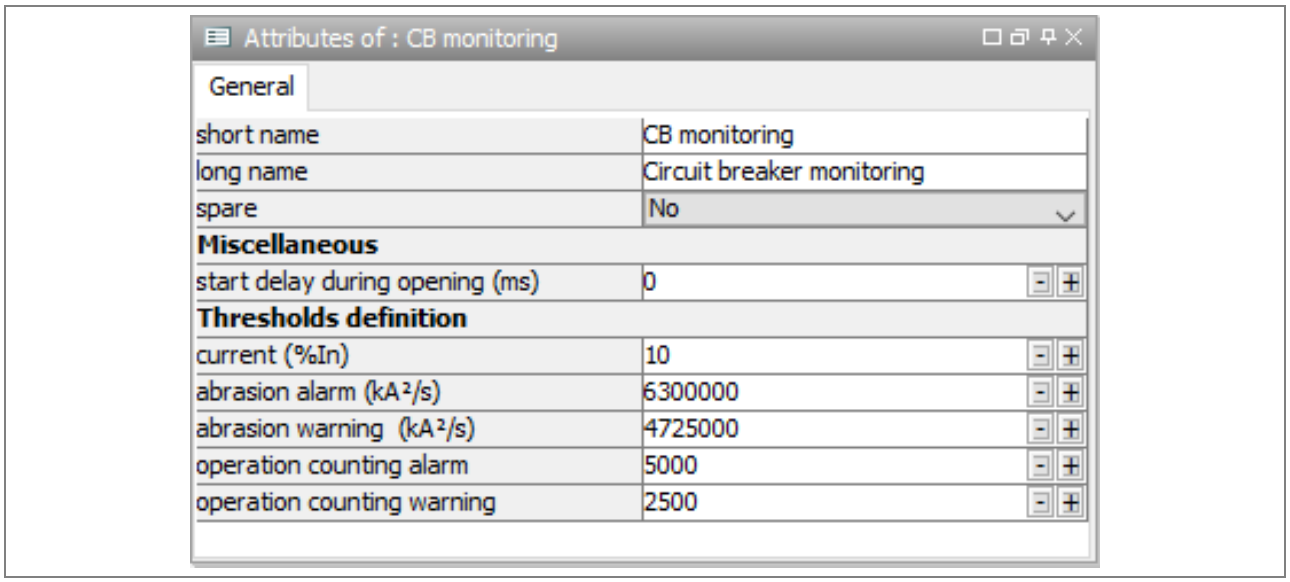


Figure 276: Motor Monitoring attributes

General: Miscellaneous

Attribute	Description
Start delay during opening (ms)	Delay between primary contact separation and auxiliary contact position change (in ms). This is the adjustable Delay to wait before starting the It summation function. Min: -20 Max: 20 Default: 0 Unit: milli seconds

General: Thresholds definition

Attribute	Description
Current (%In)	Current threshold under which the It summation counting is stopped. Threshold of current under which the IT calculation function is stopped Min: 5 Max: 50 Default: 10 Unit: % of In
Abrasion alarm kA².s	Threshold over which the "Abrasion alarm" (“AbrAlr” SPS) is set (in kA² second). Min: 0 Max: 100 000 000 Default: 6 300 000 Unit: kA².s
Abrasion warning kA².s	Threshold over which the "Abrasion warning" (“AbrWrn” SPS) is set (in kA² second). Min: 0 Max: 100 000 000 Default: 4 725 000 Unit: kA².s

Attribute	Description
Operation counting alarm	Threshold over which the “Operation Counting alarm” (OpCntAlm) SPS is set Min: 0 Max: 100 00 Default: 5 000
Operation counting warning	Threshold over which the “Operation Counting warning” (OpCntWrn) SPS is set Min: 0 Max: 100 000 Default: 2 500

5.2.1.4 CONTACTS ABRASION

The “**Contact abrasion**” function is automatically added to the CB monitoring

For each phase A/B/C, the following mandatory datapoints are defined:

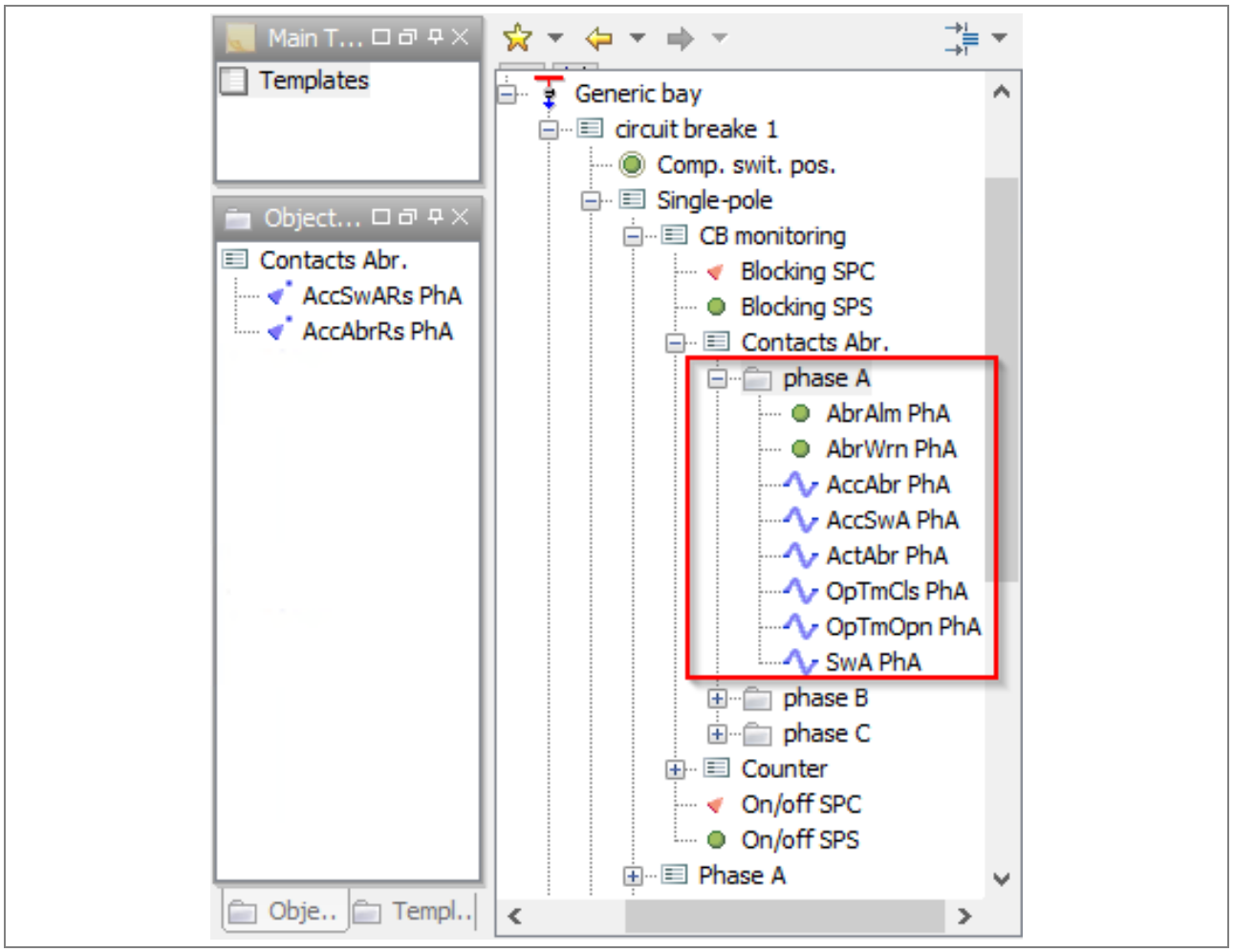


Figure 277: Contacts abrasion mandatory function datapoints

Datapoint	Description
AbrAlm PhX	The "Abrasion alarm" SPS for pole X is set when the cumulative I².t for pole X measurement reaches the "Contact abrasion function alarm" threshold.
AbrWrn PhX	The "Abrasion warning" SPS for pole X is set when the cumulative I².t for pole X measurement reaches the "Contact abrasion function warning" threshold
AccAbr PhX	Cumul. abrasion phX (kA²/s)
AccSwA PhX	Sum. of switched current ph X
ActAbr PhX	Abrasion last open phX (kA²/s)
OpTmCls PhX	Closing time meas. phX (ms)
OpTmOpn PhX	Opening time meas. phX (ms)
SwA PhX	Last switched current ph X (A/s)

For each phase A/B/C, the following optional datapoints are defined:

Datapoint	Description
AccSwARs PhX	Reset cumul. switched current phase A
AccAbrRs PhX	Reset cumul. abrasion phX

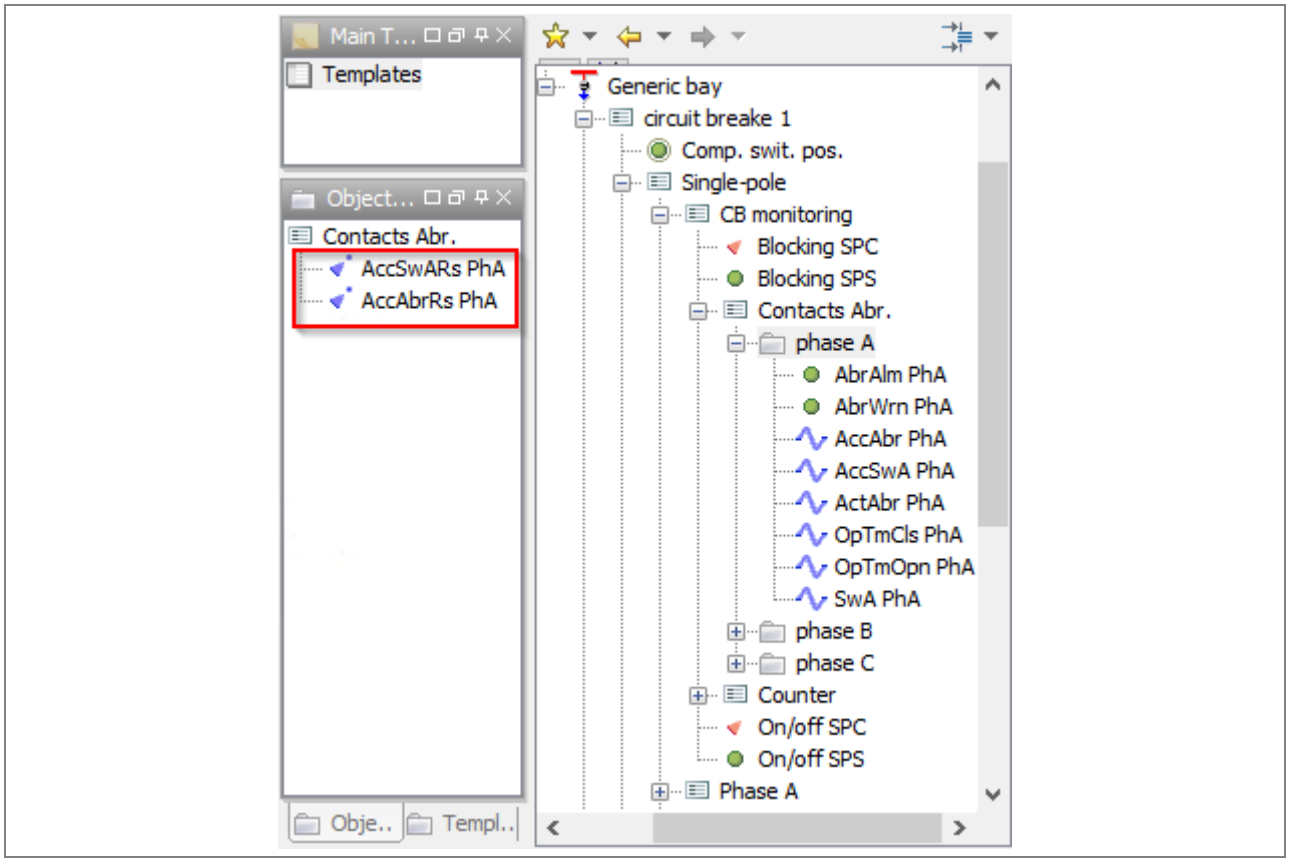


Figure 278: Contacts abrasion optional function datapoints

5.2.1.5 OPERATIONS COUNTER

The “**Operation Counter**” function is automatically added to the CB monitoring

For each phase A/B/C, the following mandatory datapoints are defined:

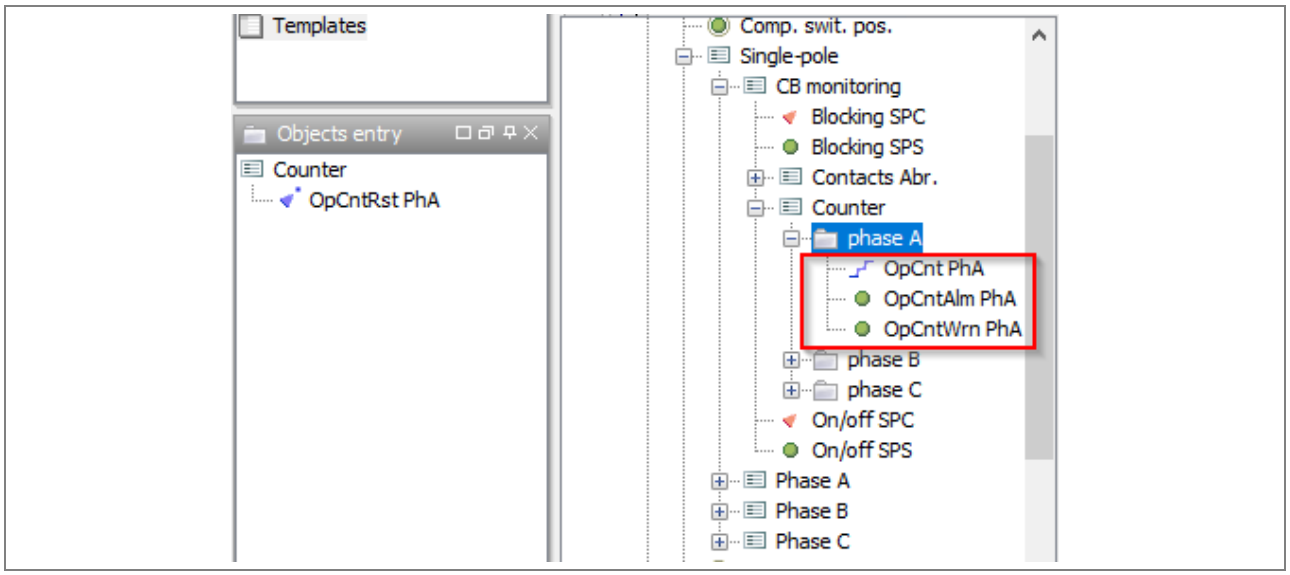


Figure 279: Operations counters mandatory function datapoints

Datapoint	Description
OpCnt PhX	Cumulated number of CB operation on phase X
OpCntAlm PhX	Operation counting alarm ph X
OpCntWrn PhX	Operation counting warning ph X

For each phase A/B/C, the following optional datapoints are defined:

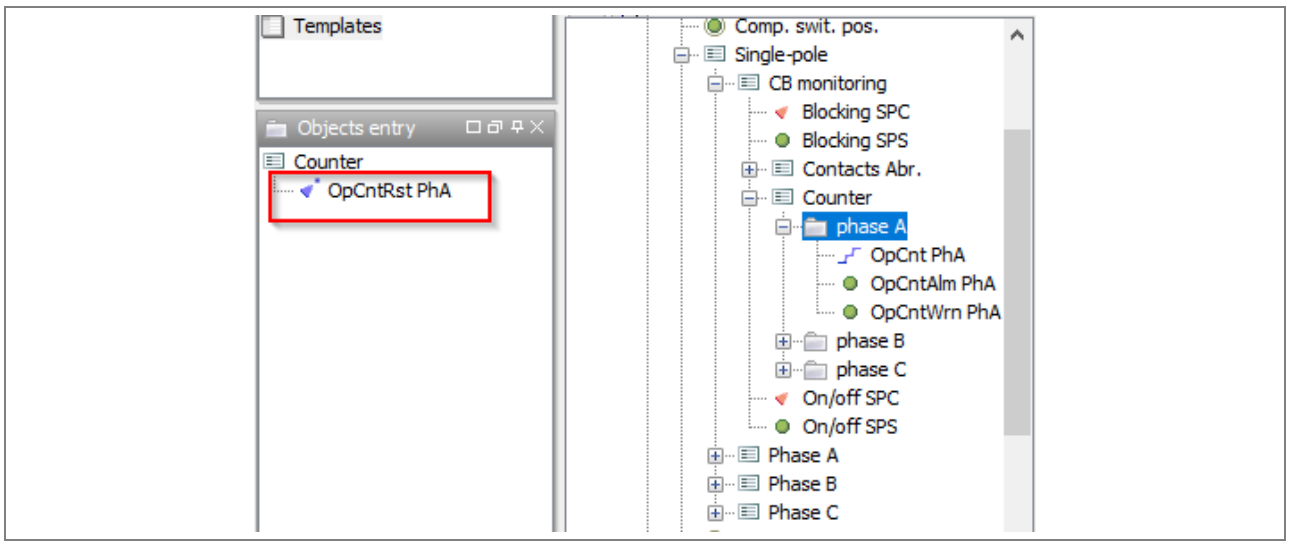


Figure 280: Operations counters optional function datapoints

Datapoint	Description
OpCntRst PhX	Reset cumul. OpCnt phX

5.2.2 CONFIGURING A SWITCHGEAR MONITORING FUNCTION

A “SW monitoring" function can be added under the "switchgear” module, within the electrical topology.

To add a switchgear monitoring function:

1 Select the **Substation level** and then, click the appropriate **Voltage level**.

1 From the **Object entry** panel, expand the Bay folder. Select and add the desired electrical device.

2 In the **Object view** panel, click on that device and add a **switchgear** module.

3 In the **Object view** panel, click the switchgear and add the **SW monitoring** function:

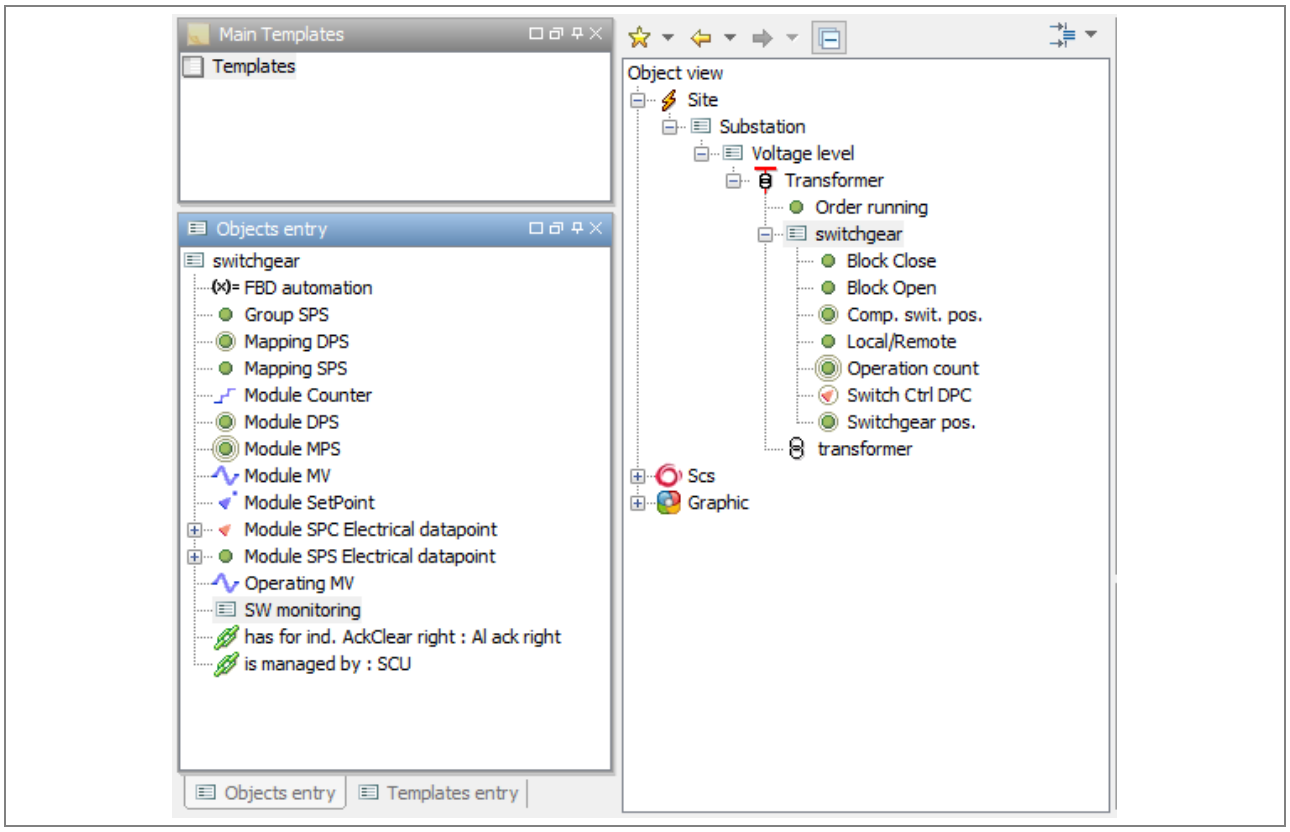


Figure 281: Adding a Switchgear monitoring feature

Up to 64 switchgear monitoring functions can be added per C264.

5.2.2.1 DATAPOINTS

When adding a switchgear monitoring function, a number of mandatory datapoints are automatically created at function level and must be configured (see section *4 Defining a datapoint*):

- **Blocking SPC**: blocks/unblocks the switchgear monitoring function
- **Blocking SPS**: blocking state of the switchgear monitoring function
- **on/off SPC**: enables/disables the switchgear monitoring function
- **on/off SPS**: start/stop state of the switchgear monitoring function
- **opCnt**: operation counter. Counts the number of Start actions
- **opCntAlm**: operation counting alarm. This alarm is raised when its corresponding “start-up counting alarm” is reached
- **OpCntWrn**: Operation counter Warning. This warning is risen when its corresponding “start-up counting warning” is reached.
- **OpTmCls**: closing time measurement (ms)
- **OpTmOpn**: opening time measurement (ms)

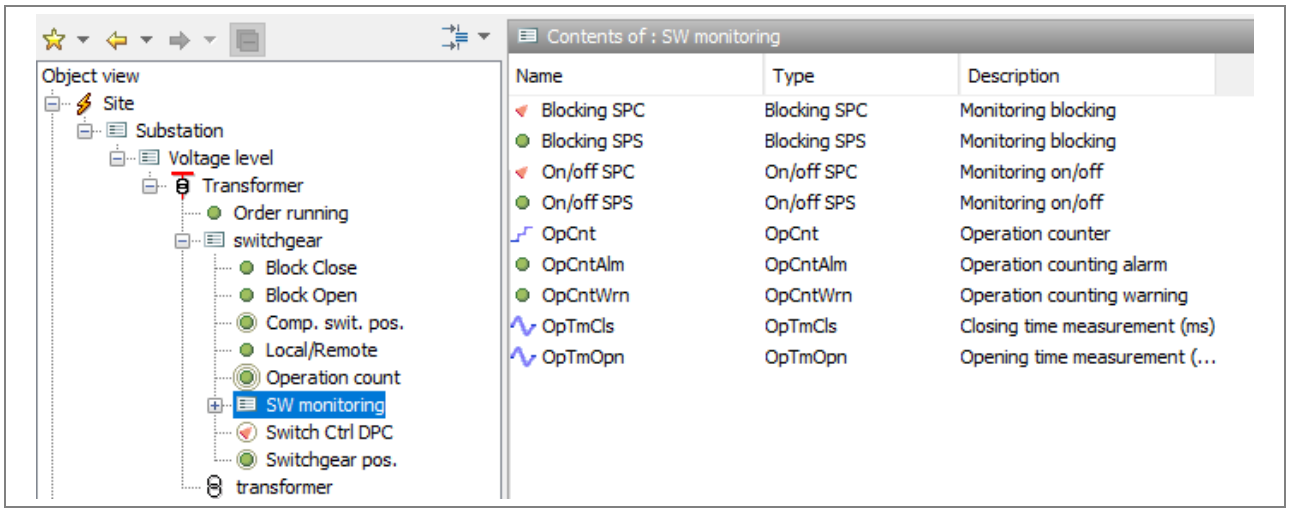


Figure 282: switchgear monitoring function datapoints

5.2.2.2 ATTRIBUTE PARAMETERS

When adding a switchgear monitoring function, the following specific attributes must be updated:

General attributes

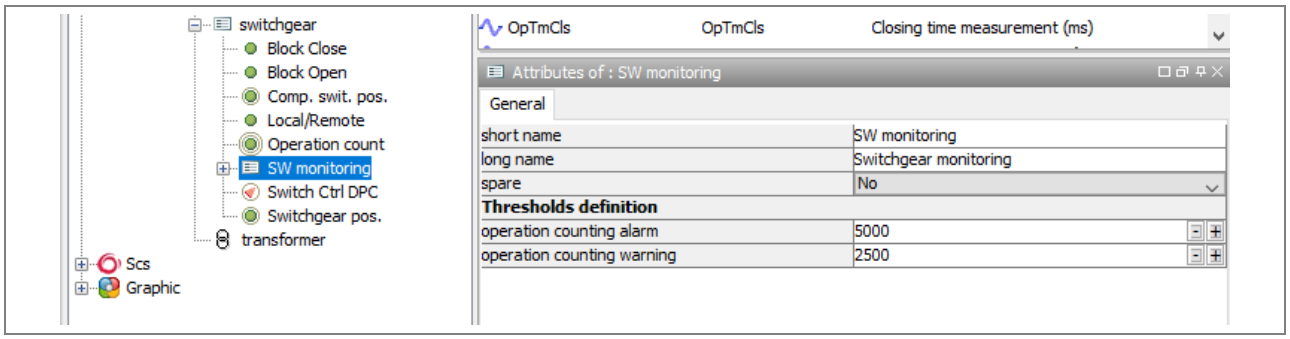


Figure 283: switchgear monitoring function attributess

- **Operation counting alarm**: Threshold over which the “OpCntAlm” SPS is set (Min 0, Max: 100000, Step: 1, Defaut: 5000)
- **Operation counting warning**: Threshold over which the “OpCntWrn” SPS is set (Min 0, Max: 100000, Step: 1, Defaut: 2500)

5.2.3 CONFIGURING AN OLTC MONITORING FUNCTION

The OLTC monitoring function is made up of:

- a "Switch monitor" function
- a "Tap monitoring" function

The diverter switch element is unique on each OLTC device, while the "Tap monitoring" function must be duplicated as many times as the number of taps present into the OLTC device (related value to **maximal usable position**, at Tap changer attributes level).

To monitor a Tap changer and/or a diverter switch, an “OLTC Monitoring" function can be added under the "Tap changer” built-in function.

To add an OLTC Monitoring function:

1 Select the **Substation level** and then, click the appropriate **Voltage level**.

2 From the **Object entry** panel, expand the **Bay** folder. Right-click on **Transformer** and select **Add**.

3 In the **Object view** panel, click on the transformer device.

4 In the **Object entry** panel, expand the **Built-in folder** and then, right-click on **Tap Changer** and select **Add**.

5 In the **Object view** panel, click on the **Tap Changer** function

6 In the **Object entry** panel, right-click on **OLTC monitoring** and select **Add**:

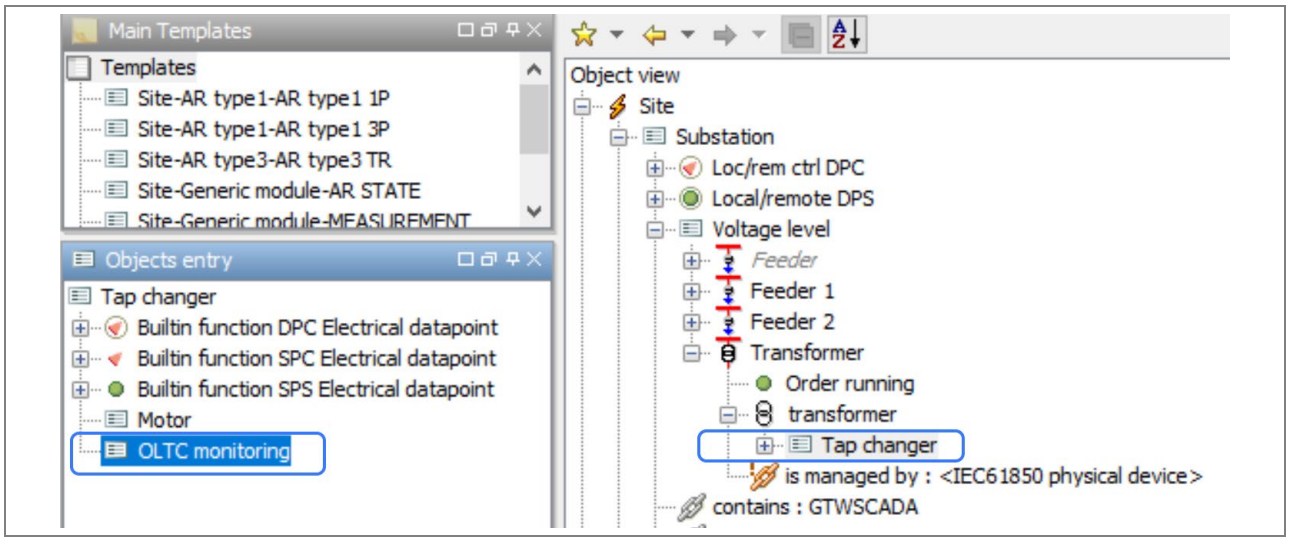


Figure 284: Adding an OLTC monitoring feature

5.2.3.1 OLTC THRESHOLDS

For each **On Load Tap Changer monitoring** function, the following thresholds must be configured:

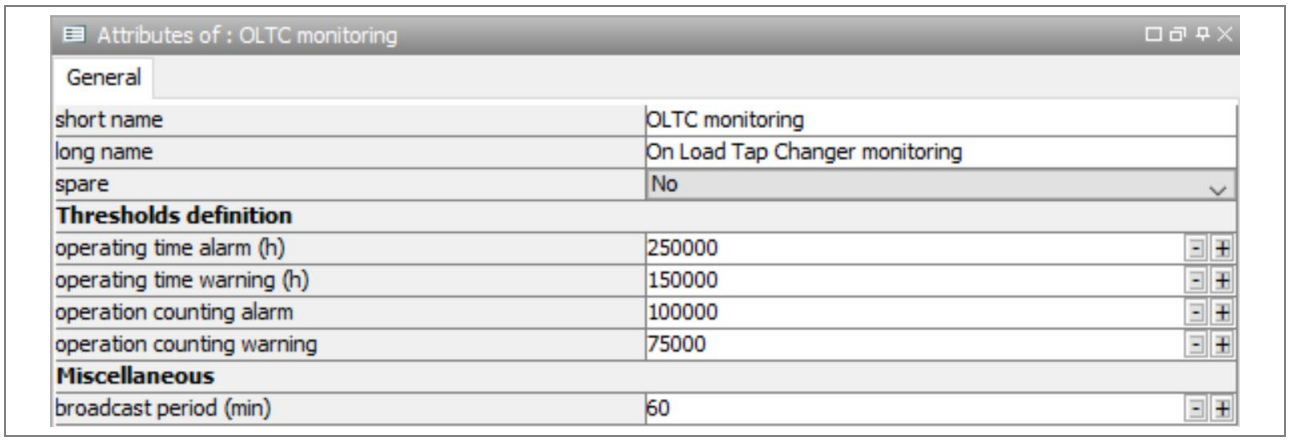


Figure 285: Attributes of the OLTC monitoring function

- **operating time alarm**: threshold value (in hours) for all tap positions to raise a time-based maintenance alarm (Min 1, Max: 1000000, Step: 1, Defaut: 250000)
- **operating time warning**: threshold value (in hours) for all tap positions to raise a time-based maintenance warning (Min 1, Max: 1000000, Step: 1, Defaut: 150000)
- **operating counting alarm**: threshold value for all tap positions to raiseoperation-based maintenance alarm, based on operation number (Min 1, Max: 1000000, Step: 1, Defaut: 100000)
- **operating counting warning**: threshold value for all tap positions to raise operation-based maintenance warning based on operation number (Min 1, Max: 1000000, Step: 1, Defaut: 75000)
- **broadcast period**: broadcast period of monitoring information in minutes (Min 1, Max: 1440, Step: 1, Defaut: 60). Monitoring information is refreshed at HMI level (aView) every hour, by default.

5.2.3.2 VOLTAGE PRESENCE

At "transformer" level, add the **Voltage present** Module SPS electrical datapoint. This information is required by the OLTC monitoring function (tap changer, and diverter switch).

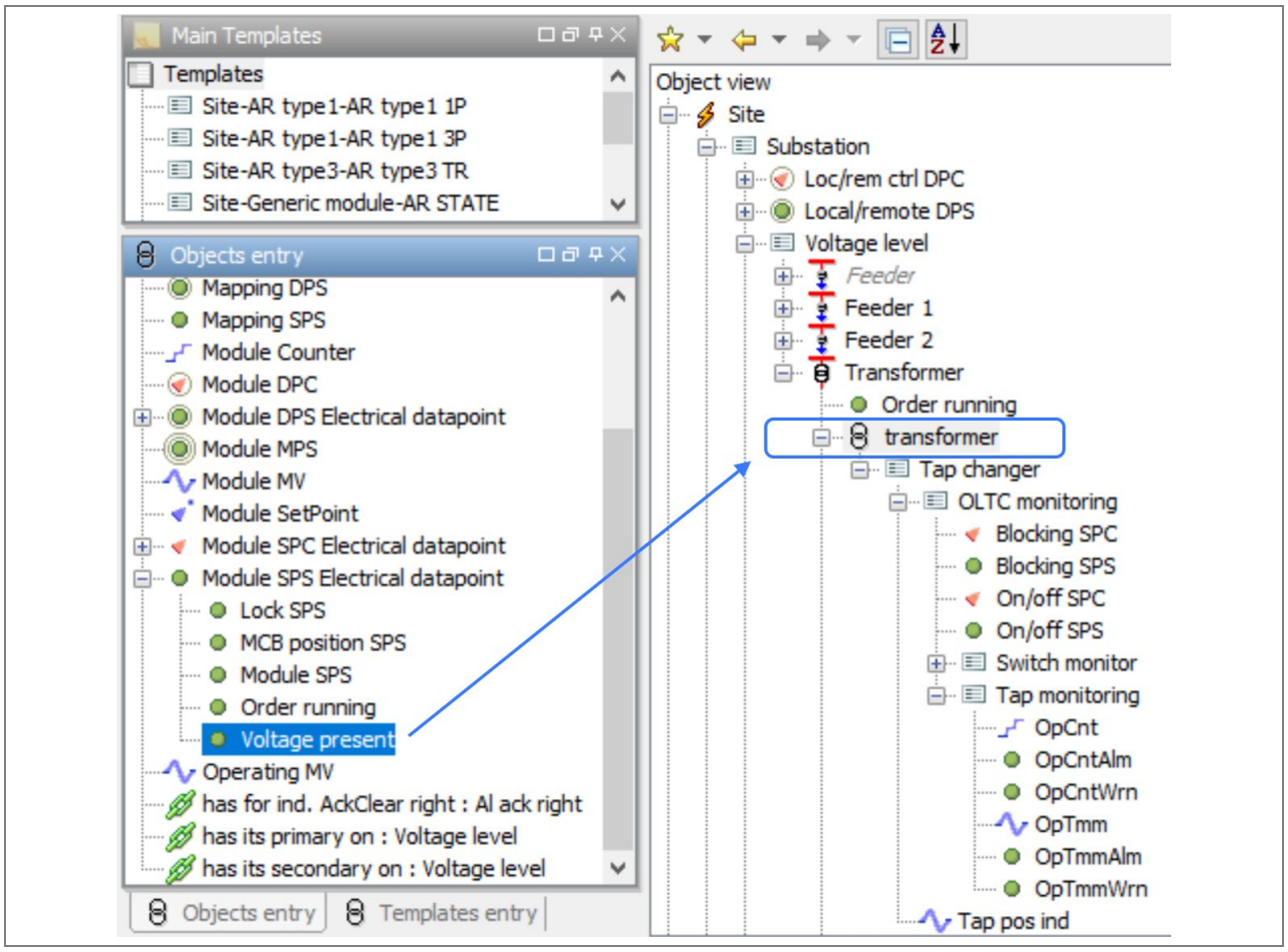


Figure 286: Adding the Voltage presence information

Refer to the Functional Description chapter of the C264 user manual chapter for more information on the function input behaviour.

This input must be linked to an automation output (ISAGRAF, FBD) determining the high voltage level at primary side of power transformer or fixed by default to SET.

5.2.3.3 CONFIGURING A DIVERTER SWITCH MONITORING FUNCTION

The “Switch monitor" function is added with the OLTC monitoring function, under the "tap changer” node, within the electrical topology.

5.2.3.3.1 Datapoints

To use the switch monitor function, a number of mandatory datapoints are automatically created at function level and must be configured (see section *4 Defining a datapoint*):

- **Blocking SPC**: blocks/unblocks the Switch monitor function
- **Blocking SPS**: blocking state of the Switch monitor function
- **on/off SPC**: enables/disables the Switch monitor function
- **on/off SPS**: start/stop state of the Switch monitor function

For each phase A/B/C:

- **AbrAlm PhX**: contact abrasion alarm.
- **AbrWrn PhX**: contact abrasion warning.
- **OpCntAlm PhX**: operation counter alarm. This alarm is raised when its corresponding “start-up counting alarm” is reached.
- **OpCntWrn PhX**: operation counter Warning. This warning is raised when its corresponding “start-up counting warning” is reached.
- **SwA**: last switched current value phase X
- **AccAbr**: accumulated abrasion phase X
- **OpCnt**: operation counter phase X

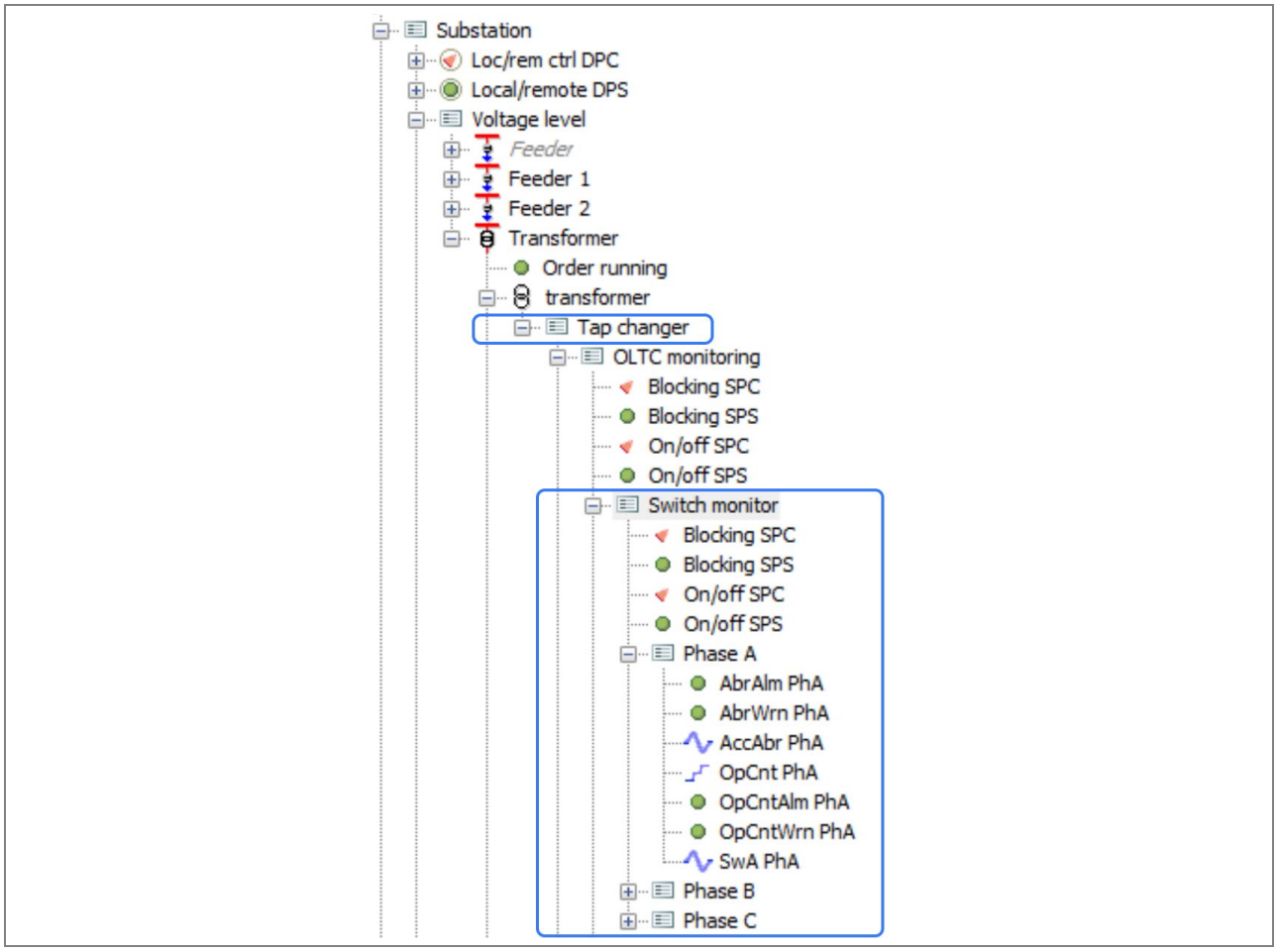


Figure 287: switch monitor datapoints

5.2.3.3.2 Attribute parameters

To use the switch monitor function, the following specific attributes must be updated:

General attributes

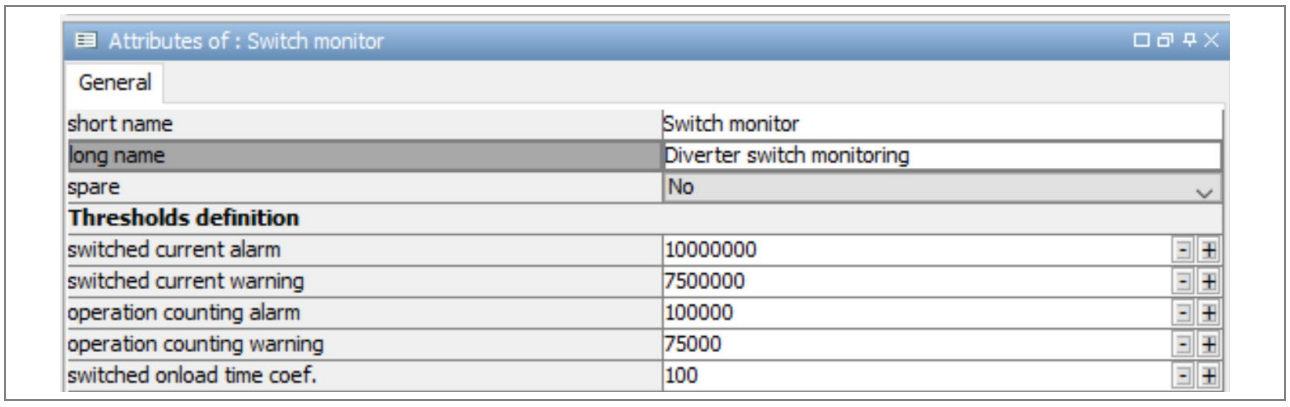


Figure 288: switch monitor function attributes

- **Switched current alarm**: switched current threshold over which the “Switched current alarm” SPS is set (Min 0, Max: 100,000,000, Step: 1, Defaut: 1,000,000)
- **Switched current warning**: switched current threshold over which the “Switched current warning” SPS is set (Min 0, Max: 100,000,000, Step: 1, Defaut: 7,500,000)
- **Operation counting alarm**: switch operation count threshold over which the “OpCnt alarm” SPS is set (Min 0, Max: 1,000,000, Step: 1, Defaut: 1,00,000)
- **Operation counting warning**: switch operation count threshold over which the “OpCnt warning” SPS is set (Min 0, Max: 1,00,000, Step: 1, Defaut: 75,000)
- **Switched onload time coef**.: switched operating time coefficient in % (Min 0, Max: 100, Step: 1, Defaut: 100). This attribute is not used by the C26x in this DS Agile version. Its setting has no effect.

5.2.3.4 CONFIGURING A TAP CHANGER MONITORING FUNCTION

The “Tap monitoring," function is added with the OLTC monitoring function, under the "tap changer” node, within the electrical topology.

The "Tap monitoring" must be duplicated as many times as the number of taps present into the OLTC device (related value to **maximal usable position**, at Tap changer attributes level).

5.2.3.4.1 Datapoints

When adding a Tap Changer monitoring function, a number of mandatory datapoints are automatically created at function level and must be configured (see section *4 Defining a datapoint*):

- **opCnt**: operation counter. Counts the number of Start actions
- **opCntAlm**: operation counting alarm. This alarm is raised when its corresponding “start-up counting alarm” is reached
- **OpCntWrn**: Operation counter Warning. This warning is risen when its corresponding “start-up counting warning” is reached.
- **OpTmm**: operating time measurement (ms)
- **OpTmmAlm**: operating time alarm (ms)
- **OpTmmWrn**: operating time warning (ms)

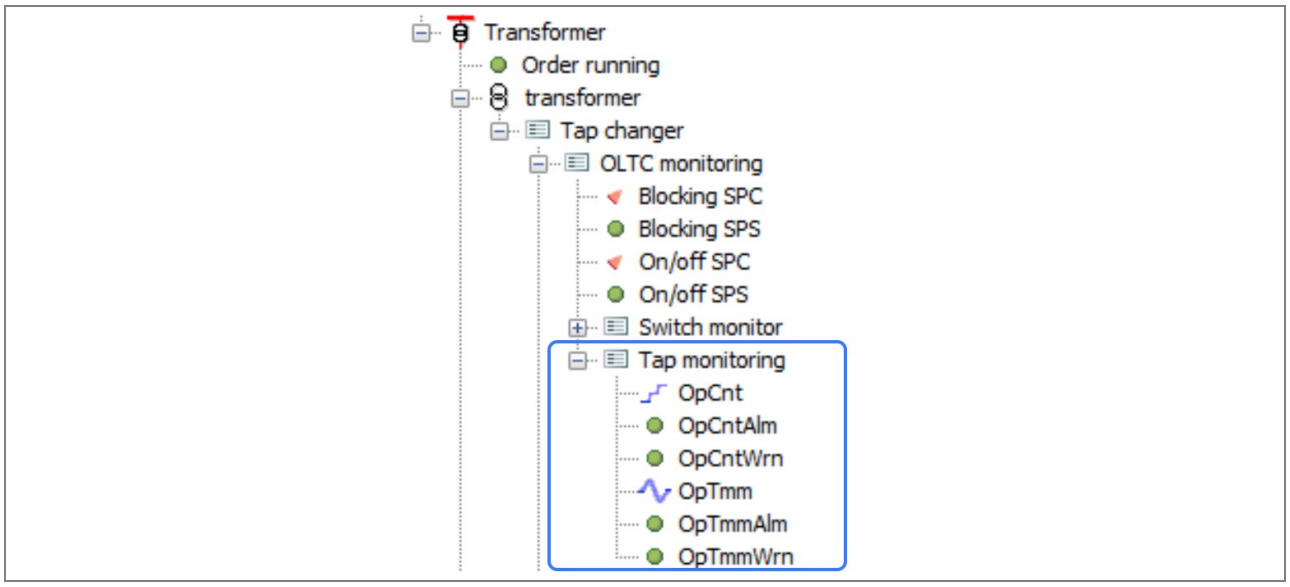


Figure 289: Tap Changer monitoring datapoints

5.2.3.4.2 Attribute parameters

When adding a Tap Changer monitoring function, the following specific attributes must be updated:

General attributes

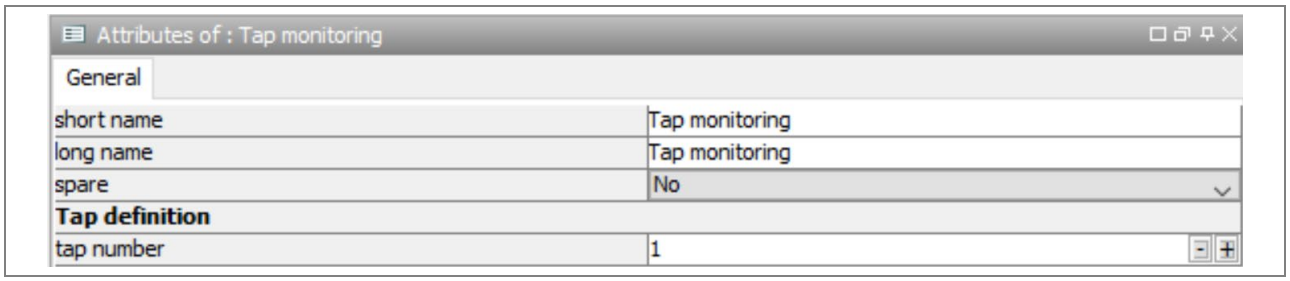


Figure 290: Tap monitoring function attributes

- **Tap number**: enter a unique tap position number (Min 1, Max: 49, Step: 1, Defaut: 1)

5.2.4 CONFIGURING THE MOTOR MONITORING FUNCTION

You can add a Motor Monitoring function to an existing Low Voltage Motor.

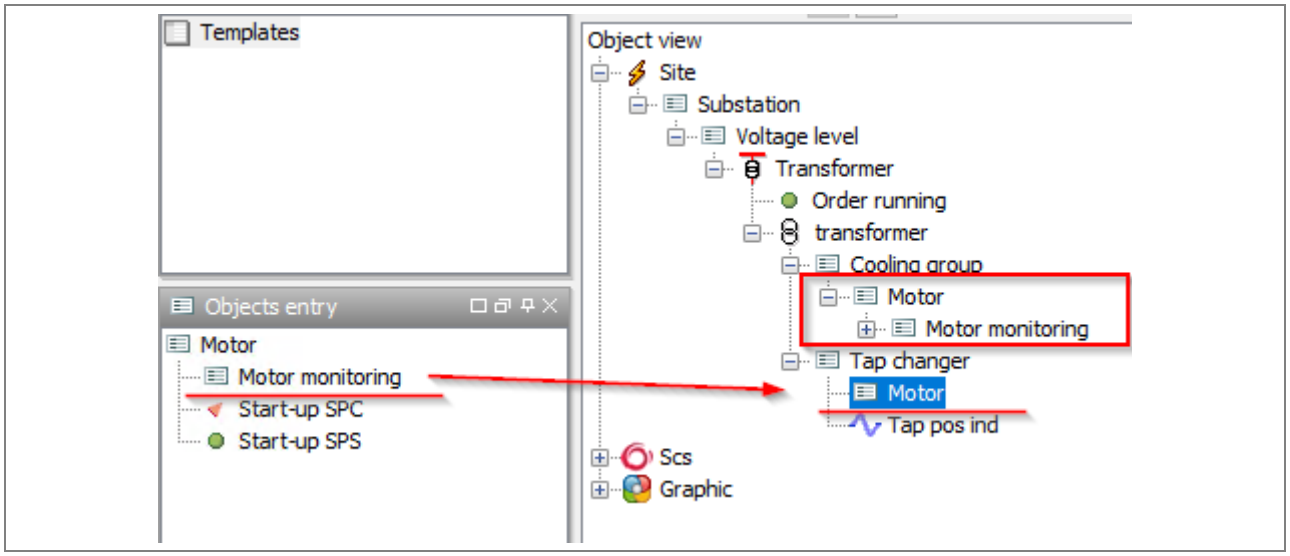


Figure 291:Adding a Motor Monitoring function

By default, the motor monitoring function is stopped and unblocked; thus, no start counting nor operating time measurement are performed.

Note 1: The computer can manage up to 64 motors.

Note 2: If an OFF control is received during the motor operation, then the control is automatically refused by the computer (negative acknowledge). The motor monitoring function cannot be set to OFF if the motor is operating.

Note 3: If a BLOCK control is received during the motor operation, then the control is automatically refused by the computer (negative acknowledge). The motor monitoring function cannot be set to blocked if the motor is operating.

Note 4: The Motor object can be added only to a cooling group object (up to 9 motors) or to a tap changer (up to 1 motor). Both objects an be added only to Transformer objects.

5.2.4.1 DATAPOINTS

The Motor Monitoring function contains several mandatory datapoints. These datapoints are automatically created at function level and must be configured (see section *4 Defining a datapoint*):

Datapoint	Description
Blocking SPC	Blocks/Unblocks motor monitoring function
Blocking SPS	Blocking state of the motor monitoring function
on/off SPC	Starts/stops the motor monitoring function
on/off SPS	Start/stop state of the motor monitoring function
OpCnt	Operation counter Counts the number of Start operation in the motor

Datapoint	Description
OpCntAlm	Operation counter alarm This alarm is risen when its corresponding “start-up counting alarm” attribute is reached.
OpCntWrn	Operation counter Warning This warning is risen when its corresponding “start-up counting warning” attribute is reached
OpTmm	Operating time measurement in minutes This measurement is updated: • every minute or • upon reception of a ‘end operating event’
OpTmmAlm	Operating time measurement alarm This alarm is risen when its corresponding “operating time alarm” attribute is reached. The alarm is verified when updating the OpTmm datapoint.
OpTmmWrn	Operating time measurement warning This warning is risen when its corresponding “operating time warning” attribute is reached. The alarm is verified when updating the OpTmm datapoint.

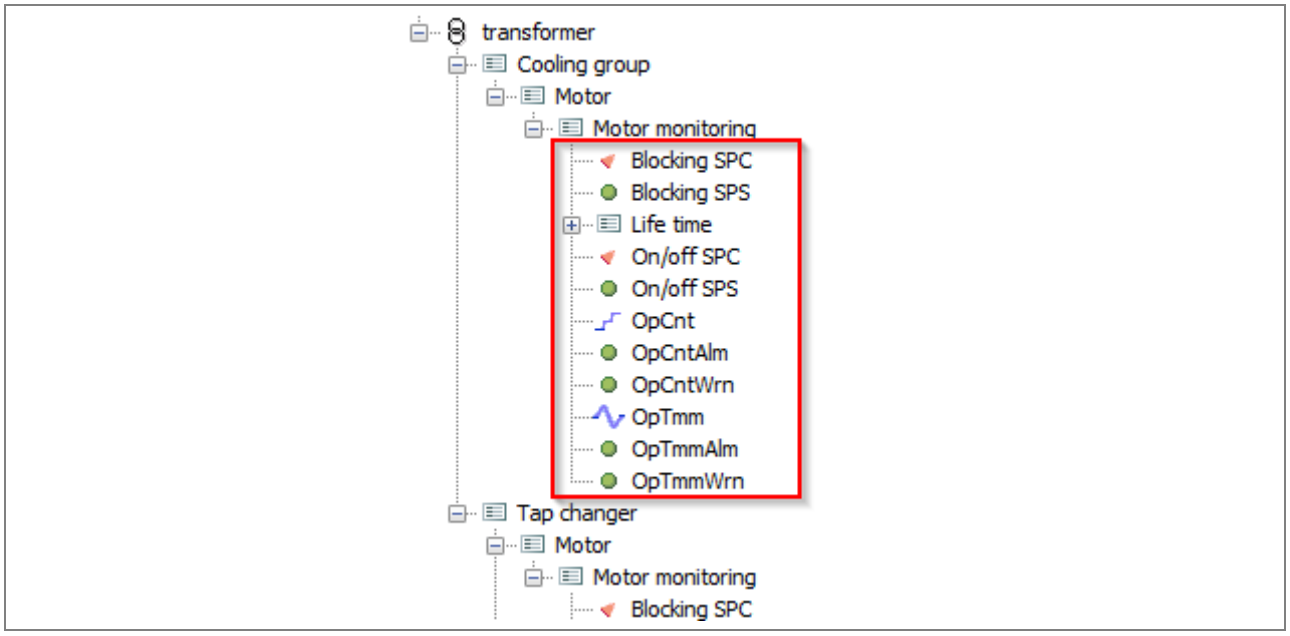


Figure 292: Motor Monitoring function datapoints

The Motor Monitoring function also contains two optional electrical datapoints. These datapoints are can be added from the Object group.

Datapoint	Description
OpCntRst	Reset start-up counter
OpTmmRst	Reset operating time

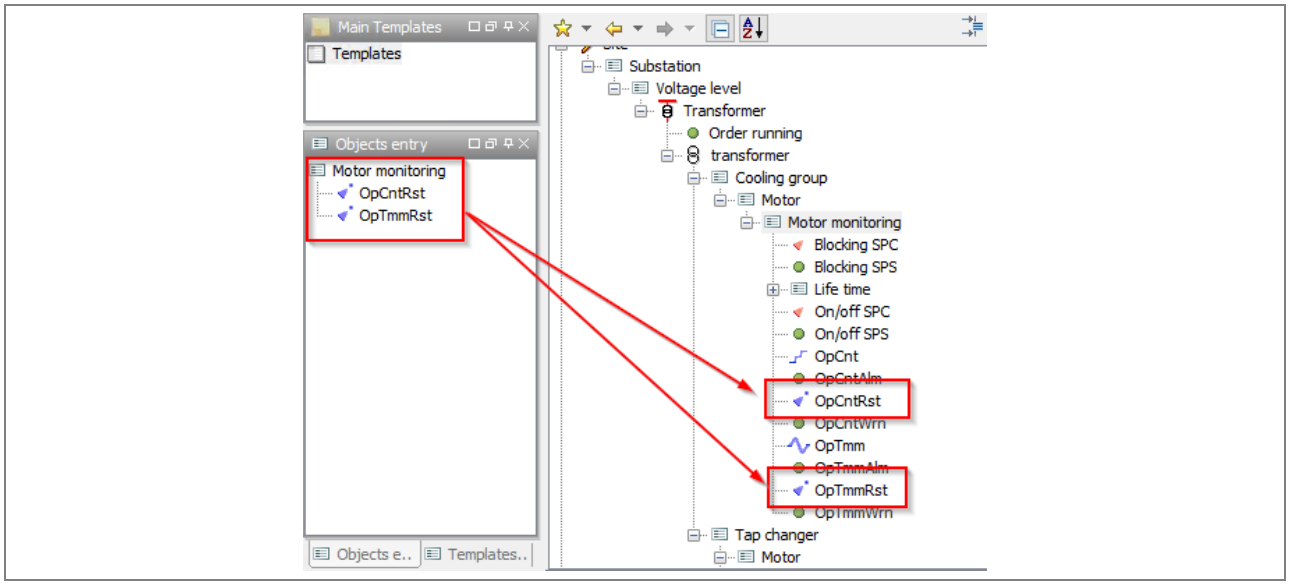


Figure 293: Motor Monitoring function datapoints

5.2.4.2 LOW VOLTAGE MOTOR MONITORING ATTRIBUTES

The Motor Monitoring function can be configured by using the following attributes

General: Thresholds definition

Attribute	Description
Operating time alarm (h)	OpTmmAlm alarm is risen after a given time of operation Min: 1 Max: 1 000 000 Default: 200 000 Unit: hours
Operating time warning (h)	OpTmmWrn warning is risen after a given time of operation Min: 1 Max: 1 000 000 Default: 150 000 Unit: hours
Start-up counting alarm	OpCntAlm alarm is risen after a given number of start-up operations Min: 1 Max: 100 000 Default: 10 000
Start-up counting warning	OpCntWrn warning is risen after a given number of start-up operations Min: 1 Max: 100 000 Default: 5 000

General: Miscellaneous

Attribute	Description
Broadcast period (min)	Indicates the frequence in minutes at which the operation time measurement is transmitted to the HMI Min: 1 Max: 1 440 Default: 60 Unit: minutes

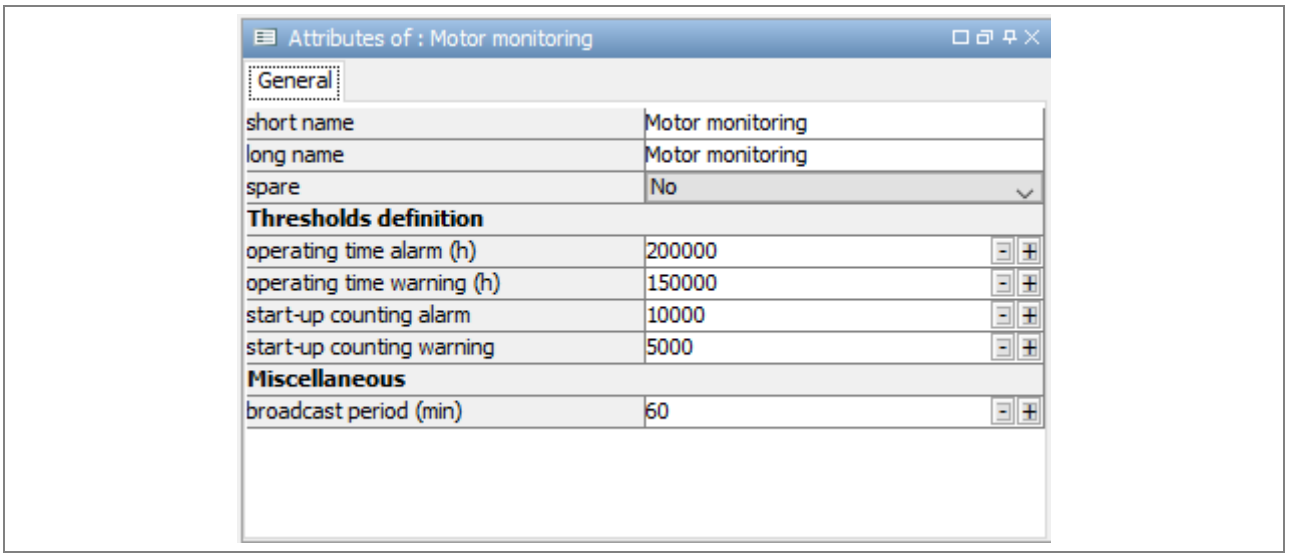


Figure 294: Motor Monitoring attributes

5.2.5 CONFIGURING THE RESIDUAL LIFE TIME FUNCTION

The Life time function is automatically added to a Low Voltage Motor Monitoring function upon creation.

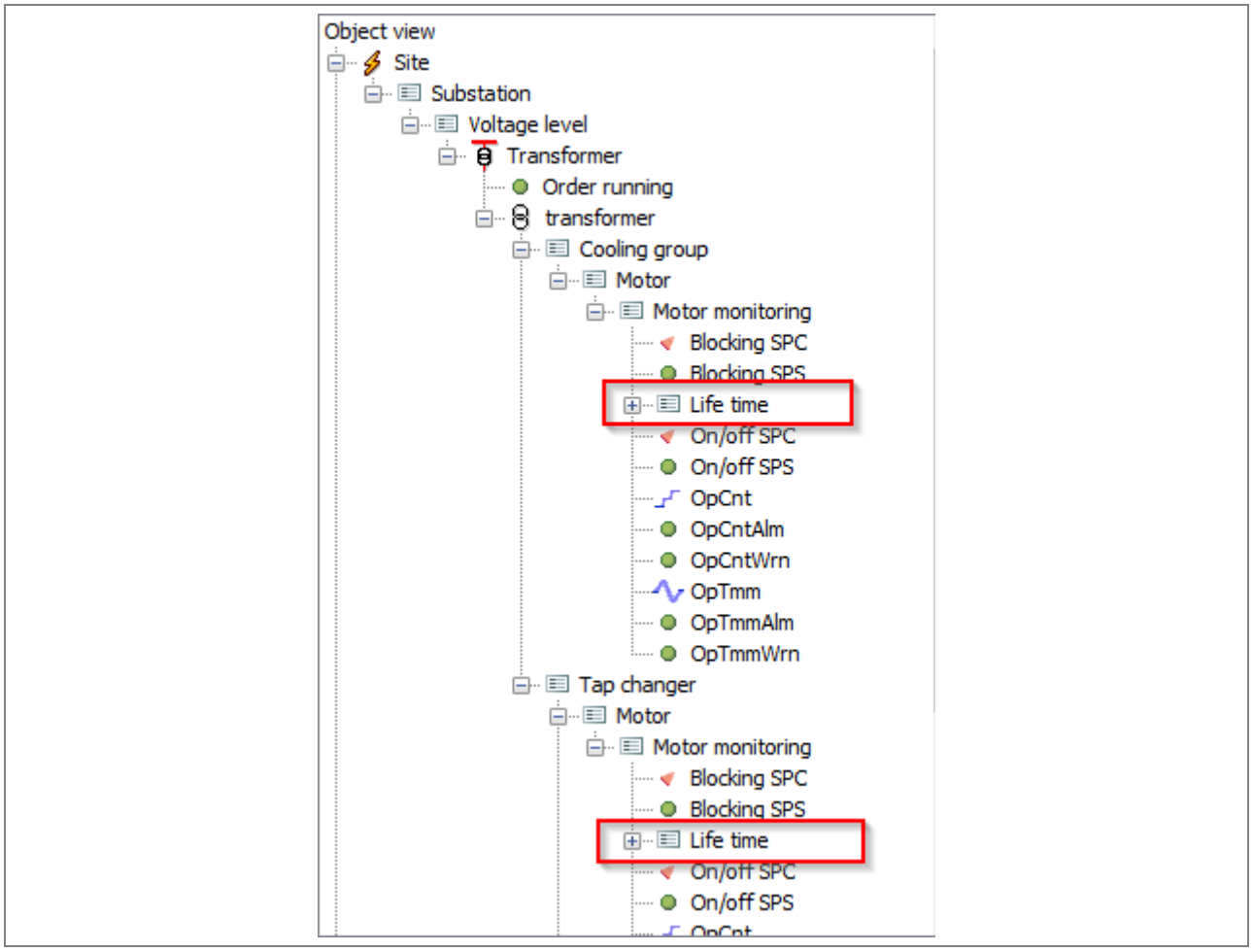


Figure 295: Life time function

Note that the life time function cannot be directly stopped nor blocked. However, it only computes the residual lifetime when its container Low Voltage Motor Monitoring function is started and unblocked.

5.2.5.1 DATAPOINTS

The Life time function contains several mandatory datapoints. These datapoints are automatically created at function level and must be configured (see section *4 Defining a datapoint*):

Datapoint	Description
Life time alarm	Remaining lifetime alarm Raisen when its corresponding “minimum life time threshold” limit is reached
Life time MV	Measures the residual lifetime

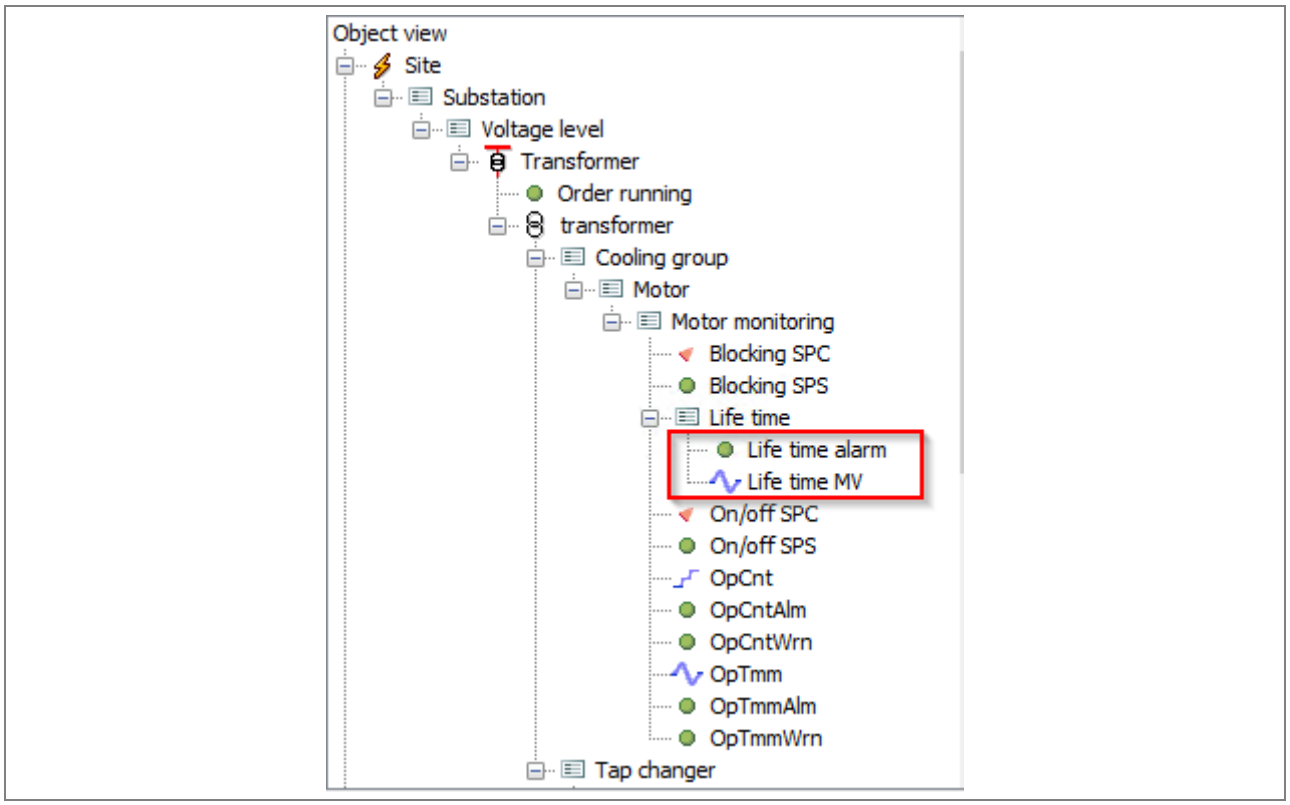


Figure 296: Motor Monitoring function datapoints

5.2.5.2 RESIDUAL LIFE TIME ATTRIBUTES

The time function can be configured by using the following attributes:

General: Thresholds definition

Attribute	Description
minimum life time threshold	Minimum remaining life time threshold (in hours) This is the limit at which the Life time alarm will be risen Min: 1 Max: 100 000 Default: 5 000

Attribute	Description
delay between 2 operating periods (h)	Delay between two operating periods (in hours). This is the frequency at which the life time measurement is updated. Min: 1 Max: 24 Default: 24

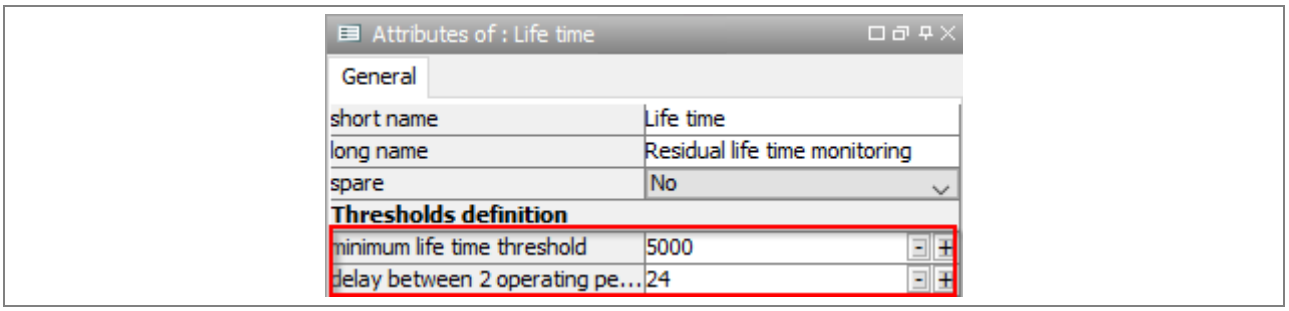


Figure 297: Residual life time attributes

It also requires two other attributes to be defined based on manufacturer information; these attributes are part of the Motor function:

Attribute	Description
Life time (h)	The initial lifetime of a motor as provided by the manufacturer. Min: Max: 1 000 000 Default: 200 000
Life time consumption (h)	Lifetime consumption at each motor start. Min: 0 Max: 100 Default: 1

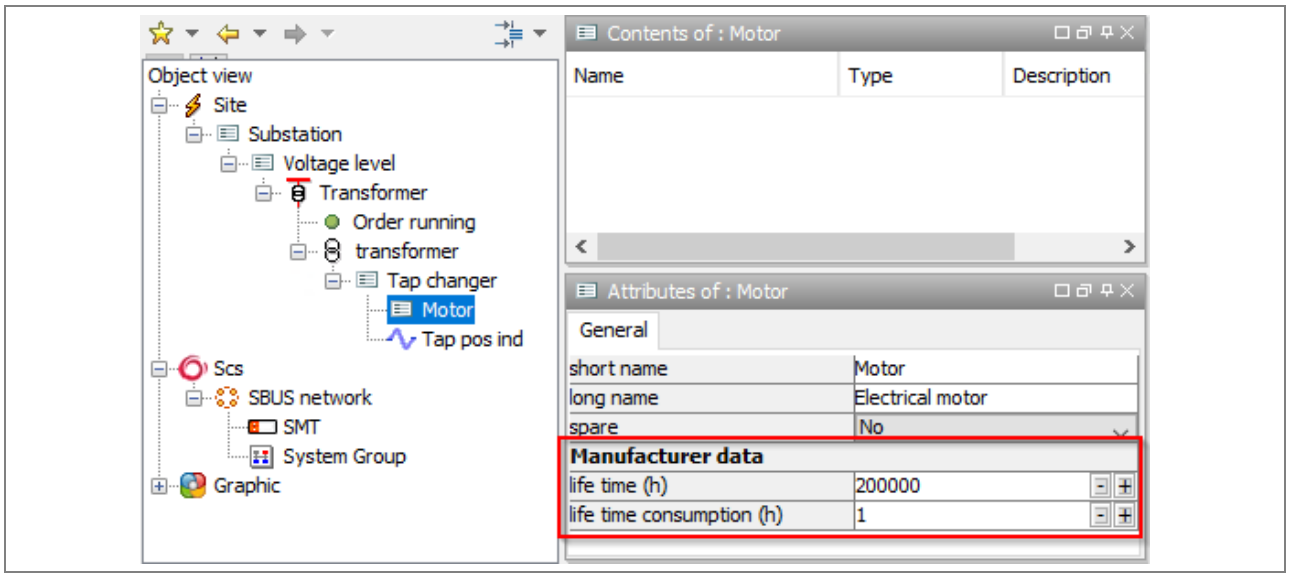


Figure 298: Manufacturer data attributes

5.3 DEFINING A SYNCHROCHECK FUNCTION

Caution:
If it manages two electrical bays, the BCU can manage two synchrocheck functions of the same type, either type 1 or type 4. Mixes are not supported.

5.3.1 CIRCUIT-BREAKER DEFINITION FOR SYNCHROCHECK

The following screenshots and tables give the inputs and outputs for three-pole and single-pole circuit-breakers, with regards to the synchrocheck function. The SCE label of each datapoint is assigned a number for reference in the above figures.

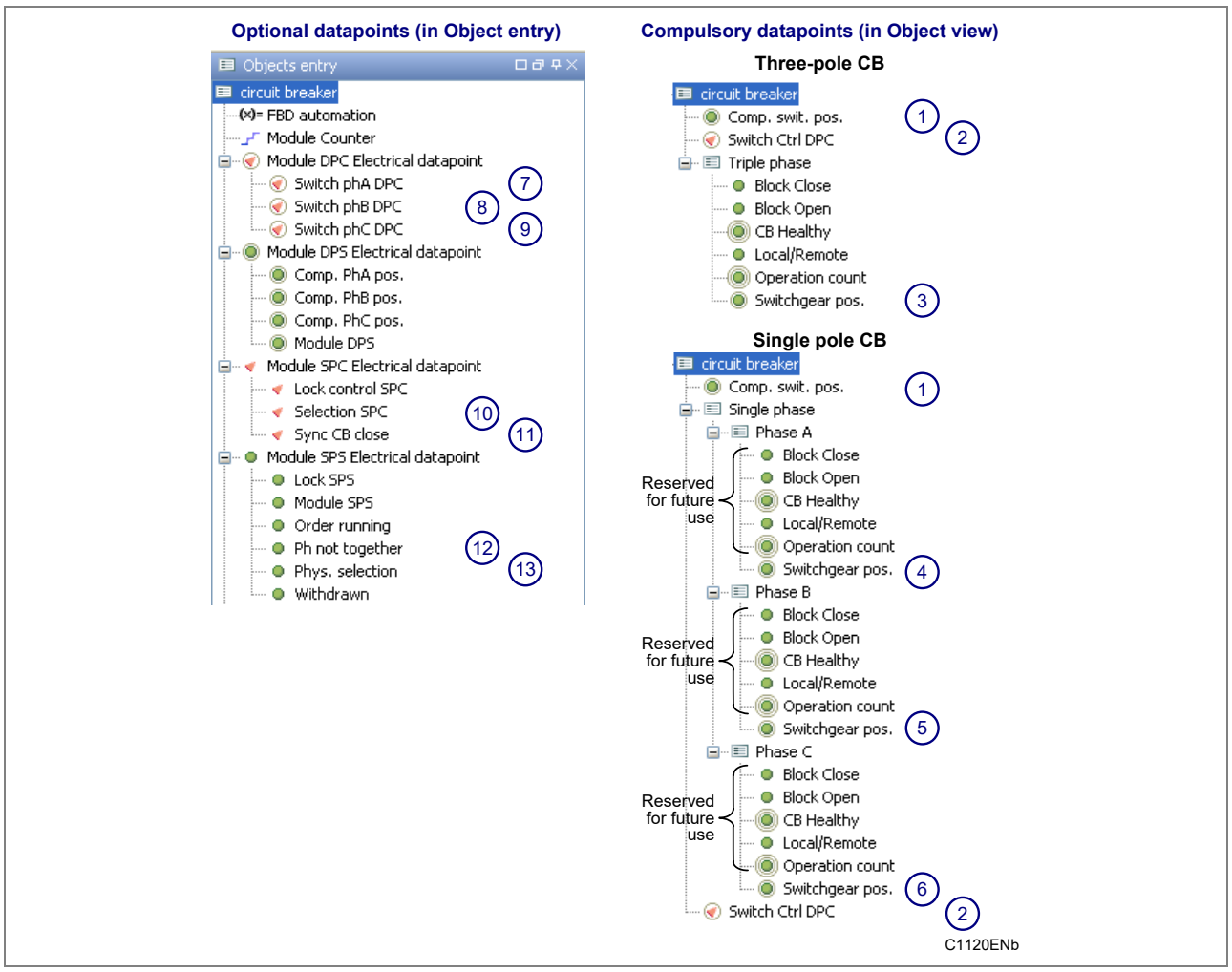


Figure 299: Available pre-defined datapoints for a circuit-breaker with synchrocheck

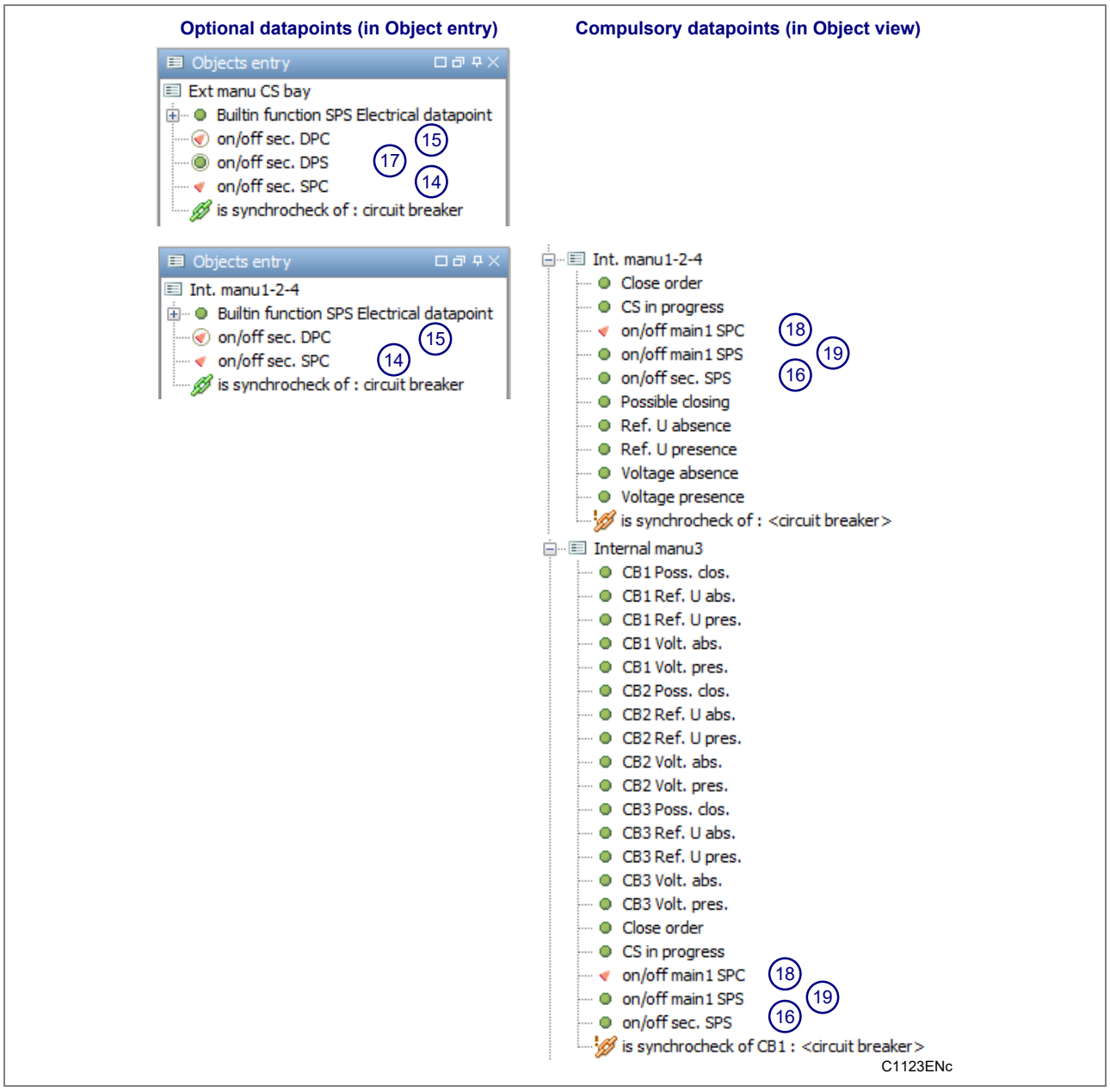


Figure 300: Common pre-defined datapoints for synchrocheck

5.3.1.1 CIRCUIT BREAKER CONFIGURATON

To correctly configure a circuit-breaker module with synchrocheck:

- add the relevant datapoints according to the tables below.
- configure them (see section *4 Defining a datapoint*).
- do not forget to link the control (2) of the circuit-breaker to the computed switch position (1) datapoint with the **has for feedback** relation.
- link the circuit-breaker to an existing synchrocheck function created at bay or substation level. This link is placed at synchrocheck level (for details see *5.3.2 Creating a synchrocheck function*). Only 1 circuit breaker can be linked to the same standard (type 1 or 4) internal synchrocheck.
- correctly configure the function itself (see *5.3.2 Creating a synchrocheck function*).

5.3.1.1.1 Three-Pole Circuit-Breaker Definition for Synchrocheck

Three-pole circuit-breaker with synchrocheck		
	Outputs to CB	**Inputs from CB**
Device control	(2) DPC: device open/close control (11) SPC: close with synchrocheck control	(3) DPS: physical position of the device (1 pole) (12) SPS (optional): pole discrepancy (ph not together) indication (1) system DPS: feedback of the control (i)
Device selection (hardware)	(10) SPC (optional): device selection control	(13) SPS (optional): device selection position indication
Enable/disable close with synchrocheck schemes	(14) SPC or (15) DPC (optional): synchrocheck scheme on/off control	(16) SPS or (17) DPS (optional for external S/C): synchrocheck scheme on/off indication
Enable/disable synchrocheck function (internal S/C only) (vi)	(18) SPC: synchrocheck function on/off control for specific CB	(19) SPS: synchrocheck function on/off control for specific CB

5.3.1.1.2 Blocking Open & Close Controls

In **conventional DCS architectures** (TMU220), Three-pole circuit breaker opening and closing can be controlled using **Block Close** (BlkCls) and **Block Open** (BlkOpn) datapoints:

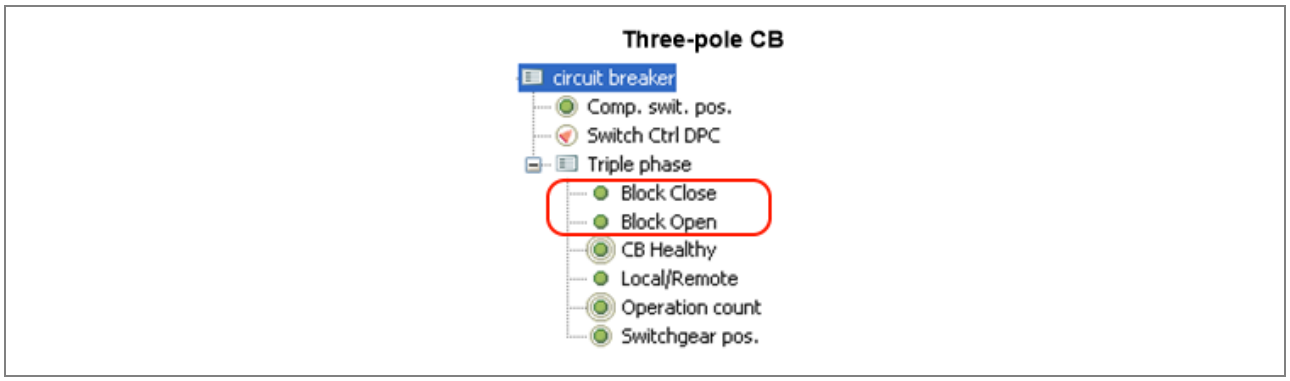


Figure 301: Opening and closing datapoints for a Three-pole circuit breaker

- **Block Close** (SET/RESET): SET to inhibit the circuit breaker closing. Closing control can be used with an FBD automation, the Synchrocheck type 5 and AR type 3 functions. As part of the Synchrocheck type 5, once the **Delay for coupling** timer has elapsed, the message "**Blocked by process 9 Control action is blocked due to some external event at process level that prevents a successful operation**" is sent.
- **Block Open**: (SET/RESET): SET to inhibit the circuit breaker opening

When adding a generic SPS datapoint, some general attributes must be updated:

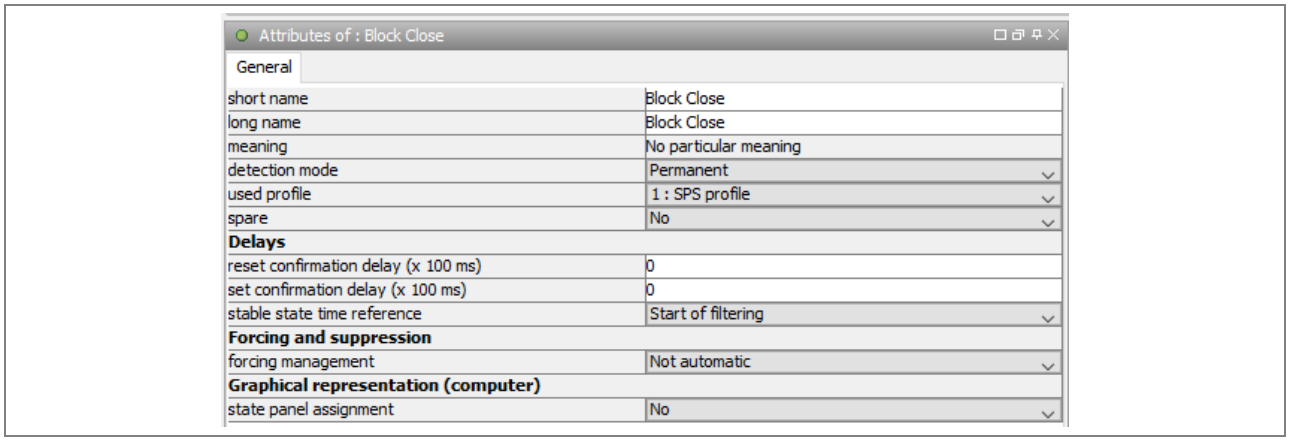


Figure 302: Setting the general attributes of the Block Close SPS datapoint

(9) **short name** and **long name** of the datapoint used for logging, alarms ...

(10) **detection mode** (*Permanent* / *Transient* / *Permanent with computer auto-reset*): when this attribute is set to *Permanent with computer auto-reset* the SPS is reset automatically after 1 ms

(11) **used profile**: the drop-down list refers to the SPS tab of the **Profiles** table

(12) **reset confirmation delay** (range [0 s, 300 s], step 100 ms]: confirmation delay for stable 'reset' state

(13) **set confirmation delay** (range [0 s, 300 s], step 100 ms]: confirmation delay for stable 'set' state

(14) **stable state time reference** (Start of filtering / End of filtering)

(15) **forcing management** *Not automatic* / *Automatic to reset state* / *Automatic to set state*): when an SPS goes to invalid state, C26x can force or not its status to set or reset state automatically. This attribute defines the way this forcing management is done. Automatic forcing management is independent of the FSS enable facility provided in the SPS profile

(16) **state panel assignment** (*No* / *Yes*): set to *Yes* to enable SPS state display at local HMI level

5.3.1.1.3 Single-Pole Circuit-Breaker Definition for Synchrocheck

Single pole circuit-breaker with synchrocheck			
	Outputs to CB 3-p operations	**Outputs to CB 1-p operations (conventional wiring only)**	**Inputs from CB**
Device control	**(2)** DPC: Device open/close control **(11)** SPC: Close control with synchrocheck	**(7)** DPC: open phase A control **(8)** DPC: open phase B control **(9)** DPC: open phase C control **(2)** DPC: close of device control **(11)** SPC: Close control with synchrocheck	**(4)** DPS: physical position of phase A **(5)** DPS: physical position of phase B **(6)** DPS: physical position of phase C **(12)** System SPS: ph not together indication (ii) **(1)** System DPS: control feedback (iii)
Device selection (hardware)	**(10)** SPC: (optional) device selection control	**(10)** SPC (optional): device selection control	**(13)** SPS (optional): device selection position indication
Enable/disable close with synchrocheck schemes (iv)	**(14)** SPC or **(15)** DPC: (optional) synchrocheck scheme on/off control	**(14)** SPC/ **(15)** DPC: (optional) synchrocheck scheme on/off control	**(16)** SPS or **(17)** DPS: (optional for external S/C) synchrocheck scheme on/off indication
Enable/disable synchrocheck function (internal S/C only)	**(18)** SPC: synchrocheck function on/off control for specific CB	**(18)** SPC: synchrocheck function on/off control for specific CB	**(19)** SPS: synchrocheck function on/off control for specific CB

(i) The computed double signal is equal to the state of the CB auxiliary contacts when there is no pole discrepancy, i.e. if the value of **ph not together** is *false*, otherwise the computed signal is equal to *jammed*.

(ii) The computed **ph not together** signal is equal to *false* if all the poles are in the same open or closed position. It is equal to *true* when a pole discrepancy is detected.

(iii) The computed signal is equal to the state of phase A if the state of **ph not together** is equal to “false” (i.e. no pole discrepancy is detected), otherwise the computed signal is equal to “jammed”.

(iv) Wired SPC and SPS for external synchrocheck and system SPC and SPS for internal synchrocheck. If not configured, the external synchrocheck module or the internal synchrocheck function is considered as permanently disabled. DPC & DPS are used only for manual synchrocheck.

The mandatory **Comp. swit. pos.** DPS is implicitly created at circuit-breaker level. It cannot be deleted.

5.3.1.1.4 Configuration rules and checks

- If the physical position of the device is given by an SPS (21), the **ph not together** indication (15) must be configured.
- A Circuit Breaker may only be linked once to a Synchrocheck function (relation **is synchrocheck of**).
- If a Circuit Breaker is linked to an automatic Synchrocheck function (relation **is synchrocheck of**), then its **Sync CB close** SPC datapoint must be present.
- The **Sync CB close** datapoint of a **Circuit breaker** linked to an **Ext manual CS** or **Int synchrocheck** synchrocheck must have its profile attribute **Control mode** set to *Direct Execute* or *Direct Execute with SBO popup*.
- The **Sync CB close** datapoint of a **Circuit breaker** linked to an **Ext auto CS** synchrocheck must have its profile attribute **Control mode** set to *SBO Operate Once*.
- The **Sync CB close** datapoint of a **Circuit breaker** linked to an internal automatic synchrocheck must have its profile attribute **Order off** set to *No*. (Setting it to *Yes* would be nonsensical and as a result the control popup would freeze.)
- All commands (except the **Sync CB close** SPC) under a circuit breaker associated with an automatic synchrocheck or an internal manual synchrocheck must have their **control mode** set to *SBO Operate Once* in their profile. For details on circuit-breaker control, see section *Control Sequences* in the Functional Description chapter of the C264 user manual.

“Open” control sequence for synchronized circuit breakers

This sequence is identical to the sequence for non-synchronized circuit-breakers (see section *5.1.5.5 Defining a circuit-breaker*).

“Close” control sequence for synchronized circuit breakers

This sequence varies depending on the type of synchrocheck configured:

- External synchrocheck: the CB is closed by an external synchrocheck module.
- Internal synchrocheck: the CB is closed by a C26x internal synchrocheck function

The close control sequence can be defined with:

- Manual activation of the external synchrocheck module or internal synchrocheck function.
- Automatic activation of the external synchrocheck module or internal synchrocheck function.

Furthermore, while waiting for the external module to close the CB, the initiator of the request can:

- Cancel the request.
- Force the closing of the device.

5.3.2 CREATING A SYNCHROCHECK FUNCTION

The synchrocheck function can be created at several levels of the electrical topology:

- Substation level:
  - if the synchrocheck function is shared by several breakers (external manual only)
- Bay level:
  - if the synchrocheck function is dedicated to a particular breaker of the bay

To add a synchrocheck function, select the substation or bay level. At substation level, select Built-in function in the contextual **Objects entry** window, expand it and double-click on **Ext manual CS** (external manual synchrocheck, only available synchrocheck option at this level). At bay level, scroll down to Built-in function, expand it, select Synchrocheck Built-in function and expand it.

Double-click on the appropriate function:

- **Ext auto CS**: External automatic synchrocheck
- **Ext manu CS bay**: External manual synchrocheck
- **Int. manu1-2-4**: Internal manual synchrocheck for standard topology

Synchrocheck functions can only be added to the following typed bays:

- Busbar,
- Bus coupler,
- Bus section,
- Feeder,
- Transformer,
- Generic bay.

5.3.3 INTERNAL SYNCHROCHECK AUTOMATION

There are several types of internal synchrocheck:

(1) Internal automatic synchrocheck (not used)

(2) Internal manual synchrocheck for standard topology

(3) Internal manual synchrocheck for breaker-and-a-half topology (not available with system version v7.0.1)

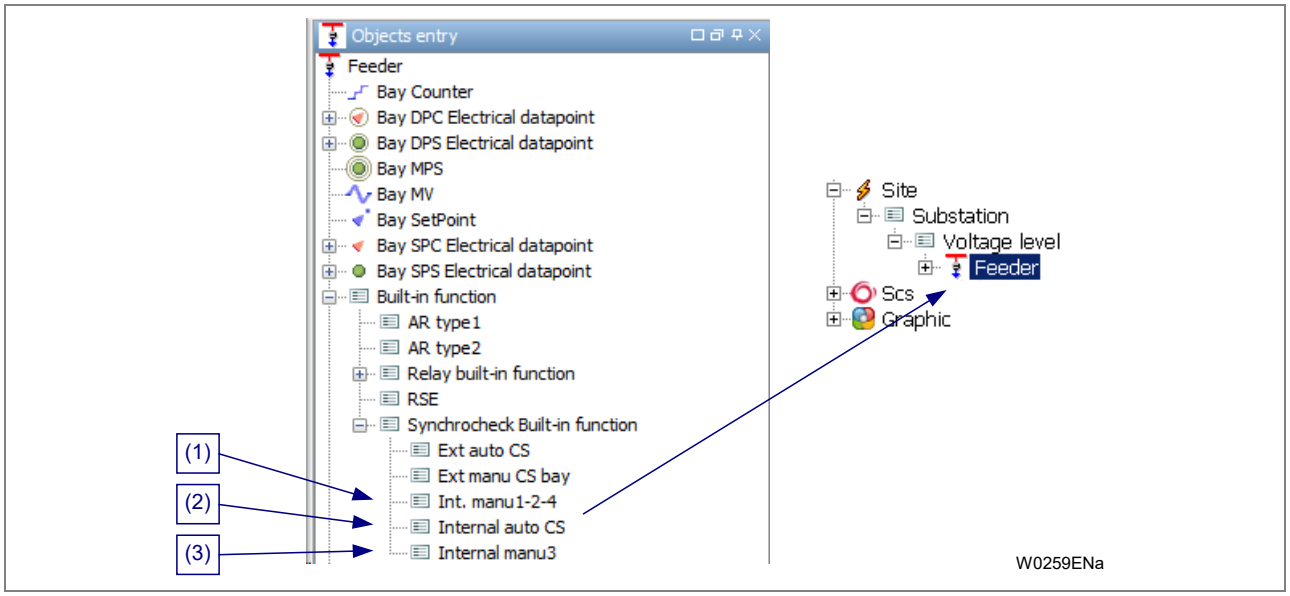


Figure 303: Adding a synchrocheck function at bay level (example for a feeder)

Principle

The above three types of internal synchrocheck can be used in conjunction with the following schemes:

	Close scheme	Close with synchro scheme	Autorecloser
Power system locking for live line - live bus + delta checks	X	X	X
Power system coupling for live line - live bus + delta checks		X	
Live line - dead bus	X	X	X
Dead line - live bus	X	X	X
Dead line - dead bus	X	X	X

The authorized schemes are defined during the configuration process. The behaviour of manual close with synchrocheck is described in the following sections.

Process bus precaution

If a synchrocheck type 1 or type 4 is configured, the circuit-breaker can be managed through an SCU if the “CS locked” datapoint (see below) is used to block the function during communications failures on the Process Bus.

5.3.3.1 INTERNAL SYNCHROCHECK FUNCTION FOR STANDARD CB TOPOLOGY (TYPES 1 AND 4)

5.3.3.1.1 Datapoints

When adding an internal synchrocheck, a number of mandatory system datapoints are automatically created at function level and must be configured (see section *4 Defining a datapoint*). They give information about internal synchrocheck context (both voltage presences and absences) and statuses. They are managed by the C26x that runs the internal synchrocheck.

- **Close order**: Transient SPS, *SET* when a coupling close command is issued
- **CS in progress**: Transient SPS, *SET* when a synchronized closure is in progress
- **on/off main1 SPC**: Enable/disable command for synchrocheck function
- **on/off main1 SPS**: Permanent SPS, synchrocheck function on/off information

Note:
*Do not forget to define **on/off main1 SPS** as feedback of **on/off main1 SPC** if they exist, or as the result of an FBD logic.*

- **on/off sec. SPS** (implicitly created): Permanent SPS, selection of the closing scheme: when the datapoint is *SET*, the enabled **Close with synchro** schemes will be used, when it is *RESET*, the **Close schemes** will be used.

The remaining available datapoints depend on the type of selected synchrocheck (type 1 or type 4).

The following datapoints are mandatory for synchrocheck types 1 and 4. They are automatically created when an **Int. manu1-2-4** synchrocheck function is added to a bay:

- **Possible closing** SPS: Permanent SPS, in locking mode, *SET* when all the conditions after delay are met to authorize synchronized closing
- **Ref. U absence** SPS: Permanent SPS, *SET* when the reference (usually busbar) voltage is absent, i.e. the measured voltage is lower than the set threshold **bus voltage under threshold (%)**
- **Ref. U presence** SPS: Permanent SPS, *SET* when the reference (usually busbar) voltage is present, i.e. the measured voltage is higher than the set threshold **bus voltage over threshold (%)**
- **Voltage absence** SPS: Permanent SPS, *SET* when the main (usually line) voltage is absent, i.e. the measured voltage is lower than the set threshold **line voltage under threshold (%)**
- **Voltage presence** SPS: Permanent SPS, *SET* when the main (usually line) voltage is present, i.e. the measured voltage is higher than the set threshold **line voltage over threshold (%)**

More datapoints can be added from the contextual **Objects entry** window:

Datapoint		S/C Type 1		S/C Type 4
busbar V choice:	Permanent SPS, indicates which busbar input voltage is used: either 0 (*RESET*) = **busbar 1** or 1 (SET) = **busbar 2**. This datapoint is usable **only** if the selected use case is "2 busbar topology" and if the bay controller is equipped with a "TMU220" analogue acquisition module.	✓		✓
Split sync mode:	Permanent SPS, *SET* when Split and Coupling conditions are met.	✓		

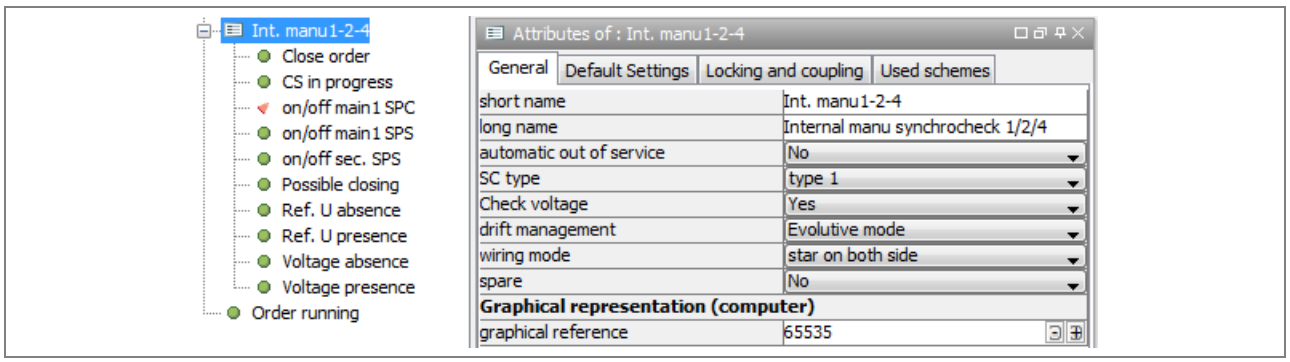
Datapoint		S/C Type 1		S/C Type 4
Delta drift:	Information on frequency delta drift from Coupling range to Locking range, Evolutive mode only (see Synchrocheck functional description in chapter C26x/EN FT).	✓		✓
Locking mode:	Permanent SPS, *SET* when the Locking conditions are met.	✓		✓
on/off sec. SPC:	Selection of the closing scheme: when the datapoint is *SET*, the enabled **Close with synchro** schemes will be used, when it is *RESET*, the **Close schemes** will be used.	✓		✓
on/off sec. DPC:	Selection of the closing scheme: when the datapoint is CLOSED, the enabled **Close with synchro** schemes will be used, when it is OPEN, the **Close schemes** will be used.	✓		✓
CS locked:	Permanent SPS, *SET* when the Synchrocheck function is blocked. When SET, it prevents the synchrocheck algorithms from starting, and thus prohibits CB closing. In addition, if it becomes *SET* while a synchronism check is in progress, the check is terminated with a negative acknowledge, and no close command is sent to the CB.	✓		✓
Fusion first U:	Permanent SPS, fuse failure information for main (usually line) voltage transformer.	✓		✓
Fusion ref U:	Permanent SPS, fuse failure information for reference (usually busbar) voltage transformer.	✓		✓

5.3.3.1.2 Attribute parameters

The default settings for the internal synchrocheck function are dependent on the parameters for the corresponding automation.

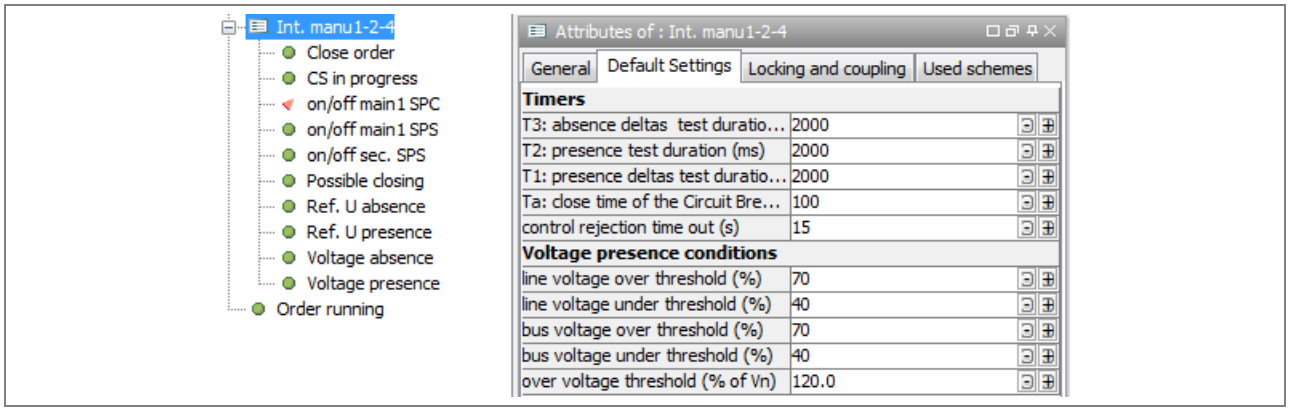
When adding an internal synchrocheck, the following specific attributes must be updated:

General attributes



- **automatic out of service** (*No* / *Yes*)
- **SC type**: there are two types of internal manual synchrocheck features for standard breaker topology:
  - *type 1* (standard variant with split mode)
  - *type 2* (frequency shift-based, not available with system version v7.0.1)
  - *type 4* (standard variant with overvoltage threshold and “retry” timeout)
- **Check voltage**: Check the voltage conditions in the synchrocheck process (*No* / *Yes*)
- **drift management**: mode used to manage drift between locking and coupling ranges:
  - *Exclusive mode*
  - *Evolutive mode*
  - *Split mode* (type 1 only)
- **wiring mode**: VT connection arrangements on line and busbar sides:
  - *star on both side*
  - *delta on both side*
  - *star on line – delta on busbar*
  - *delta on line – star on busbar*

Default Settings



Timers

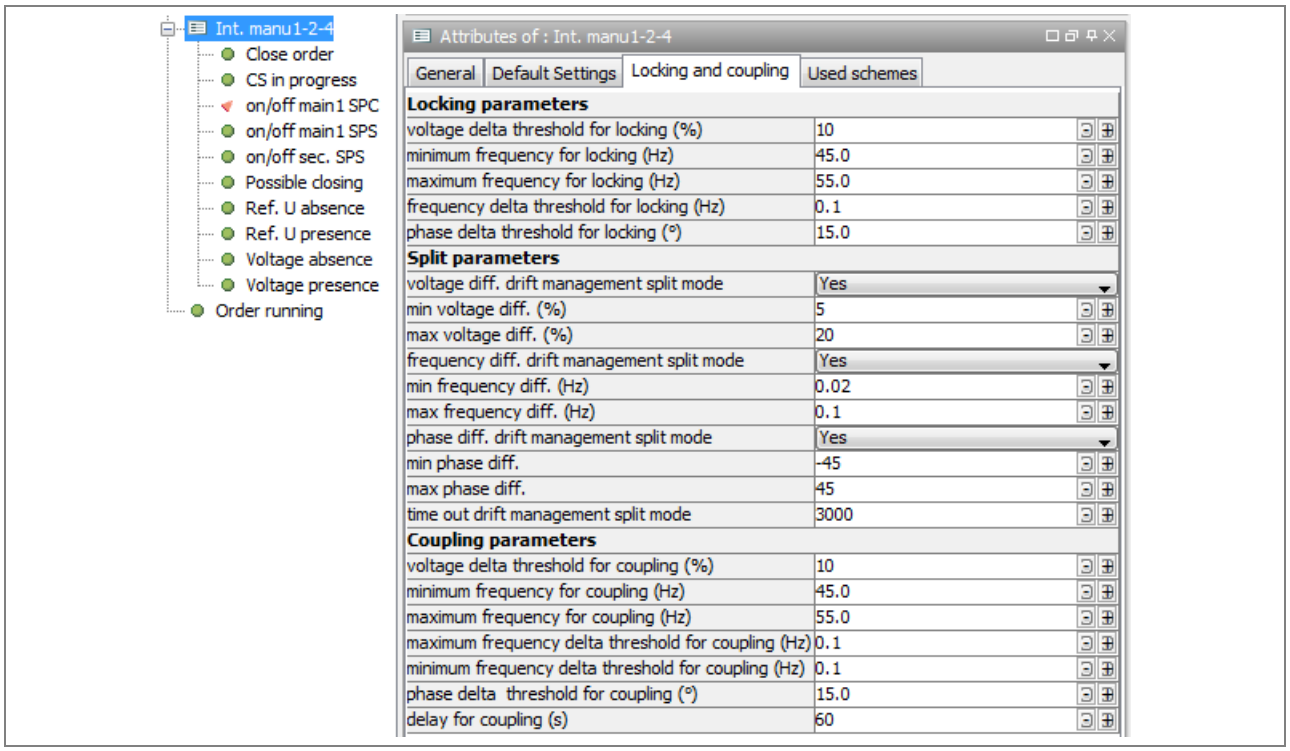
	Type 1	Type 4
• **T3: absence deltas test duration (ms)** (range [200 ms, 10 s], step 20 ms)	✓	✓
• **T2: presence test duration (ms)** (range [200 ms, 10 s], step 20 ms)	✓	✓
• **T1: presence deltas test duration (locking) (ms)** (range [20 ms, 10 s], step 10 ms)	✓	✓
• **Ta: close time of the Circuit Breaker (ms)** (range [0, 1 s], step 10 ms)	✓	✓
• **control rejection time out (s)** (range [0, 60 s], step 1 s)		✓

Note:
The control rejection time out (s) must be set to a higher value than the three confirmation timers, T1, T2 and T3, otherwise it may expire before a closing condition can be confirmed and thus systematically prevent CB closing.

Voltage presence conditions

	Type 1		Type 4
• **line voltage over threshold (%)** (range [0, 100% Vn], step 1% Vn)	✓		✓
• **line voltage under threshold (%)** (range [0, 100% Vn], step 1% Vn)	✓		✓
• **bus voltage over threshold (%)** (range [0, 100% Vn], step 1% Vn)	✓		✓
• **bus voltage under threshold (%)** (range [0, 100% Vn], step 1% Vn)	✓		✓
• **over voltage threshold (% of Vn)** (range [100, 150% Vn], step 1% Vn)			✓

Coupling and locking



Locking parameters

	Type 1		Type 4
• **voltage delta threshold for locking (%)** (range [0, 100% Vn], step 1% Vn)	✓		✓
• **minimum frequency for locking (Hz)** (range [45, 59.5 Hz], step 0.1 Hz)	✓		✓
• **maximum frequency for locking (Hz)** (range [50.5, 66 Hz], step 0.1 Hz)	✓		✓
• **frequency delta threshold for locking (Hz)** (range [0, 1 Hz], step 0.01 Hz)	✓		✓
• **phase delta threshold for locking (°)** (range [0, 90°], step 1°)	✓		✓

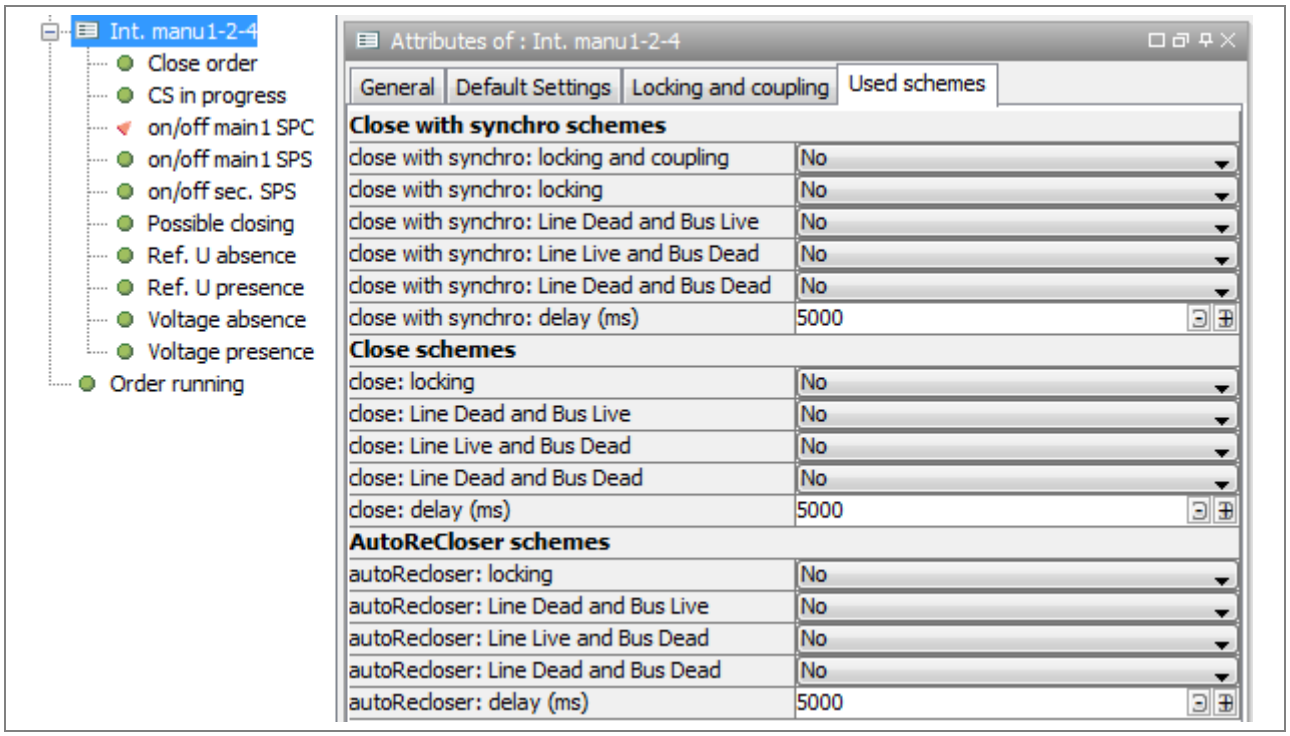
Split parameters (type 1 only)

- **voltage diff. drift management split mode** (*No* or *Yes*)
- **min voltage diff. (%)** (range [0, 100% Vn], step 1% Vn)
- **max voltage diff. (%)** (range [0, 100% Vn], step 1% Vn)
- **frequency diff. drift management split mode** (*No* or *Yes*)
- **min frequency diff. (Hz)** (range [0, 1 Hz], step 0.01 Hz)
- **max frequency diff. (Hz)** (range [0, 1 Hz], step 0.01 Hz)
- **phase diff. drift management split mode** (*No* or *Yes*): This attribute must be set to *Yes* if split mode is used.
- **min phase diff.** (range [0, -180°], step 1°)
- **max phase diff.** (range [0, 180°], step 1°)
- **time out drift management split mode** (range [0, 10000 ms], step 100 ms)

Coupling parameters

	Type 1	Type 4
• **voltage delta threshold for coupling (%)** (range [0, 100% Vn], step 1% Vn)	✓	✓
• **minimum frequency for coupling (Hz)** (range [45, 59.5 Hz], step 0.1 Hz)	✓	✓
• **maximum frequency for coupling (Hz)** (range [50.5, 66 Hz], step 0.1 Hz)	✓	✓
• **maximum frequency delta threshold for coupling (Hz)** (range [0, 1 Hz], step 0.01 Hz)	✓	✓
• **minimum frequency delta threshold for coupling (Hz)** (range [0, 1 Hz], step 0.01 Hz)	✓	✓
• **phase delta threshold for coupling (°)** (range [0, 90°], step 1°)	✓	
• **delay for coupling (s)** (range [1 s, 3600 s], step 1 s)	✓	✓

Used schemes



Close with synchro schemes

- **close with synchro: locking and coupling** (*No* or *Yes*)
- **close with synchro: locking** (*No* or *Yes*)
  (only visible if **close with synchro: locking and coupling** is set to *No*)
- **close with synchro: Line Dead and Bus Live** (*No* or *Yes*)
- **close with synchro: Line Live and Bus Dead** (*No* or *Yes*)
- **close with synchro: Line Dead and Bus Dead** (*No* or *Yes*)
- **close with synchro: delay (ms)** (range [200 ms, 10 s], step 10 ms)

Close schemes

- **close: locking** (*No* or *Yes*)
- **close: Line Dead and Bus Live** (*No* or *Yes*)
- **close: Line Live and Bus Dead** (*No* or *Yes*)
- **close: Line Dead and Bus Dead** (*No* or *Yes*)
- **close: delay (ms)** (range [200 ms, 10 s], step 10 ms)

AutoRecloser schemes

- **autoRecloser: locking** (*No* or *Yes*)
- **autoRecloser: Line Dead and Bus Live** (*No* or *Yes*)
- **autoRecloser: Line Live and Bus Dead** (*No* or *Yes*)
- **autoRecloser: Line Dead and Bus Dead** (*No* or *Yes*)
- **autoRecloser: delay (ms)** (range [200 ms, 10 s], step 10 ms)

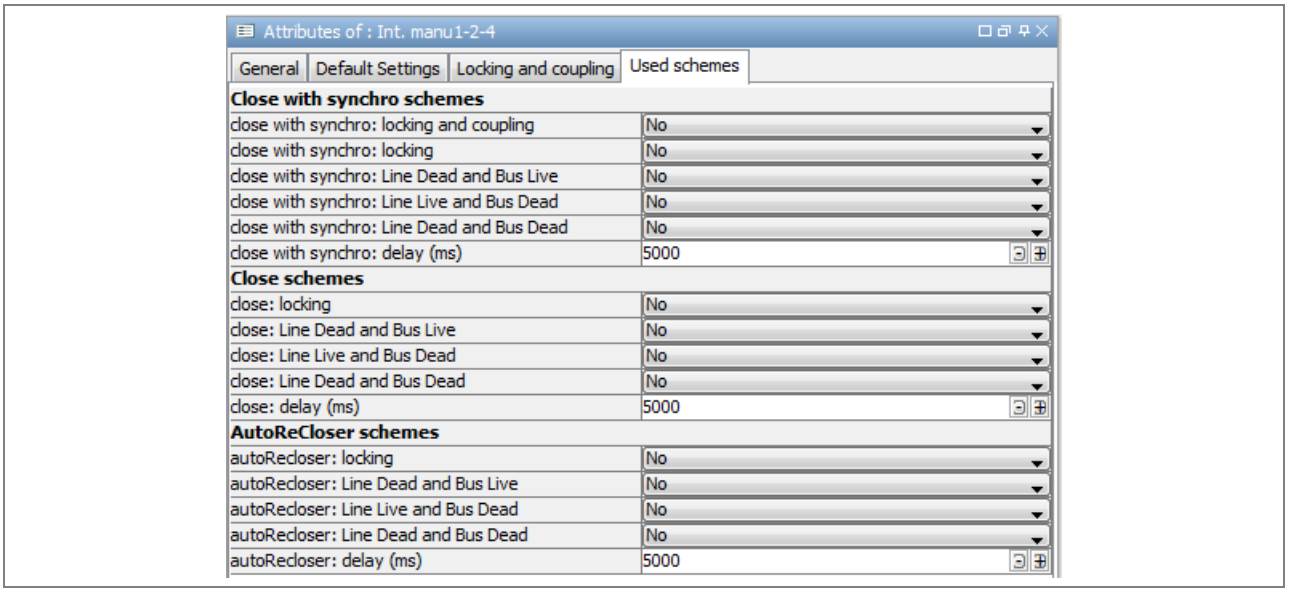


Figure 304: Setting the used schemes attributes of an internal synchrocheck function (types 1, 2 and 4)

5.3.3.2 INTERNAL SYNCHROCHECK FUNCTION FOR BREAKER-AND-A-HALF TOPOLOGY (TYPE 3)

NOT AVAILABLE WITH SYSTEM VERSION V7.0.x

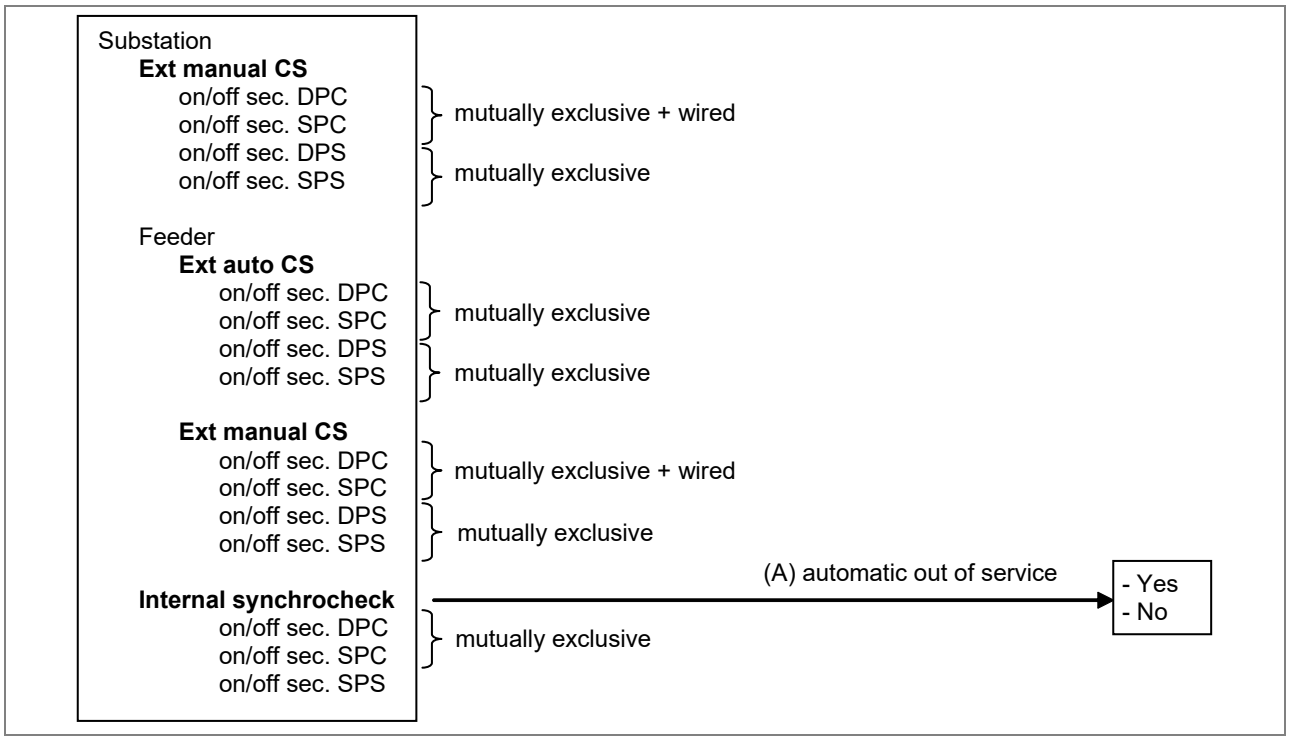
5.3.3.3 GENERAL RULES FOR CB DATAPOINT CONFIGURATION

The difference between the automatic synchrocheck and the manual synchrocheck is in the way it is set up: The Internal Manual S/C function uses the datapoint **on/off sec. SPC/DPC** to enable (if SET) or disable (if RESET) the use of the set synchronizing schemes to authorise closing whereas the Internal Automatic S/C function automatically sets **on/off sec. SPC/DPC** to SET and uses the **Sync CB Close** SPC to issue the close command.

	Automatic Synchrocheck	Manual Synchrocheck
Synchrocheck	The 4 SPS datapoints that give the dead/live status for busbar/line must have a profile with initial status = RESET	
	on/off sec. SPS: profile with initial status = SET	on/off sec. SPC/DPC with on/off sec. SPS/DPS for feedback (no need to have initial status = SET; it depends on the customer's requirements)
Circuit-Breaker	The Sync CB Close SPC has no IEC 61850 address. It is used to set the synchrocheck bits in the IEC 61850 command message. The profile for the Sync CB Close SPC must be the same as for Switch Ctrl DPC with regards to DE/SBO. They must also be controlled by the same pop-up. The SCADA address of the "close with synchrocheck" command is an SPC SCADA address.	There is no Sync CB Close SPC. - When on/off sec. SPS/DPS is SET, Switch Ctrl DPC is considered to be "close with synchrocheck" - When on/off sec. SPS is RESET, Switch Ctrl DPC is considered to be "close without synchrocheck" The SCADA address of the "close with synchrocheck" command is a DPC SCADA address.

Configuration rules and checks

- As shown in the diagram below, under a Synchrocheck function, some datapoints are mutually exclusive and some must be wired. Here, "wired" means that the datapoint must be linked to a digital/analogue channel of a C26x, or linked to an IED address



- For an internal synchrocheck function, having its **automatic out of service** attribute set to the *Yes*, the **on/off sec. DPC** or **on/off sec. SPC** datapoint must be present.
- The **on/off sec. DPC** or **on/off sec. SPC** datapoint for internal synchrocheck must have its profile attribute **SBO mode** set to *Direct Execute* or *Direct Execute with SBO popup*

5.3.4 EXTERNAL SYNCHROCHECK

5.3.4.1 DATAPOINTS

External synchrocheck has equivalent datapoints and settings for the three available functions:

(1) **Ext manual CS**: manual external synchrocheck at substation level

(2) **Ext auto CS**: automatic synchrocheck at bay level

(3) **Ext manu CS Bay**: manual synchrocheck at bay level

At substation level, only 'external manual synchrocheck' is available:

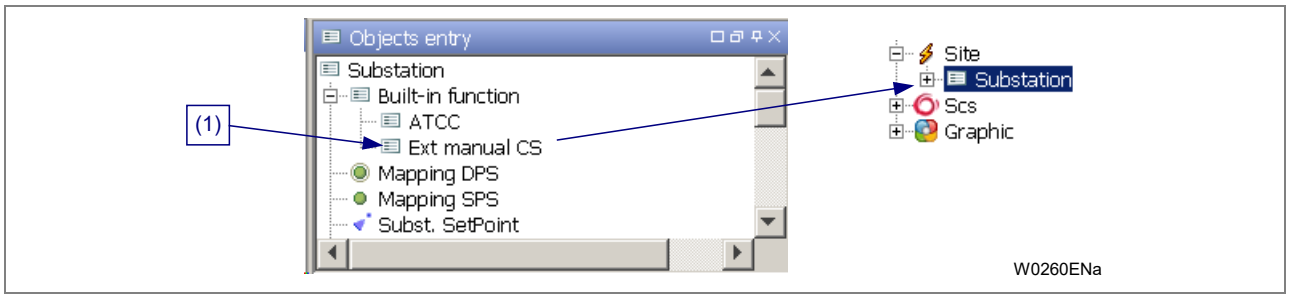


Figure 305: Adding an external synchrocheck function at substation level

At bay level, two types of external synchrocheck functions are available: manual and automatic.

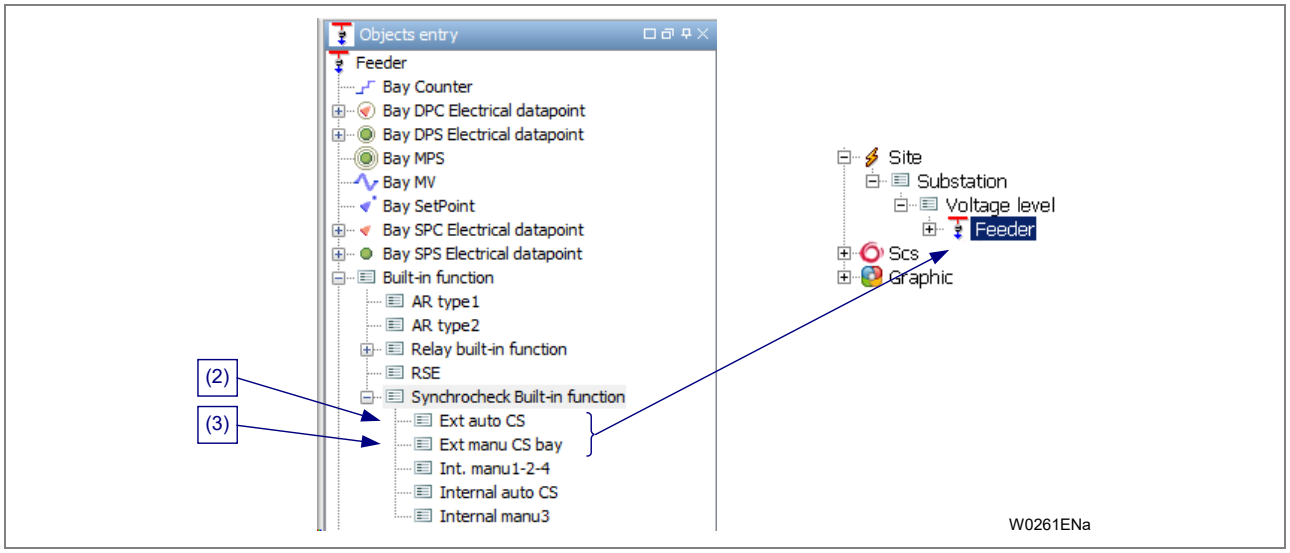


Figure 306: Adding an external synchrocheck function at bay level

Select the substation or bay and insert the relevant external manual synchrocheck field from the contextual **Objects entry** window, under **Synchrocheck Built-in function**. When adding an external synchrocheck function, no compulsory datapoint is implicitly created. Five functional datapoints are available that can be added from the contextual Objects entry window:

(1) **on/off sec. DPC**: globally enable/disable the synchrocheck function via a DPC

(2) **on/off sec. DPS** (external synchrocheck only): global in/out of service status of the synchrocheck function via a DPS

(3) **on/off sec. SPC**: globally enable/disable the synchrocheck function via an SPC

(4) **on/off sec. SPS**: global in/out of service status of the synchrocheck function via an SPS

Do not forget to define **on/off sec. SPS/DPS** as feedback of **on/off sec. SPC/DPC** if they exist.

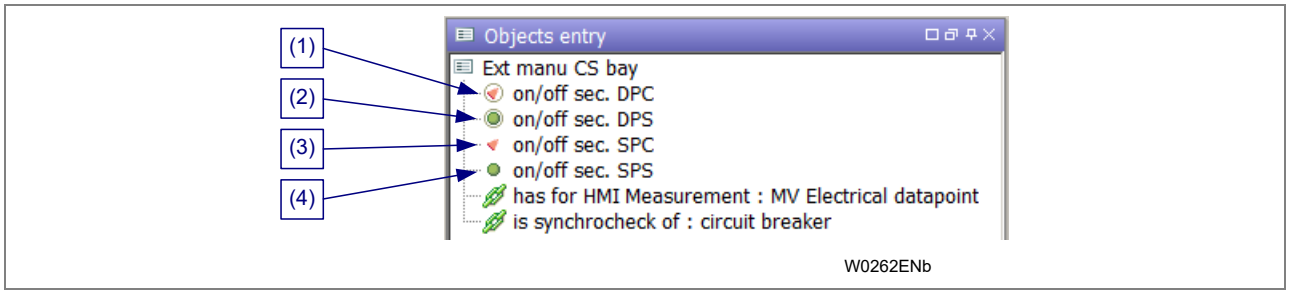


Figure 307: Synchrocheck optional datapoints

Note:
Automatic synchrocheck offers the possibility to automatically select the default closing schemes. It has no relation to automatic reclosing of circuit-breakers upon electrical faults.

5.3.4.2 ATTRIBUTE PARAMETERS

Once added, external synchrocheck general features must be set at SCE level:

(1) Fill in the relation **is synchrocheck of**, indicating which circuit-breaker module is concerned by the function. For substation synchrocheck, several relations **is synchrocheck of** can be added and filled in for all the circuit-breakers managed by the same synchrocheck. For bay synchrocheck, one or two relations **is synchrocheck of** can be filled in for the circuit-breakers of two different bays. Nevertheless, these bays must be managed by the same C26x, and the same synchrocheck parameters will be used to close both circuit-breakers.

(2) **short name** and **long name** of the synchrocheck used for logging, alarms ...

(3) **automatic out of service** (*No* / *Yes*): defines whether the synchrocheck is disabled manually (*No*) or automatically (*Yes*). When it is manually disabled, an extra sequence is performed by the C26x (see above sections). For automatic synchrocheck, it is fixed to *Yes*.

(4) **running time** (range [0, 60s], step 1 s): it is visible when **automatic out of service** is set to *Yes*. It corresponds to a time-delay before disabling the synchrocheck after a successful or unsuccessful close command of the synchronized breaker.

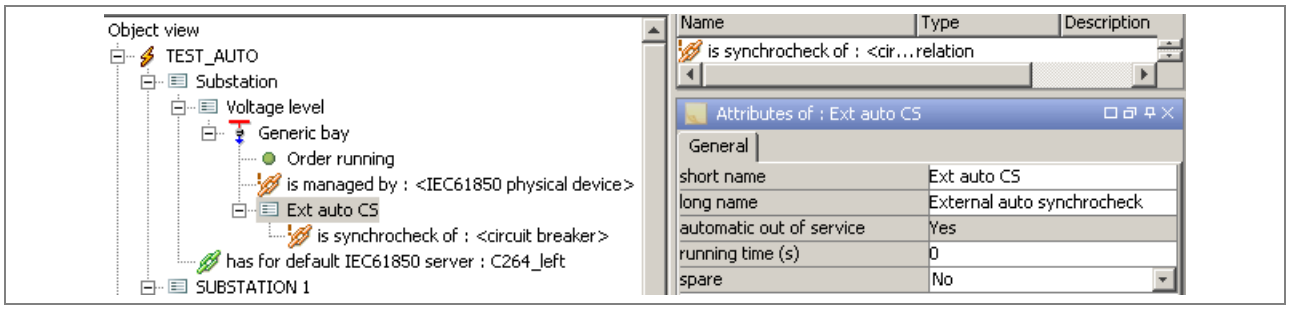


Figure 308: Setting synchrocheck general features (example for an external automatic synchrocheck at bay level)

5.3.5 SYNCHROCHECK POP-UP IN AVIEW

In order to display the synchrocheck measurements in the form of a “synchroscope” on aView, the synchrocheck function (**Int. manu1-2-4**) must be linked to the 3 measurements:

- *frequency_difference (Standard Synchrocheck)* (or *signed dV*)
- *voltage difference (Standard Synchrocheck)* (or *signed dF*)
- *phase difference (Standard Synchrocheck)* (or *signed dPhi*)

by the relation **has for HMI Measurement : MV Electrical datapoint**.

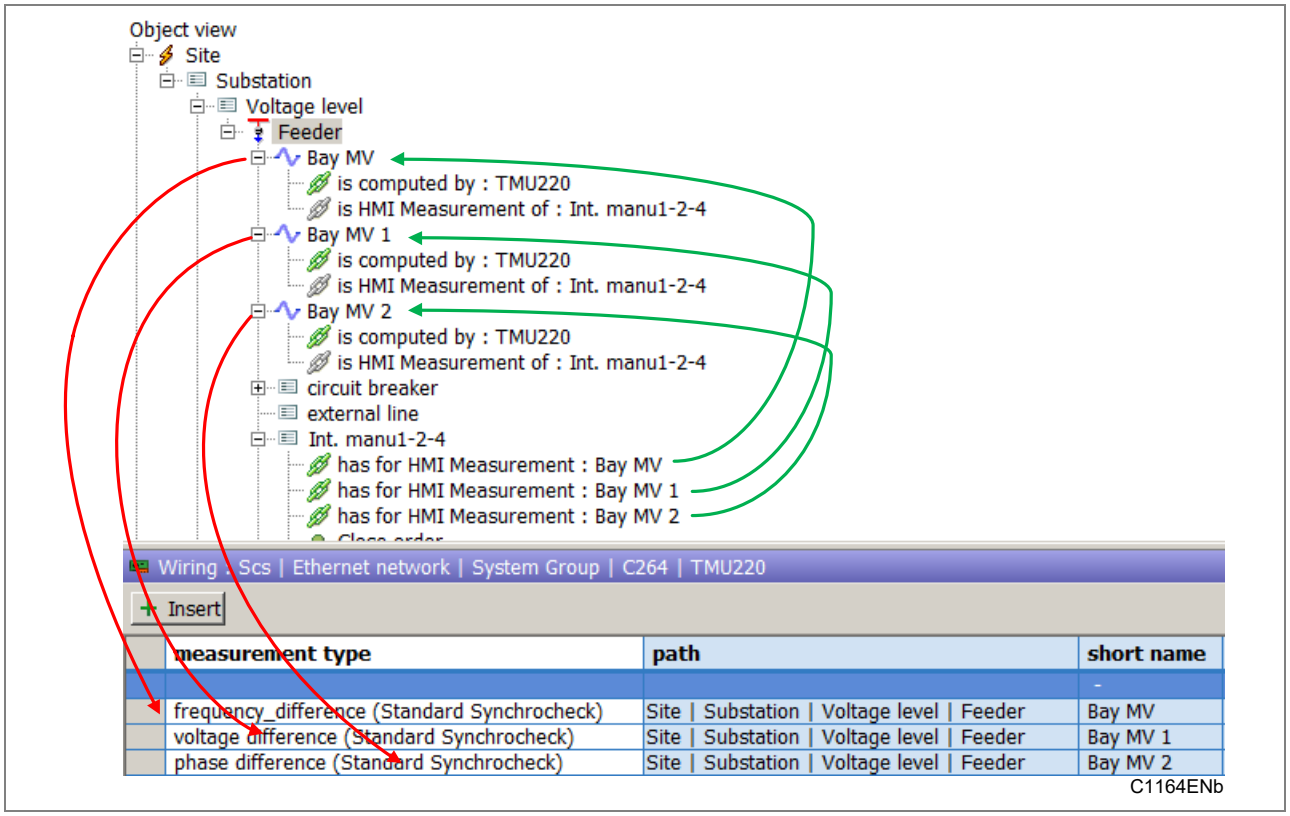


Figure 309: Linking the synchrocheck function to aView

5.3.6 ADDING A SYNCHROCHECK TYPE 5 FUNCTION

The Synchrocheck type 5 function can only be added to the following bays:

- Bus coupler,
- Feeder,
- Transformer,
- Generic bay,
- Capacitor bank (SC type 5 only),
- Shunt (SC type 5 only).

Based on Synchrocheck type 4, the Synchrocheck type 5 built-in function is used in conventional DCS architectures.

The Synchrocheck can be used with Synchrocoupler function depending on configuration to check the network synchronism and control the CB reclosing synchronism schemes conditions.

The SC type 5 runs with a permanent mode and reacts to manual closing orders transmitted by the operator, or to automatic CB reclosing sent by the AR function.

To add a synchrocheck function at bay level:

- Scroll down to **Built-in function** expand the folder;
- Expand the **Synchrocheck Built-in function** folder and double-click on the **SC type 5**.

5.3.6.1 DATAPOINTS

When adding a SC type 5 built-in function, a number of mandatory datapoints are automatically created at function level and must be configured. They give information about the synchrocheck context (voltage presence and absence) and statuses. They are managed by the C264 that runs the synchrocheck function.

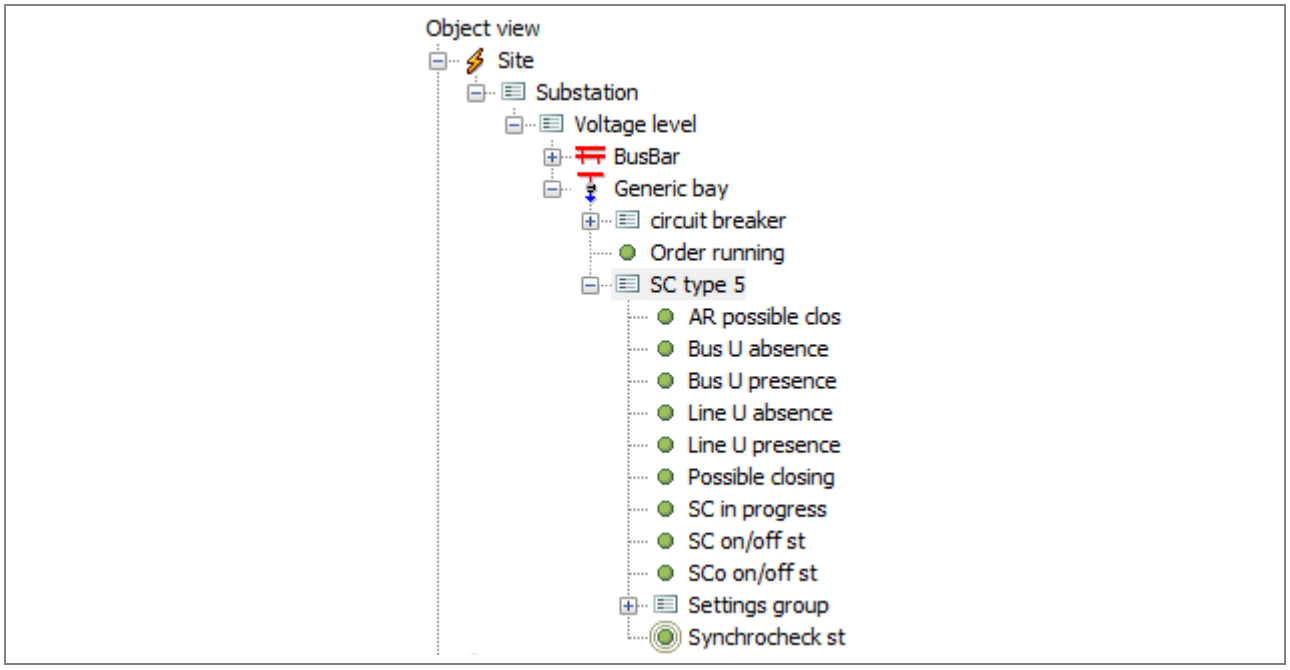


Figure 310: Default SC type 5 datapoints

- **AR possible clos**: Permanent SPS used for possible closing by Synchrocheck function with AR. This datapoint is *SET* when all the automatic voltage condition(s) after delay are met to authorize synchronized closing and RESET in case of manual recloser.
- **Bus U absence**: Permanent SPS, *SET* when the reference (usually busbar) voltage is absent, i.e. the measured voltage is lower than the set threshold **busbar voltage under threshold (% Vn)**
- **Bus U presence**: Permanent SPS, *SET* when the reference (usually busbar) voltage is present, i.e. the measured voltage is higher than the set threshold **busbar voltage over threshold (% Vn)**
- **Line U absence**: Permanent SPS, *SET* when the main (usually line) voltage is absent, i.e. the measured voltage is lower than the set threshold **line voltage under threshold (% Vn)**
- **Line U presence**: Permanent SPS, *SET* when the main (usually line) voltage is present, i.e. the measured voltage is higher than the set threshold **line voltage over threshold (% Vn)**
- **Possible closing**: Permanent SPS, *SET* when all the manual or automatic voltage condition(s) after delay are met to authorize synchronized closing (used for the physical contacts of the Synchrocheck relay put in serial with circuit breaker coil circuitry, to reinforce the security of reclosing order).
- **SC in progress**: Permament SPS, *SET* when a synchronized closure is in progress (voltage control, locking or coupling).
- **SC on/off st**: Permanent SPS, synchrocheck function on/off information.
- **SCo on/off st**: Permanent SPS, synchrocoupler function on/off information
- **Synchrocheck st**: MPS indicating the Synchrocheck status:
  - *synchrocheck-ready (in service and unlocked)*
  - *synchrocheck-bypass*
  - *synchrocheck-in-progress*
  - *synchrocheck-ok (positive acknowledge for CB reclosing request)*
  - *synchrocheck-ko (negative acknowledge for CB reclosing request)*
  - *synchrocheck-locked*

Note:

- If the **SC on/off co** and/or **SCo on/off co** control datapoints are not configured, the **Synchrocheck** or **Synchrocheck/Synchrocoupler** (depending on configuration attribute) function is considered as “enabled” by default.
- If the **SC on/off co** or **SCo on/off co** control datapoint is/are received with an invalid state, the synchrocheck function is locked.

Optional SPSdatapoints can be added from the contextual **Objects entry** window:

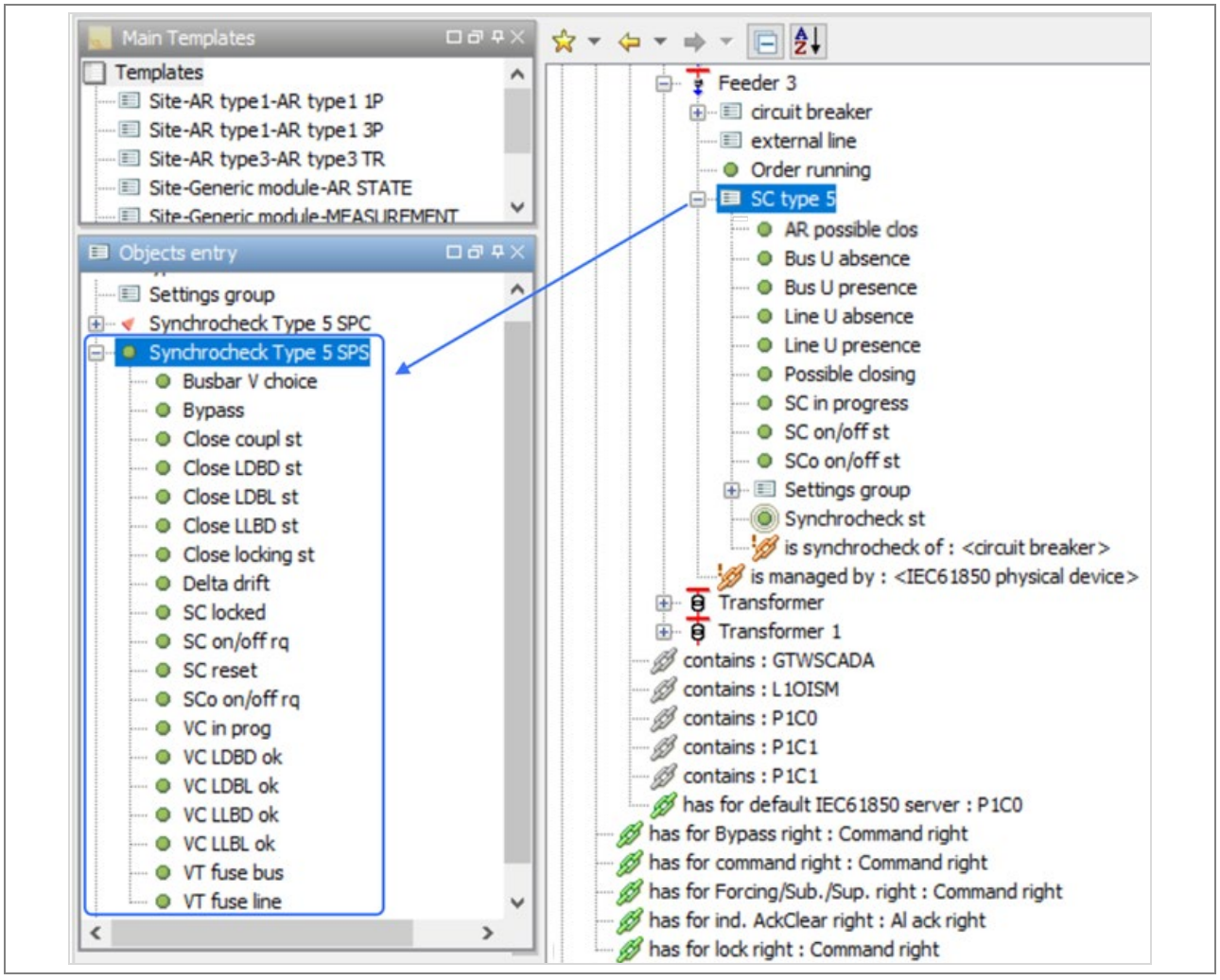


Figure 311: Optional Synchrocheck Check type 5 SPS datapoints

- **Busbar V choice**: Permanent SPS, indicates which busbar input voltage is used: either 0 (*RESET*) = **busbar 1** or 1 (SET) = **busbar 2**. This datapoint is usable **only** if the selected use case is "2 busbar topology" and if the bay controller is equipped with a "TMU220" analogue acquisition module.
- **Bypass**: Permanent SPS, when this datapoint is SET, the voltage check is bypassed, i.e. ignored, to allow CB closure.
- **Close coupl st**: State of the closing scheme during coupling conditions.
- **Close LDBD st**: State of the closing scheme during dead line/dead bus conditions.
- **Close LDBL st**: State of the closing scheme during dead line/ live bus conditions.
- **Close LLBD st**: State of the closing scheme during live line/dead bus conditions.
- **Close locking st**: State of the closing scheme during locking conditions.
- **Delta drift**: Information on frequency delta drift from Coupling to Locking conditions, Evolutive mode only (see Synchrocheck functional description in chapter C26x/EN FT).

- **SC locked**: Permanent SPS, *SET* when the Synchrocheck function is blocked. When SET, it prevents the synchrocheck algorithms from starting, and thus prohibits CB closing. In addition, if it becomes *SET* while a synchronism check is in progress, the check is terminated with a negative acknowledge, and no close command is sent to the CB.
- **SC on/off rq**: SPS. Enables or disables the synchrocheck.
- **SC reset**: Transient SPS. Indicates a synchrocheck cycle reset (can be added to the Synchrocoupler function).
- **SCo on/off rq**: SPS. Enables or disables the synchrocoupler.
- **VC in prog**: SPS indicating that a search for voltage conditions is in progress.
- **VC LDBD ok**: SPS. State of voltage conditions in case of dead line/dead bus scheme.
- **VC LDBL ok**: SPS. State of voltage conditions in case of dead line/live bus scheme.
- **VC LLBL ok**: SPS. State of voltage conditions in case of live line/live bus scheme.
- **VT fuse bus**: SPS. State of the line voltage fuse. If a miniature circuit breaker (MCB) is tripped on the secondary side of VT transducer located on the line, the synchrocheck/Synchrocoupler function is locked.
- **VT fuse line**: SPS. State of the busbar voltage fuse. If a miniature circuit breaker (MCB) is tripped on the secondary side of VT transducer located on the busbar, the synchrocheck/Synchrocoupler function is locked.

Optional SPC datapoints can be added from the contextual **Objects entry** window:

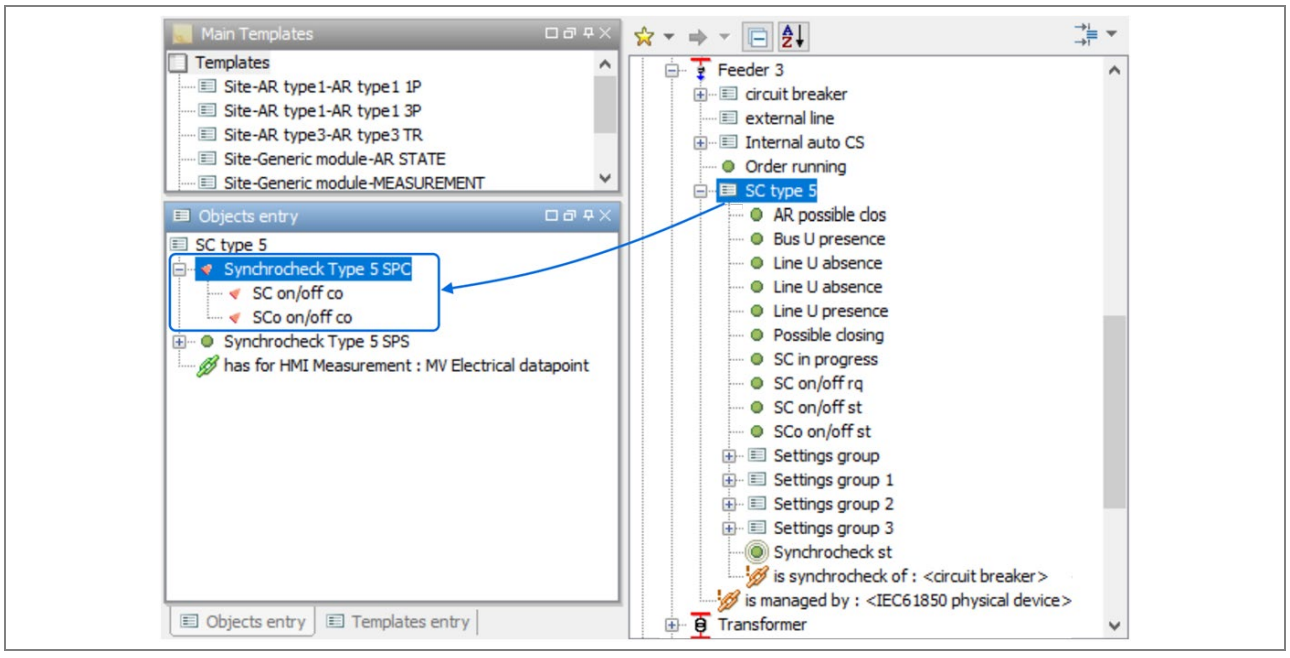


Figure 312: Optional Synchrocheck Check type 5 SPC datapoints

- **SC on/off co**: SPC. Enables or disables the Synchrocheck.
- **SCo on/off co**: SPC. Enables or disables the Synchrocoupler.

5.3.6.2 ATTRIBUTES PARAMETERS

Once added, synchrocheck type 5 general features can be set at SCE level:

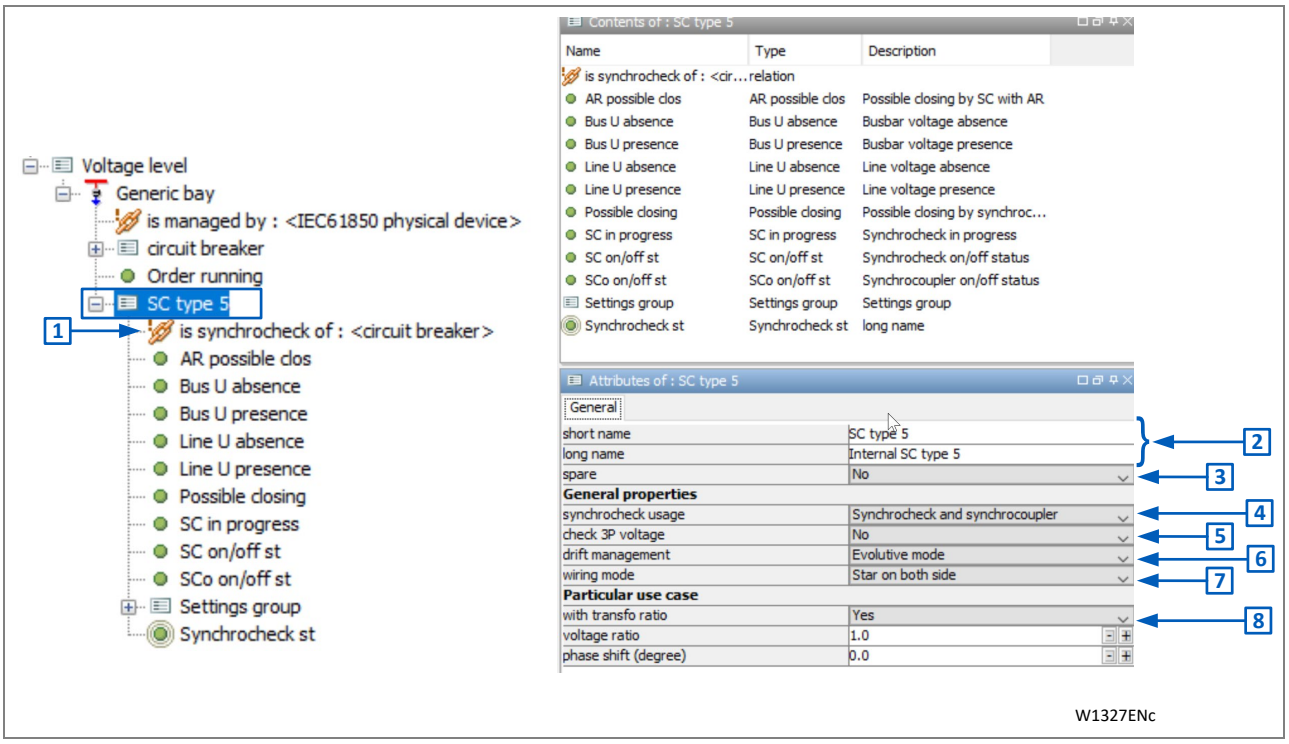


Figure 313: "SC type 5" function attributes

(1) Fill in the relation **is synchrocheck of**, indicating which circuit-breaker module is concerned by the function. Note that a "**SC type 5**" function can be linked to only one CB of a same Bay and only one "SC type 5" function can be used per bay. If the C264 manages two bays, then a "SC type 5" function can be created in each bay.

(2) **short name** and **long name** of the synchrocheck used for logging, alarms ...

(3) **automatic out of service** (*No* / *Yes*): defines whether the synchrocheck is disabled manually (*No*) or automatically (*Yes*). When it is manually disabled, an extra sequence is performed by the C26x (see above sections). For automatic synchrocheck, it is fixed to *Yes*.

(4) **Synchrocheck usage**: defines the synchrocheck type. There are two types of synchrocheck features for standard breaker topology:

- *Synchrocheck only*
- *Synchrocheck & Synchrocoupler*

(5) **Check 3P voltage** (*No* / *Yes*): checks the line voltage condition on the three phases during the synchrocheck process.

- *No: the line voltage condition is tested on a single "reference phase" (A or B, or C), according to the over and under voltage thresholds defined at function level.*
- *Yes: the line voltage condition is tested on the three phases (A and B and C), according to the over and under voltage thresholds defined at function level.*

(6) **drift management**: mode used for managing frequency drift between locking and coupling ranges:

- *Exclusive mode*
- *Evolutive mode*

(7) **wiring mode**: VT connection arrangements on line and busbar sides:

- *star on both side*
- *delta on both side*

(8) **with transformer ratio**: when VTs are on either side of a transformer, the SC function takes into account the transformation ratio and the possible phase displacement to compare voltages.
With transformer ratio set to **Yes**:

- The attributes "**Voltage ratio (V)**" defines the ratio between the secondary voltage of VT located at secondary side of power transformer AND the secondary voltage of VT located at primary side of power transformer.

  Example:

  VT at **primary** side of power transformer: 150 000 / 110V (delta)
  VT at **secondary** side of power transformer: 70 000 / 63,5V (star)
  Voltage ratio (V) = 63,5V / 110V = **0,577**

- The attribute "**phase shift (degree)**" defines the phase shift (leading=positive, lagging=negative) of voltage vectors, between VT located at secondary side of power transformer vs voltage of VT located at primary side of power transformer. By convention, the primary vector is taken as reference (phase = 0°)

5.3.6.3 SETTING GROUP

The Synchrocheck built-in function checks the network synchronism according different settings.

When adding a SC type 5 function, a default setting group is created. You may add up to 4 setting groups per SC type 5 function but only one setting group may be active at a time.

The setting groups activation status can be monitored by dedicated datapoints, which can be modified by online parameter (MiCOM S1).

5.3.6.3.1 Datapoints

When adding a SC type 5 built-in function, a number of datapoints are automatically created at setting group level and must be configured (see section *4 Defining a datapoint*):

- **Settings grp co**: Transient SPC to enable/disable the setting group.
- **Settings grp st**: Permanent SPS indicating the setting group state

Note: Link the control with the status datapoint via the relation "has for feedback".

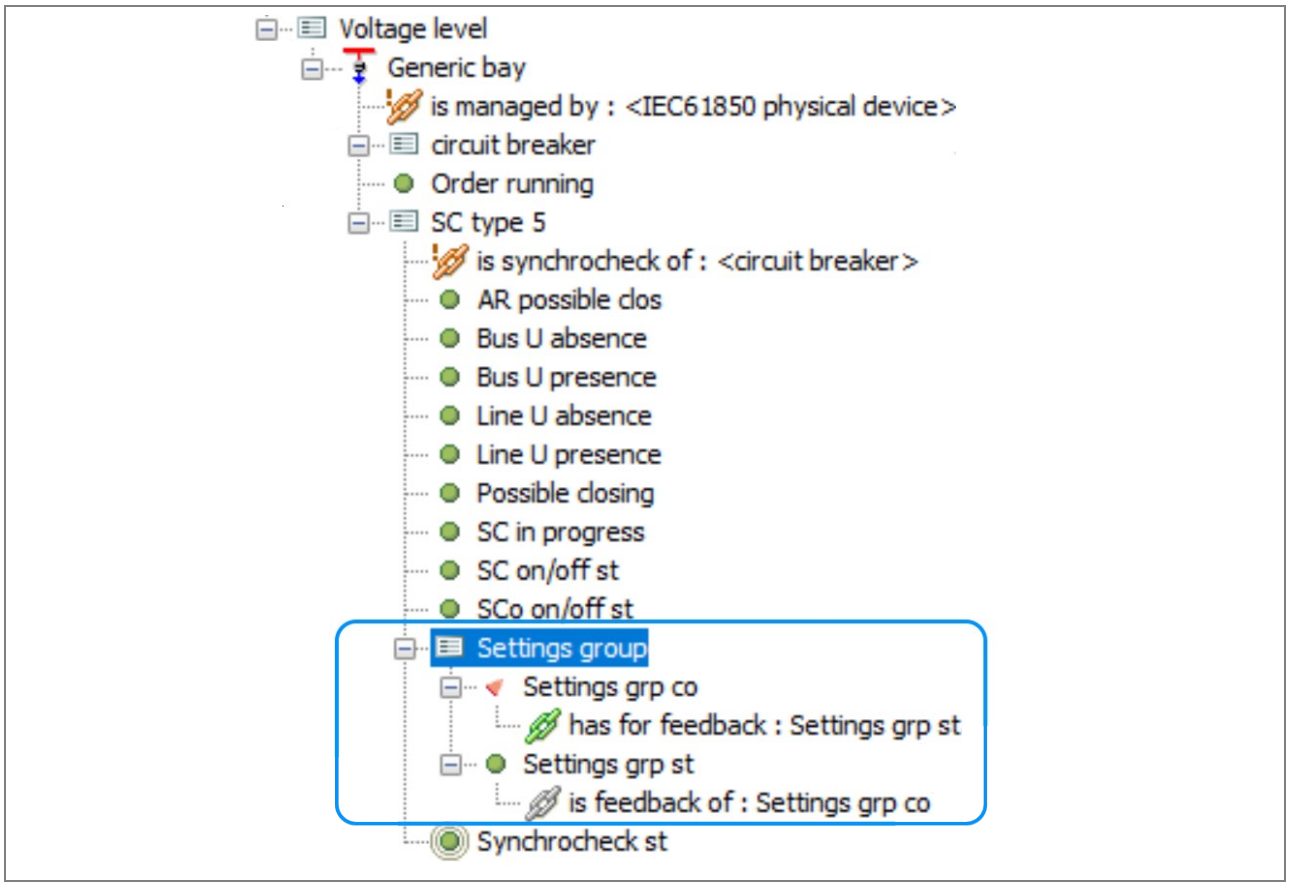


Figure 314: Default setting group datapoints

5.3.6.4 ATTRIBUTE PARAMETERS

5.3.6.4.1 General attributes

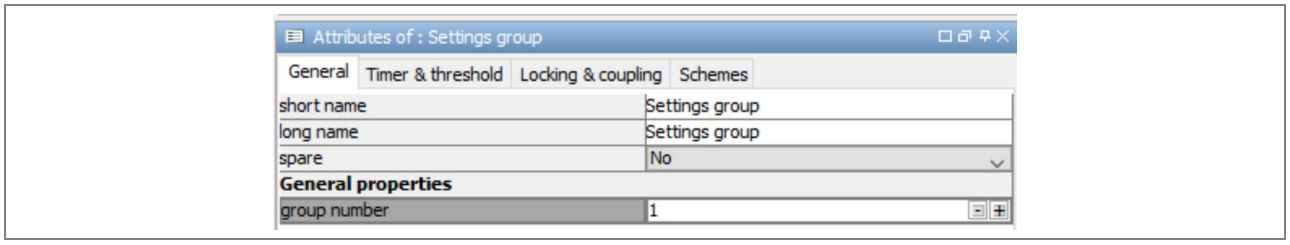


Figure 315: Setting group general attributes

- **short name** and **long name** of the setting group
- **group number**: settings group number for identification

5.3.6.4.2 Timer and Threshold

Timers

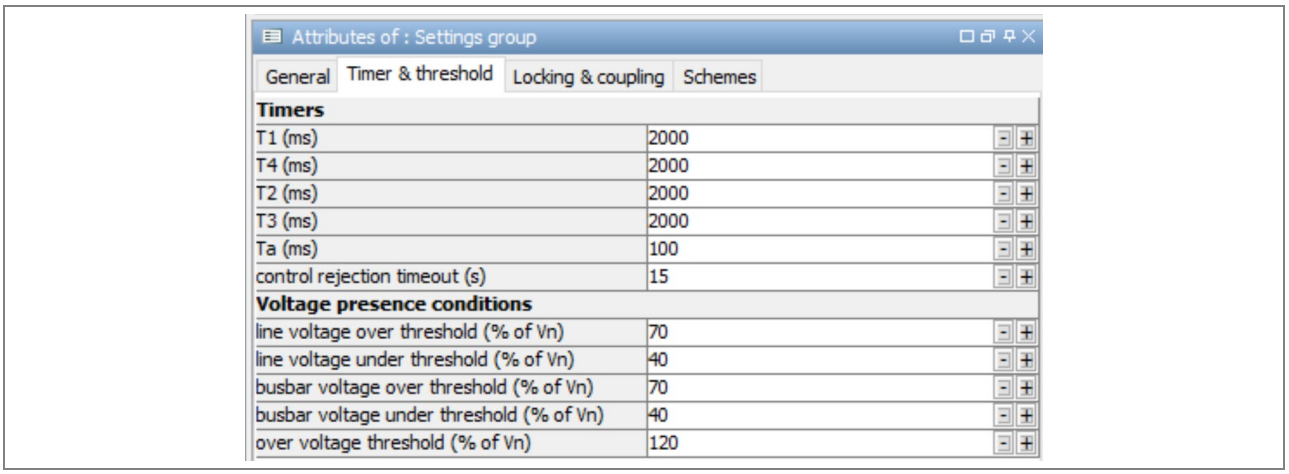


Figure 316: Setting group timer and thereshold attributes

- **T1 (ms)**: time-delay (in ms) at the end of which the presence of both voltages is confirmed and so are the **locking** conditions. This timer is used for LL/LB scheme. Range [0, 10000 ms], step 10 ms).
- **T4 (ms)**: time-delay (in ms) at the end of which the presence of both voltages is confirmed and so are the **coupling** conditions. This timer is used for LL/LB scheme. This parameter is available only if the **Synchrocheck usage** attribute is set to **Synchrocheck & Synchrocoupler**. Range [0, 10000 ms], step 10 ms).
- **T2 (ms)**: time-delay (in ms) at the end of which the presence of only one voltage is confirmed. This timer is used for DL/LB scheme. Range [0, 10000 ms], step 20 ms).
- **T3 (ms)**: time-delay (in ms) at the end of which the absence of both voltages. This timer is used for DL/DB scheme. Range [0, 10000 ms], step 20 ms).
- **Ta (ms)**: closing time of the Circuit Breaker in synchro close conditions. For optimal performance, it should be higher or equal to 50ms. Range [0, 1000 ms], step 10 ms)
- **Control rejction timeout (s)**: timer (in s) during which the voltage control scheme is in progress, even if the electrical conditions are missing. Range [0, 600 s], step 1 s).

Voltage presence conditions

- **line voltage over threshold (% Vn)**: high threshold for the line voltage value. Range [0, 100%], step 1% Vn).
- **line voltage under threshold (% Vn)**: low threshold for the line voltage value. Range [0, 100%], step 1% Vn).
- **busbar voltage over threshold (% Vn)**: high threshold for the busbar voltage value. Range [0, 100%], step 1% Vn).
- **busbar voltage under threshold (% Vn)**: low threshold for the busbar voltage value. Range [0, 100%], step 1% Vn).
- **over voltage threshold (% Vn)**: overvoltage threshold for the line or busbar, at which synchrocheck is no longer allowed. Range [100, 150%], step 1% Vn).

5.3.6.4.3 Locking and Coupling

Locking and coupling parameters depend on the **Synchrocheck usage** attribute.

Locking

Locking parameters appear when the **Synchrocheck usage** attribute is set to **Synchrocheck only**:

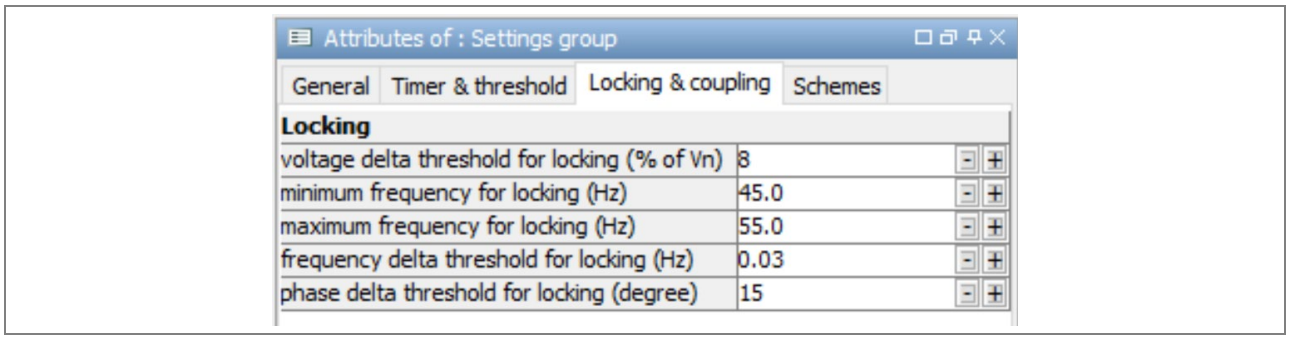


Figure 317: Setting group locking parameters

- **voltage delta threshold for locking (% Vn)**: threshold below which the voltage difference between line and busbar is considered as acceptable for locking. Range [0, 100%], step 1% Vn).
- **minimum frequency for locking (Hz)**: Minimun frequency accepted for both electrical networks for locking. Range [45, 59.5 Hz], step 0.1 Hz).
- **maximum frequency for locking (Hz)**: Minimun frequency accepted for both electrical networks for locking. Range [50.5, 66 Hz], step 0.1 Hz).
- **frequency delta threshold for locking (Hz)**: threshold below which the frequency difference between line and busbar is considered as acceptable for locking. Range [0.015, 1Hz], step 0.005 Hz).
- **phase delta threshold for locking (°)**: threshold below which the phase difference between line and busbar is considered as acceptable for locking. Range [0, 90°], step 1°).

Coupling

Locking and coupling parameters appear when the **Synchrocheck usage** attribute is set to **Synchrocheck and Synchrocoupler**:

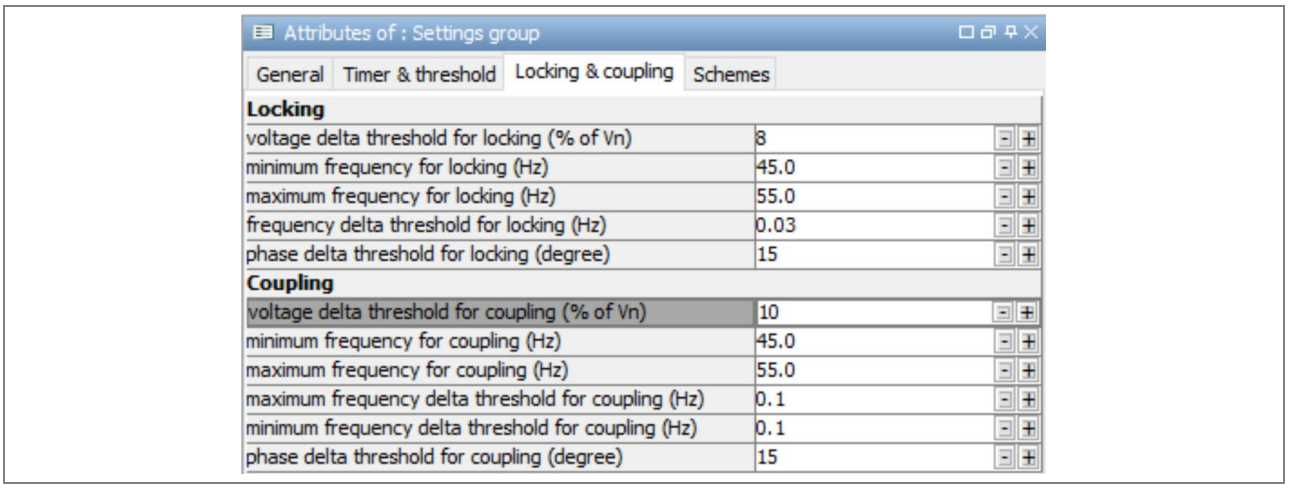


Figure 318: Setting group locking & coupling parameters

- **voltage delta threshold for coupling (% Vn)**: threshold below which the voltage difference between line and busbar is considered as acceptable for coupling. Range [0, 100%], step 1% Vn).
- **minimum frequency for coupling (Hz)**: Minimun frequency accepted for both electrical networks for coupling. Range [45, 59.5 Hz], step 0.1 Hz).
- **maximum frequency for coupling (Hz)**: Minimun frequency accepted for both electrical networks for locking. Range [50.5, 66 Hz], step 0.1 Hz).
- **maximum frequency delta threshold for coupling (Hz)**: threshold below which the frequency difference between line and busbar is considered as acceptable for coupling. Range [0, 1 Hz], step 0.01 Hz).
- **minimum frequency delta threshold for coupling (Hz)**: threshold over which the frequency difference between line and busbar is considered as acceptable for coupling. Range [0, 1 Hz], step 0.01 Hz).
- **phase delta threshold for coupling (°)**: threshold below which the phase difference between line and busbar is considered as acceptable for coupling. Range [0, 90°], step 1°)

5.3.6.4.4 Locking and Coupling

Close Schemes parameters depend on the **Synchrocheck usage** attribute.

Synchrocheck only mode:

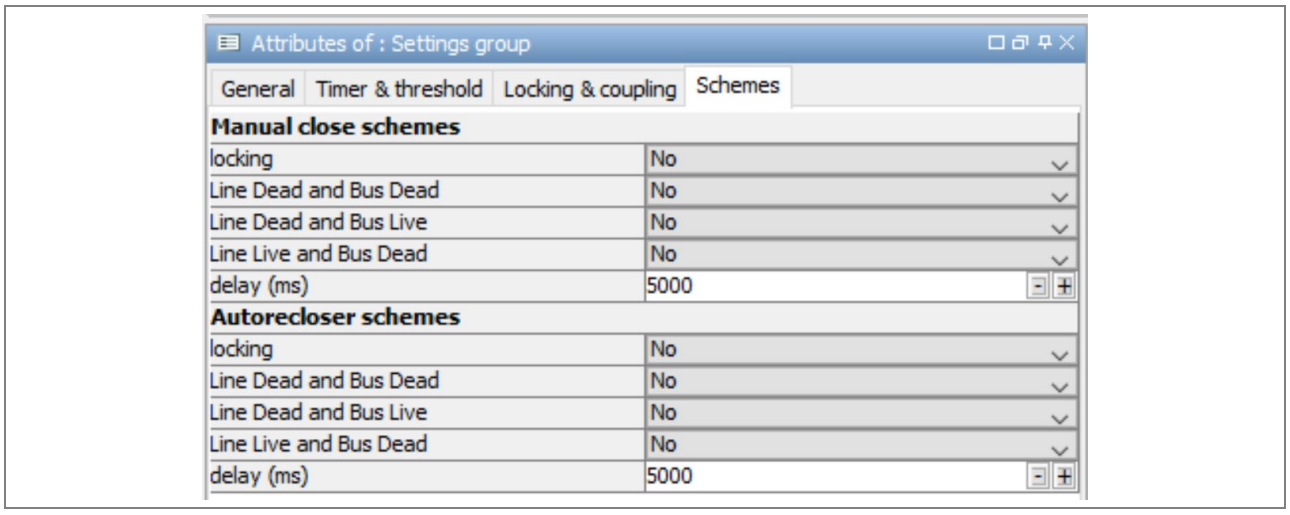


Figure 319: Setting group schemes in "Synchrocheck only" mode

Synchrocheck & Synchrocoupler mode:

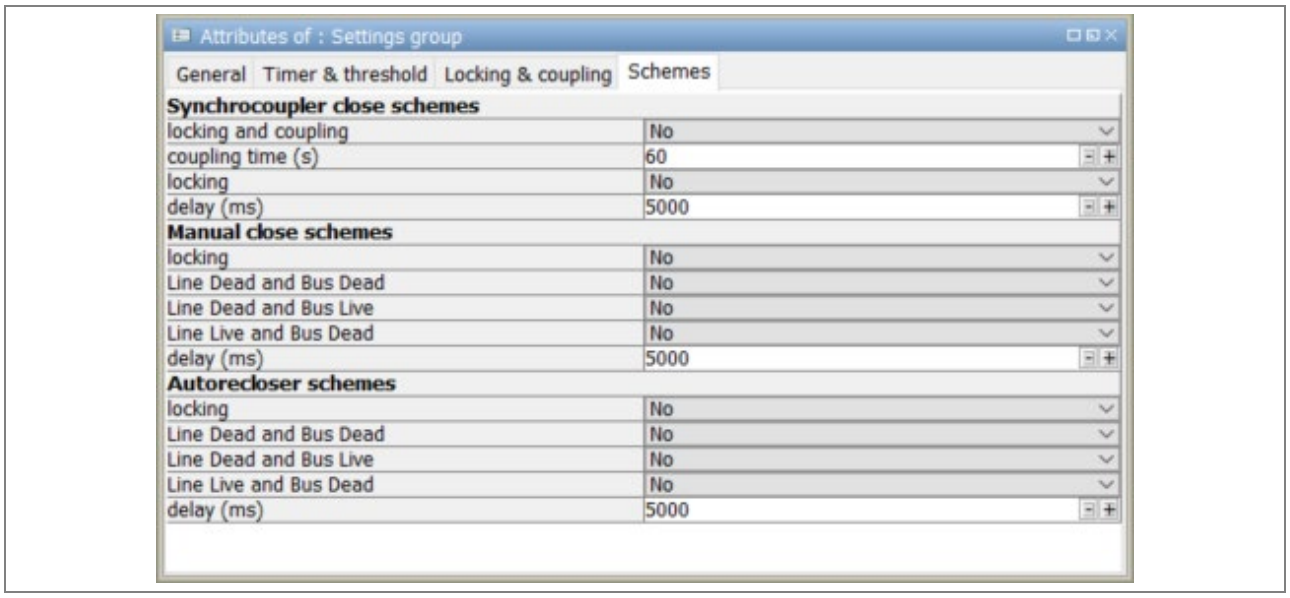


Figure 320: Setting group schemes in "Synchrocheck & Synchrocoupler" mode

Synchrocoupler close schemes

- **Locking and coupling**: synchrocoupler closing authorization for locking and coupling mode (*No* or *Yes*). If Yes is selected, **locking** field gets hidden.
- **coupling time (s)**: time (in s) allocated to reach coupling conditions: search for min(Δφ). Range [1, 3600 s], step 1 s).

- **locking**: synchrocoupler closing authorization for locking mode only (*No* or *Yes*).
- **delay (ms)**: time delay in case of confirmation of voltage conditions in progress (in ms). Range [200, 10000 ms], step 10 ms).

Manual close schemes

- **locking**: manual closing authorization for locking mode (*No* or *Yes*).
- **Line Dead and Bus Dead**: manual closing authorization in DL/DB scheme (*No* or *Yes*).
- **Line Dead and Bus Live**: manual closing authorization in DL/LB scheme (*No* or *Yes*).
- **Line Live and Bus Dead**: manual closing authorization in LL/DB scheme (*No* or *Yes*).
- **delay (ms)**: time delay in case of confirmation of voltage conditions in progress (in ms). Range [200, 10000 ms], step 10 ms).

Autorecloser schemes

- **locking**: automatic reclosing authorization for locking mode (*No* or *Yes*).
- **Line Dead and Bus Dead**: automatic reclosing authorization in DL/DB scheme (*No* or *Yes*).
- **Line Dead and Bus Live**: automatic reclosing authorization in DL/LB scheme (*No* or *Yes*).
- **Line Live and Bus Dead**: automatic reclosing authorization in LL/DB scheme (*No* or *Yes*).
- **delay (ms)**: time delay in case of confirmation of voltage conditions in progress (in ms). Range [200, 10000 ms], step 10 ms).

5.3.6.5 SUPERVISING MV IN AVIEW

The operator can monitor – from DS Agile aView - computed MVs used in the "**SC type 5**" function, using the relation link "**has for HMI Measurement : <MV Electrical datapoint>**".

The MV types computed by the TMU220 board are:

- voltage difference (signed or not signed),
- frequency difference (signed or not signed),
- phase difference (signed or not signed).

Combining signed and not signed MV is forbidden.

5.4 DEFINING AN AUTO-RECLOSER BUILT-IN FUNCTION

5.4.1 AUTO-RECLOSER BEHAVIOUR

Several type of Auto–Recloser built-in functions can be configured in the SCE.

The Auto–Recloser Type 3 built-in function addresses the need of an automatic re-closing of circuit breakers without primary contact position.

The Auto–Recloser functions are described in the Functional Description chapter of the C264 user manual.

5.4.2 CREATING AN AUTO-RECLOSER FUNCTION

5.4.2.1 AR TYPE 1

Only the following typed bays allow the creation of an auto-recloser Type 1 function:

- Busbar,
- Bus coupler,
- Bus section,
- Feeder,
- Transformer,
- Generic bay.

5.4.2.2 AR TYPE 3

Only the following typed bays allow the creation of an auto-recloser function:

- Generic bay,
- Feeder (overhaead line)
- Bus section,
- Bus coupler
- Transformer,

5.4.3 ADDING AN AUTO-RECOLOSER FUNCTION

1 In the **Object view** panel, expand the **Voltage level** node and select an electical bay.

2 In the **Objects entry** panel, expand the **Built-in function > Automatc Reclosing CB** node.

3 Right-click on the desired **AR type** function and click on **Add**.

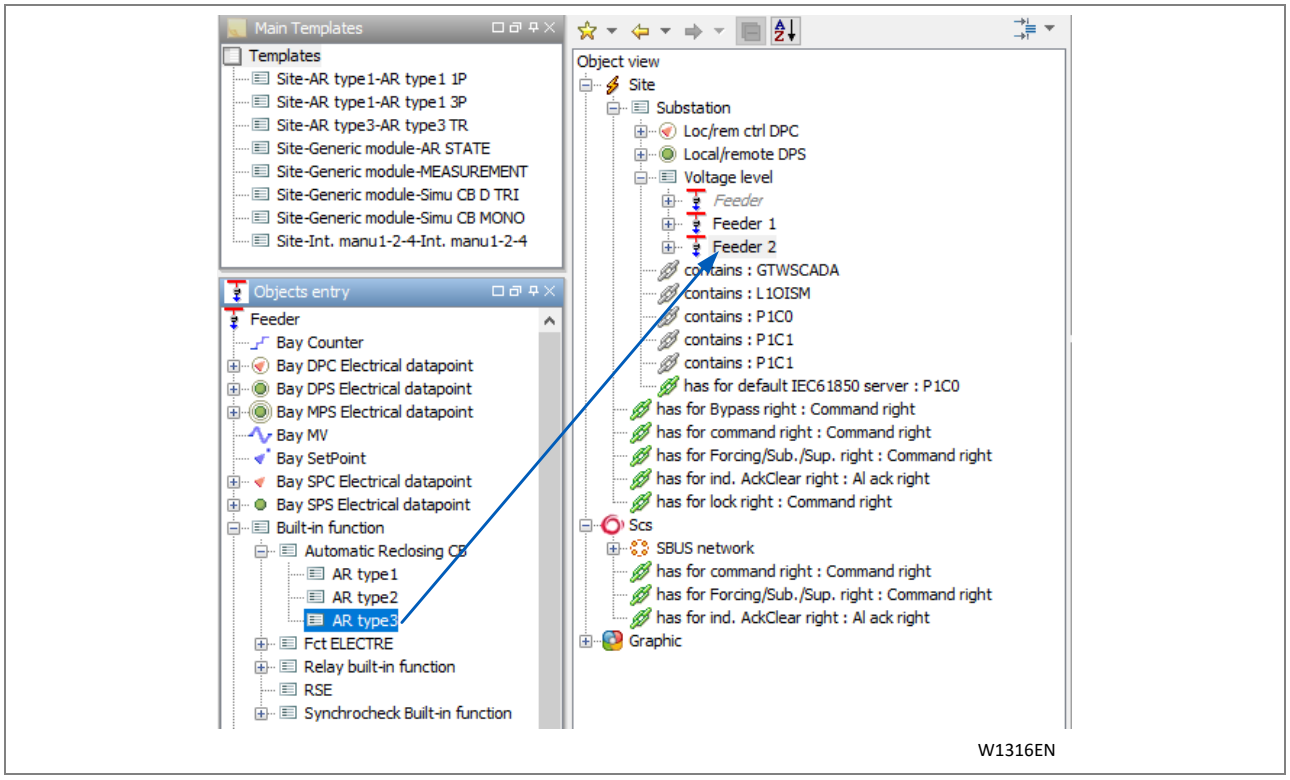


Figure 321: Adding an auto-recloser (type 3) at bay level

5.4.4 AR TYPE 1

Once added, auto-recloser general features must be set at SCE level:

5.4.4.1 SETTING AR GENERAL PROPERTIES

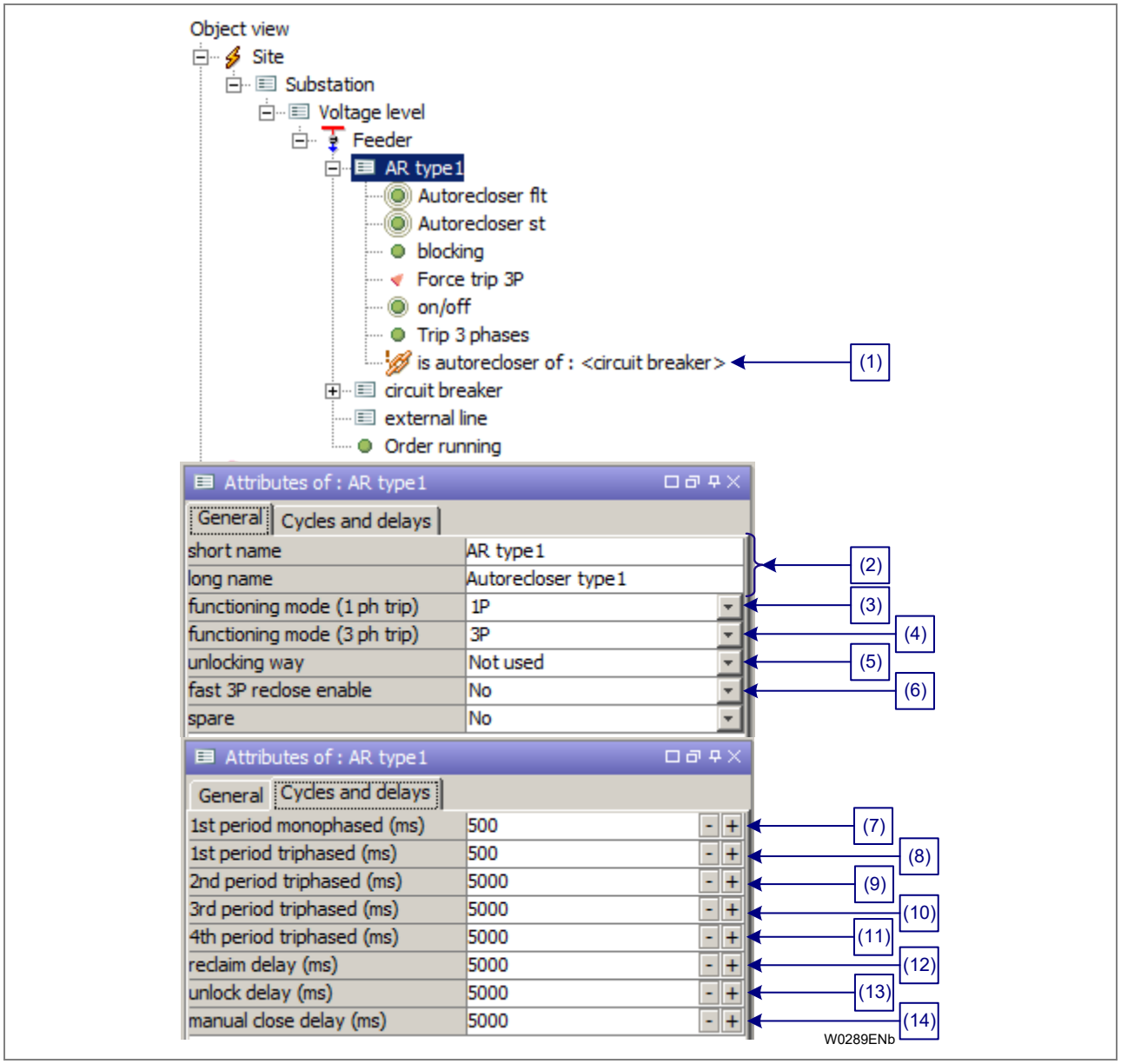


Figure 322: Setting auto-recloser (type 1) features

(1) Fill in the relation **is auto-recloser of**, indicating with which circuit-breaker module (single-pole / Three-pole) the function is associated.

a. A single-pole CB can manage **1P**, **3P** or mixed auto-recloser cycles;

b. A Three-pole CB can manage **3P** auto-recloser cycles only.

At CB level, fill in the relation **has for autorecloser** indicating with which AR function the CB is associated.

You may also add the relation **has for synchrocheck** at CB level if required.

(2) **short name** and **long name** of the auto-recloser used for logging, alarms ...

(3) **functioning mode (1 ph trip)** (Not used / 1P / 1P-3P / 1P-3P-3P / 1P-3P-3P-3P): useable only for single-pole circuit-breaker. Up to 4 cycles where the first one is single-pole (“monophased”) and the others three-pole (“triphased”).

(4) **functioning mode (3 ph trip)** (Not used / 3P / 3P-3P / 3P-3P-3P / 3P-3P-3P-3P): useable for single-pole and three-pole circuit-breakers. Up to 4 cycles where all are three phase.

(5) **unlocking way** (Not used / Reinitialisation / Manual close / Both ways). For details, refer to the AUTO-RECLOSER (AR) section in the Functional Description chapter of the C264.

(6) **Fast 3 P reclose enable** (No / Yes): if a synchrocheck exists for the breaker, auto-recloser can bypass it during the 3-phases first cycle if the attribute is set to ‘Yes’.

(7) **1st period monophased** (range [100 ms, 5 s], step 10 ms): time-delay for the first single-pole shot.

(8) **1st period triphased** (range [1 s, 60 s], step 10 ms): time-delay for the first 3-pole shot.

(9) **2nd period triphased** (range [1 s, 3600 s], step 1 s): time-delay for the second 3-pole shot.

(10) **3rd period triphased** (range [1 s, 3600 s], step 1 s): time-delay for the third 3-pole shot.

(11) **4th period triphased** (range [1 s, 3600 s] step 1 s): time-delay for the fourth 3-pole shot.

(12) r**eclaim delay** (range [1 s, 600 s], step 1 s): corresponds to ‘reclaimc recovering timer’ described in the AUTO-RECLOSER (AR) section in the Functional Description chapter of the C264 .

(13) **unlock delay** (range [1 s, 600 s], step 1 s): corresponds to ‘reclaimml recovering timer’ described in refer to the AUTO-RECLOSER (AR) section in the Functional Description chapter of the C264.

(14) **manual close delay** (range [1 s, 600 s], step 1 s): corresponds to ‘reclaimmc recovering timer’ described in the AUTO-RECLOSER (AR) section in the Functional Description chapter of the C264.

Configuration rules and checks

- The two attributes **functioning mode (1 ph trip)** and **functioning mode (3 ph trip)** must not be both set to *Not used*
- If **functioning mode (1 ph trip)** value is set to *1P-3P-3P-3P*, then the following rules must be respected:
  - **1st period monophased** < **2nd period triphased**
  - **1st period monophased** < **3rd period triphased**
  - **1st period monophased** < **4th period triphased**
- If **functioning mode (1 ph trip)** is set to *1P-3P-3P*, then the following rules must be respected:
  - **1st period monophased** < **2nd period triphased**
  - **1st period monophased** < **3rd period triphased**
- If **functioning mode (1 ph trip)** is set to *1P-3P*, then the following rule must be respected:
  - **1st period monophased** < **2nd period triphased**
- If **functioning mode (3 ph trip)** is set to *3P-3P-3P-3P*, then the following rules must be respected:
  - **1st period triphased** < **2nd period triphased**
  - **1st period triphased** < **3rd period triphased**
  - **1st period triphased** < **4th period triphased**
- If **functioning mode (3 ph trip)** is set to *3P-3P-3P*, then the following rules must be respected:
  - **1st period triphased** < **2nd period triphased**
  - **1st period triphased** < **3rd period triphased**

- If **functioning mode (3 ph trip)** is set to *3P-3P*, then the following rule must be respected:
  - **1st period triphased < 2nd period triphased**
- If **functioning mode (1 ph trip)** is different from *Not used*, then the circuit-breaker type must be *Single-pole*.
- If **functioning mode (3 ph trip)** is set to *Not used*, then the circuit-breaker type must be *Single-pole.*

5.4.4.2 CONFIGURING MANDATORY DATAPOINTS

To obtain the behaviour described above, when adding an auto-recloser, a number of mandatory datapoints are automatically created at function level and must be configured (see section *4 Defining a datapoint*):

(1) **Autorecloser flt**: is an MPS datapoint, given the failure reason of auto-recloser function. This a system datapoint whose available states are:

- State0: failure due to the synchrocheck
- State1: failure to hardware, lock of device or another running automation linked to the device
- State2: failure due to interlocking function
- State3: no failure

(2) **Auto-recloser st**: is an MPS datapoint which gives the status of the auto-recloser function. This is a system datapoint whose available states are:

- State0: auto-recloser is in service, unlocked and no cycle is in progress
- State1: auto-recloser is waiting CB opening
- State2: the first single-phase cycle is in progress
- State3: the first 3-phases cycle is in progress
- State4: the second 3-phases cycle is in progress
- State5: the third 3-phases cycle is in progress
- State6: the fourth 3-phases cycle is in progress
- State7: the auto-recloser is waiting CB closing
- State8: the Reclaimc timer is launched
- State9: auto-recloser locking due to a max number of reclosing cycles
- State10: an auto-recloser locking
- State11: the reclaimml timer is launched
- State12: the reclaimmc timer is launched

(3) **Force trip 3 P**: is an SPC, used during a 3 phase cycle as mentioned in ‘Waiting CB opening’ in the **AUTO-RECLOSER (AR)** section in the Functional Description chapter of the C264.

(4) **on/off**: is a status DPS, corresponding to in / out of service status of the auto-recloser

(5) **Trip 3 phases**: is an SPS, giving information 3-phase trip provided by a relay

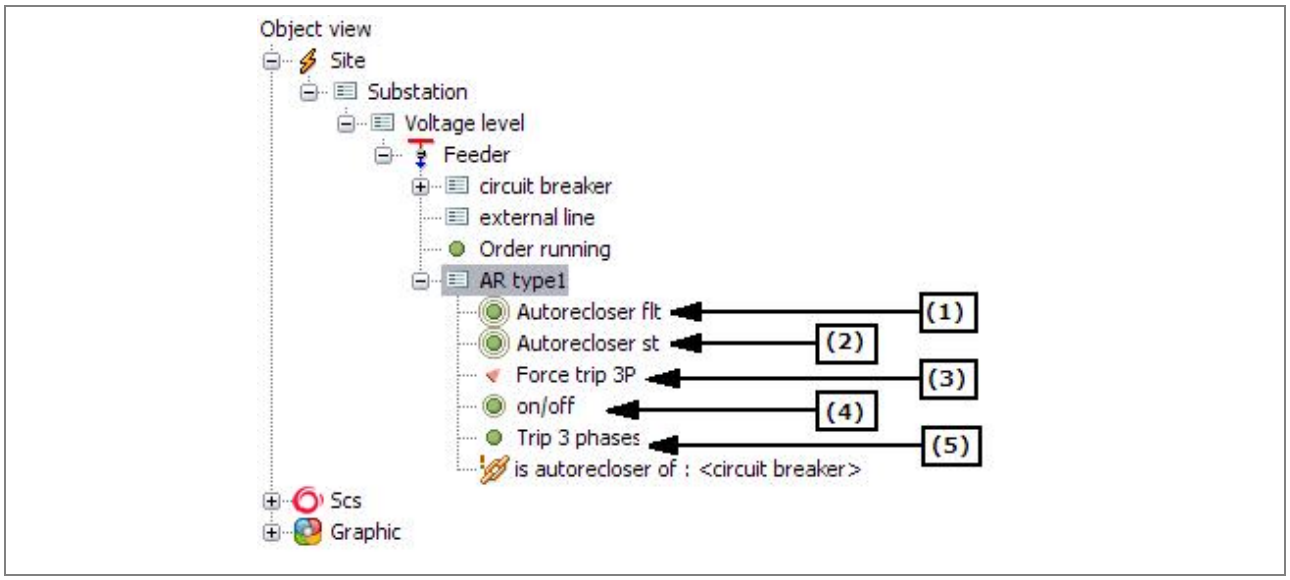


Figure 323: Auto-recloser (type 1) mandatory datapoints

5.4.4.3 CONFIGURING OPTIONAL DATAPOINTS

To obtain the behaviour described above, when adding an auto-recloser, some optional datapoints can be created at function level and must be configured (see section *4 Defining a datapoint*):

(1) **Trip PhA**: is an SPS corresponding to trip status for pole A

(2) **Trip PhB**: is an SPS corresponding to trip status for pole B

(3) **Trip PhC**: is an SPS corresponding to trip status for pole C

(4) **blocking** SPS: corresponds to the 'AR_BLOCKING' BI described in the **AUTO-RECLOSER (AR)** section in the Functional Description chapter of the C264.

(5) **lock/reinit**: is an SPS used to lock / unlock the auto-recloser via SPS. Corresponds to the 'AR_LOCK' signal described in the **AUTO-RECLOSER (AR)** section in the Functional Description chapter of the C264.

(6) **lock/reinit SPC**: Signal to lock/unlock the auto-recloser via SPC. Corresponds to the 'AR_LOCK' signal described in the **AUTO-RECLOSER (AR)** section in the Functional Description chapter of the C264.

(7) **on/off ctrl DPC**: to control in/out of service of the auto-recloser via DPC

(8) **on/off ctrl DPS**: to control in/out of service of the auto-recloser via DPS

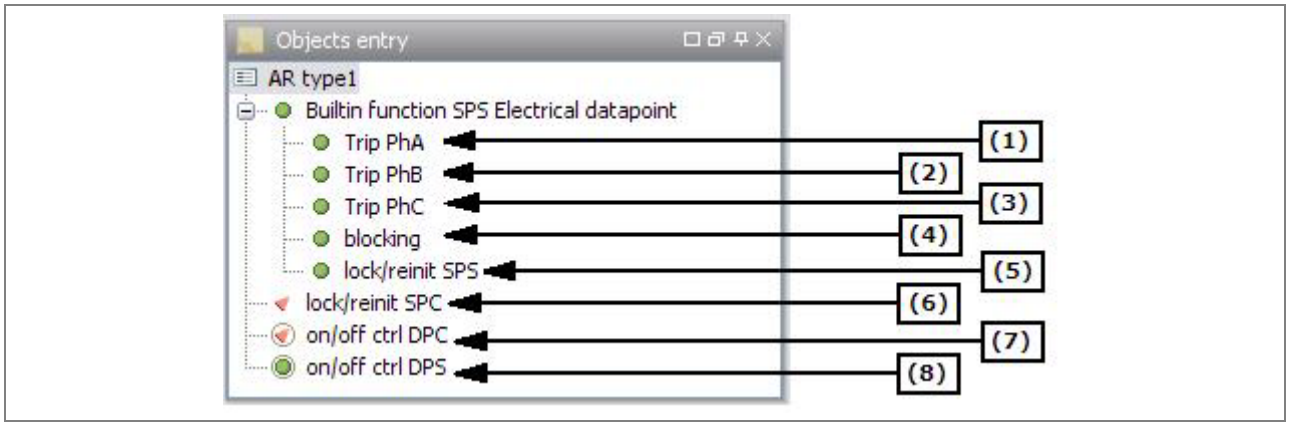


Figure 324: Auto-recloser (type 1) optional datapoints

Configuration rules and checks

- If "functioning mode (1 ph trip)" value is different from "Not used", then at least one of the three SPS datapoints { "Trip PhA", "Trip PhB", "Trip PhC" } is mandatory
- If "functioning mode (1 ph trip)" value is set to "Not used", then none of the three SPS datapoints { "Trip PhA", "Trip PhB", "Trip PhC" } is allowed
- The two datapoints { "on/off ctrl DPC", "on/off ctrl DPS" } are mutually exclusive and, at least one of them is mandatory
- The two datapoints { "lock/reinit SPC", "lock/reinit SPS" } are mutually exclusive. If the "unlocking way" attribute value is set to "Reinitialization" or "Both ways" then, at least one of the two datapoints is mandatory



Caution:
The DS Agile System generates CB automatic reclosing only on a 3-pole basis.
The SCU can only manage 3-pole reclosing.

5.4.4.4 CONFIGURING CONTROL AND STATUS DATAPOINTS

So that the operator can change the auto-reclosing cycle from the substation HMI (DS Agile aView), up to 5 pairs of Control and Status datapoints (SPC/SPS) can be added at function level and must be configured for each AR functioning mode.

To add a control datapoints

- Click on the auto-recloser function,
- From the contextual **Objects entry** window, select the required control (Co) and status (St) datapoints

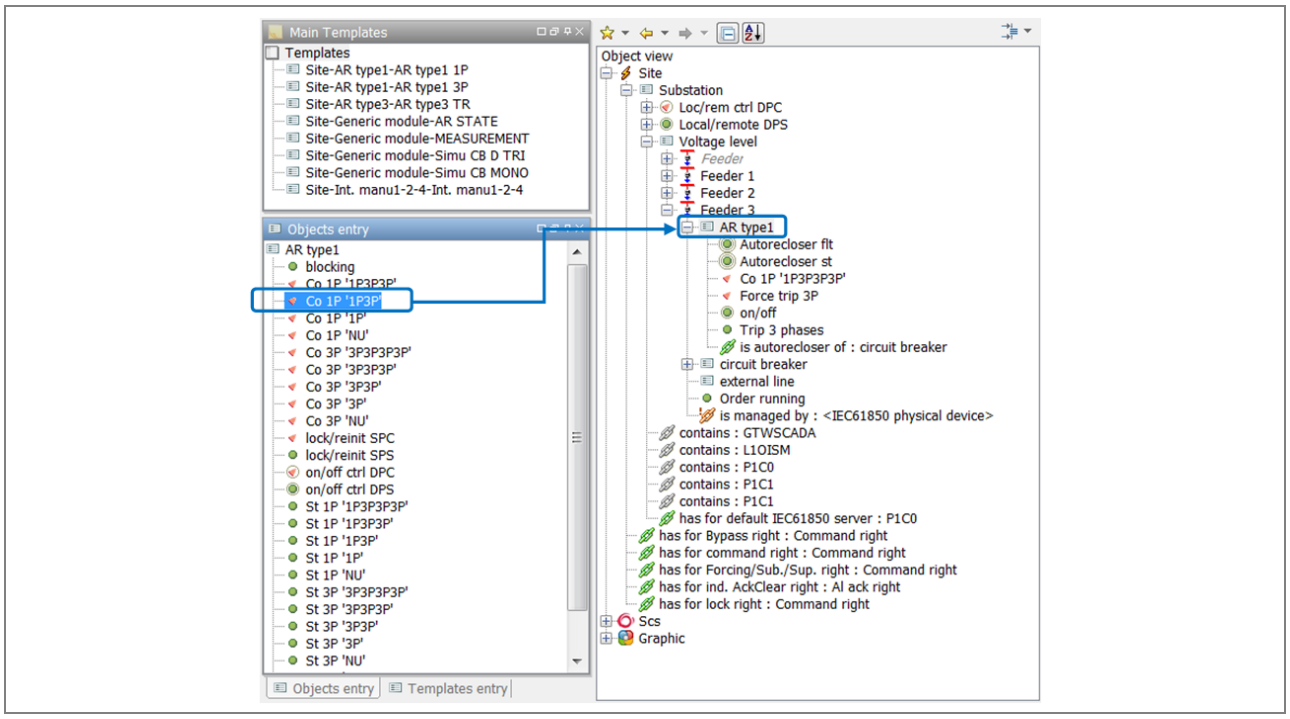


Figure 258: Adding control and status datapoints at Auto-recloser function level

1 Depending on the circuit breaker, combine control and status datapoints to match one of the possible AR mode.

AR Functioning modes	1 ph trip datapoints	3 ph trip datapoints
Not used (NU)	Co 1P "NU" (SPC) / St 1P "NU" (SPS)	Co 3P "NU" (SPC) / St 3P "NU" (SPS)
1 automatic reclosing cycle	Co 1P "1P" (SPC) / St 1P "1P" (SPS)	Co 3P "3P" (SPC) / St 3P "3P" (SPS)
2 automatic reclosing cycles	Co 1P "1P3P" (SPC) / St 1P "1P3P" (SPS)	Co 3P "3P3P" (SPC) / St 3P "3P3P" (SPS)
3 automatic reclosing cycles	Co 1P "1P3P3P" (SPC) / St 1P "1P3P3P" (SPS)	Co 3P "3P3P3P" (SPC) / St 3P "3P3P3P" (SPS)
4 automatic reclosing cycles	Co 1P "1P3P3P3P" (SPC) / St 1P "1P3P3P3P" (SPS)	Co 3P "3P3P3P3P" (SPC) / St 3P "3P3P3P3P" (SPS)

As a pair of datapoints:

- If a St datapoint (SPS) is configured, its related Co datapoint (SPC) must be configured too
- If Co datapoint (SPC) is configured, its related St datapoint (SPS) must be configured too

Note: Two pairs of control and status datapoints are mandatory (one for functioning mode "1ph trip" and one for "3 ph trip"). Among them, one pair must be different than "not used".

For three-pole circuit-breakers, only 3P cycles are accepted
For single-pole circuit-breakers, you can apply 1P, 3P or mix auto-reclosing cycles.

2 For each Co and St datapoint, fill in the relation **has for IEC address**.

Updating Control datapoint attributes

When adding a control datapoint (SPC), some general attributes must be updated:

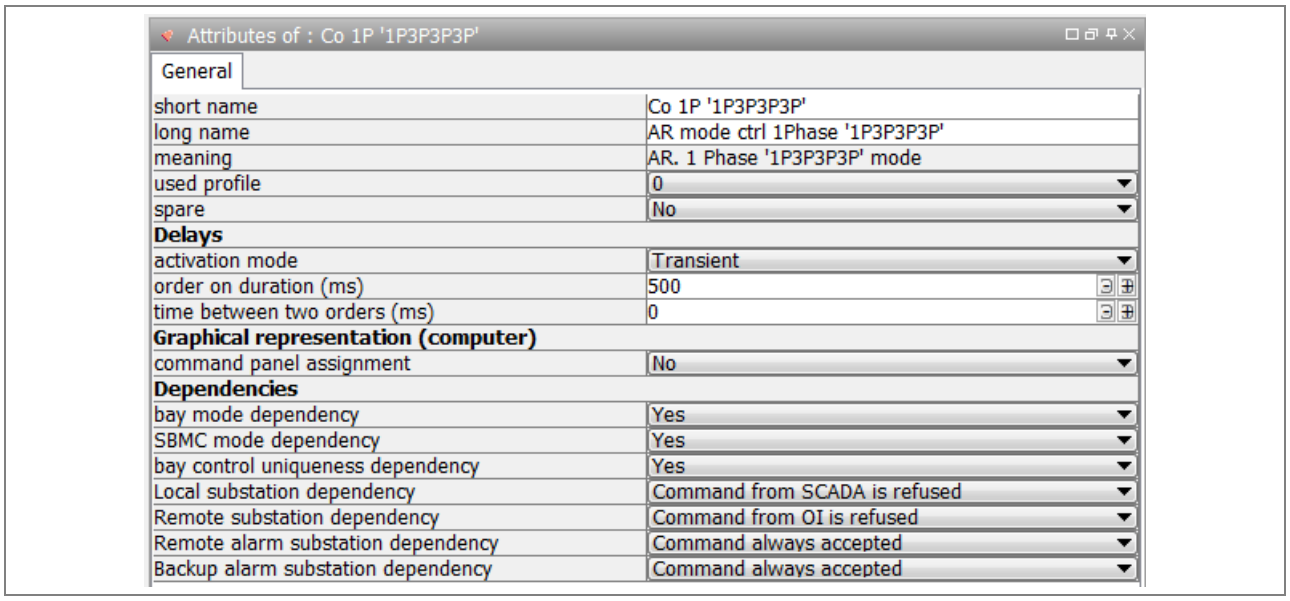


Figure 259: Setting the general attributes of an SPC datapoint

(1) **short name** and **long name** of the datapoint used for AR cycle.

(9) **detection mode** (*Permanent* / *Transient* / *Permanent with computer auto-reset*): when this attribute is set to *Permanent with computer auto-reset* the SPS is reset automatically after 1 ms

(10) **used profile**: the drop-down list refers to the SPC tab of the Profiles table

(11) **activation mode**: *Permanent* / *Transient* / *Permanent until feedback*

(12) **order on duration (ms)**: range [0, 15 s], step 10ms): this attribute is only available if the activation mode is set to *Transient*. It defines the time while the contact is closed before re-opening.

(13) **time between two orders**: (range [0, 10 s], step 100ms): this attribute corresponds to the intercontrol delay

(14) **command panel assignment** (*No* / *Yes*): set to *Yes* to enable SPC control at C26x local HMI level

(15) **bay mode dependency**: *Yes* / *No*

(16) **SBMC mode dependency**: *Yes* / *No*

(17) **bay control uniqueness dependency**: *No* / *Yes*): only significant if control uniqueness is set to bay at substation level

(18) **Local substation dependency**: *Command from SCADA is refused* / *Allowed*

(19) **Remote substation dependency**: *ommand from OI* (OI = substation control point, i.e. aView) *is refused* / *Allowed*

(20) **Remote alarm substation dependency**: Customer-specific, not used in system versions V7.0.0. It should be set to its default value: *Command always accepted*.

(21) **Backup alarm substation dependency**: Customer-specific, not used in system versions V7.0.1. It should be set to its default value: *Command always accepted*

Updating Status datapoint attributes

When adding a Status datapoint (SPS), some general attributes must be updated

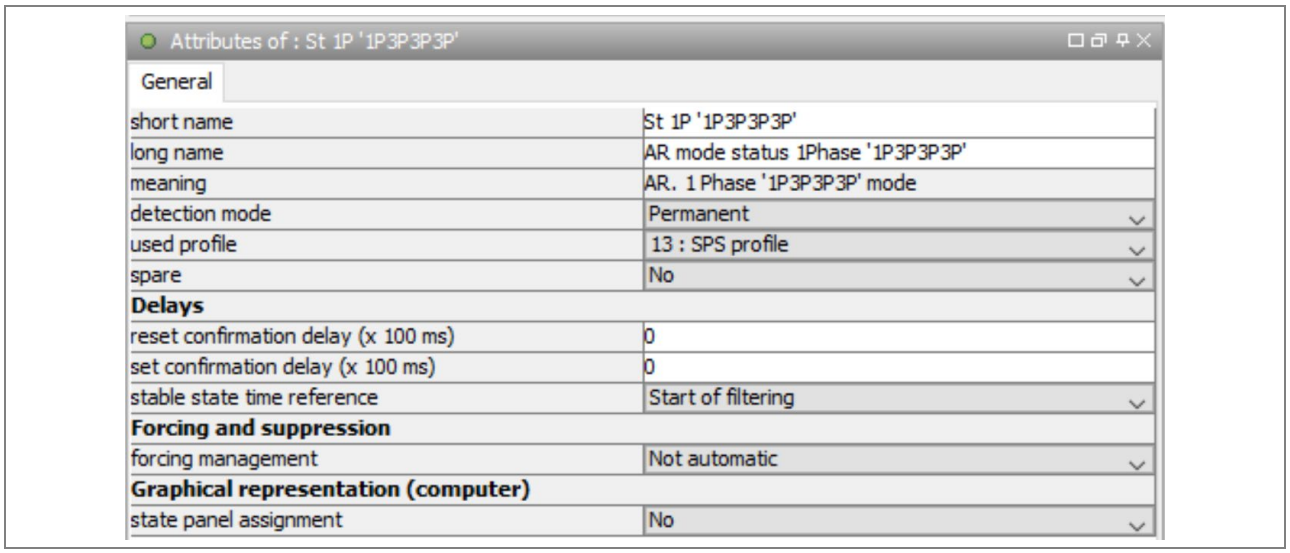


Figure 260: Setting the general attributes of an SPS datapoint

(1) **short name** and **long name** of the datapoint used for AR cycle.

(22) **detection mode** (*Permanent* / *Transient* / *Permanent with computer auto-reset*): when this attribute is set to *Permanent with computer auto-reset* the SPS is reset automatically after 1 ms

(23) **used profile**: the drop-down list refers to the SPC tab of the Profiles table

(24) **reset confirmation delay (x 100 ms)**: confirmation delay for stable 'reset' state (range [0 s, 300 s], step 100 ms]

(25) **set confirmation delay (x 100 ms)**: confirmation delay for stable 'set' state (range [0 s, 300 s], step 100 ms]

(26) **stable state time reference**: Start of filtering / End of filtering

(27) **forcing management**: *Not automatic* / *Automatic to reset state* / *Automatic to set state*): when an SPS goes to invalid state, C26x can force or not its status to set or reset state automatically. This attribute defines the way this forcing management is done. Automatic forcing management is independent of the FSS enable facility provided in the SPS profile

(28) **state panel assignment**: (*No* / *Yes*): set to *Yes* to enable SPS state display at C26x local HMI level

5.4.5 AR TYPE 3

Once added, auto-recloser general features must be set at SCE level:

5.4.5.1 SETTING AR GENERAL PROPERTIES

Once added, auto-recloser general features must be set at SCE level:

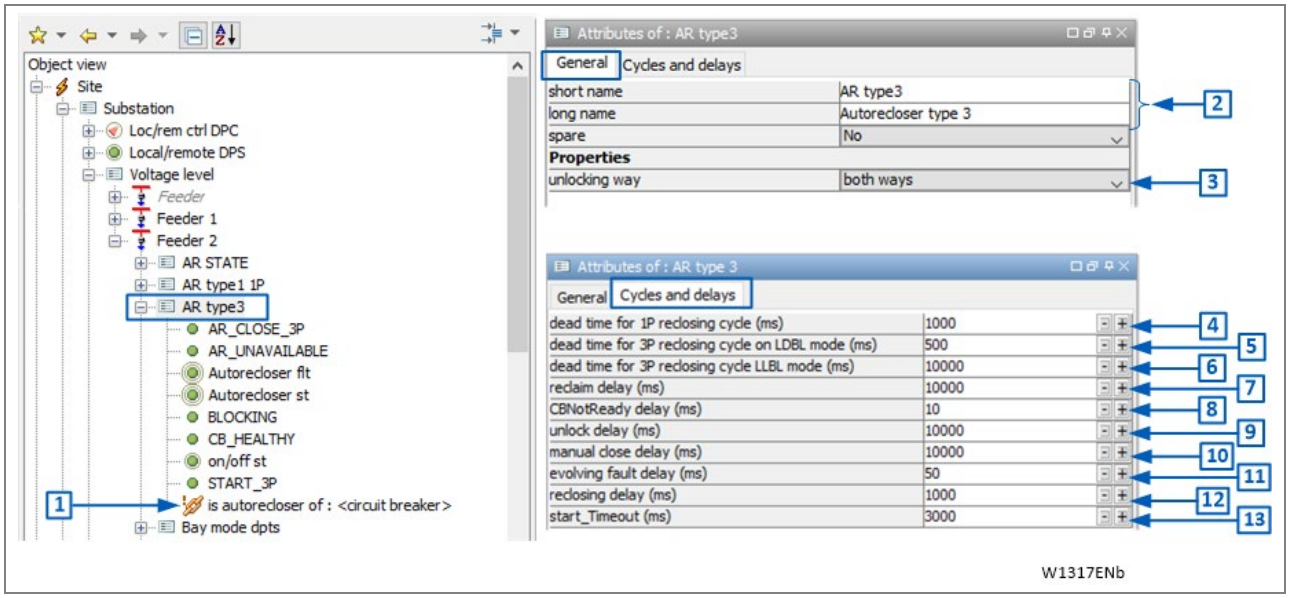


Figure 326: Setting auto-recloser (type 3) features

(1) Fill in the relation **is auto-recloser of**, indicating with which circuit-breaker module the function is associated.

(29) **short name** and **long name** of the auto-recloser used for logging, alarms ...

(30) **unlocking way** (*Reinitialization* / *Manual close* / *Both ways*). For details refer to the description of the '**Auto-recloser unlocking methods**' in section **AR Type 3** of the C264 Functional Description chapter (C26x/EN FT).

(31) **deadtime for 1P reclosing cycle** (range [1000 ms, 10000 ms], step 100 ms): time interval between the start of the AR 1P cycle and the time when the closing order is given.

(32) **deadtime 3P for T3phi reclosing cycle on LDBL mode** (range [100 ms, 20 000 ms], step 10 ms): time interval between the start of the AR 3P cycle and the time when the closing order is given on DL/LB scheme. Dead time management is described in section **AR Type 3** of the C264 Functional Description chapter (C26x/EN FT).

(33) **deadtime 3P for T3phi reclosing cycle on LLBL mode** (range [1000 ms, 60000 ms], step 100 ms): time interval between the start of the AR 3P cycle and the time when the closing order is given on LL/LB or LL/DB scheme (00 ms by default).

(34) **reclaim delay** (range [1000 ms, 600000 ms], step 1000 ms): CB reclaim delay (RECLAIM_TIMER) after an OC cyle.

(35) **CBNotReady delay** (range [0, 100 ms], step 1 ms): delay used to test the CB_Healthy input during the protection start.

(36) **unlock delay** (range [1000 ms, 600000 ms], step 1000 ms): corresponds to 'reclaimml recovering timer' described in 'lock of auto-recloser' in section **AR Type 3** of the C264 Functional Description chapter (C26x/EN FT).

(37) **manual close delay** (range [1000 ms, 600000 ms], step 1000 ms): corresponds to 'reclaimmc recovering timer' described in 'lock of auto-recloser' of section in section **AR Type 3** of the C264 Functional Description chapter (C26x/EN FT).

(38) **Evolving fault delay** (range [0, 100 ms], step 1 ms): time for checking evolving faults during 1P cycles

(39) **Reclosing delay** (range [0, 3000 ms], step 10 ms): time for maintaining the AR_CLOSE_xP order.

(40) **Start timeout** (range [0, 10000 ms], step 10 ms): time delay for receiving the protection start signal.

5.4.5.2 CONFIGURATING MANDATORY DATAPOINTS

When adding an auto-recloser function, a number of mandatory datapoints are automatically created at function level and must be configured (see section *4 Defining a datapoint*):

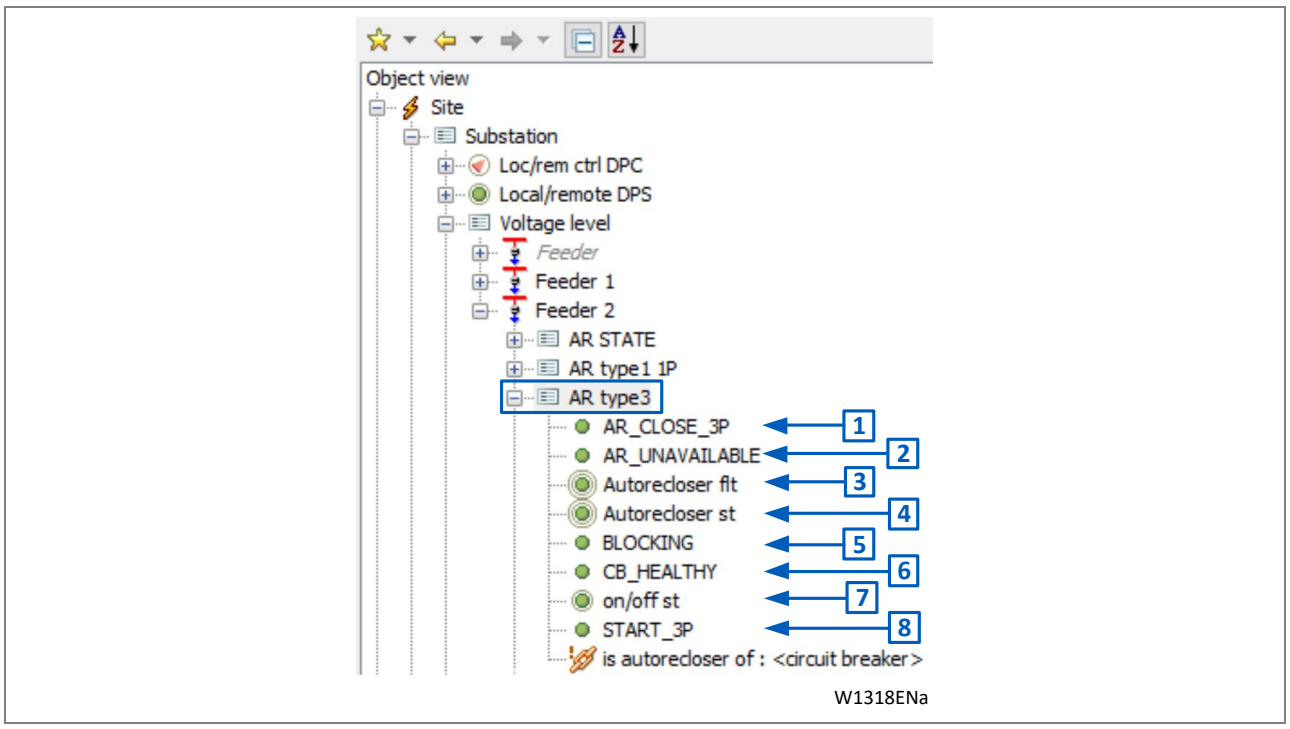


Figure 327: Auto-recloser type 3 mandatory datapoints

(1) **AR_CLOSE 3P**: circuit breaker reclosing order after a 3P autorecloser cycle. Refer to "reclosing delay" described in section in section **AR Type 3** of the C264 Functional Description chapter.

(41) **AR_UNAVAILABLE**: output status (SPS) of the Auto-recloser function (un)availibility.

(42) **Autorecloser flt**: MPS datapoint, given the failure reason of auto-recloser function. This a system datapoint whose available states are:

- State0: Auto-recloser failure (AR_NOK)
- State2: no failure (AR_OK)

(43) **Auto-recloser st:** MPS datapoint which gives the status of the auto-recloser function. This is a system datapoint whose available states are:

- State0: auto-recloser is in service, unlocked and no cycle is in progress
- State1: auto-recloser is waiting CB opening
- State2: the first single-phase cycle is in progress

- State3: the first 3-phases cycle is in progress
- State4: the second 3-phases cycle is in progress
- State5: the third 3-phases cycle is in progress
- State6: the fourth 3-phases cycle is in progress
- State7: the auto-recloser is waiting CB closing
- State8: the Reclaimc timer is launched
- State9: auto-recloser locking due to a max number of reclosing cycles
- State10: an auto-recloser locking
- State11: the reclaimml timer is launched
- State12: the reclaimmc timer is launched

(44) **BLOCKING**: SPS signal which blocks the closing of the circuit breaker. This datapoint corresponds to the 'AR_BLOCKING' described in section in section **AR Type 3** of the C264 Functional Description chapter (C26x/EN FT).

(45) **CB_HEALTHY**: SPS status of the circuit breaker operating mechanism.

(46) **on/off st**: is a status DPS, corresponding to in / out of service status of the auto-recloser

(47) **START_3P**: protection start signal (SPS) for three-pole or single-pole circuit breaker

5.4.5.3 CONFIGURING OPTIONAL DATAPOINTS

When adding an auto-recloser type 3, some optional datapoints can be created at function level and must be configured (see section *4 Defining a datapoint*):

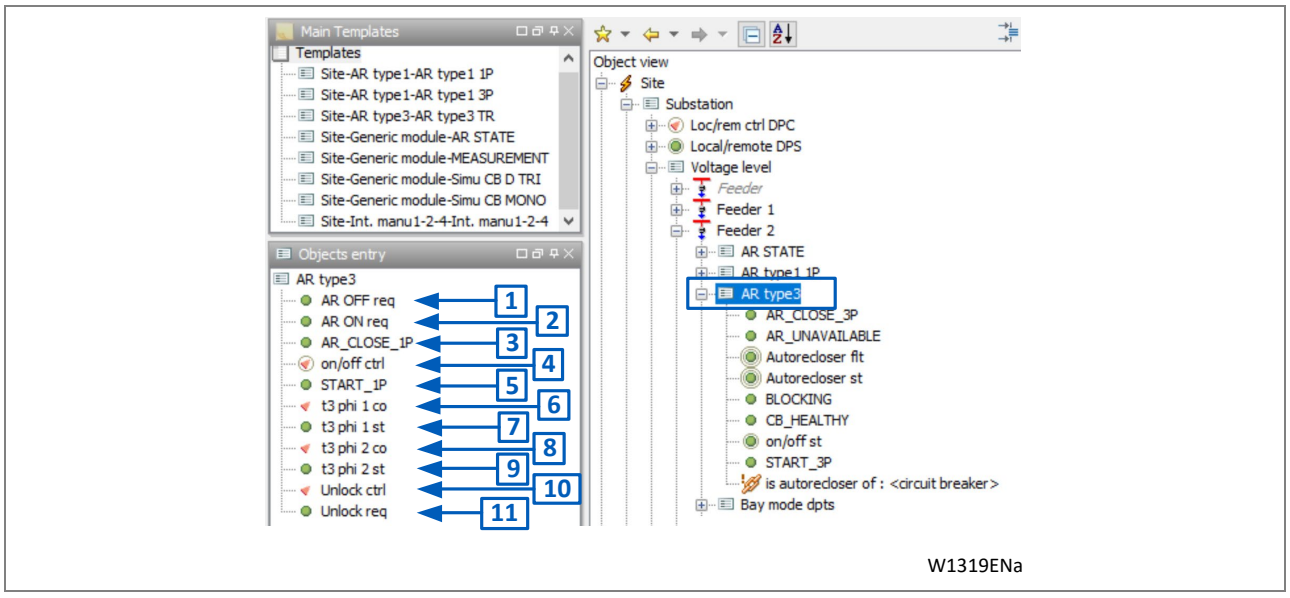


Figure 328: Auto-recloser (type 3) optional datapoints

(1) **AR OFF req**: request to put the auto-recloser function out of service

(48) **AR ON req**: request to put the auto-recloser function in service

(49) **AR_CLOSE_1P**: to reclose the CB after a 1P cycle. Corresponds to the 'AR_CLOSE_xP signal described in in the **AUTO-RECLOSER (AR)** section in the Functional Description chapter of the C264.

(50) **on/off ctrl**: to control in/out of service of the auto-recloser via DPC

(51) **START_1P**: protection start signal to be configured in case of single-pole CB (A or B or C)

(52) **t3 phi 1 co** (range [0 ms, 15 s], step 10 ms): time for short 3P cycle

(53) **t3 phi 1 st**: short 3P cycle time status

(54) **t3 phi 2 co** (range [0 ms, 15 s], step 10 ms): time for long 3P cycle

(55) **t3 phi 2 st**: long 3P cycle time status

(56) **unlock ctrl**: signal to unlock the auto-recloser via SPC. Corresponds to the 'AR_LOCK' signal described in in the **AUTO-RECLOSER (AR)** section in the Functional Description chapter of the C264.

(57) **unlock req**: is an SPS used to unlock the auto-recloser via SPS. Corresponds to the 'AR_LOCK' signal described in the **AUTO-RECLOSER (AR)** section in the Functional Description chapter of the C264.

Configuration rules and checks

The two datapoints { "on/off ctrl DPC", "on/off ctrl DPS" } are mutually exclusive and, at least one of them is mandatory



Caution:
The DS Agile System generates CB automatic reclosing only on a 3-pole basis.
The SCU can only manage 3-pole reclosing.

5.4.5.4 LIMITS

- Only **1** Auto-recloser function can be associated with **1** Circuit Breaker (per bay).
- The maximum number of AR type 3 fucntions managed per C264 is **2**.
- The maximum number of recloser cycles is **4**.
- The "functioning modes" (1 ph trip and 3 ph trip) cannot be changed from MS1 or from DS Agile aVview via control datapoints (SPC) while an AR cycle is in progress (1P or 3P cycle in progress, wait CB open/wait CB close, reclaim times).
- The "functioning modes" cannot be changed from DS Agile aView while parametes are being sent to MS1.

5.4.5.5 FINAL ADJUSTEMENTS

Once you have configured the AR function and datapoints:

1 Generate your SCE database and deploy it to your system,
2 Then, configure a widget in your Mimic view in order to manage AR cycles from DS Agile aView, as shown in the example below (Refer to the Human Interface chapter of Blend user manual for widget configuration details):

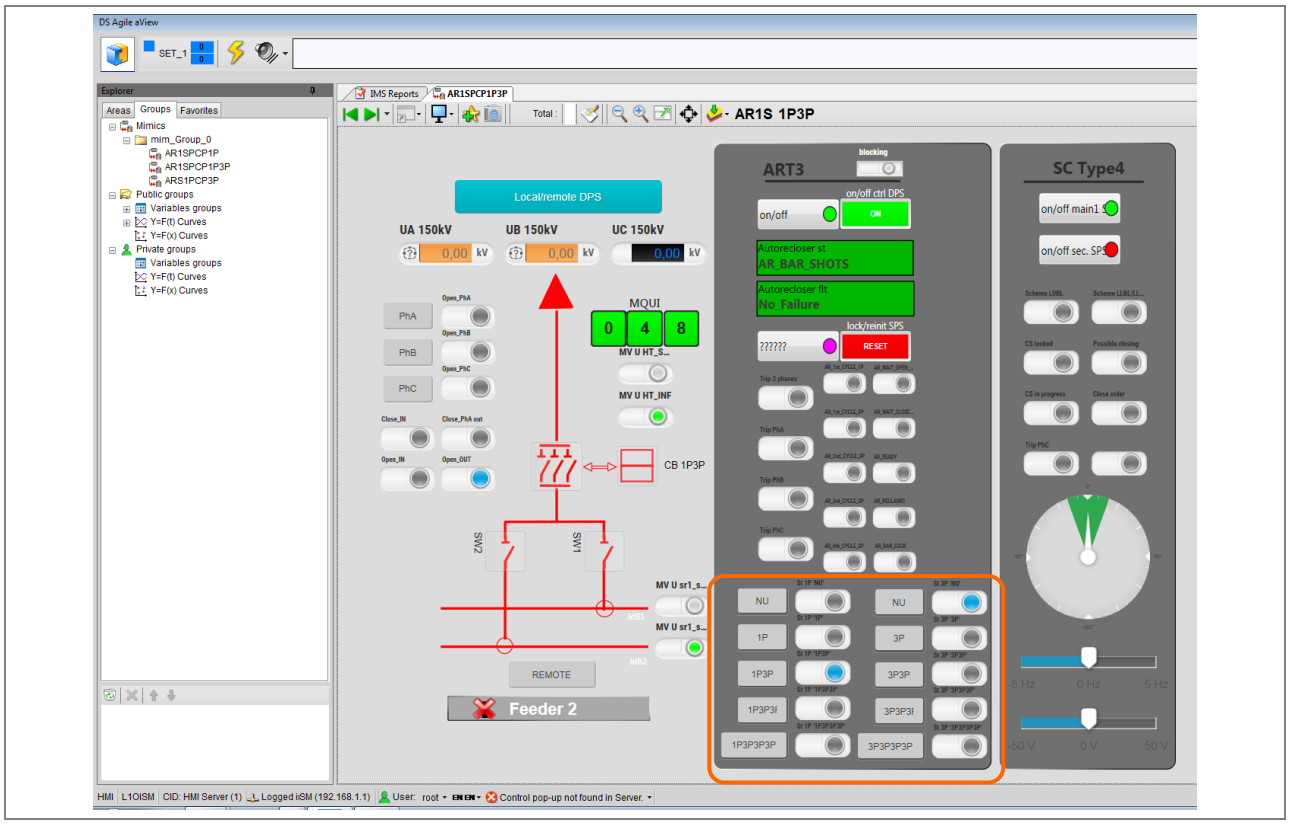


Figure 261: Managing AR cycles from the operator's workstation

Any changes made from DS Agile Aview will be reflected in MS1 and vice versa.

When a new AR cycle is selected from DS Agile Aview, the new functioning mode (1ph trip and 3 ph trip) is set as the active mode in the C26x (the previous one is disabled automatically).

*Note: In case of C26x reboot or DB switch, the last changes made to the **functioning modes** and saved at the C264 level will remain active.*

5.5 DEFINING A TAP CHANGER BUILT-IN FUNCTION

5.5.1 TAP CHANGER BEHAVIOUR

The control sequence of a transformer is described in section *Control of Transformers*, in the Functional Description of the C264 user manual.

Control of a transformer is done via tap changer built-in function and can be performed in the three modes “Direct Execute”, ”SBO once” and “SBO many mode”.

TCIP feature:

The TCIP input information is used to confirm the correct execution of the low/raise control. When adding a TCIP at tap changer level, the two configurable delays must be set at TCIP datapoint level for the correct TCIP management:

(1) **reset confirmation delay** (range [0 s, 120 s], step 100 ms): this delay corresponds to time-out T_R given in section *Persistence filtering* available in the **Function Description** chapter of the C264 user manual.

(2) **set confirmation delay** (range [0 s, 120 s], step 100 ms): this delay corresponds to time-out T_S given in section *Persistence filtering* available in the **Function Description** chapter of the C264 user manual.

(3) **start confirmation delay** (range [1 s, 60 s], step 100 ms): the TCIP information must appear before the time-out of this delay

(4) **stop confirmation delay** (range [1 s, 60 s], step 100 ms): the TCIP information must disappear before the time-out of this delay

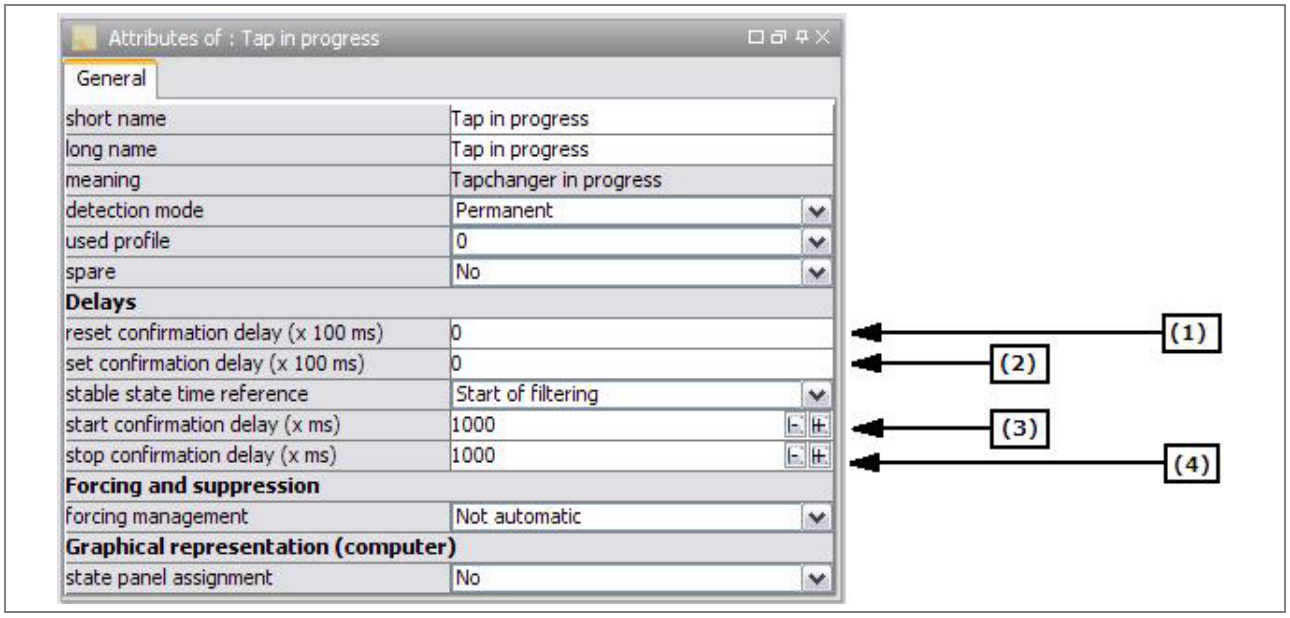


Figure 329: Setting the TCIP general attributes of a TCIP

TPI feature:

Because the TCIP input information is not always configured, the tap control is performed using only the Tap Position Indication (TPI) value to verify the right execution of the request. The TPI value must change in the given delay.

Control of a transformer with TCIP

This feature is described in chapter C26x/EN FT.

Control of a transformer without TCIP

This feature is described in chapter C26x/EN FT.

Suppression, Forcing or Substitution of the TPI

This feature is described in chapter C26x/EN FT.

5.5.2 CREATING A TAP CHANGER BUILT-IN FUNCTION

Tap changer is considered as a function because it verifies maximal and minimal useable positions of tap position indicator. It is like a sub-module of transformer module and owns the tap position indicator and optional controls (Raise/Lower, Goto Min/Max).

To create a tap-changer function, add it from object entry at transformer module level (1).

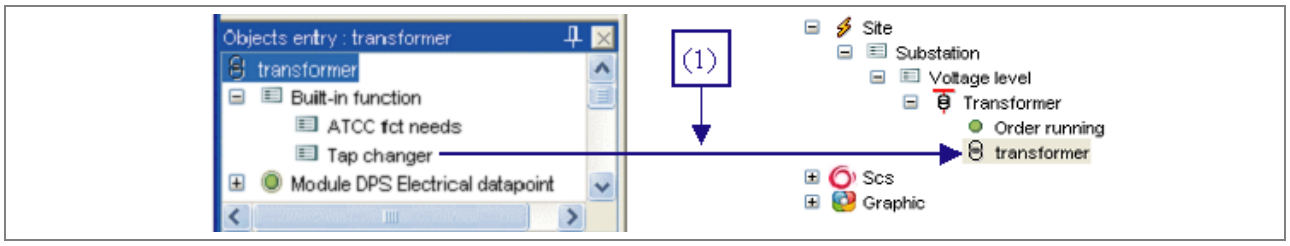


Figure 330: Adding a tap changer built-in function to a transformer

When adding a tap changer function, the following general attributes must be updated:

(1) **short name** and **long name** of the tap changer used for logging, alarms ...

(2) **minimal usable position** (range [1, 64], step 1).

(3) **maximal usable position** (range [1, 64], step 1): must be greater than attribute (2).

(4) **execution timeout** (range [0, 60 s], step 100 ms): It is the maximum delay in which tap position must have changed relatively to the current tap control in progress. If delay expired bad acknowledgement is sent for tap control.

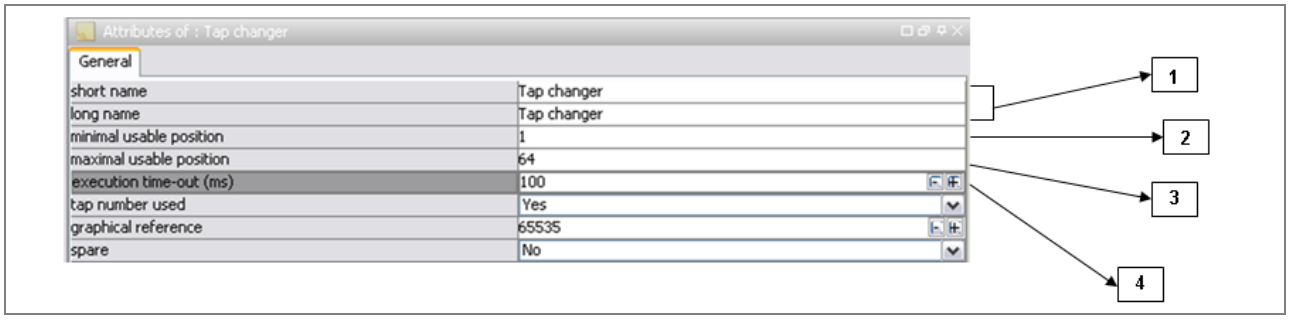


Figure 331: Setting the attributes of a tap changer

When adding a tap changer function, the mandatory datapoint ‘Tap position indicator’ (TPI) is automatically created at function level (8).

The following table gives inputs and outputs tap changer’s features controlled by the C26x. For each datapoint its SCE identification is given by a number, referenced in the following figure.

To configure correctly the tap changer of a transformer module:

- add the relevant datapoints, relatively to the following tables,
- configure them (see section *4 Defining a datapoint*).

Tap changer for transformer		
	OUTPUTS	**INPUTS**
DEVICE CONTROL	(2) DPC raise/lower (1) DPC (optional) goto min/max	(8) TPI value (7) SPS (optional) tap change in progress
DEVICE SELECTION (HARDWARE)	(4) SPC (optional) transformer selection	(i) SPS (optional) selection position information

(i) This SPS is a generic one added at transformer module level and configured as feedback of SPC transformer selection (4).

Datapoints list

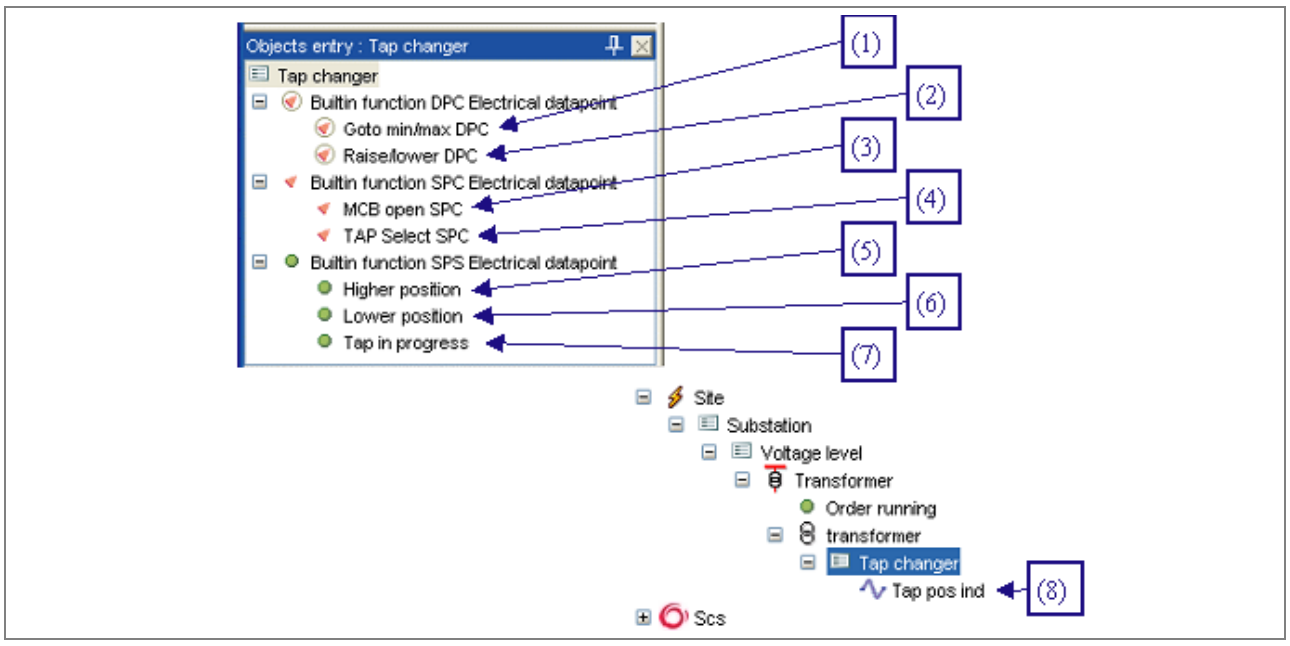


Figure 332: Available pre-defined datapoints for a tap changer

(1) **Goto min/max DPC**: if it is not wired to a board DO, this datapoint is managed by an ISaGRAF automation from a Gateway or an aView command:

- If the expected position is Min position, the automation must send one or several commands to the transformer to decrease the current position until the transformer reaches the Min position,
- If the expected position is Max position, the automation must send one or several commands to the transformer to increase the current position until the transformer reaches the Max position.

(2) **Raise/lower DPC**: this datapoint is managed by the tap changer built-in function.

(3) **MCB open SPC**: this datapoint is managed by the tap changer built-in function.

(4) **TAP Select SPC**: this datapoint is managed by the tap changer built-in function

(5) **Higher position**: if it is not wired to a board DI, this SPS is managed by an ISaGRAF automation:

- set it to 1 if the Tap pos indicator is greater than the max position
- reset it otherwise

(6) **Lower position**: if it is not wired to a board DI, this SPS is managed by an ISaGRAF automation.

- set it to 1 if the Tap pos indicator is lower than the min position
- reset it otherwise

(7) **Tap in progress**: this SPS is taken into account by the tap changer built-in function.

(8) **Tap pos ind**: tap position indication (TPI).

Configuration rules and checks

The "Raise/lower DPC" datapoint must have its profile attribute “SBO mode” set to "SBO Operate Many"

5.5.3 SETTING THE TPI PARAMETERS

The settings for Tap Position Indications are very similar to those of MV datapoints:

5.5.3.1 SETTING THE GENERAL ATTRIBUTES OF A TPI DATAPOINT

When adding a TPI datapoint, some general attributes must be updated:

(1) **short name** and **long name**: used for logging, alarms ...

(2) **type**: available values are:

- *Analogue tap position* (current input, acquired via an AIU board or an external IED)
- *Digital tap position coded ‘1 among n’* (digital acquisition only)
- *Digital tap position coded ‘decimal’* (digital acquisition only)
- *Digital tap position coded ‘gray’* (digital acquisition only)
- *Digital tap position coded ‘BCD’* (digital acquisition only)
- *Digital tap position coded ‘PCCN code’* (customer-specific)

(3) **used profile**: the drop-down list refers to the MV tab of the Profiles table

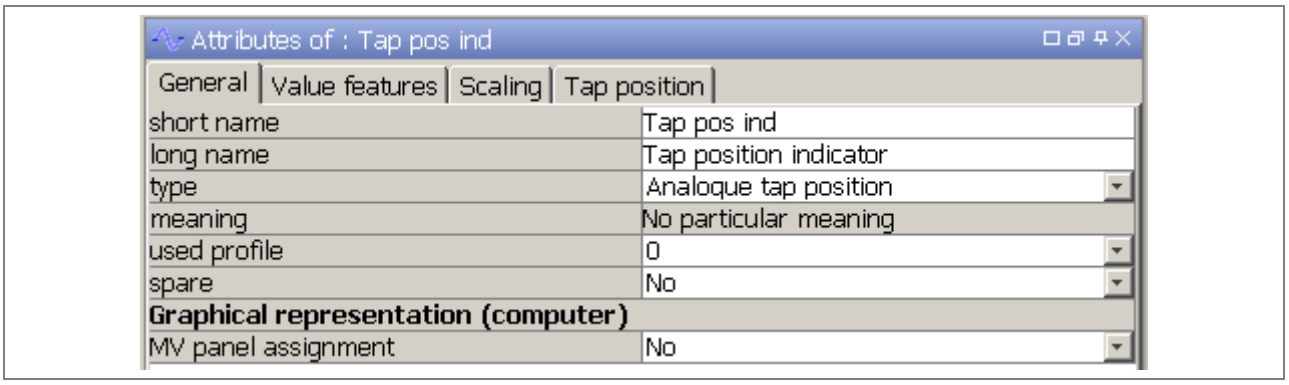


Figure 333: Setting the general attributes of a TPI datapoint

5.5.3.2 SETTING THE VALUE FEATURES ATTRIBUTES OF A TPI DATAPOINT

When adding a generic MV datapoint, some 'Value features' attributes must be updated:

(1) **minimum value** (range [-3.4E38, 3.4E38]: used for full scale calculation and scaling. It must match the **minimal usable position** attribute set for the Tap changer.

(2) **maximum value** (range [-3.4E38, 3.4E38]: used for full scale calculation and scaling. (Full scale = maximum value - minimum value). It must match the **maximal usable position** attribute set for the Tap changer.

(3) **zero value suppression** (% of full scale value) (range [0, 10], step 0.1): this parameter is used to define the zero suppression area (deadband) for zero value suppression processing. This attribute is only visible if the **type** of tap position acquisition is set to Analogue.

(4) **Hysteresis** (% of full scale value) (range [0, 50], step 1): used for threshold detection

(5) **threshold usage** (*No* / *Yes*): for each of the three low thresholds and the three high thresholds, defines whether or not the corresponding threshold is used

(6) **threshold** values (range [-3.4E38, 3.4E38]: value for each threshold, relevant only if the corresponding **threshold usage** attribute is set to *Yes*.

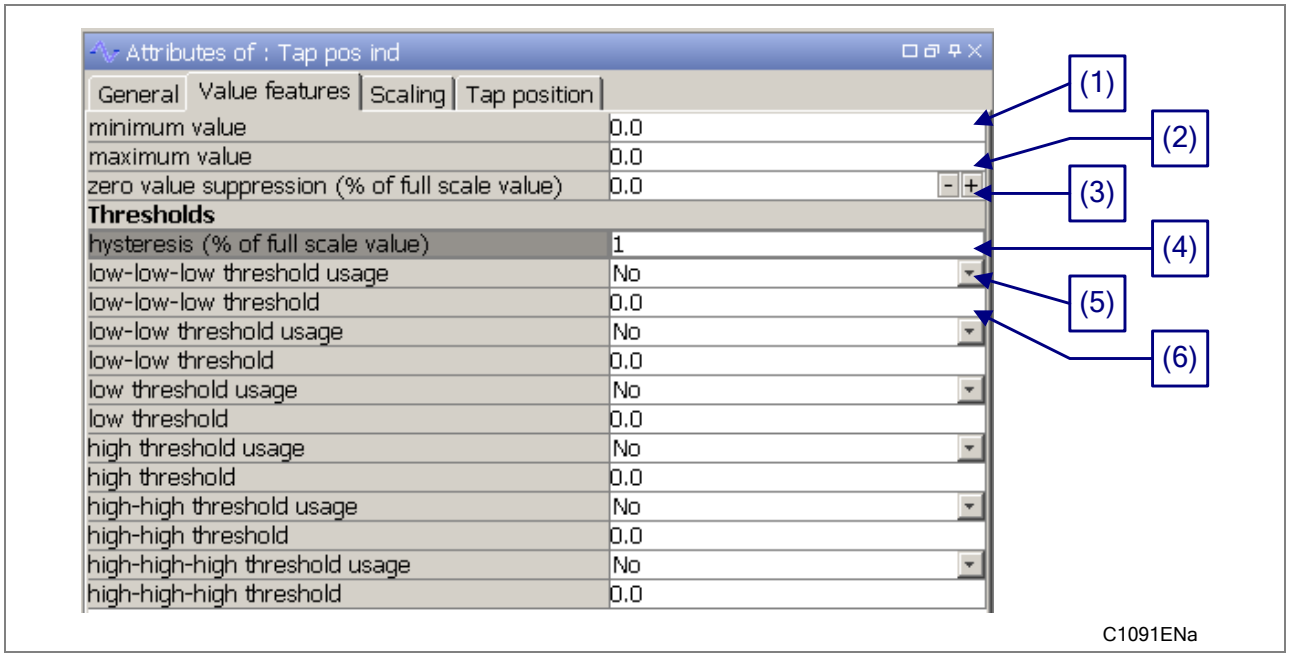


Figure 334: Setting the value features attributes OF A TPI datapoint

5.5.3.3 SETTING THE SCALING ATTRIBUTES OF A TPI DATAPOINT

The **Scaling** attributes are only relevant if the **type** of tap position acquisition is set to Analogue (not available in Process Bus configuration).

Note:
*TPI value scaling is always linear. Therefore there is no **scaling rule** attribute to set.*

(1) **minimum acq. value** (range [-3.4E38, 3.4E38])

(2) **maximum acq. value** (range [-3.4E38, 3.4E38])

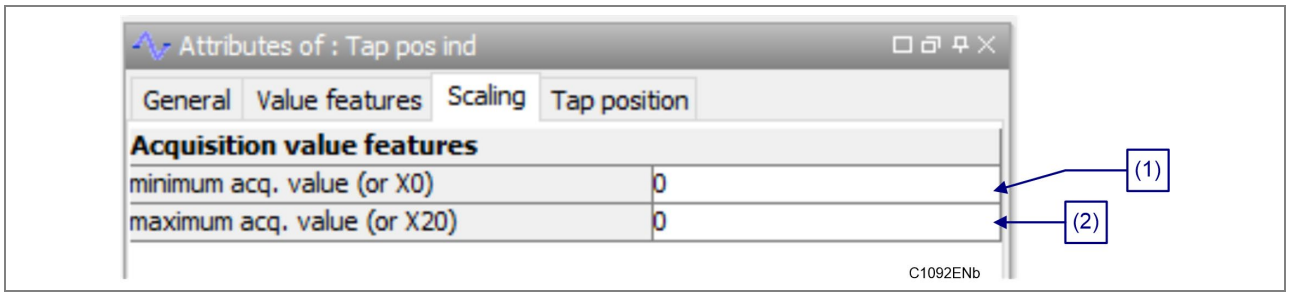


Figure 335: Setting the scaling attributes of a TPI datapoint

5.5.3.4 SETTING THE TAP POSITION ATTRIBUTES OF A TPI DATAPOINT

The Tap position attributes depend on the set **type** of tap position acquisition, analogue or digital.

Analogue tap position acquisition

(1) **filtering delay (x 10 ms)** (range [0 s, 6553.5 s], step 10 ms): confirmation time for tap position change indication

(2) **current valid range (% maximum value)** (range [0, 20%], step 1%): minimum value of the current level required for position change indication

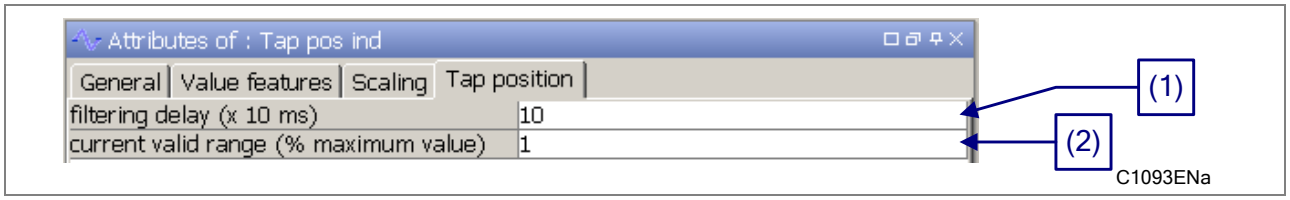


Figure 336: Setting the Tap position attributes of an analogue TPI datapoint

Digital tap position acquisition

(1) **filtering delay (x 10 ms)** (range [0 s, 6553.5 s], step 10 ms): confirmation time for tap position change indication

(2) **inhibition delay (x 10 ms)** (range [0 s, 6553.5 s], step 10 ms): transient intertap filtering time-delay

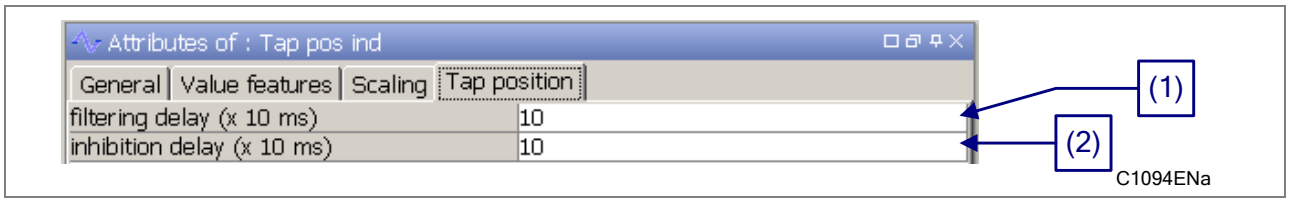


Figure 337: Setting the Tap position attributes of a digital TPI datapoint

5.5.3.5 TAP POSITION WIRING

The permitted tap positions defined in the range [**minimal usable position**, **maximal usable position**] when the Tap change function was created must be wired to digital inputs on the C26x.

To do so, select the **Tap pos ind** measurement under **Tap changer** in the **Object view**. In the contextual **Object entry** window, double-click all the relevant **'bit xx' wired on : DI channel** to place them under **Tap pos ind**. When this is done, double-click each of these relations to display the **Relation link editor** window that contains the list of available DIs and for each, select the corresponding DI.

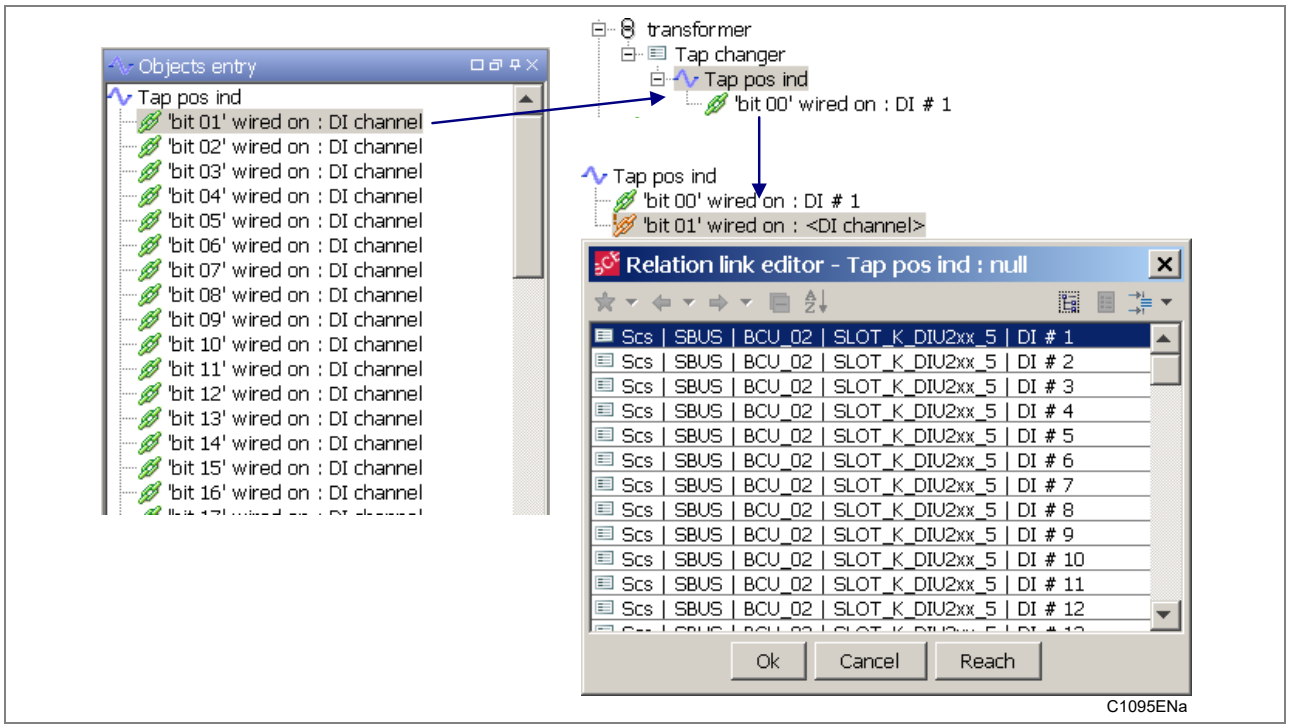


Figure 338: Wiring the Tap position bits to digital inputs

5.6 DEFINING AN AUTOMATIC VOLTAGE REGULATION – AVR – BUILT-IN FUNCTION

5.6.1 CREATING AN AVR FUNCTION

The Automatic Voltage Regulation (AVR) relates to the transformer bays; hence the configuration is done at this level.

The electrical topology shall be defined by “node” references of each individual transformer.

Transformers in parallel, located in separate bays can be controlled by a specific method:

- Master-Follower (MF): one is declared as “master” by configuration, the others are declared “followers”
- Minimization of Circulating Currents (MCC): one is declared as “master” by configuration, the others are declared “slaves”

In the case of Minimization of Circulating Currents (MCC) method, several independent groups can be automatically defined in the same substation. The electrical topology of the transformers among the group(s) is checked by the method.

5.6.1.1 DEFINING THE ELECTRICAL TOPOLOGY FOR AN AVR FUNCTION

For correct behavior of AVR function, electrical topology of shall de defined for each transformer present at substation level:

- connection of the primary side of transformer to the HV busbar, through the circuit breaker and the busbar disconnectors
- connection of the secondary of the transformer to the MV busbars, through the circuit breaker and the busbar disconnectors

Any electrical topology can be defined by modules (circuit breaker, switchgears…) interconnected by electrical nodes.
A node is in relation with at least one module. The most common “node” is the connection to a busbar.
Electric modules are mostly dipoles. In this case, the dipole is defined by two nodes. Switchgears and circuit-breakers are connected to two nodes.

Special module cases are:

- motor/generator: defined only by one node
- line arrival: defined by one node
- double switch disconnector (association of an earth switch and a disconnector): defined by three nodes
- transformer: defined by 3 nodes (the third node is reserved to neutral compensation).

At SCE level, nodes are special attributes presents into each module (circuit breaker, switchgears…). Nodes values are defined by integers. Each identified node in the electrical topology shall be a unique arbitrary value. Two interconnected modules shall have the samenode value. The best practice to value nodes is to define them directly from the substation electrical diagram.

Note: For AVR MCC method, the built-in detects automatically an electrical topology change, and informs the operator by status datapoints. For AVR MF method, an external automation managing the electrical topology is required.

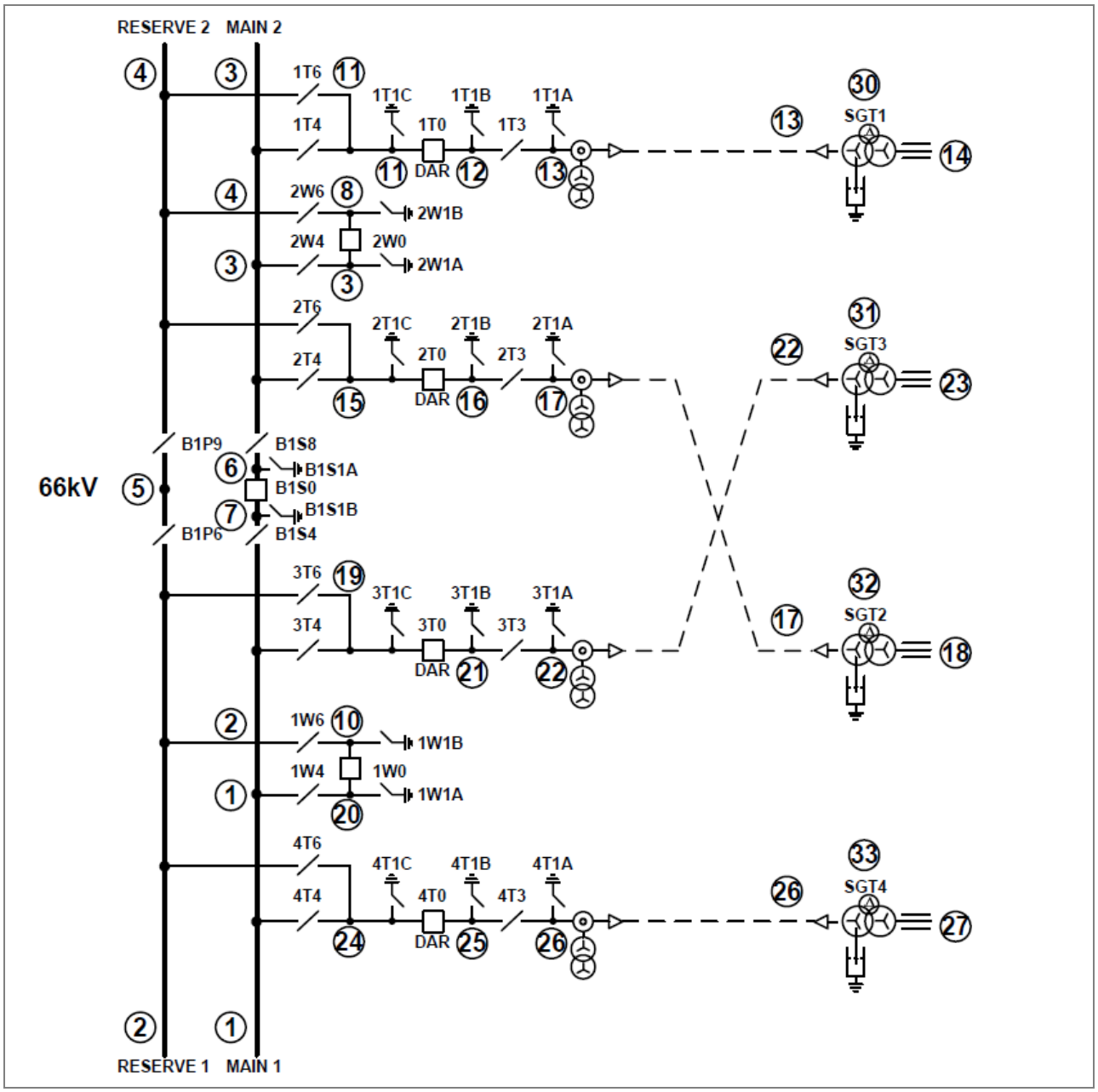


Figure 339: Identifying nodes in an electrical diagram (example)

This manual approach of nodes identification must be projected at SCE electrical object level:

- “Busbar” bay, where one node reference must be filled (1),
- “External line” module of “Feeder” bay, where one node reference must be filled (2),
- “Circuit-breaker” and “Switchgear” module, where two node references must be filled (3),
- “Transformer” module, where at least two node references must be filled, and an extra one in case of neutral compensation (4),
- “Capacitor” & “inductor” module, used for neutral compensation, where one node reference must be filled (5); it corresponds to the neutral node of the associated transformer

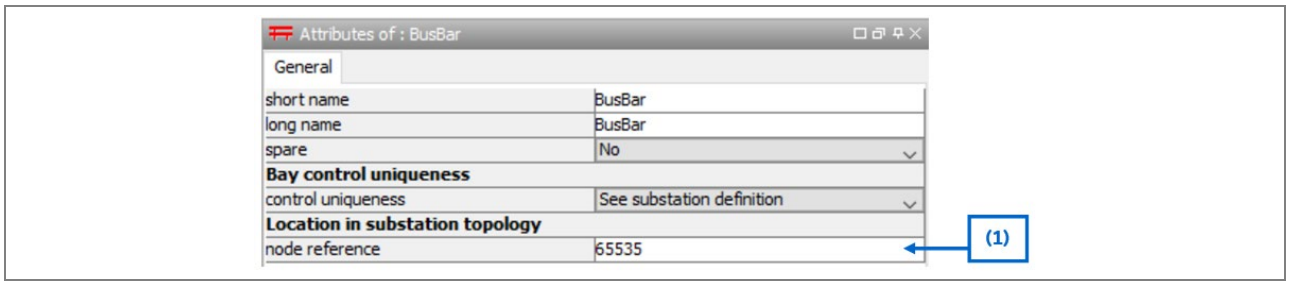


Figure 340: Setting the busbar node reference (AVR function)

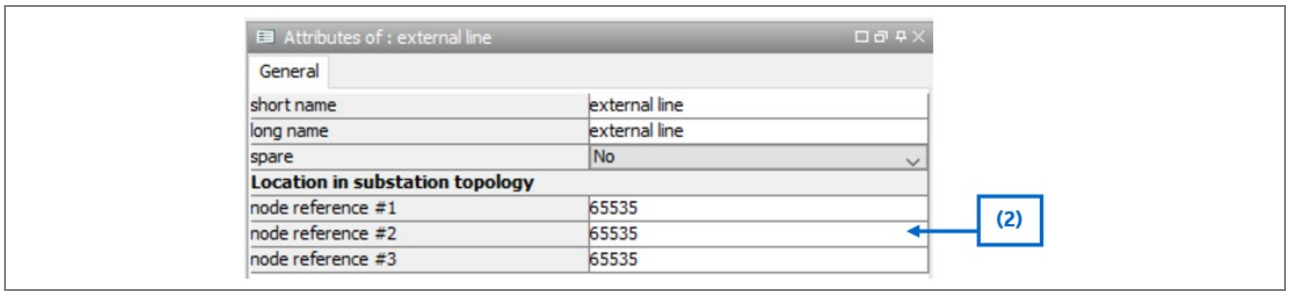


Figure 341: Setting the external line node references (AVR function)

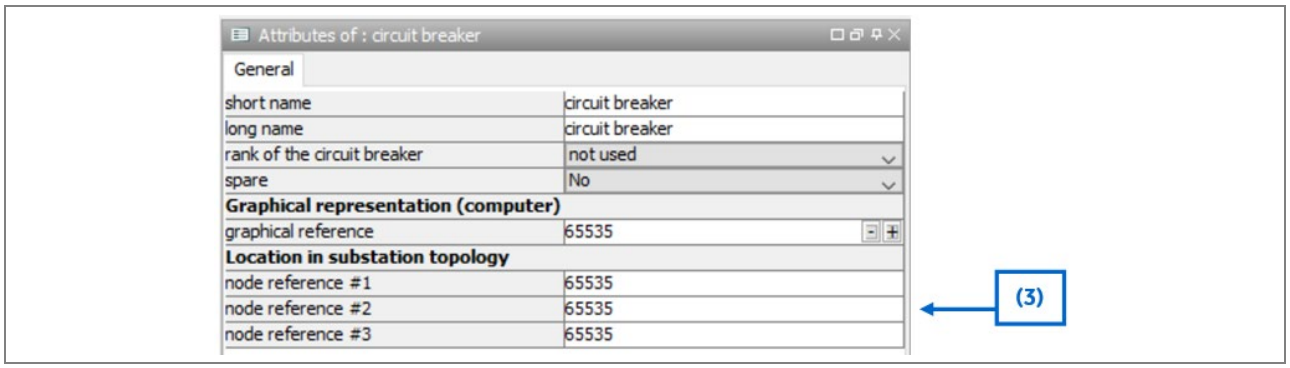
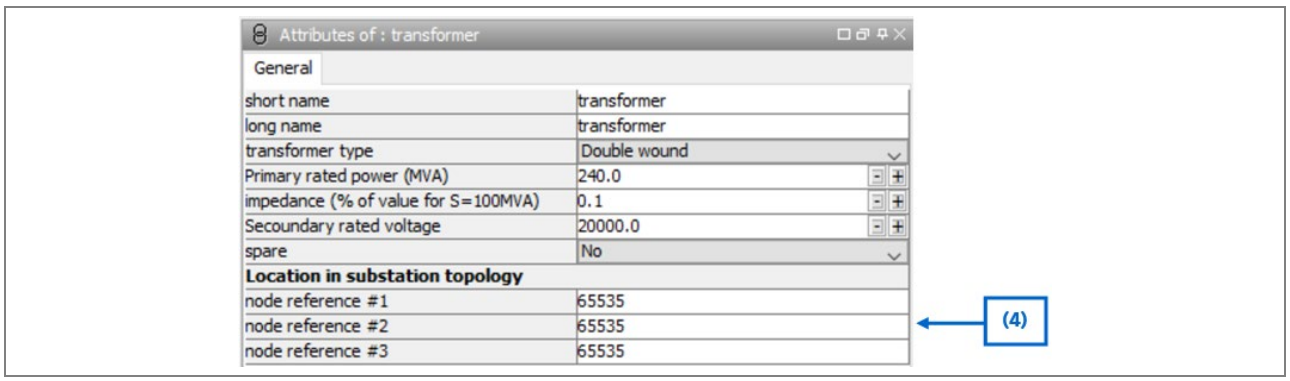
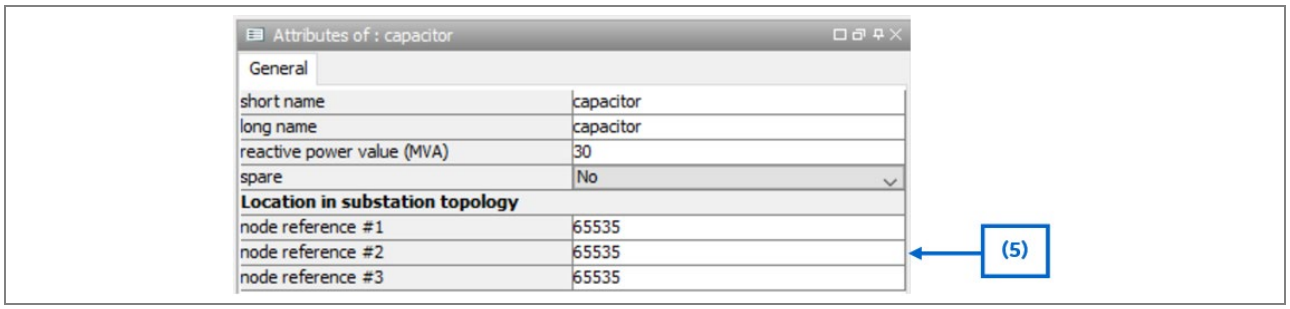


Figure 342: Setting the circuit breaker node references (AVR function)



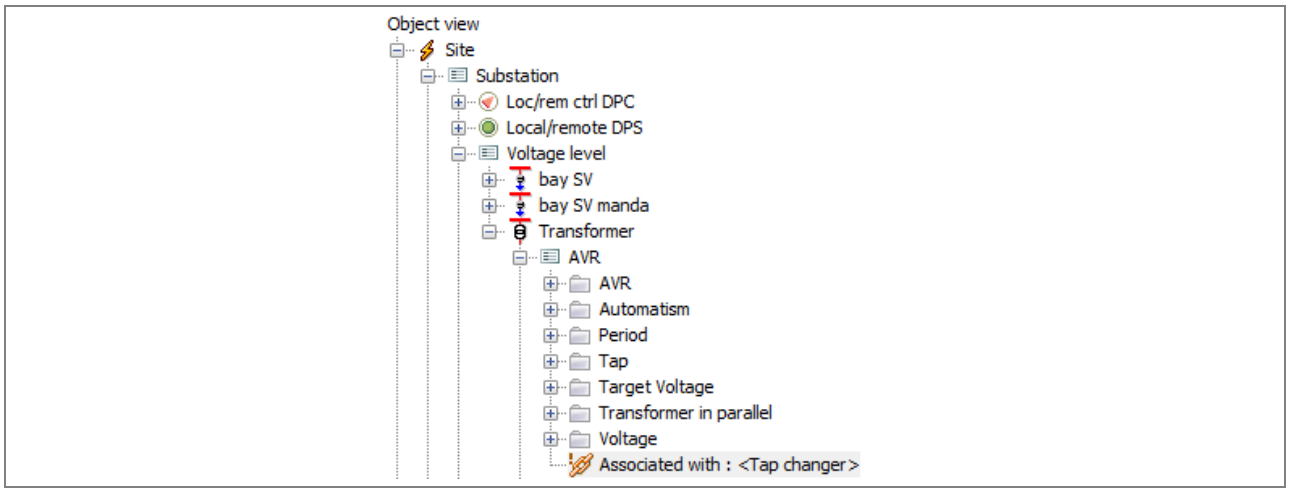


5.6.1.2 ADDING THE AVR BUILT-IN FUNCTION

In the **Objects entry** window, select the AVR built-in function and right click on *Add*. This permits creation of datapoints related to the AVR real-time information & controls of the transformer bay.

To define the transformer, see section *5.1.5.7 Defining a transformer*. To associate the AVR with a Tap changer:

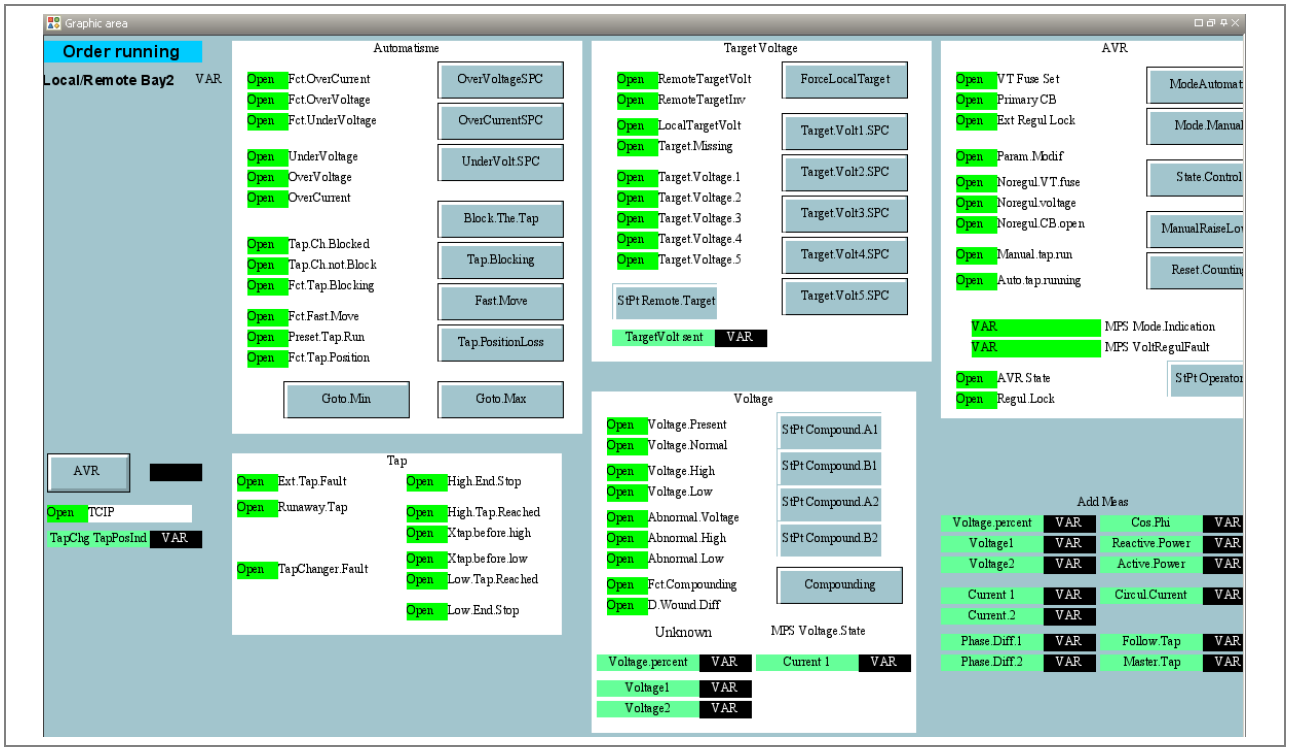
- double click the link 'Associated with'; this opens the Relation link editor
- select the desired path in the list beneath
- click OK



To assign an IEC address to each datapoint:

- select the data point
- tap into the 'Objects entry' window to add a link
- double click the link
- select the path in the list
- click **OK**

5.6.2 GRAPHIC SECTION (EXAMPLE OF OPERATOR WORKSTATION LISTING OUT THE DATAPOINTS)



5.6.3 AVR BEHAVIOUR

The AVR built-in function is described in chapter C26x/EN FT.

5.6.3.1 LIST OF ATTRIBUTES

Tab	Parameter name	Values	Min	Max	Step	Default
AVR	Nominal voltage	Vn	100	120	1	100V
	Nominal current	In	1	5	4	1A
	Regulation type	Phase-to-Neutral Voltage / Phase-to-Phase Voltage	-	-	-	Phase-to-Neutral Voltage
	Manual controls allowed	No / Only on AVR locked / Always				No
	Automatic move manual on error	No / Yes (immediately) / Yes only after a delay				No
	Manual Mode on Error		0	120	1	60
	AVR State	On / Off	-	-	-	On
	AVR Mode	Manual / Automatic	-	-	-	Automatic
	Transformer Nominal voltage		0	800 000.0	500	60 000.0V
TAP	Tap changer fault function	Internal only / External only / Internal and External	-	-	-	Internal only
	Tap changer fault behaviour	Automatic reset /manual reset/manual mode	-	-	-	Manual reset
	Highest tap value		1	64	1	64
	Lowest tap value		1	64	1	1
	Intermediate position	No/yes	-	-	-	No
	Intermediate position active	Off/on				Off
	Intermediate tap delay		0s	60s	1s	10s
	Intermediate tap		1	64	1	1
	First step delay	TA1	10s	70s	5s	60s
	Next tap delay	TA2	2s	30s	2s	10s
	End Tap delay		0s	180s	5s	60s
	First tap delay bypass delay	TA3	20s	120s	10s	30s
	Preset tap		1	39	1	1
	Preset tap delay		0s	10s	1s	1 s
	Tcip delay		5s	180s	5s	10 s
	Tcip end delay		1s	120s	1s	10 s
	Tap changer fault delay		60s	600s	10s	120 s
	Tap Pulse Duration		0.5s	30s	0.1s	0.5 s
	Number of taps before highest tap		1	10	1	4
	Number of taps before lowest tap		1	10	1	4
	Slipping period for counting	Period in days	1	120	1	30
	Runaway tap delay		0s	60s	1s	30 s

VOLTAGE	Voltage confirmation delay		0s	10s	0.1s	3s
	Double wound	Yes/no	-	-	-	No
	Double wound voltage	Voltage 1 / voltage 2 / average				Voltage 1
	Double wound voltage difference	% of Vn	0%	10%	1%	5%
	Voltage presence threshold	Displayed in volt but used as % Vn	20%	80%	10%	50%
	Voltage Confirm delay	?	0	10	0.1	0.5
	Double Wound	Yes/no	-	-	-	No
	Double Wound Voltage	Voltage 1 / voltage 2 / average				Voltage 1
	Voltage presence (threshold)	Displayed in volt but used as % Vn	20%	80%	10%	50%
	Regulation deadband	% of target voltage	0%	4%	0.25%	1.25%
	Abnormal voltage (threshold)	% of target voltage	2%	11%	1%	5%
	Abnormal voltage present delay		0s	600s	1s	0s
	Abnormal voltage delay present	T4	20s	600s	10s	300s
	Abnormal voltage delay missing		0s	600s	10s	0s
	Voltage present delay	Tp	0s	120s	1s	0s
	Voltage missing delay	Ta	30s	180s	10s	120s
	Compounding activation*	Off / On	-	-	-	Off
	Compounding method	Active / Reactive	-	-	-	Active
	Active compounding method par. A1**	% of Vn/In	0%	20%	0.5%	0%
	Active compounding method par. B1**	% of Vn/In	0%	20%	0.5%	0%
	Reactive compounding method p A2**	% of Vn/In	0%	20%	0.5%	0%
	Reactive compounding method p B2**	% of Vn/In	0%	20%	0.5%	0%
	Double wound Volt diff		0	10	1	
	Compound nominal current		0	10	0.01	2
	Voltage correction		0		0.01	0%
	Compounding method double a1**	No / Yes				No
	Compounding method double b1**	No / Yes				No
	Compounding method double a2**	No / Yes				No
	Compounding method double b2**	No / Yes				No
TARGET VOLTAGE	Target voltage management	Controls/Remote-Local	-	-	-	Controls
	Target voltage active	No/1/2/3/4/5				No
	No target voltage active delay		10	300	10	60
	Remote target voltage min value	In % of Vn	90%	105%	0,25%	90%
	Remote target voltage max value	In % of Vn	95%	110%	0,25%	110%
	Remote target maximum difference between 2 target voltages	In Volt (MV range value)	50V	500V	10V	200V
	End of remote target voltage delay		0mn	480mn	10mn	60mn
	End of local target voltage delay		3mn	10mn	1mn	5 mn
	Target voltage 1	Displayed in volt but used as % Vn of nominal voltage	88%	112%	0.1%	100%
	Target voltage 2	Displayed in volt but used as % Vn of nominal voltage	100%	104%	0.1%	102%

	Target voltage 3	Displayed in volt but used as % Vn of nominal voltage	103%	107%	0.1%	105%
	Target voltage 4	Displayed in volt but used as % Vn of nominal voltage	106%	110%	0.1%	108%
	Target voltage 5	Displayed in volt but used as % Vn of nominal voltage	93%	97%	0.1%	95%
	Local Target Voltage	Displayed in volt but used as % Vn of nominal voltage	90%	110%	0.25%	100%
AUTO	Tap Changer Set	Only lower / Only raise / Both raise and lower				Both raise and lower
	Voltage loss position tap	on defined tap/lock automatic reg				On defined tap
	Tap changer position behaviour	Current tap / Preset tap /Lowest tap				preset
	Topology Status (primary CB state)	Open/close				close
	Overcurrent behavior	Signalisation / Signalation & locking				signalisation
	Overvoltage behavior	Signalisation / Signalation & locking				signalisation
	Undervoltage behavior	Signalisation / Signalation & locking				signalisation
	Tap changer position active*	Off/on	-	-	-	off
	Tap changer fast move active*	Off/on	-	-	-	off
	Overcurrent detection active *	Off/on	-	-	-	off
	Overcurrent threshold	% of In	50%	500%	10%	250%
	Overcurrent delay		0s	30s	0.1s	2 s
	Overvoltage detection active*	Off/On	-	-	-	Off
	Overvoltage threshold	% of Vn	100%	130%	1%	130%
	Overvoltage delay		0s	30s	0.1s	2 s
	Undervoltage detection active*	Off/on	-	-	-	off
	Undervoltage threshold	% of Vn	50%	100%	1%	70%
	Undervoltage delay		0s	30s	0.1s	2 s
	Tap Changer blocking *	Off/on	-	-	-	off
	Tap Changer blocking delay		0s	300s	10s	60 s
TRANSFO in //	Transformer in parallel	Yes/No	-	-	-	No
	Used Parrallel method	Master-Follower method / Minimize circulating current method				Master-Follower method
	Master/Follower Management					
	Role	Master/Follower/Follower master backup				Master
	State	State of the tap changer in Master/Follower mode: Off /On				On
	Master failure management	Follower Master backup active / Follower master backup inactive	-	-	-	Follower Master Backup active
	Backup mode delay		0s	120s	1s	60s

	Minimize circulating current Management					
	Computer role	Computer role in MCC mode • Master • Slave 1 • Slave 2 • Slave 3	-	-	-	Master
	Initial state	Initial state on MCC • Off • On	-	-	-	On
	Excessive circ. current threshold	Excessive circ. current threshold in % of In	0.0	40.0	1.0	15.0
	Upper tapping range	Upper tapping range of the power transformer secondary voltage in % of Vn	0.0	30.0	0.1	20.0
	Lower tapping range	Lower tapping range of the power transformer secondary voltage in % of Vn	0.0	30.0	0.1	20.0
	Coefficient A voltage	Coefficient A of the voltage measurement	0.0	1.0 E+32	-	0.0
	Coefficient B voltage	Coefficient B of the voltage measurement	0.0	1.0 E+32	-	0.0
	Coefficient A current	Coefficient A of the current measurement	0.0	1.0 E+32	-	0.0
	Coefficient B current	Coefficient B of the current measurement	0.0	1.0 E+32	-	0.0
	LDC R value	Line Drop Compensation R value	0.0	1.0 E+32	-	0.0
	LDC X value	Line Drop Compensation X value	0.0	1.0 E+32	-	0.0

* means that it can be modified through operator controls, ** through setpoints

5.6.3.2 LIST OF DATAPOINTS

5.6.3.2.1 AVR

Datapoint	Profile	Mode	Comments
Auto.Tap.running	SPS	Permanent	Automatic Tap Changer order running
AVR.State	SPS	Permanent	AVR "state" activation/deactivation status
Ext.Regul.Lock	SPS	Permanent	External voltage regulation lock, used to activate the "Regul.Lock" signalisation
Manual.Tap.run	SPS	Permanent	Automatic Tap Changer order running
Mode Automatic	SPC	Permanent	AVR "automatic mode" activation control
Mode.Indication	MPS	Permanent	AVR Mode indication: • 0: Off (AVR is inactive) • 1: Manual (AVR is in manual mode) • 2: not used (hidden state - AVR is waiting for the end of "Tap Control Sequence" before switching to Manual mode) • 3: Automatic (AVR is in automatic mode) • 4: not used (hidden state - AVR is waiting for the end of "Tap Control Sequence" before switching to Automatic mode) • 5: Automatic Locked (AVR is in automatic mode, but it is locked) • 6: Tap Changer Fault (AVR is in "Tap Changer Fault" state (the tap changer is in error) • 7: Manual after Meas Error (AVR is waiting the end of the "Manual after Meas Error" confirmation time out) • 8: Measurement Error (AVR is in measurement error mode) • 9: Automatic Follower (AVR is a Follower in automatic mode)
Mode.Manual	SPC	Permanent	AVR "manual mode" activation control
Noregul.Cb.open	SPS	Permanent	Voltage regulation not active due to topology status
Noregul.voltage	SPS	Permanent	Voltage regulation not active - voltage missing
Noregul.VT.Fuse	SPS	Permanent	Voltage regulation not active - VT Fuse
Operator.Tap	SETPOINT	Permanent	Operator tap position request, active only "AVR manual" mode
Param.Modif	SPS	Permanent	Modification of paramater(s) signalisation
Regul.Lock	SPS	Permanent	Regulation locked active according to: • "Ext.Regul.Lock" input • or "Overcurrent detection" • or "Tap Changer Blocking" When this signalisation is set, the automatic regulation is locked. The manual regulation is active even if the regulation is configured as "automatic regulation" (refer to "Manual Controls Allowed").
State.Control	SPC	Permanent	AVR "state" activation/deactivation control

Datapoint	Profile	Mode	Comments
Topology.status	SPS	Permanent	Status of the topology of Transformer bay, managed by the C264. Configuration on regulation by the parameter "Topology State" note: this input is provided by an automation in charge to provide complete transformer bay toplogy (primary, secondary CB, disconnectors ...)
Volt.Regul.Fault	MPS	Permanent	Voltage Regulation Fault status, according values described below (the error nmuber is used to concatene errors): 0. none 1. tap position impossible / invalid 2. tap changer blocked (TCIP not disappearance) 3. TCIP not appearance (transient) 4. VT fuse 5. 4 & 1 6. 4 & 2 7. TCIP positioned before control 8. measurements error 9. 8 & 1 10. 8 & 2 11. abnormal voltage 12. 8 & 4 13. 8 & 4 & 1 14. 8 & 4 & 2 15. not used
VT.Fuse.Set	SPS (failure: set)	Permanent	status of fuse present on secondary winding of instrument voltage transformer. note: if the transformer is a "Double Wound" transformer, VT.Fuse.Set indication is a computed status.

5.6.3.2.2 Automatism

Attributes	Profile	Mode	Comments
Block.The.Tap	SPC	Permanent	Tap changer blocking control
Fast.Move	SPC	Permanent	"Tap Changer acceleration" function control replaces the temporization "First step delay" by the "Next tap delay" during the temporization "First tap delay bypass delay"
Fct.Fast.Move	SPS	Permanent	"Fast Move" function status
Fct.OverCurrent	SPS	Permanent	"Overcurrent detection" function status
Fct.OverVoltage	SPS	Permanent	"Overvoltage detection" function status
Fct.Tap.Blocking	SPS	Permanent	"Tap Changer blocking" function status
Fct.Tap.Position	SPS	Permanent	"Tap changer position active" function status
Fct.UnderVoltage	SPS	Permanent	"Undervoltage detection" function status
Goto.Max	SPC	Permanent	"Tap changer in highest tap position" control (the tap changer goes from current tap position to highest tap position) note : define a timeout for this control feedback : GotoMax timeout = max(first tap delay) + (Highest Tap value * max(next tap delay))

Attributes	Profile	Mode	Comments
Goto.Min	SPC	Permanent	"Tap changer in lowest tap position" control (the tap changer goes goes from current tap position to highest tap position) note : define a timeout for this control feedback : GotoMax timeout = max(first tap delay) + (Highest Tap value * max(next tap delay))
OverCurrent	SPC	Permanent	"Line overcurrent detection" function activation control
OverCurrent	SPS	Permanent	OverCurrent detection status
OverVoltage	SPC	Permanent	"Overvoltage detection" function activation control
OverVoltage	SPS	Permanent	OverVoltage detection status
Preset.Tap.Run	SPS	Permanent	Preset Tap running status
Tap.Block.Prog	SPS	Permanent	"Tap Changer blocking" in progress status
Tap.Blocking	SPC	Permanent	"Tap Changer blocking" function activation control
Tap.Ch.Blocked	SPS	Transient	tap changer blocked status
Tap.Ch.not.Block	SPS	Transient	tap changer Not blocked status
Tap.Position	SPC	Permanent	"Tap changer position active" function activation control. The tap changer goes to a predefined tap position "Presset Tap", when "Noregul.voltage" status is set.
UnderVoltage	SPC	Permanent	"Undervoltage detection" function activation control
UnderVoltage	SPS	Permanent	UnderVoltage detection status

5.6.3.2.3 Target Voltage

Attributes	Profile	Mode	Comments
ForceLocalTarget	SPC		Force the target voltage in "local" mode
LocalTargetVolt	SPS	Permanent	Local target voltage activation status
Remote.Target	SETPOINT		Remote order used in case of "remote/local target voltage management". Target Voltage sets by RCP (Remote Control Point), exprimed in voltage value on primary side of transformer (ex : 245000.0)
RemoteTargetInv	SPS	Permanent	Remote target voltage invalidity status
RemoteTargetVolt	SPS	Permanent	Remote target voltage activation status
Target.Voltage.1	SPS	Permanent	"Target voltage 1" activation status
Target.Voltage.2	SPS	Permanent	"Target voltage 2" activation status
Target.Voltage.3	SPS	Permanent	"Target voltage 3" activation status
Target.Voltage.4	SPS	Permanent	"Target voltage 4" activation status

Attributes	Profile	Mode	Comments
Target.Voltage.5	SPS	Permanent	"Target voltage 5" activation status
Target.Missing	SPS	Permanent	Absence of "target voltage active" detection status (temporized)
Target.Volt1.SPC	SPC		"Target voltage 1" activation control
Target.Volt2.SPC	SPC		"Target voltage 2" activation control
Target.Volt3.SPC	SPC		"Target voltage 3" activation control
Target.Volt4.SPC	SPC		"Target voltage 4" activation control
Target.Volt5.SPC	SPC		"Target voltage 5" activation control
Target.Voltage	MV	-	value of target voltage

5.6.3.2.4 Tap

Attributes	Profile	Mode	Comments
Ext.Tap.Fault	SPS	Permanent	"Tap Changer fault" external indication
High.End.Stop	SPS	Permanent	"Tap Changer highest position is reached" indication
High.Tap.Reached	SPS	Permanent	Active when the "highest tap value" is reached. This signalisation can be set by the "Highest Tap Value", or by the digital input "High.End.Stop".
Low.End.Stop	SPS	Permanent	"Tap Changer lowest position is reached" indication
Low.Tap.Reached	SPS	Permanent	Active when the "lowest tap value" is reached. This signalisation can be set by the "Lowest Tap Value", or by the digital input "Low.End.Stop".
Runaway.Tap	SPS	Permanent	tap changer position change, without any control transmitted
TapChanger.Fault	SPS	Permanent	"Tap Changer Fault" status
Xtap.before.high	SPS	Permanent	"X last taps before highest tap" indication status
Xtap.before.low	SPS	Permanent	"X last taps before lowest tap" indication status

5.6.3.2.5 Voltage

Attributes	Profile	Mode	Comments
Abnormal.High.	SPS	Permanent	Voltage status "set" if "Voltage" is higher than the "Abnormal Voltage" threshold
Abnormal.Low	SPS	Permanent	Voltage status "set" if "Voltage" is lower than the "Abnormal Voltage" threshold
Abnormal.Voltage	SPS	Permanent	Voltage status "set" when the "Abnormal.High" and "Abnormal.Low" status are "set", after the temporization "Voltage present delay"
Active.Power	MV	-	Total active power value Pt: total active power
Apparent.Power	MV	-	Calculated Apparent Power value
Compound.A1	MV	-	AVR compounding parameter A1
Compound.A2	MV	-	AVR compounding parameter A2
Compound.B1	MV	-	AVR compounding parameter B1
Compound.B2	MV	-	AVR compounding parameter B2
Coumponding	SPC	Permanent	"Compounding" methods activation control
Cos.Phi	MV	-	Power factor value selection cosPhi(t): total power factor
Current1	MV	-	On all types of power transformers: RMS current related to "Voltage1" selection In case of Phase-to-Neutral voltage selection for Voltage1: • I_A RMS value of the current phase A (if Van selected for Voltage1) • I_B RMS value of the current phase B (if Vbn selected for Voltage1) • I_C RMS value of the current phase C (if Vcn selected for Voltage1) In case of Phase-to-Phase voltage selection for Voltage1: • I_{AB} RMS value of the current phase AB (if Vab selected for Voltage1) • I_{BC} RMS value of the current phase BC (if Vbc selected for Voltage1) I_{CA} RMS value of the current phase CA (if Vca selected for Voltage1)
Current2	MV	-	Only for double-wound transformer (measured on second wound of power transformer): RMS current related to "Voltage2" selection (in "CPU470_266 / measurement type" attribute) In case of Phase-to-Neutral voltage selection for Voltage2: • I_A RMS value of the current phase A (if Van selected for Voltage2)

Attributes	Profile	Mode	Comments
			• I_B RMS value of the current phase B (if Vbn selected for Voltage2) • I_C RMS value of the current phase C (if Vcn selected for Voltage2) In case of Phase-to-Phase voltage selection for Voltage2: • I_{AB} RMS value of the current phase AB (if Vab selected for Voltage2) • I_{BC} RMS value of the current phase BC (if Vbc selected for Voltage2) I_{CA} RMS value of the current phase CA (if Vca selected for Voltage2)
D.Wound.Diff	SPS	Permanent	Voltage status "set" when the difference between the voltages of the two wounds is greater than "Double wound Volt diff"
Fct.Coumponding	SPS	Permanent	"Coumponding" methods function status
Phase.Diff1	MV	-	On all types of power transformers: Phase difference between "Voltage1" and "Current1" selection (in "CPU470_266 / measurement type" attribute) • In case of Phase-to-Neutral voltage selection for Voltage1: • Phase difference I_A / V_A for AVR (if Van selected for Voltage1) • Phase difference I_B / V_B for AVR (if Vbn selected for Voltage1) • Phase difference I_C / V_C for AVR (if Vcn selected for Voltage1) In case of Phase-to-Phase voltage selectionfor Voltage1: • Phase difference I_{AB} / U_{AB} for AVR (if Vab selected for Voltage1) • Phase difference I_{BC} / U_{BC} for AVR (if Vbc selected for Voltage1) Phase difference I_{CA} / U_{CA} for AVR (if Vca selected for Voltage1)
Phase.Diff.2	MV	-	Only in case of of double-wound transformer (measured on second wound of power transformer): Phase difference between "Voltage2" and "Current2" selection. In case of **Phase-to-Neutral voltage** selection for Voltage2: • Phase difference I_A / V_A for AVR (if Van selected for Voltage2) • Phase difference I_B / V_B for AVR (if Vbn selected

Attributes	Profile	Mode	Comments
			for Voltage2) • Phase difference I_C / V_C for AVR (if Vcn selected for Voltage2) in case of **Phase-to-Phase voltage** selectionfor Voltage2: • Phase difference I_{AB} / U_{AB} for AVR (if Vab selected for Voltage2) • Phase difference I_{BC} / U_{BC} for AVR (if Vbc selected for Voltage2) Phase difference I_{CA} / U_{CA} for AVR (if Vca selected for Voltage2)
Reactive.Power	MV	-	Total reactive power value selection Qt: total reactive power
V.Balanced	MV	-	Vreg - Vc Balanced
Voltage1	MV	-	On all type of power transformers: In case of "Phase-to-Neutral voltage" selection: • V_{AN}: RMS value of the voltage phase A • V_{BN}: RMS value of the voltage phase B • V_{CN}: RMS value of the voltage phase C In case of "Phase-to-Phase voltage" selection: • V_{AB}: RMS value of the voltage phase A • V_{BC}: RMS value of the voltage phase B V_{CA}: RMS value of the voltage phase C
Voltage2	MV		Only in case of double-wound transformer (measured on second wound of power transformer): In case of "Phase-to-Neutral voltage" selection: • V_{AN}: RMS value of the voltage phase A • V_{BN}: RMS value of the voltage phase B • V_{CN}: RMS value of the voltage phase C In case of "Phase-to-Phase voltage" selection: • V_{AB}: RMS value of the voltage phase A • V_{BC}: RMS value of the voltage phase B V_{CA}: RMS value of the voltage phase C
Voltage.High	SPS	Permanent	Voltage status "set" when the "Voltage" value is greater than the "regulation deadband", after the temporization "Voltage Confirm delay"
Voltage.Low	SPS	Permanent	Voltage status "set" when the "Voltage" value is lower than the "regulation deadband", after the temporization "Voltage Confirm delay"

Attributes	Profile	Mode	Comments
Voltage.Normal	SPS	Permanent	Voltage status "set" when the "Voltage" value is in the "regulation deadband", after the temporization "Voltage Confirm delay"
Voltage.Present	SPS	Permanent	Presence/absence voltage status "set" when the "Voltage presence" threshold is reached, after the temporization "Voltage presence delay" "reset" when the "Voltage presence" threshold is not reached, after the temporization "Voltage missing delay"
Voltage.State	MPS	Permanent	Voltage indication management: 0 Voltage Missing (Voltage is missing - confirmed state) 1 Voltage Normal (Voltage value is within the regulation range) 2 Voltage High (Voltage value is greater than the regulation high threshold) 3 Voltage Low (Voltage value is lower than the regulation high threshold) 4 No Conditions (one or more condition is missing for voltage indication management)

5.6.3.2.6 Transformer in parallel

Attributes	Profile	Mode	Comments
Circul.Current	MV	-	RMS value of circulating current
Specific datapoints for Master Follower method			
Master.Tap	MV	-	Master tap position (common datapoint for the two methods)
Follow.Tap	MV	-	Tap position indication, transmitted by "Follower Master Backup" to "Followers", in case of "Master Failure"
Master.Failure	SPS	Permanent	"Master Failure" status
Master.FollowSPC	SPC	Permanent	"Master/Follower" function activation control
Master.Follow	SPS	Permanent	"Master/Follower" function activation status
Master.Follow.Mo	MPS	Permanent	Master/Follower mode status: 0: Master 1: Follower 2: Follower/Master backup
Specific datapoints for Minimize circulating current method			
MCC.State	SPS	Permanent	Minimize circulating current state indication
MCC.Active	SPC	Permanent	Minimize circulating current method control
Circul.Current	MV		RMS value of circulating current

Attributes	Profile	Mode	Comments
MCC.Excessive	SPS	Permanent	Excessive Circulating current indication
DeltaUreached	SPS	Permanent	Computed information used to limit the circulating current
MCC.error.mode	MPS	Permanent	Multistate MCC regulation method status information
Master.Tap.Slv1	MV	-	Master tap position of slave 1
Master.Tap.Slv2	MV	-	Master tap position of slave 2
Master.Tap.Slv3	MV	-	Master tap position of slave 3

5.7 DEFINING AN ELECTRICAL REGULATION BY USER FUNCTION

DS Agile allows the user to configure specific control sequences or automations (e.g. switching sequences, busbar transfer, load shedding, GIS-pressure supervision, etc …) during the configuration phase.

To do that, there are two main solutions:

- Using ISaGRAF workbench for slow automations, where the execution of the automation is cyclic, based on a cycle that can not be less than 50 ms.
- Using extended logical function modeling (Boolean, timer, bistable functions) via FBD workbench, where the execution is event-driven.

User function can be put at any level of the electrical topology except Site. Moreover, slow automation is unavailable at module level. User function must always specify on which C26x it runs. For details, refer to the **Application** chapter of the **SCE** user manual.

Extra solutions for simpler needs exist at configuration level (they could be seen as restriction of particular FBD functions):

- Group modeling: SPS production based on a pre-defined Boolean function working on a set of datapoint.
- xPS-xPC association: on a particular state of xPS, ability to control a given xPC.
- SPS-DPS association: DPS production based on the synthesis of 2 SPSs.
- Interlocking definition: production of virtual SPS datapoints used to control opening and/or closure of modules. These virtual datapoints are defined through specific FBD logical diagrams where inputs are generally breaker and switch positions.
- Automatic/manual dependency set at control level (SPC, DPC or SetPoint): when a control is linked to an SPS or DPS via the automatic/manual dependency, control is refused if the SPS (resp. DPS) is in the SET (resp. CLOSED) state.

5.7.1 DATAPOINT GROUPING

A group is a logical OR, AND, NOR or NAND combination of "inputs" whose type is SPS, DPS, or groups. An input can belong to several groups. Datapoint grouping is configured in the SCE using the specific SPS called '**Group SPS**' in data modelling

A "Group SPS" can be added to any type of bay or module (except circuit-breaker). The C26x that manages the bay (or the bay containing the module) computes it.

A group SPS can be seen as a particular fast automation reduced to one Boolean function (gate) with one implicit output (the group SPS itself) and inputs corresponding to each component of the group.

5.7.1.1 DEFINING A GROUP OF DATAPOINTS

To add a "Group SPS":

1 Click on the bay or module in the electrical topology,

2 In the **Object entry** panel, right-click on the "**Group SPS**" datapoint and then, select **Add** from the context menu.

For details on electrical topology creation, see section *5.1 Defining an electrical topology*.

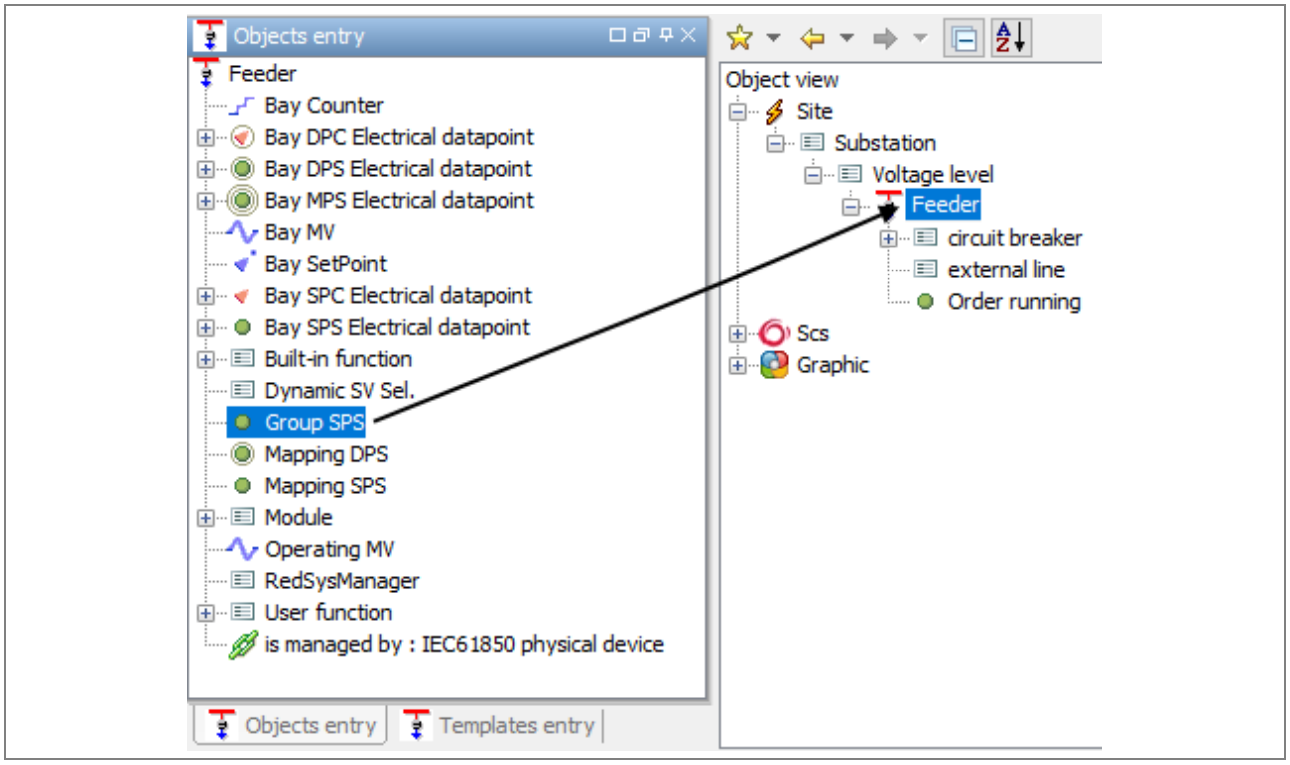


Figure 343: Adding a group SPS (example for a feeder at bay level)

Once added, set the "Group SPS" features at SCE level, as SPS datapoint. For details about SPS datapoint configuration, see section *4.3.1 Defining an SPS datapoint*.

Nevertheless, the specific attribute **operator type** (1) must be set for the group. It corresponds to the logical operator (OR, AND, NOR or NAND) applied on all the inputs (datapoints) of the group.

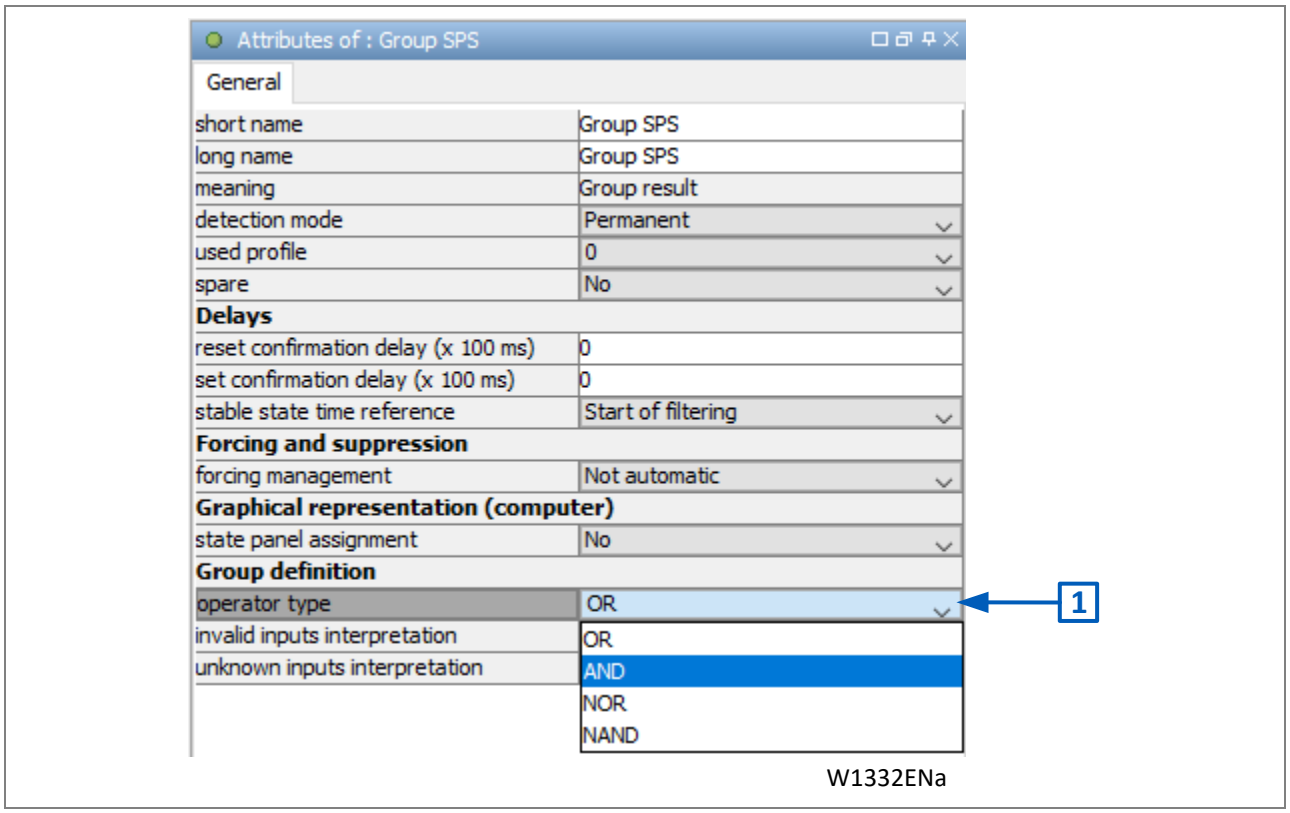


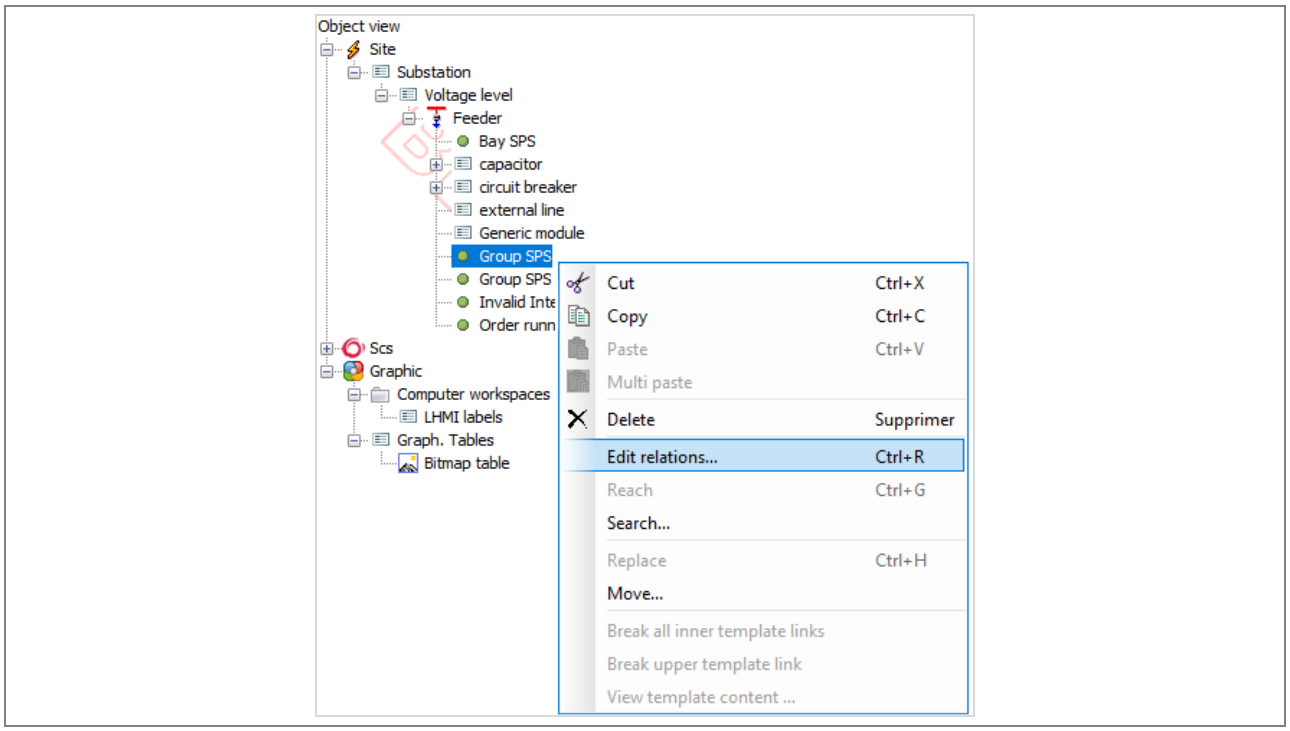
Figure 344: Setting the Group type attribute of a group SPS

Note:
*The attributes **Invalid input interpretation** and **Unknown input Interpretation** are used only when the bay and the Group SPS is managed by a Gateway. They are not taken into account for a Group SPS managed by the C26x.*

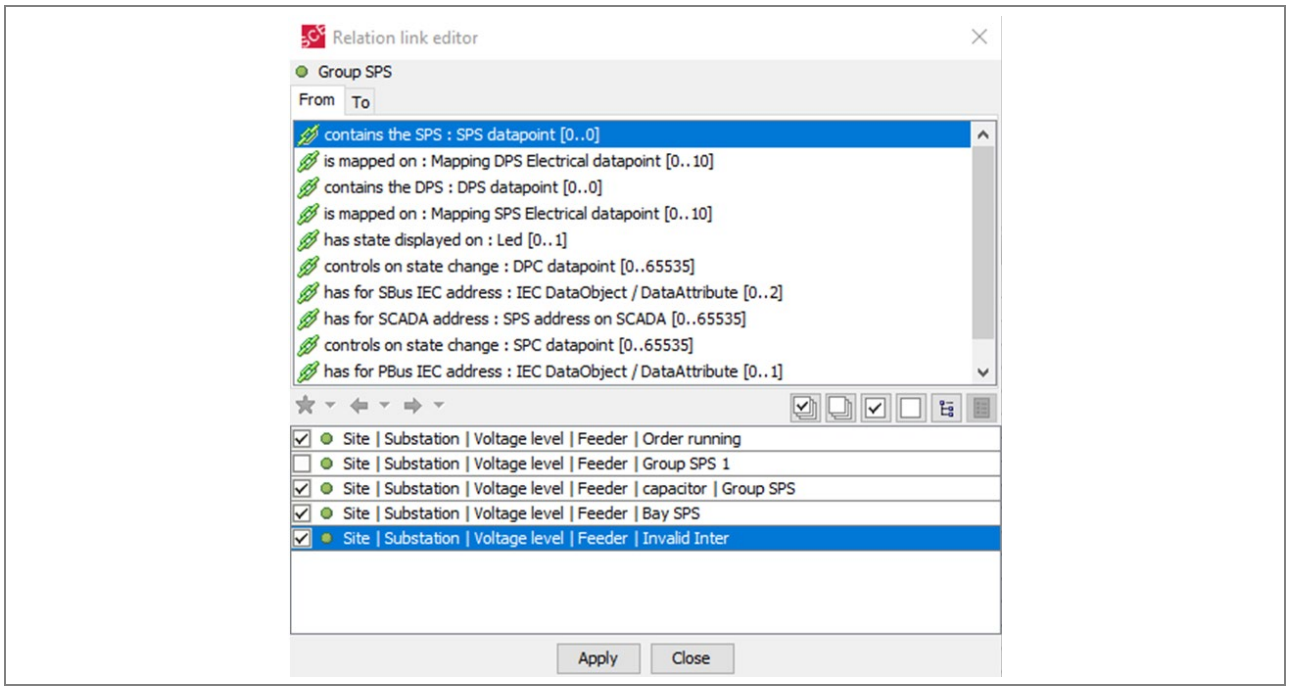
5.7.1.2 ADDING AN INPUT TO A GROUP OF DATAPOINTS

To add several inputs to a group of datapoints (SPS, DPS or group):

- Right-click on the "**Group SPS**" and select **Edit relations…** from the context menu:



- In the **From** tab, select the relation **contains the <XXX>** at "**Group SPS**" level, where XXX corresponds to the datapoint type (SPS, DPS)
- Then, fill in the relation by selecting the relevant datapoints at the bottom of the window and click **Apply** to validate your selection:



If you need to add a single input:

- Click on the “**Group SPS**” in the electrical topology,
- In the **Object entry** panel, right-click and add the relation **contains the <XXX>** at “**Group SPS**” level, where XXX corresponds to the datapoint type (SPS, DPS),

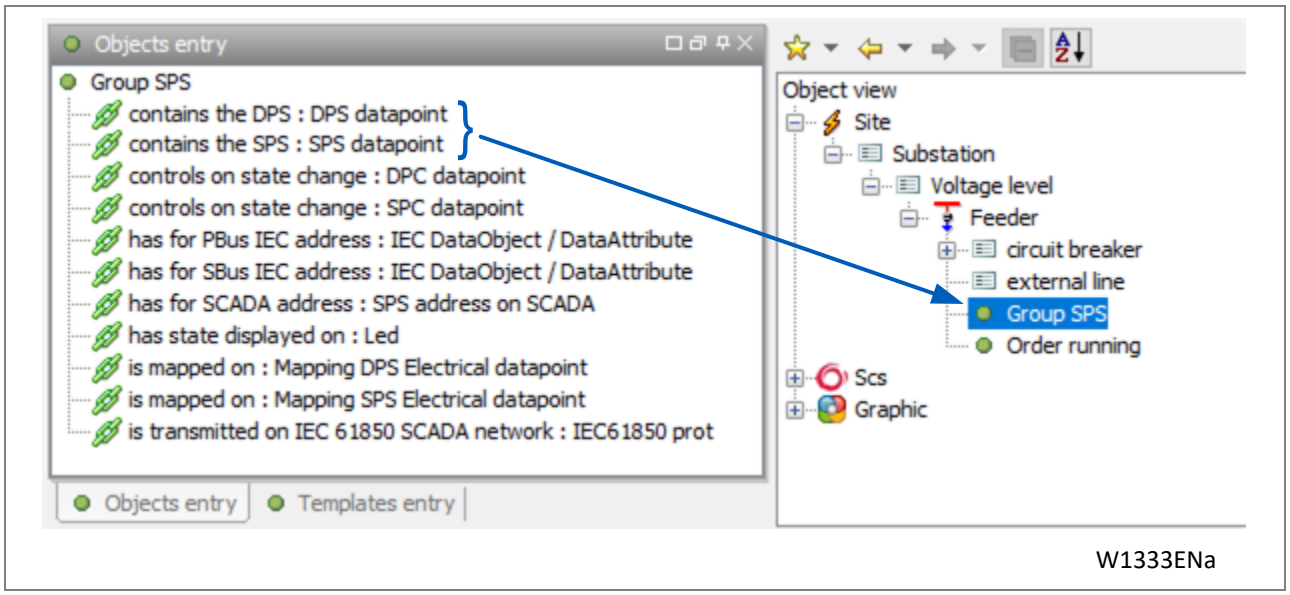


Figure 345: Adding a component (input) to a group

- Then, fill in the relation by selecting the relevant datapoint.

Configuration rules and limits

- The same datapoint whatever it is an SPS, DPS or MPS cannot be used several times in the same Group SPS.
- The maximum number of “Group SPS” managed by a C26x is **512**.
- In a bay managed by a C26x, the “Group SPS” can contain up to **255** datapoints (not spared).
- The 'Group SPS' imbrication level is limited to 8.
- In a "Group SPS", input datapoints from other devices are transmitted through IEC Report Control Block only.
- A datapoint (SPS, DPS or MPS) can not belong to more than **100** groups.

5.7.2 CONTROLLING AN XPC USING AN XPS STATE CHANGE

For specific needs, some SPS or DPS can act on SPC or DPC. This relation is called xPS-xPC association. Such an acted xPC may or may not need a channel for wiring. It can be an xPC used for automation management for instance.

The link defines for each state of the xPS which order must be sent.

To create such a relation:

- Add the relation **controls on state change** (1) at SPS/DPS level; two relations are available depending on control type to act (SPC or DPC). Choose the correct one.
- Fill the relation with the relevant SPC or DPC (2).
- Set the relation attributes (3) giving for each state of the xPS, the order to send: "*None*", *Set", "Reset" for* SPC or "*None", Close", "Open" for DPC*.
- Select the relevant control mode (4):
  - **Direct relay activation**: there is no particular control; the relay is activated directly (the xPC **shall be** wired or have an IED address).
  - **Whole control sequence**: a full control sequence is done before activating the relay.
  - **Autorecloser sequence (with interlock)**: The interlock control is done. This option is be used only in the case of **AR_CLOSE_1P** or **AR_CLOSE_3P** SPS of the AutoRecloser Type 3 buit-in function.
  - **Autorecloser sequence (bypass interlock)**: The interlock control is bypassed. This option is be used only in the case of **AR_CLOSE_1P** or **AR_CLOSE_3P** SPS of the AutoRecloser Type 3 buit-in function

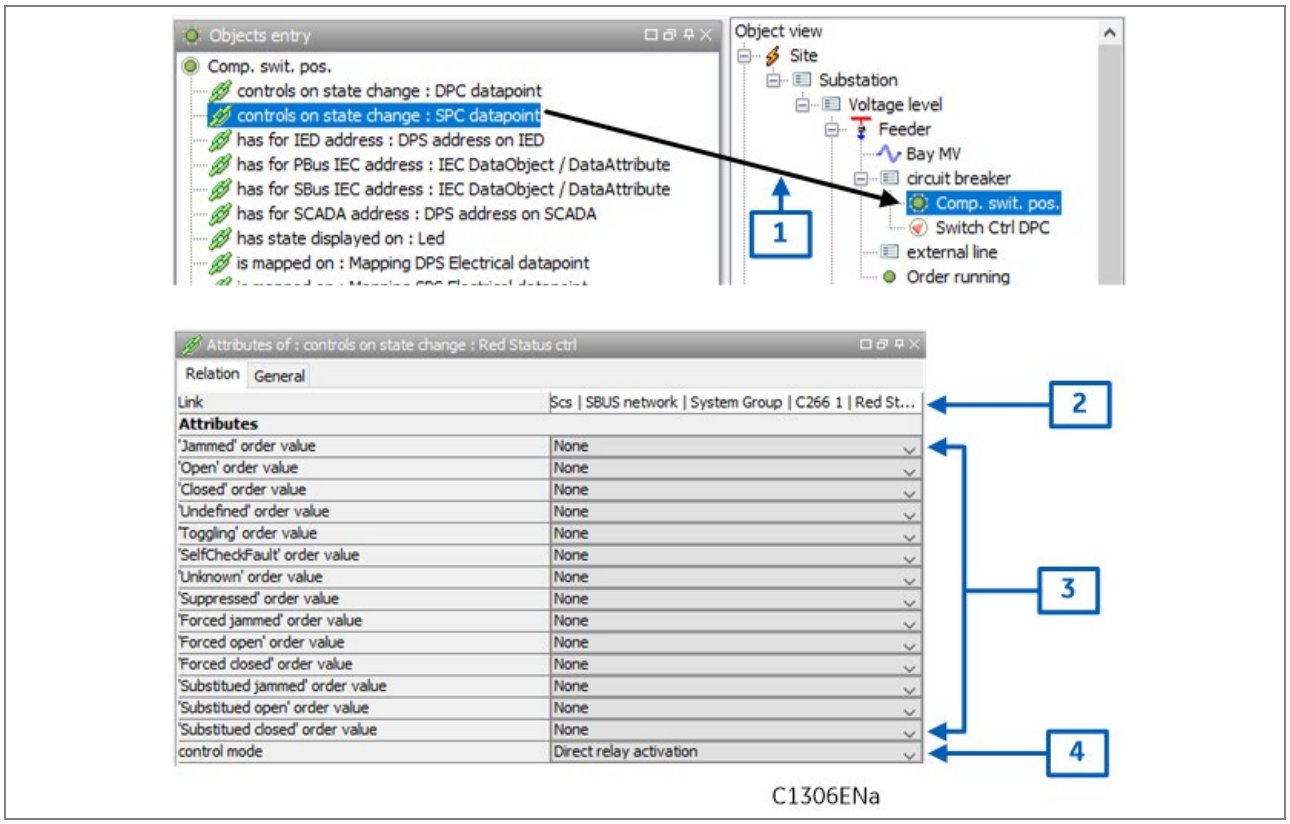


Figure 346: Controlling an xPC using an xPS state change (example)

In case of controls launched by an xPS, the Control Originator fields are:

- orCat = Bay level
- orIdent = xPS label

5.7.3 PRODUCING A DPS FROM 2 SPSS

For specific needs, two SPSs (one for open state, and the other for closed state) can be used to manage a DPS. This relation is called SPS-DPS association.

To produce a DPS from two SPS:

- Create the three datapoints and configure them (see section *4 Defining a datapoint*)
- At the DPS level, add the relations **has open state given by** (1) and **has closed state given by** (2)
- Fill the two relations with the previously created SPS datapoint

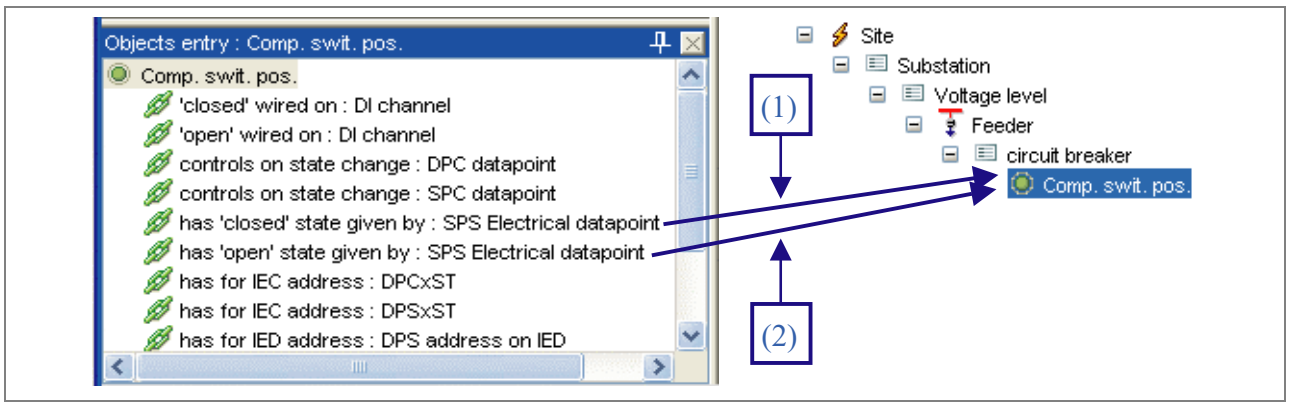


Figure 347: Producing a DPS from 2 SPSs (example)

5.7.4 DEFINING AN INTERLOCK

Any DPC (or SPC) belonging to a bay or module can have interlocking equation for opening order and/or closing order.

Interlocking equation corresponds to a logical function that must be ‘true’ to send the order.

In data modeling, interlocking equations are under SPC or DPC by adding specific SPS:

- Close/lower interlock
- Open/raise interlock

These SPSs are the result of a function coded with the FBD editor. When the SPS value is true, the control is allowed.

Interlocking equation diagrams are identical to FBD fast automation diagrams, except that:

- timer, bistable function are unusable
- there is no output plug

To add an interlock SPS, select the SPC/DPC datapoint level and add the interlock SPS from the contextual **Objects entry** window (1).

For details about electrical topology creation, refer section *5.1 Defining an electrical topology*.

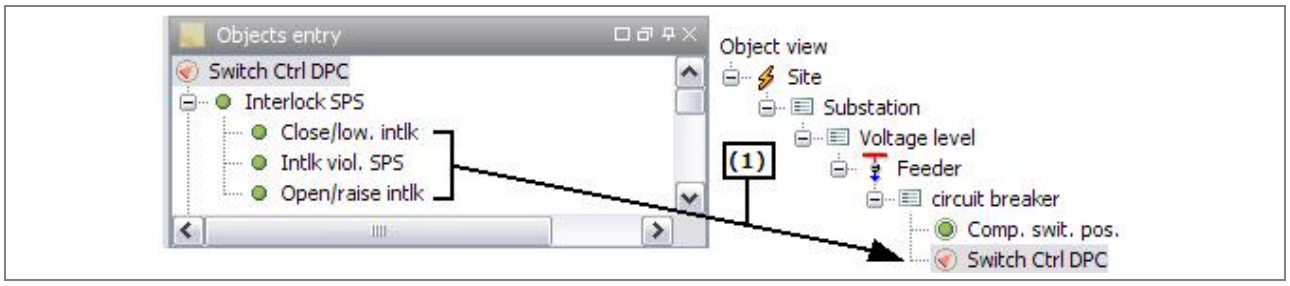


Figure 348: Adding an interlock SPS (example for a DPC)

Once added, interlock SPS features must be set at SCE level, as SPS datapoint. For details about SPS datapoint configuration, see section *4.3.1 Defining an SPS datapoint*.

To define interlocking equation for an interlock SPS:

- Add at interlock SPS level, an FBD interlock object (1):
- Configure this FBD interlock (see section *Defining an FBD fast automation* in the Application chapter of the SCE user manual), with the existing following restrictions:
  - Only input plugs are available for its interface definition.
  - For its body description via FBD editor, timer and bistable functions do not exist.

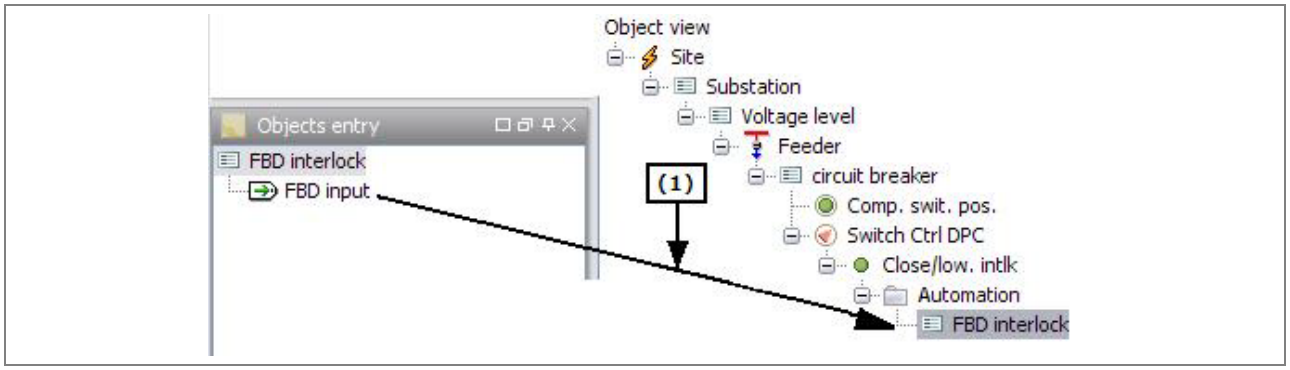
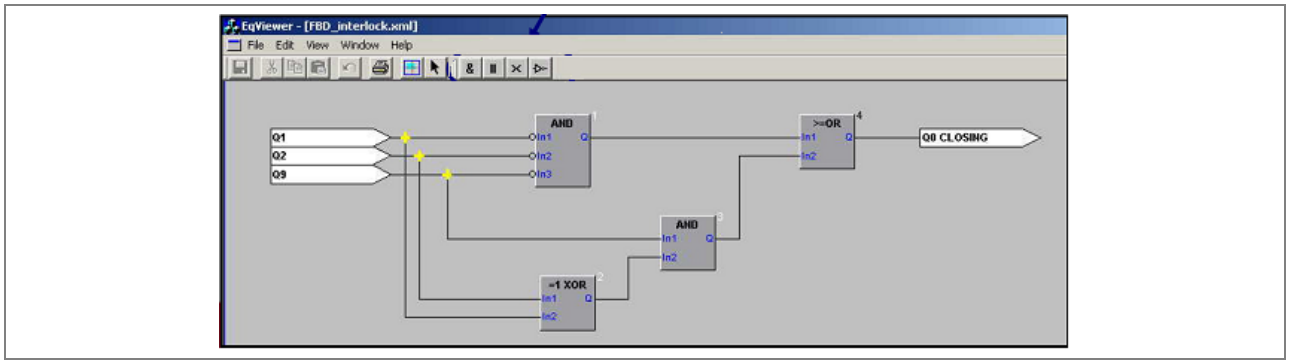


Figure 349: Defining the interlocking equation for an interlock SPS

Example



The optional SPS ‘Intlk viol. SPS’ is true when the control is rejected. It is used by some SCADAs which cannot know the reason of a NACK(especially with Modbus).

5.7.5 DEFINING AN AUTOMATIC/MANUAL DEPENDENCY

Automatic/manual dependency can be set at control level (SPC, DPC or SetPoint):
When a control is linked to an SPS or DPS via the automatic/manual dependency, control is refused if the SPS (resp. DPS) is in the SET (resp. CLOSED) state. To create an automatic/manual dependency:

- Add the relation **has for AutoManu dependency** (1) at control level; two relations are available depending on the input type setting the dependency (SPS or DPS). Choose the correct one.
- Fill the relation with the relevant SPS or DPS (2).

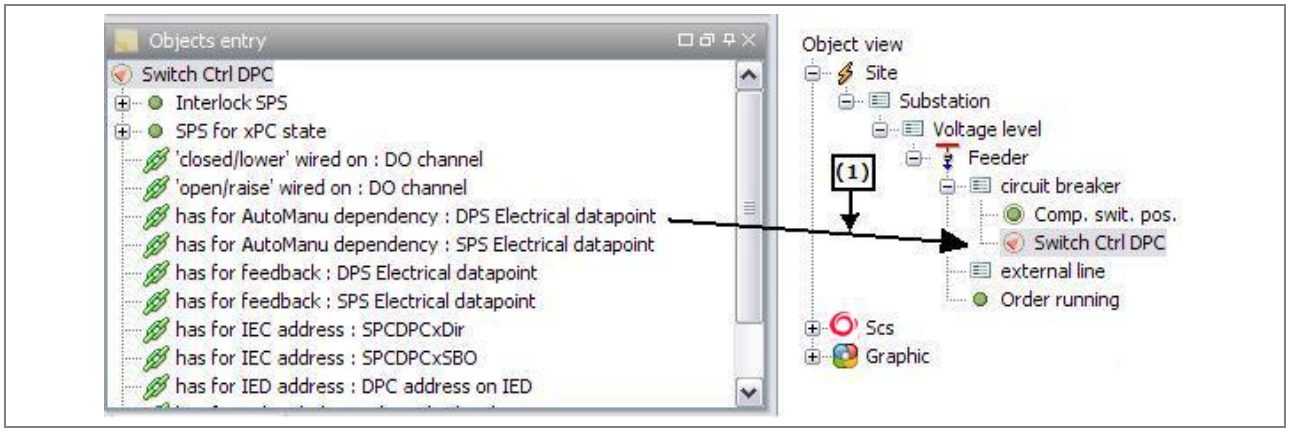


Figure 350: Defining an automatic/manual dependency (example)

Configuration rules and checks

- For each "DPC", "SPC" or "Setpoint" datapoint, 2 relations **has for AutoManu dependency** are available, but they are mutually exclusive.

5.8 DYNAMIC LINE RATING (DLR)

The thermal rating, also referred to as ampacity, of an overhead line is the maximum current that a circuit can carry without exceeding its sag temperature or the annealing onset temperature of the conductor, whichever is lower. The sag temperature is that temperature at which the legislated height of the phase conductor above ground is met. The present practice in many utilities is to monitor the power flow in overhead lines without knowledge of the actual conductor temperature or the height of the conductor above ground. There are many variables affecting the conductor temperature, such as wind speed and direction, ambient temperature and solar radiation. As these are difficult to predict, conservative assumptions have been made so far to always ensure public safety. The main purpose of real time line monitoring is to achieve a better utilization of the load current capacity of overhead lines while ensuring the regulatory clearances above ground are always met.

Different real time line monitoring methods have been applied and evaluated as described in various publications. There are fundamentally two different ways to derive ampacity dynamically. One is by direct measurement using sensors to determine the tension, conductor temperature, or sag. Alternatively, an indirect method can be used, by measuring ambient weather conditions, from which the ampacity can be calculated by solving standard equations in real time.

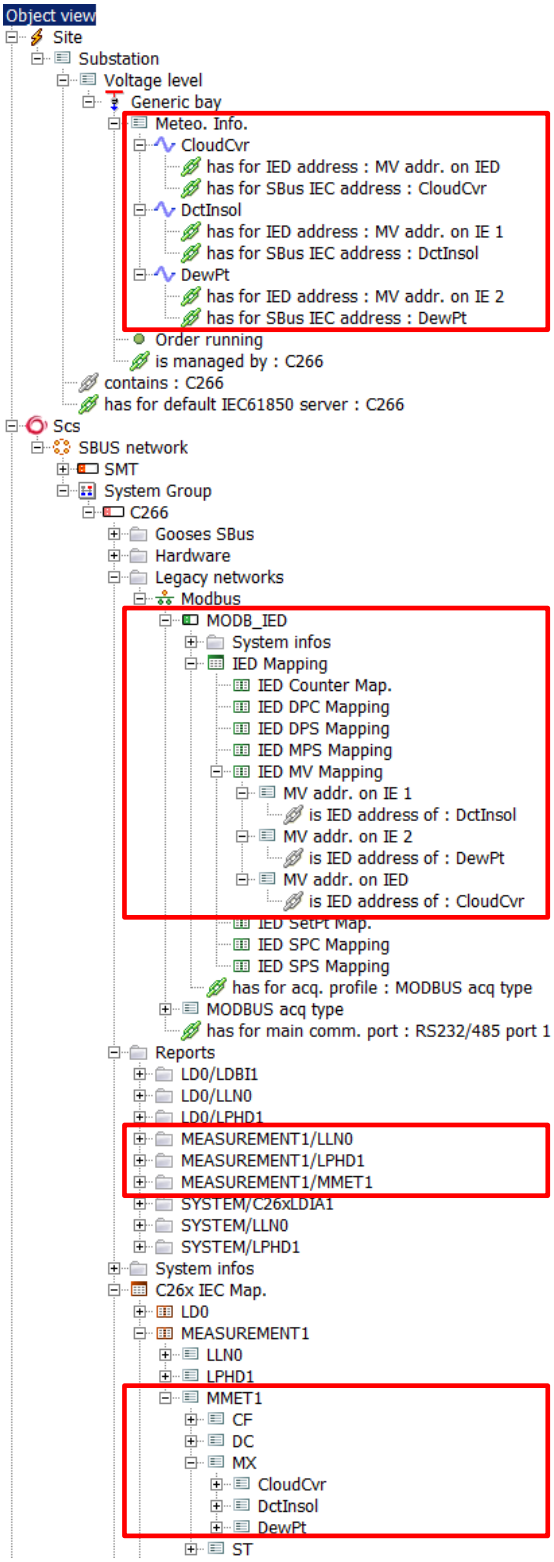
Sensors connected to a legacy bus transmit meteorological measurements at fixed intervals, usually depending on the type of measurement. The DS Agile BCU can collect these measurements and transmit them over the station bus for use in dynamic line rating applications and/or to the DS Agile aView for processing (data archiving, display, or trend/average computing).

An IEC 61850-compliant MMET logical node is available, containing the following optional MVs. They are automatically addressed on the station bus.

The typed MVs listed below can be added to a dedicated module that is only available under a Generic Bay:

Default Short name (IEC label)	Default Long name	Default Min Value	Default Max Value
EnvTmp	Temperature of environment (°C)	-50	60
WetBlbTmp	Wet bulb temperature (°C)	-50	60
CloudCvr	Cloud cover level (mm)	0	100
EnvHum	Humidity of environment (%)	0	100
DewPt	Dew point (°C)	-50	60
DffInsol	Diffuse insolation (W/m^2)	0	1400
DctInsol	Direct normal insolation (W/m^2)	0	1400
DlDur	Daylight duration *(minutes)*	0	1440
HorInsol	Total horiz. insolation (W/m^2)	0	1400
HorWdDir	Total horiz. wind direction (°)	0	359.9
HorWdSpd	Average horiz. wind speed (m/s)	0	60
VerWdDir	Vertical wind direction (°)	0	359.9
VerWdSpd	Average vert. wind speed (m/s)	0	60
WdGustSpd	Maximum wind gust speed (m/s)	0	100
EnvPres	Barometric pressure (hPa)	300	1200
RnFll	Rainfall (mm)	0	200
SnwDen	Snowfall density (g/cm^3)	0	2
SnwTmp	Snowfall temperature (°C)	-16	0
SnwCvr	Snow cover (mm)	0	100
SnwFll	Snowfall (mm)	0	200
SnwEq	Water eq. of snowfall (mm)	0	100

Note:
Measurement units and their associated min/max values are region-dependent. The default values shown here are those used in Europe.



Procedure

1 Add a **Generic Bay** under the **Voltage Level** node and set its “is managed by” relation to the relevant BCU.

2 Add one or more **Meteo. Info.** typed module(s) to the **Generic Bay**. Under each **Meteo. Info.** module, add the required MVs. Note that only one instance per typed MV can be added in each module.

3 Create the corresponding profiles and link them to the MVs.

4 Under the BCU, add the sensor’s legacy network protocol and configure it (see section *3.6 Networking IEDs on a C26x’s legacy network*).

5 Add and configure a legacy IED according to the protocol (see section *3.6.1.4 Adding an IED to a legacy network*).

6 Address the MVs to the legacy IED (see section *3.6.1.1 Setting the general attributes of a legacy network*)

7 Use the auto-addressing function (“all steps in one”) to automatically create the SBUS addresses and add them to the BCU’s mapping, as well as create the **MMET** report and link it to the clients (usually the System HMI server, aView) if these are configured to prefer unbuffered reports (**Miscellaneous** attribute **Type of report for client** set to *unbuffered*, see section *3.2.5 Miscellaneous attributes*). Otherwise, the MVs are transmitted in the **Measurement LLN0** report

Note:
In case of sensor redundancy, use a slow automation (IsaGRAF) to manage which sets of MVs are published by the BCU. In that application the MVs received from the sensors are used as inputs of the automation and the MVs output by the automation have their values included in the BCU’s MMS reports.

5.9 DEFINING A FRESNEL FUNCTION

A Fresnel diagram is the graphical representation of a three-phase system showing voltage and current as vectors, as shown on the image below:

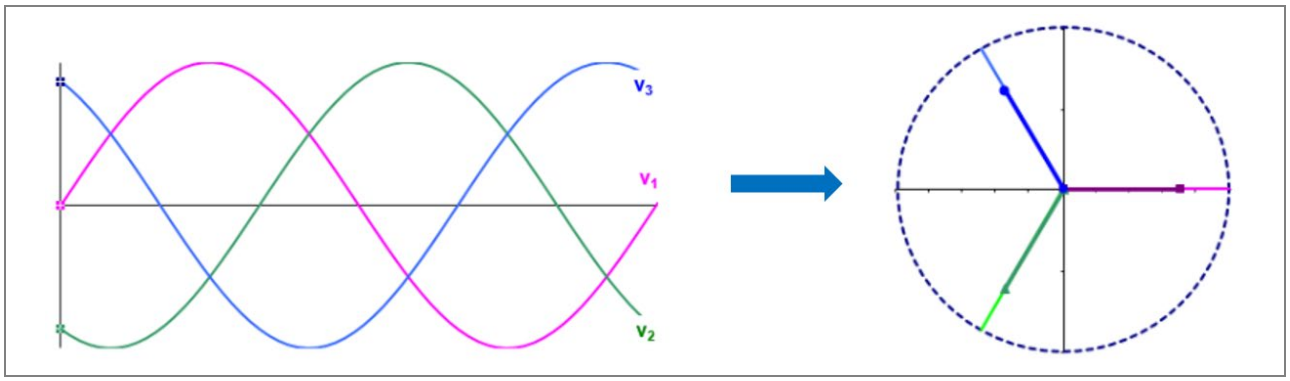


Figure 351: Representation of a three-phase voltage system in a Fresnels diagram

The Fresnel representation is mainly used for maintenance and commissioning operations to monitor voltage and current measurement values (MV) on power line, busbar, transformer or generator equipment. Measurement Values may come from CT/VT (computed by the TMU220 board), or Sample value group (MU320).

The Fresnel processing feature is embedded in the C264 while the graphical representation is managed as a Widget on the operator's HMI (DS Agile aView).

To implement a Fresnel diagram, you must observe the following configuration steps:

1 Set Fresnels vectors (MV) in the SCE;

2 Add the Fresnel widget to a Mimic view.

3 Configure the Fresnel widget (properties, colors and animations) in Mimic Designer

Once implemented, the Fresnel diagram will show the representation of voltage and current vectors in real-time.

Note:
The Fresnel feature is used on star-wiring system only.

5.9.1 CONFIGURATION

5.9.1.1 OVERVIEW

To build a Fresnel diagram, it is necessary to associate a vector to a voltage & current signal, where:

- The Fresnel vector length is equivalent to the acquired signal magnitudes $\vec{U}$
- The Fresnel vector angle is equivalent to the acquired signal angle related to the reference phase angle declared at acquisition module (TMU220 or SV group) φ

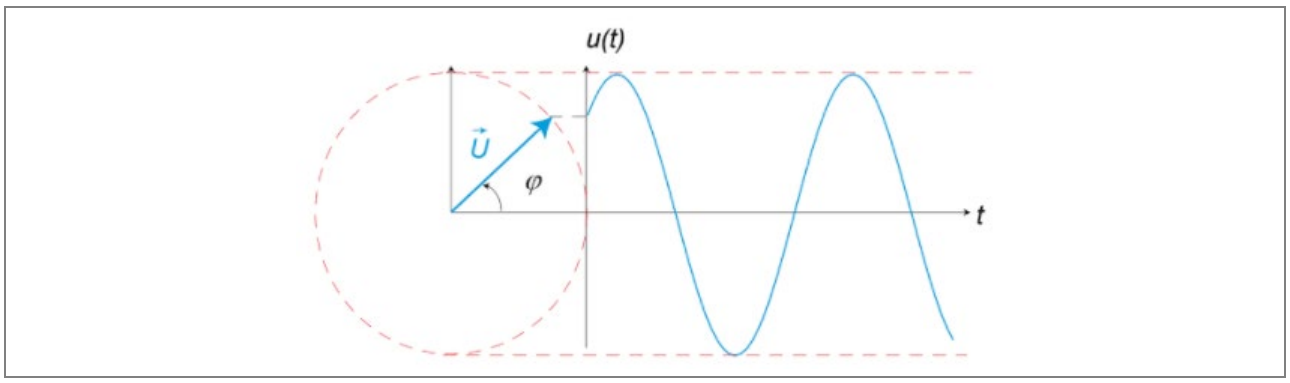


Figure 352: Correspondance between a vector and a signal in a Fresnels diagram

The list of vectors managed by the "Fresnel" function is issued from the C264. They must be configured as MV in the SCE. The signal amplitude is declared as a “Module” and the angle is declared as “Argument”:

Symbol	MV Name	Description
ρI_A	Module Ia	Amplitude of the **Ia current** vector
ρI_B	Module Ib	Amplitude of the **Ib current** vector
ρI_C	Module Ic	Amplitude of the **Ic current** vector
ρI_N	Module In	Amplitude of the **In current** vector
ρV_A	Module Va	Amplitude of the **Va voltage** vector
ρV_B	Module Vb	Amplitude of the **Vb voltage** vector
ρV_C	Module Vc	Amplitude of the **Vc voltage** vector
ρV_N	Module Vn	Amplitude of the **Vn voltage** vector
ΘI_A	Argument Ia	Angle the **Ia current vector** forms with the **reference phase**
ΘIB	Argument Ib	Angle the **Ib current vector** forms with the **reference phase**
ΘIC	Argument Ic	Angle the **Ic current vector** forms with the **reference phase**
ΘIN	Argument In	Angle the **In current vector** forms with the **reference phase**
ΘV_A	Argument Va	Angle the **Va voltage vector** forms with the **reference phase**
ΘVB	Argument Vb	Angle the **Vb voltage vector** forms with the **reference phase**
ΘVC	Argument Vc	Angle the **Vc voltage vector** forms with the **reference phase**
ΘVN	Argument Vn	Angle the **Vn voltage vector** forms with the **reference phase**

The "reference phase" is a Phase-to-Neutral voltage channel (Van, Vbn or Vcn). The "phase reference" vector argument is equal to 0° in the Fresnel representation.

5.9.1.2 CREATING THE “MV FRESNELS” GENERIC MODULE

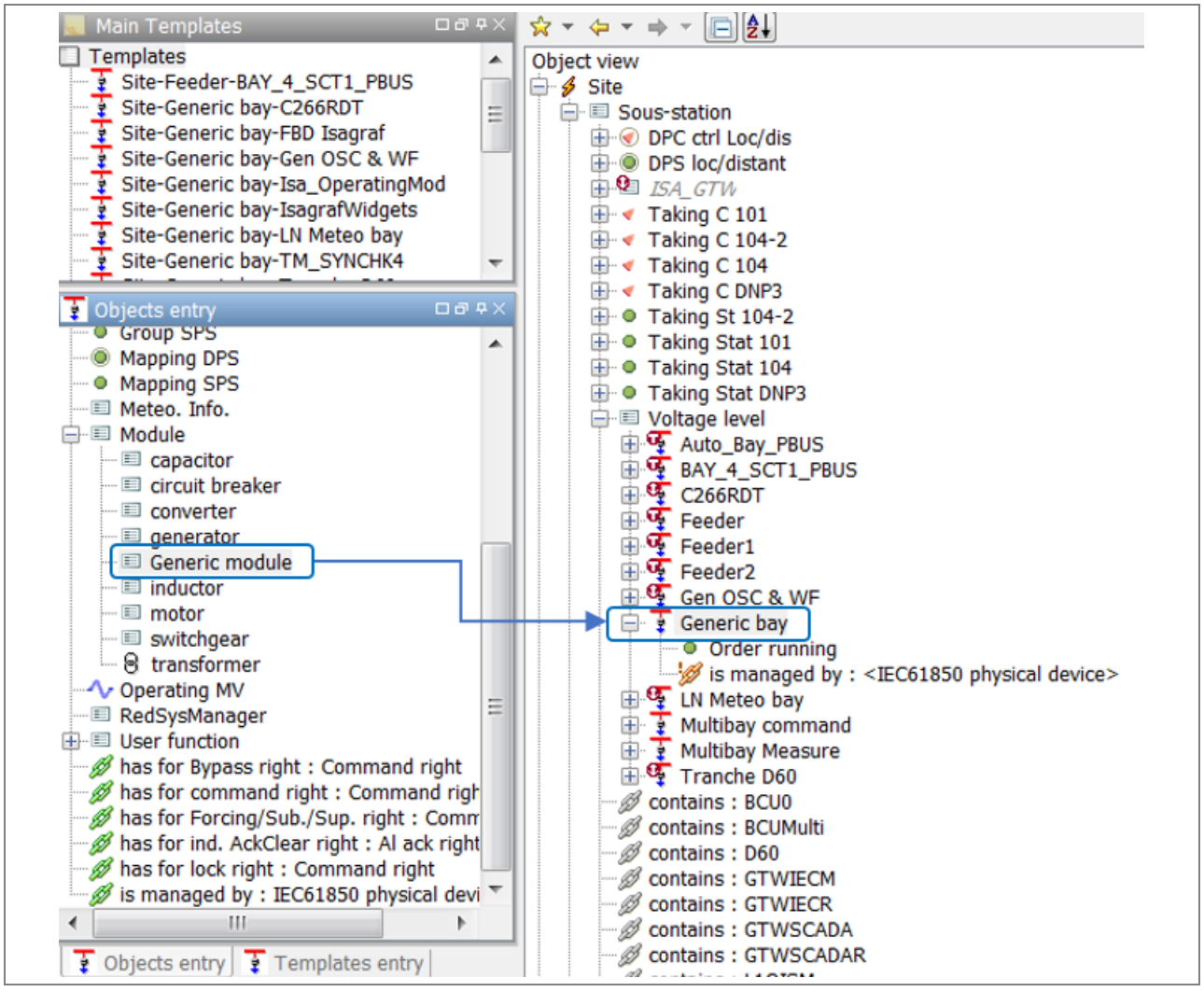
This step consists in creating a Fresnels generic module that will contain the 16 MV stated above:

1 In the **Object view** panel, click on **Site ➡ Voltage level**,

2 In the **Objects entry** panel, expand the **Bay** node. Right-click on the desired electrical bay and then, click on **Add**. Ensure this electrical bay is managed by a C264 which contains a TMU220 or Sample Value Group measurement device.

3 In the **Object view** panel, click on the electrical bay you have just added.

4 In the **Objects entry** panel, expand the **Module** node. Right-click on **Generic module** and then, click on **Add**:



5 In the **Attributes of Generic module** panel, rename the module short and long name as **MV Fresnel**.

5.9.1.3 ADDING "MODULE" FRESNELS VECTORS

This step consists in adding the following MV that will be used as "amplitude" of current and voltage vectors in the Fresnel diagram:

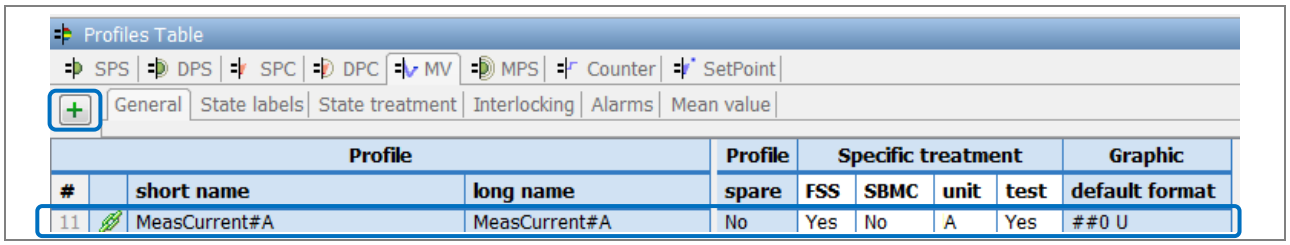
Name	Description
Module Ia	Amplitude of the **Ia current** vector
Module Ib	Amplitude of the **Ib current** vector
Module Ic	Amplitude of the **Ic current** vector
Module In	Amplitude of the **In current** vector
Module Va	Amplitude of the **Va voltage** vector
Module Vb	Amplitude of the **Vb voltage** vector
Module Vc	Amplitude of the **Vc voltage** vector
Module Vn	Amplitude of the **Vn voltage** vector

*The procedure below is given for the Module Ia (Amplitude of the **Ia current** vector) and will have to be repeated for the other vectors (Modules Ib, Ic, In, Va, Vb, Vc and Vn).*

Creating the MV profile

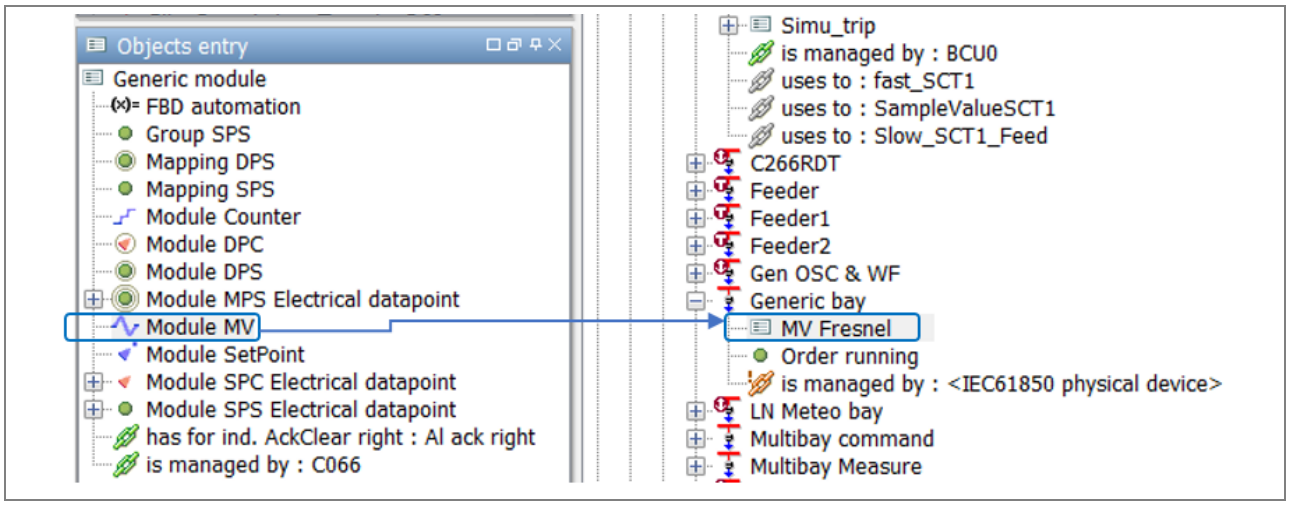
1 In the **Profile Table** panel, select the **MV** tab and click on **+** to add a new MV profile for the Module IA;

2 Rename it **MeasCurrent#A** for instance and change or complete the **Specific treatment** columns as required:



Adding MV

3 In the **Object view**, click on the **MV Fresnel** node, then, right-click on **Module MV** in the **Objects entry** panel and click on **Add**:



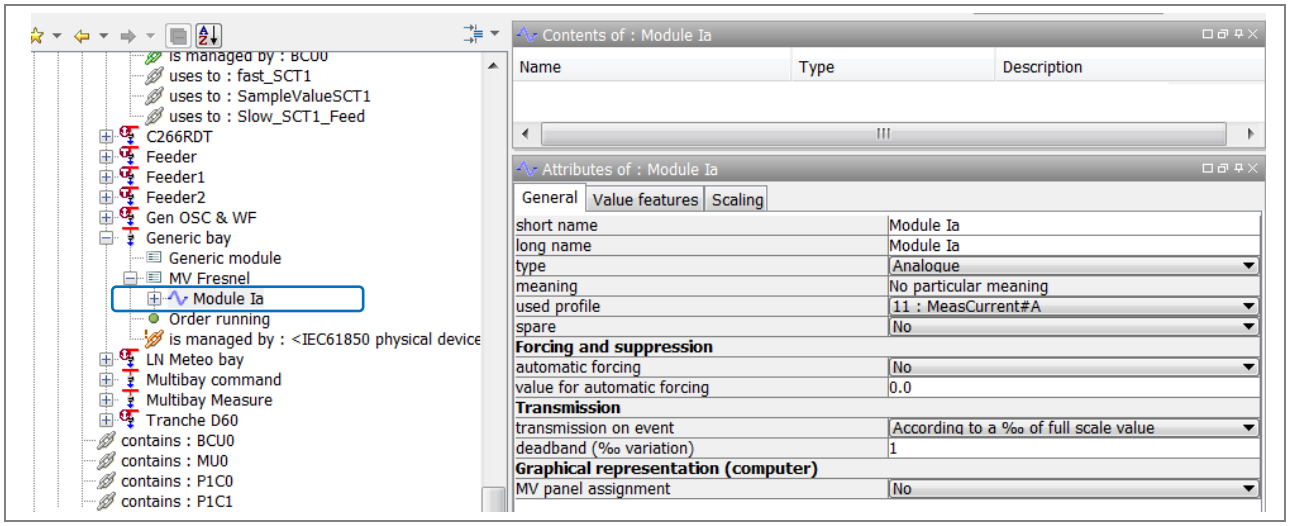
Update the MV attributes in the **Attributes of:** panel:

(1) **short name** and **long name**: enter a name for the **Ia current** vector (**Module Ia** for instance);

Used profile: select the **MeasCurrent#A** previously created;

Transmission: according to a ‰ of full scale value (the full scale values depend on the measurement device type);

Deadband: define a variation (%) to transmit the value for module vectors.



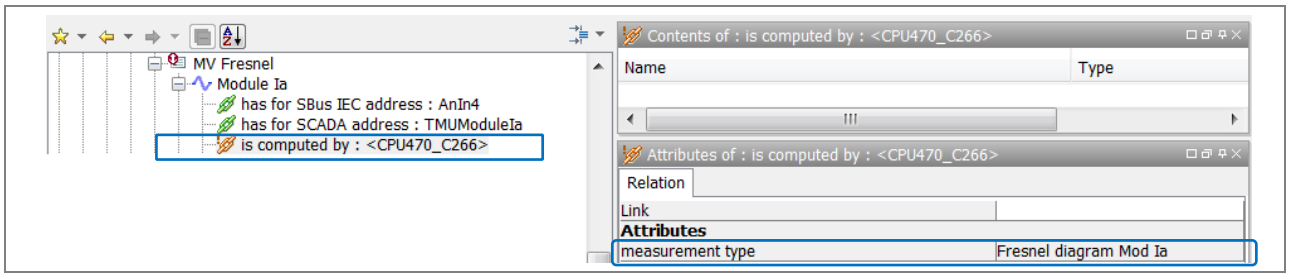
Fresnels vector Transmission

Vector MV are transmitted to HMI through REPORTS via an IEC addressing at Station Bus level (SBUS).

1 Add the relation **has for SBus IEC address** as required.

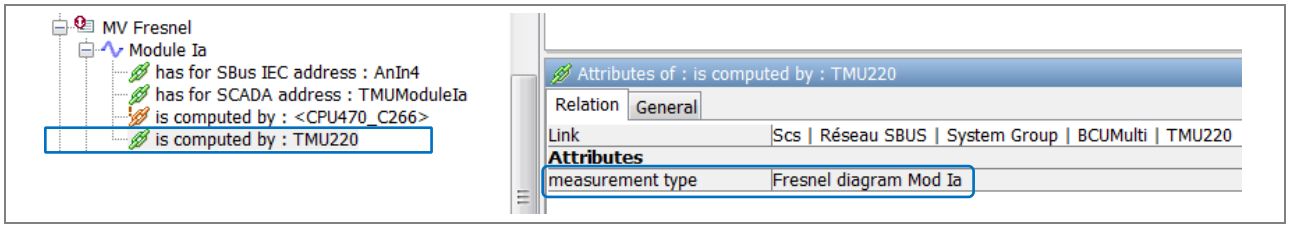
Acquisition by Sample Values:

2 Add the relation **is computed by : <CPU470_C266>**, set it to the desired BCU, and then select the measurement type **Fresnel diagram Mod Ia**:



Acquisition by TMU220:

3 Add the relation **is computed by : <TMU220>**, set it to the desired TMU board, and then select the measurement type **Fresnel diagram Mod Ia**:



4 Repeat the procedure for the other module vectors (Modules Ib, Ic, In, Va, Vb, Vc and Vn).

5.9.1.4 ADDING "ARGUMENT" FRESNELS VECTORS

This step consists in adding the following MV that will be used as "angle" of current and voltage vectors in the Fresnel diagram:

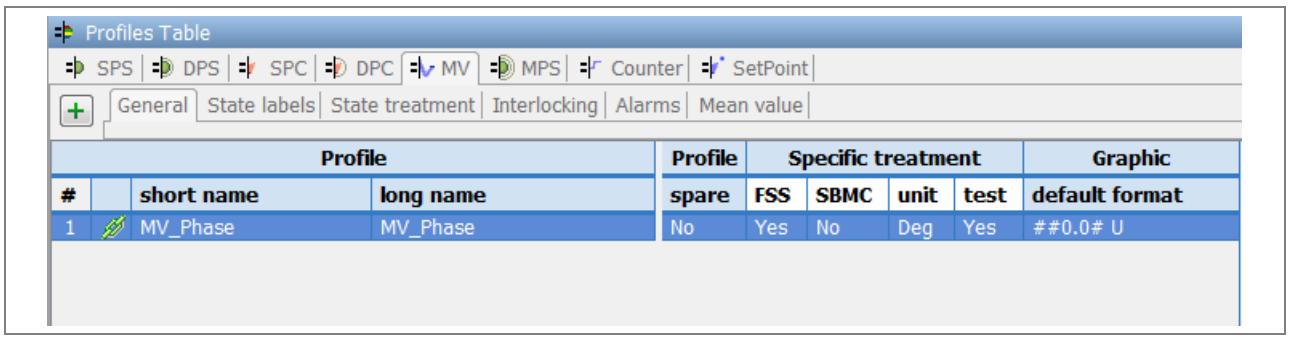
Name	Description
Argument Ia	Angle the **Ia current vector** forms with the **reference phase**
Argument Ib	Angle the **Ib current vector** forms with the **reference phase**
Argument Ic	Angle the **Ic current vector** forms with the **reference phase**
Argument In	Angle the **In current vector** forms with the **reference phase**
Argument Va	Angle the **Va voltage vector** forms with the **reference phase**
Argument Vb	Angle the **Vb voltage vector** forms with the **reference phase**
Argument Vc	Angle the **Vc voltage vector** forms with the **reference phase**
Argument Vn	Angle the **Vn voltage vector** forms with the **reference phase**

The procedure below is given for the Argument Ia (Angle of the Ia current vector) and will have to be repeated for the other vectors (Arguments Ib, Ic, In, Va, Vb, Vc and Vn).

Creating the MV profile

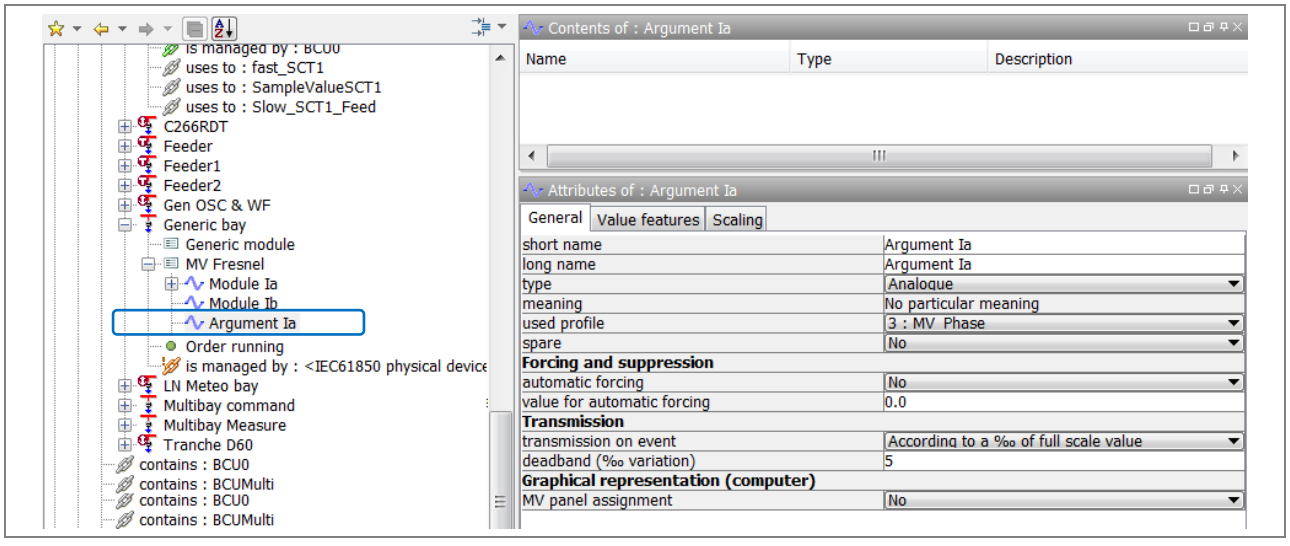
1 In the **Profile Table** panel, select the **MV** tab and click on **+** to add a new MV profile for the Argument Ia;

2 Rename it **MV_Phase** for instance and change or complete the **Specific treatment** columns as required:



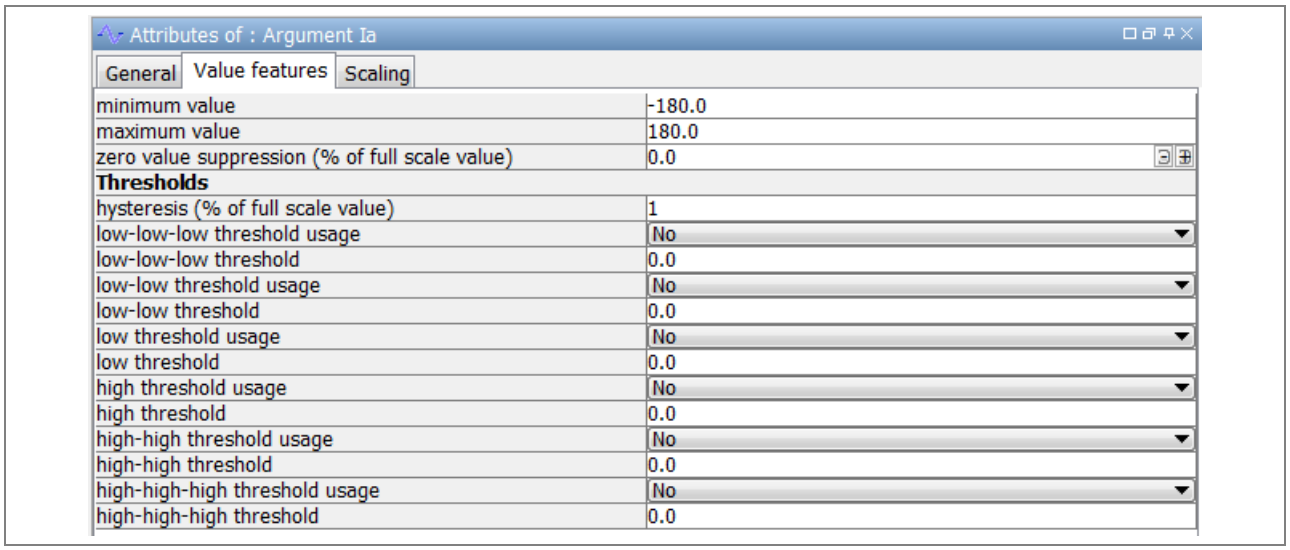
Adding MV

- In the **Object view**, click on the **MV Fresnel** node, then, right-click on **Module MV** in the **Objects entry** panel and click on **Add**.
- Update the General MV attributes in the **Attributes of:** panel:
  - (1) **short name** and **long name**: enter a name for the Ia argument vector (**Argument Ia** for instance);
  - (2) **Used profile**: select the **MV_Phase** previously created;
  - (3) **Transmission**: according to a ‰ of full scale value (the full scale values depend on the measurement device type);
  - (4) **Deadband**: define a variation (%) to transmit the value for argment vectors.



Update the Value Features in the **Attributes of: Argument Ia** panel:

(5) **Mimimum and maximum value**: set the angle value for the Ia argument vector;



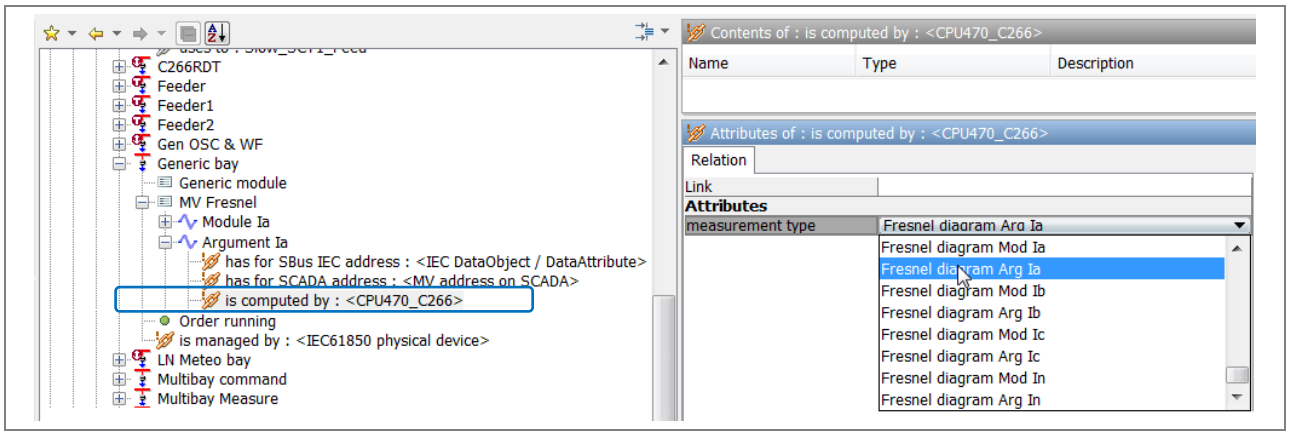
Fresnels vector Transmission

Vector MV are transmitted to HMI through REPORTS via an IEC addressing at Station Bus level (SBUS). They may have IEC61850 addresses, and optional SCADA addresses.

1 Add the relation **has for SBus IEC address** and/or **has for SCADA address** as required.

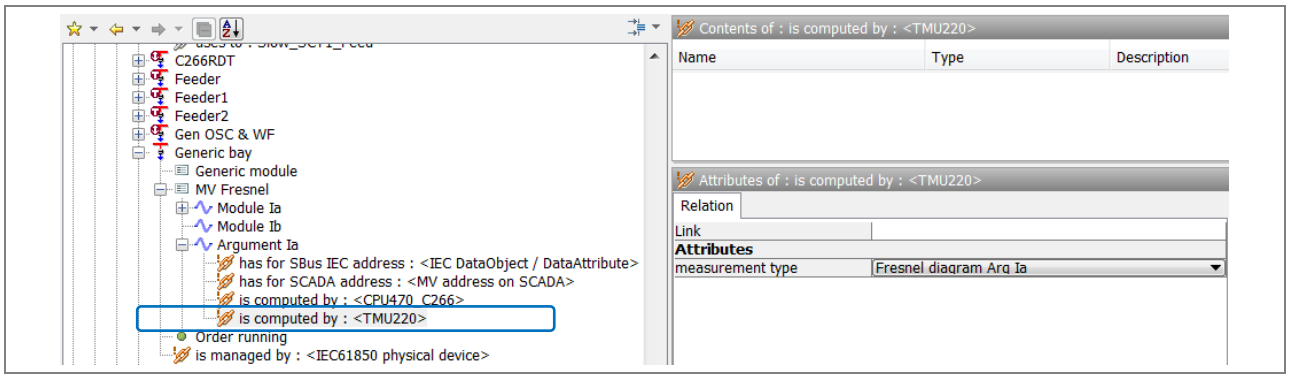
Acquisition by Sample Values:

2 Add the relation **is computed by : <CPU470_C266>**, set it to the desired BCU, and then select the measurement type **Fresnel diagram Arg Ia**:



Acquisition by TMU220:

3 Add the relation **is computed by : <TMU220>**, set it to the desired TMU board, and then select the measurement type **Fresnel diagram Arg Ia**:



4 Repeat the procedure for the other argument vectors (Arguments Ib, Ic, In, Va, Vb, Vc and Vn).

5.9.1.5 AUTO-ADDRESSING

Use the auto-addressing function (“all steps in one”) to automatically create the SBUS addresses.

5.9.1.6 GENERATE THE DATABASE

Generate the SCE database and then, refer to the **Human Interface** chapter of **Blend** user manual for information on how to configure the Fresnels widget in Mimic Design

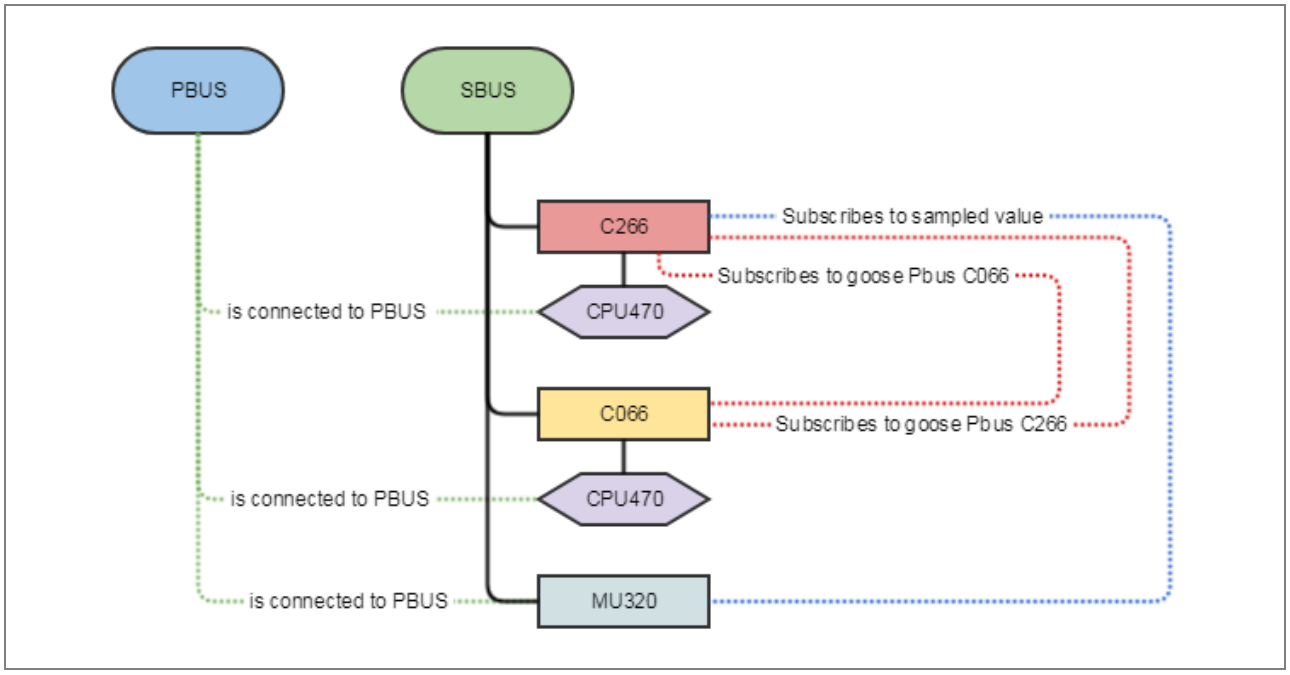
6 PROCESS BUS NETWORK

Naming convention

In the SCE application, a C26x with a BCU (Bay Control Unit) bitstream is called a C266 and a C26x with an SCU (Switchgear Control Unit) bitstream is called a C066.

Caution:
Not all standard configuration operations are described below. It is assumed that operations not directly relevant to process bus configuration are known and implemented, e.g devices are correctly linked to the Substation, datapoints profiles are configured and linked, etc.

6.1 SYSTEM CONFIGURATION

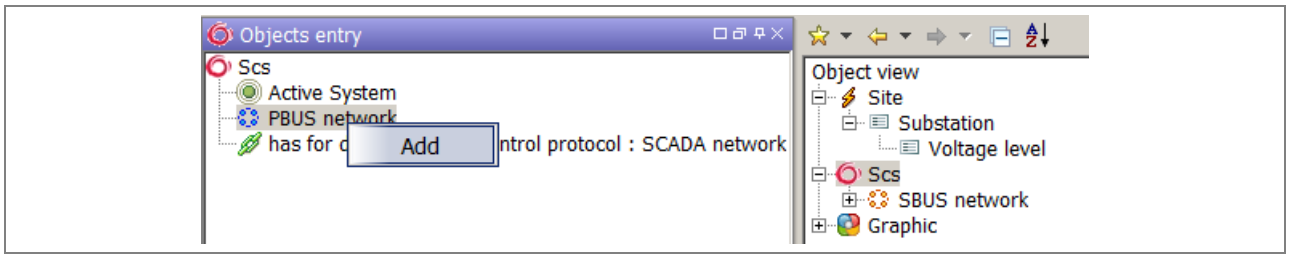


Configuration steps

1 Create a Process Bus network:

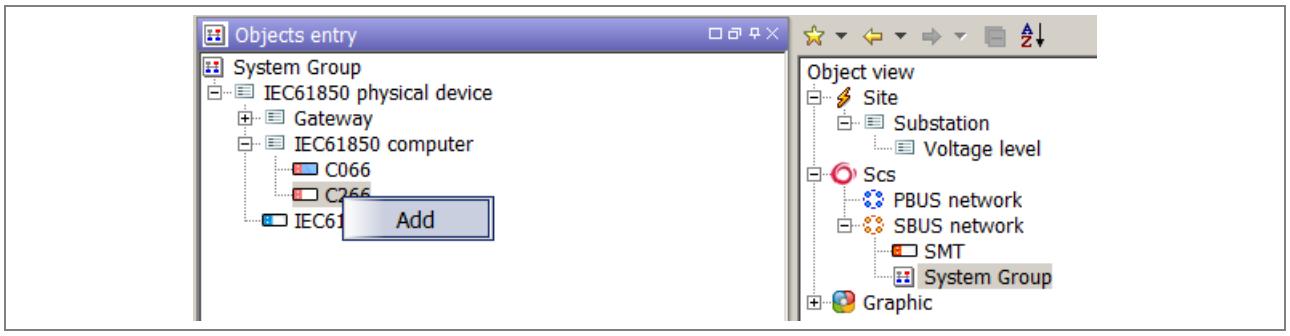
a Select Scs in the Object view window

b Right-click PBUS network in the Object entry window, and then click Add.

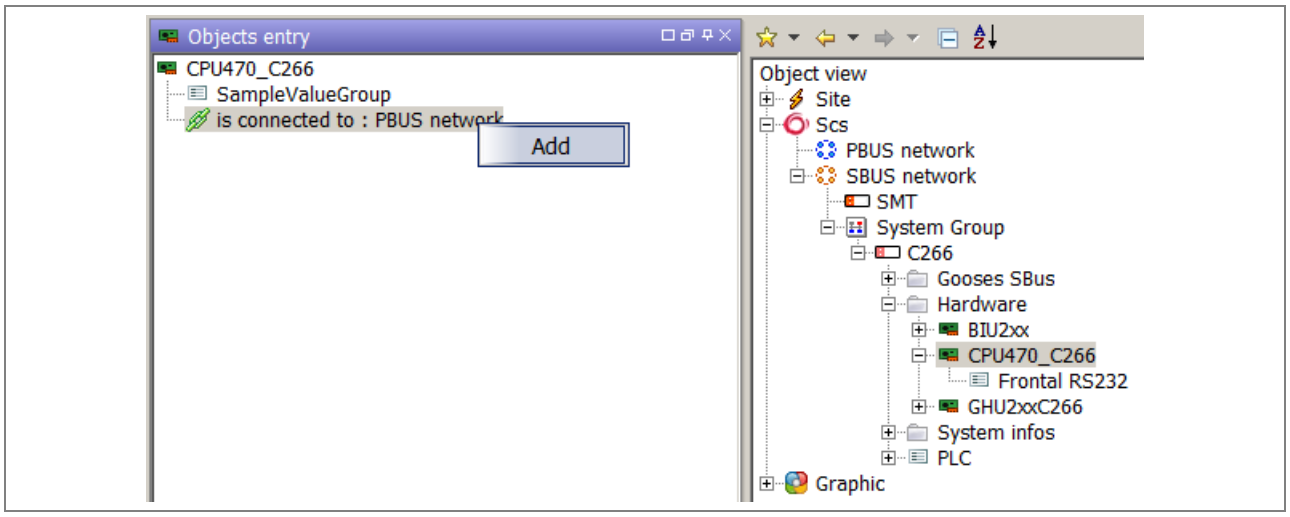


2 Create a BCU:

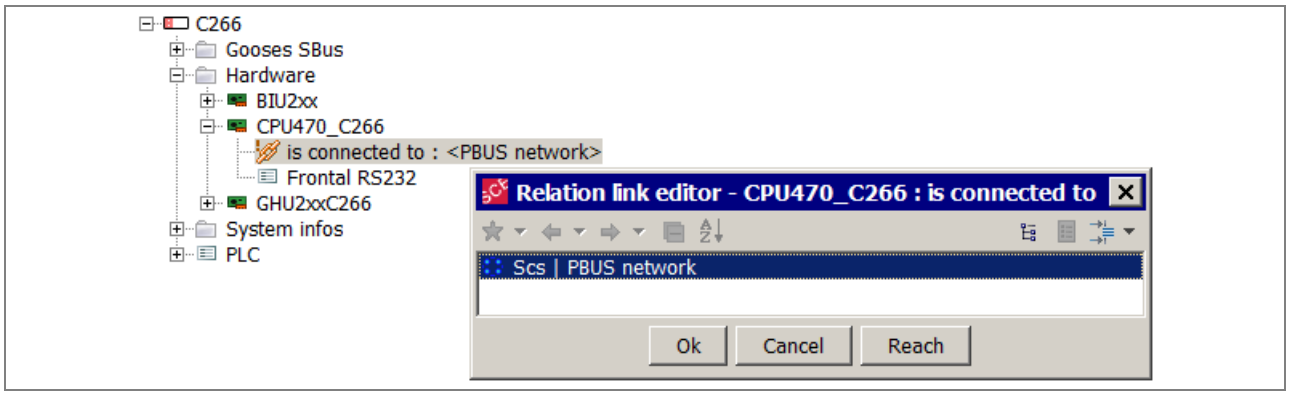
a Create a C266 to the System Group under SBUS network



b Add the relation "is connected to PBUS" to the CPU470 of the C266

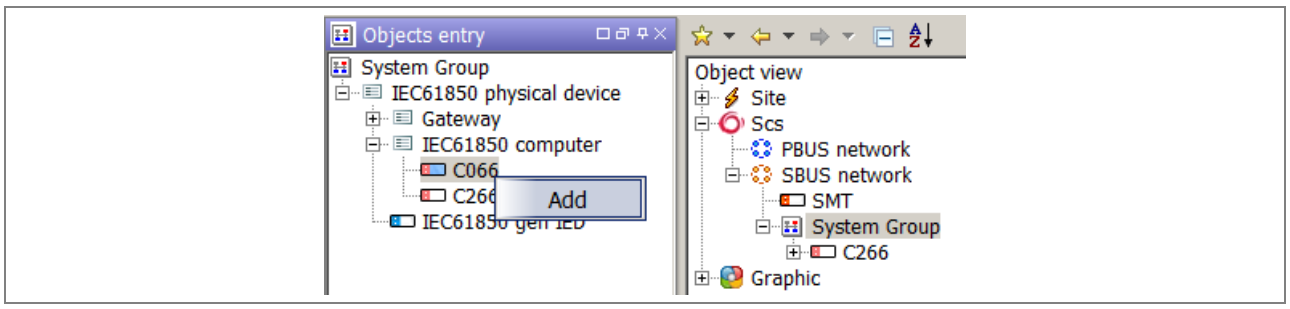


c Link the relation to the PBUS network

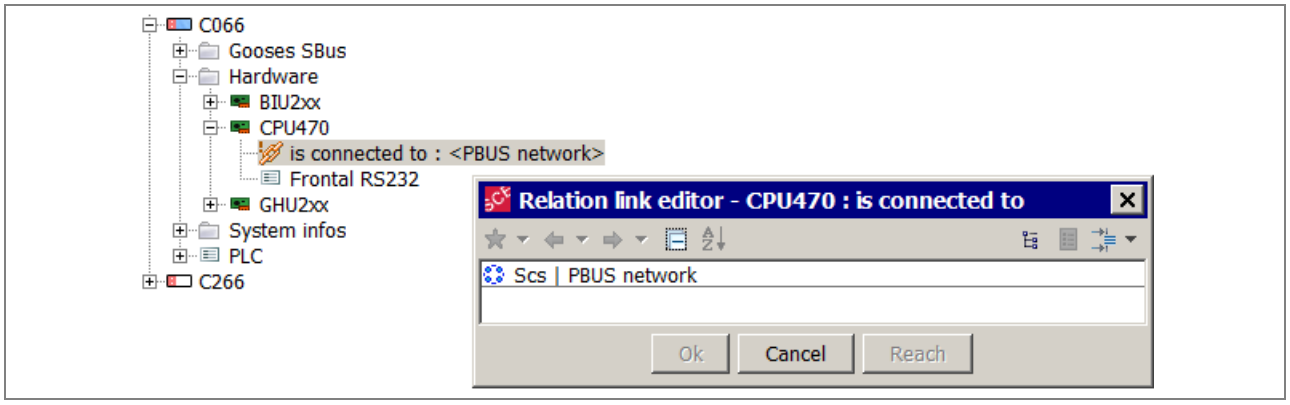


3 Create a SCU

a Create a C066.



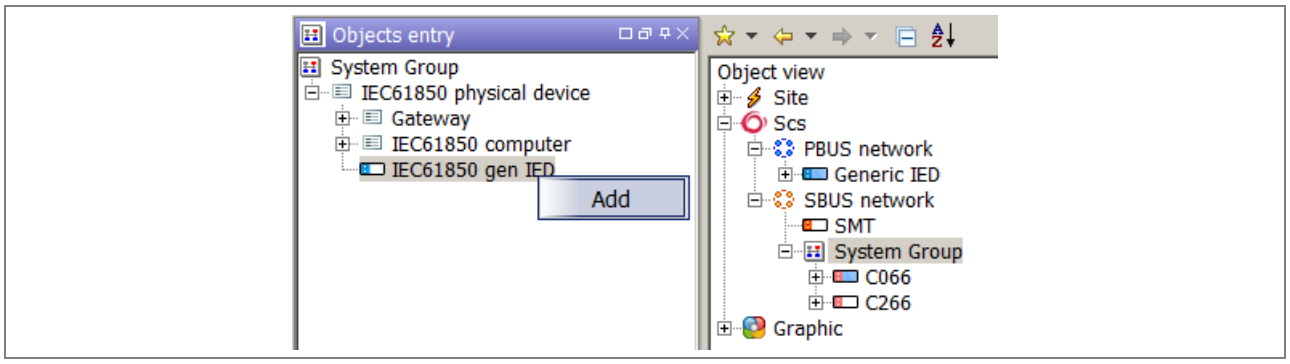
b Link the relation **is connected to : PBUS** under **CPU470** to the PBUS network



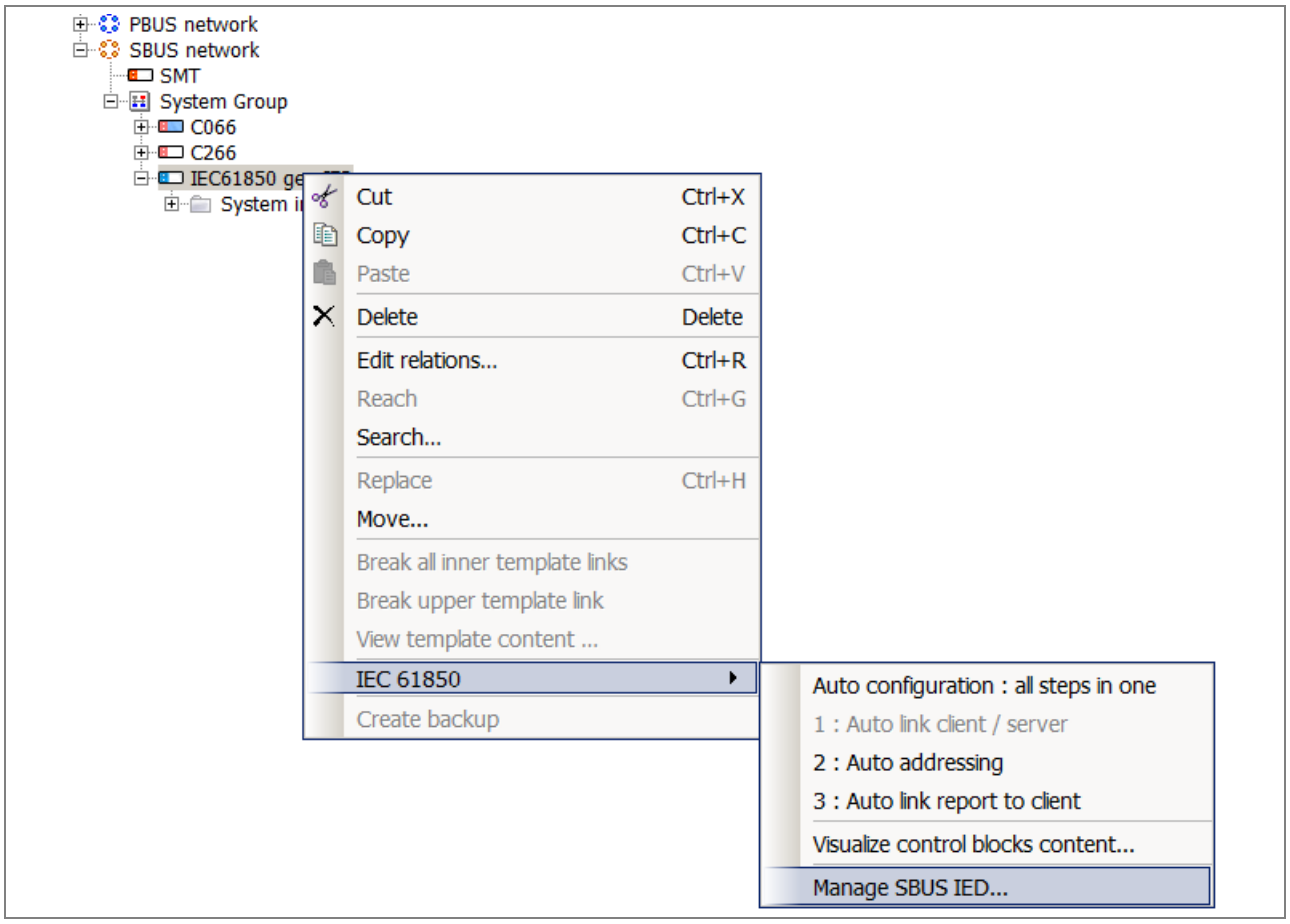
c Add the required DOU et DIU boards

4 Create a merging unit:

a Add a Generic IED to the System Group under SBUS.



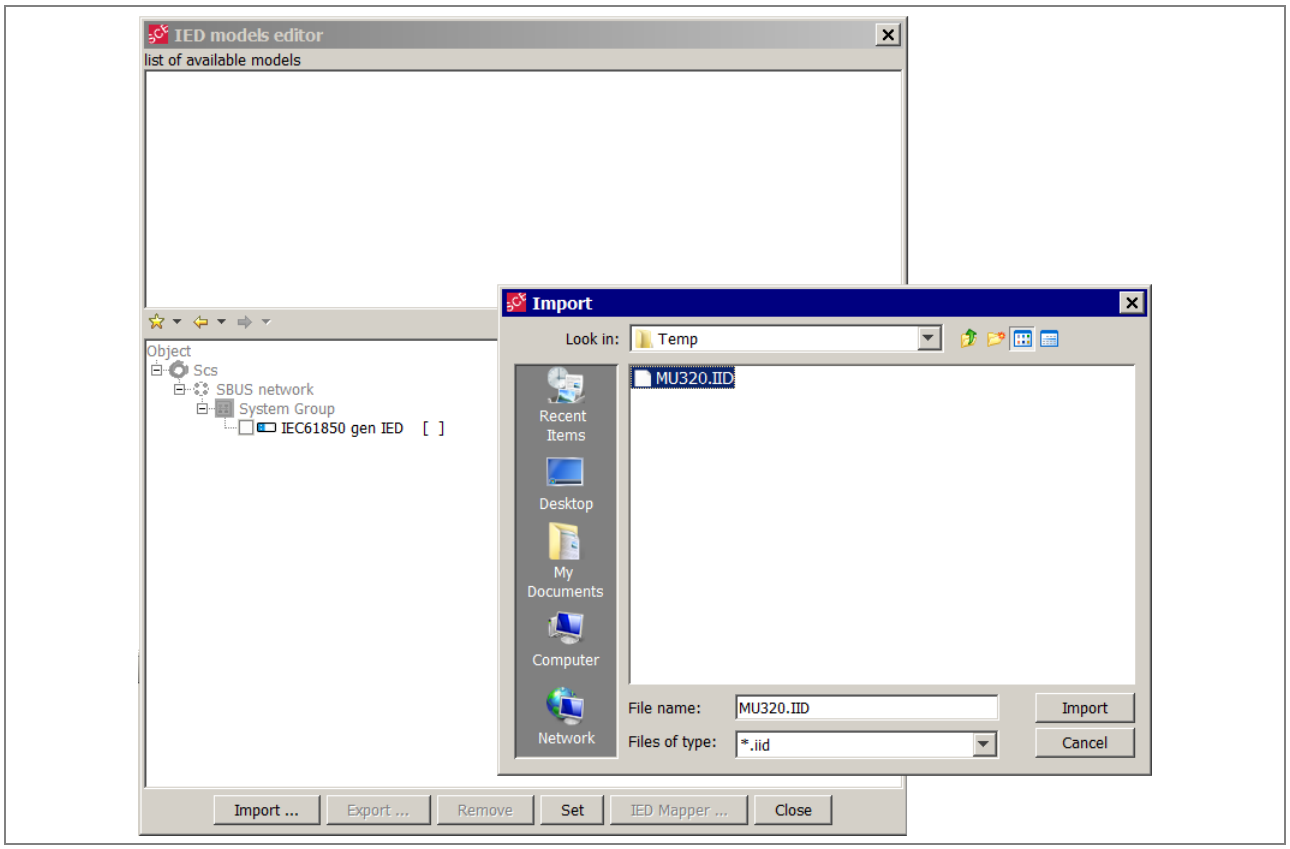
b Import the corresponding configuration file: .CID for IEC 61850 Ed.1 or .IID for IEC 61850 Ed.2. Right-click the IED, and then select **IEC 61850|Manage SBUS IED…**



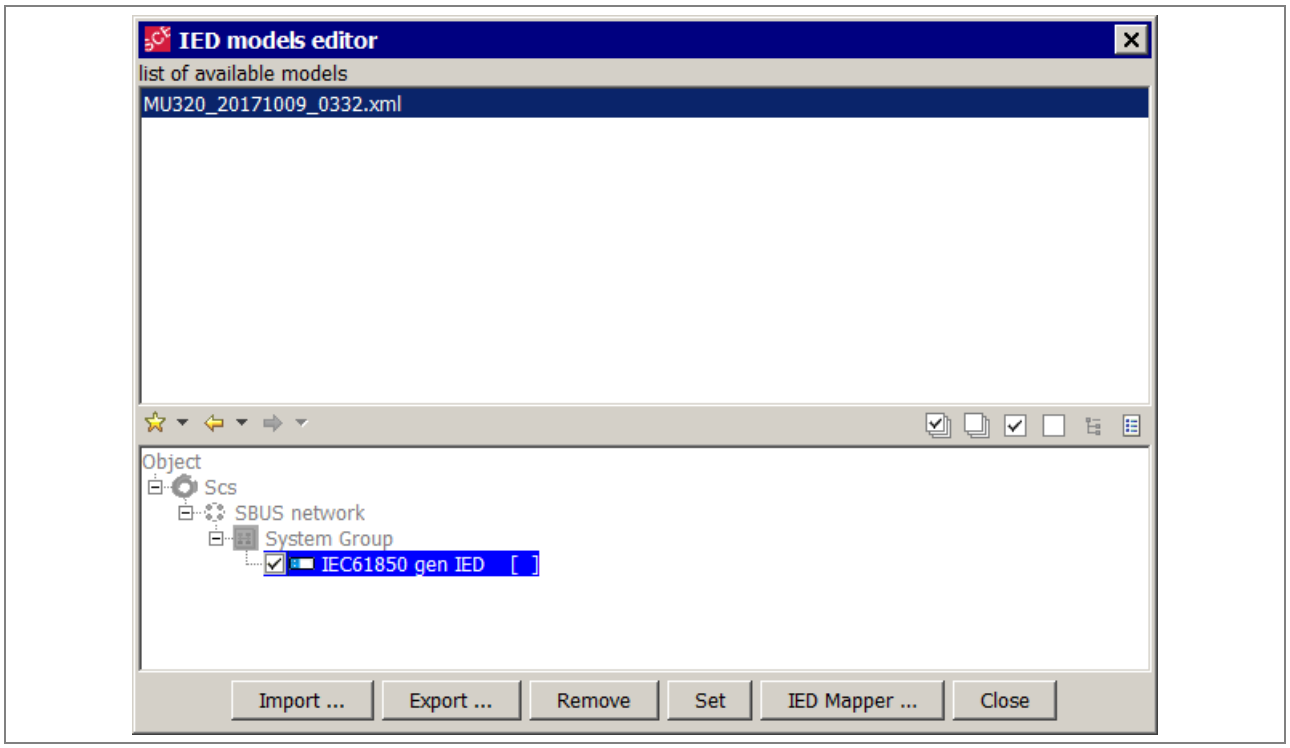
c In the IED models editor, click Import… and then select the required configuration file.

Note:
*If you wish to import a .iid file, it will not be shown in the Import list by default. You should first enter either *.* or *.iid in the File name: field and press Enter. The file will then be displayed.*

d Select the file, and then click Import.



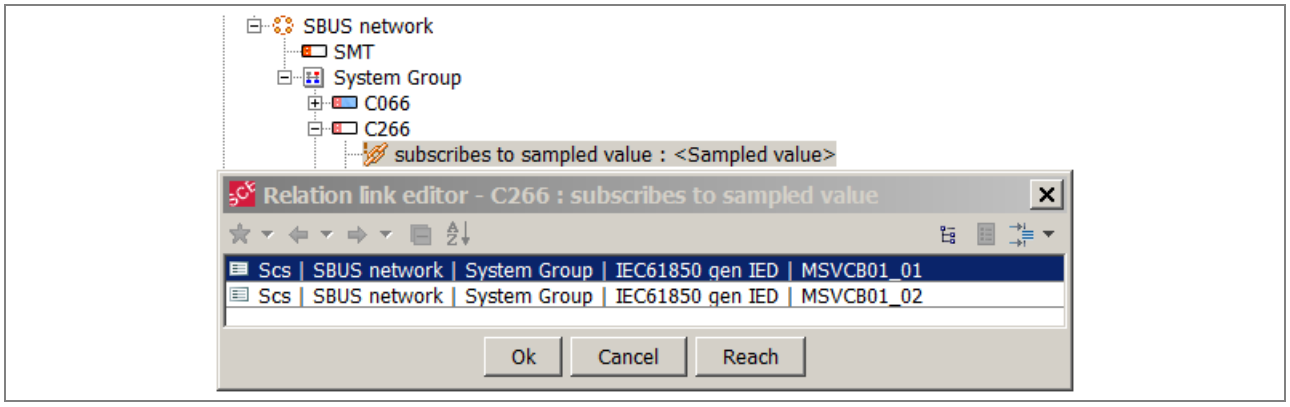
e Select the model, tick the IED, and then click **Set**.



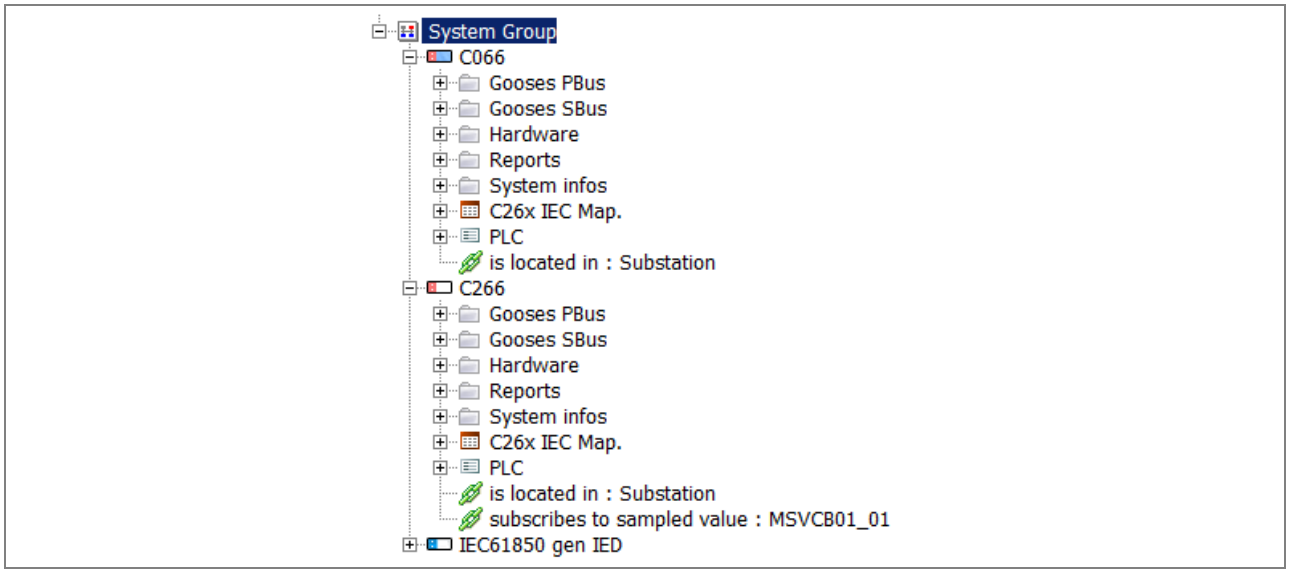
f Click Ok when the dialog “IED model setting ended” is displayed, and then close the IE**D models editor** window.

g Add the relation **is connected to : PBUS network** directly under the IED, and then link it to PBUS network.

5 Directly under the C266 (BCU), add the relation subscribe to sampled value, and then link it to the appropriate sampled value group.

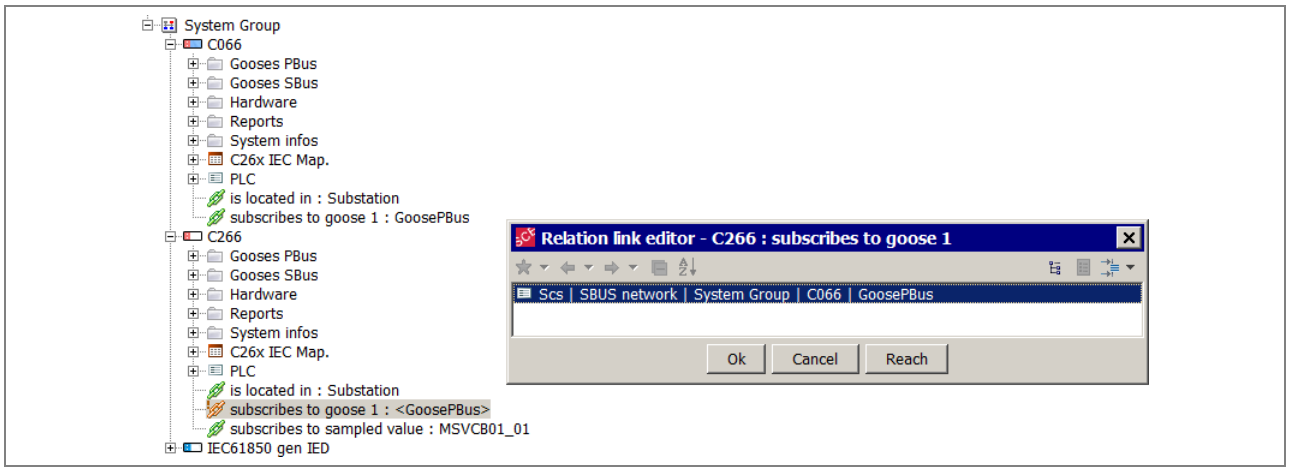


6 Launch an auto-addressing operation: the folders "Gooses PBus" are added under the C066 (SCU) and the C266 (BCU).



7 Add the relation **subscribe to goose x : Goose PBus** under the C266, and then link it to the C066.

8 Add the relation **subscribe to goose x : Goose PBus** under the C066, and then link it to the C266.

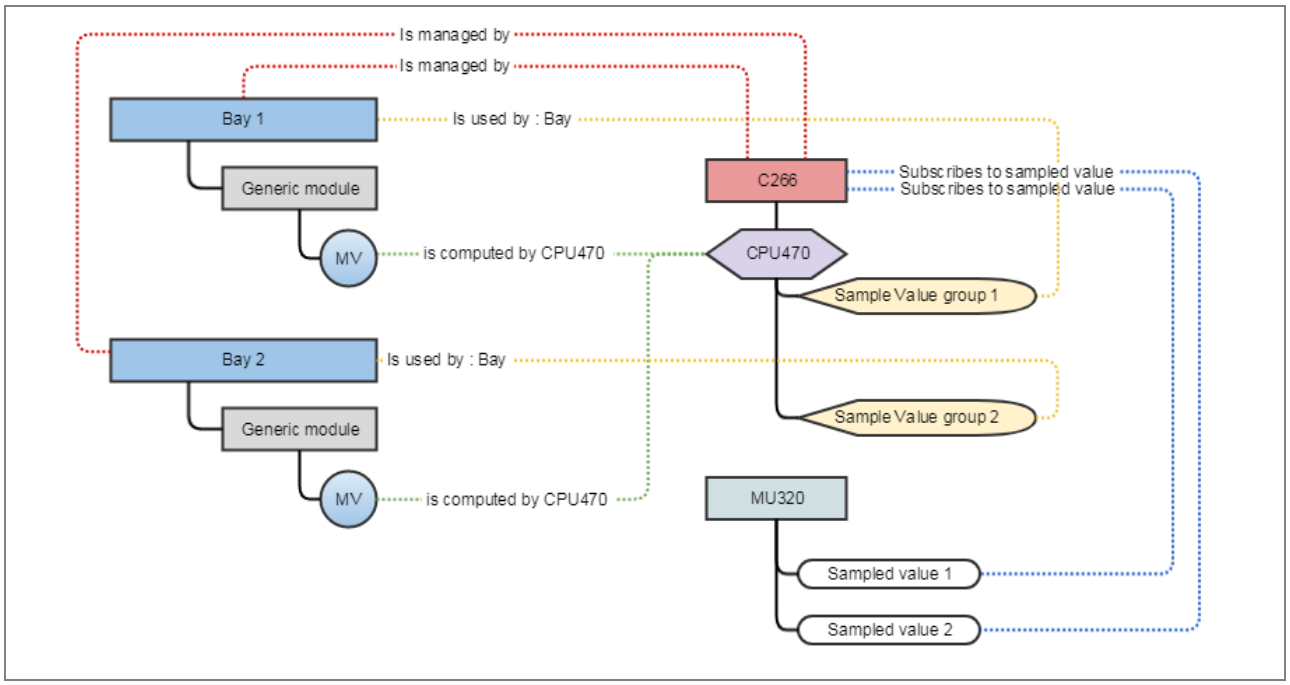


6.2 SAMPLE VALUE CONFIGURATION (BCU)

When it receives measurements from the Process Bus, i.e. in the form of sampled values, the BCU can manage up to 2 electrical bays. Each bay can send two sets of measurements, called **SampleValueGroup**: one for protection-related operations (e.g. synchrocheck) with protection class CTs, and one for measurements display with measurement class CTs. Each SV group can contain up to two SV arrangements (main and backup), which must be of the same type. These are used to manage merging unit redundancy.

For each sampled value present in a SampleValueGroup, only one arrangement (main or backup) can be active at a time. Its selection is dynamically managed by the state of an SPS datapoint, depending on the selected TC precision class associated with the SampleValueGroup (MAIN.BACK.xxxx).

These SPS dapapoints can for instance be linked inside an FBD logic scheme to "wireable" datapoints and thus be set/reset by binary input signals.

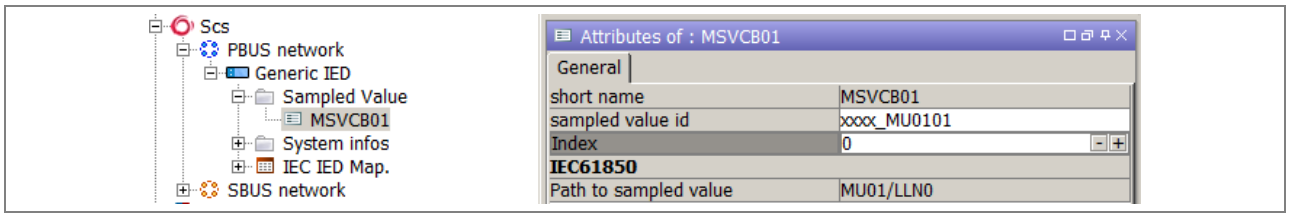


Configuration steps

1 Add a **PBUS network** under **Scs**.

2 Add a **Generic IED** under the **PBUS network** and import the relevant merging unit data model file.

The sampled values and the SV control blocks included in the datamodel are added under the IED.

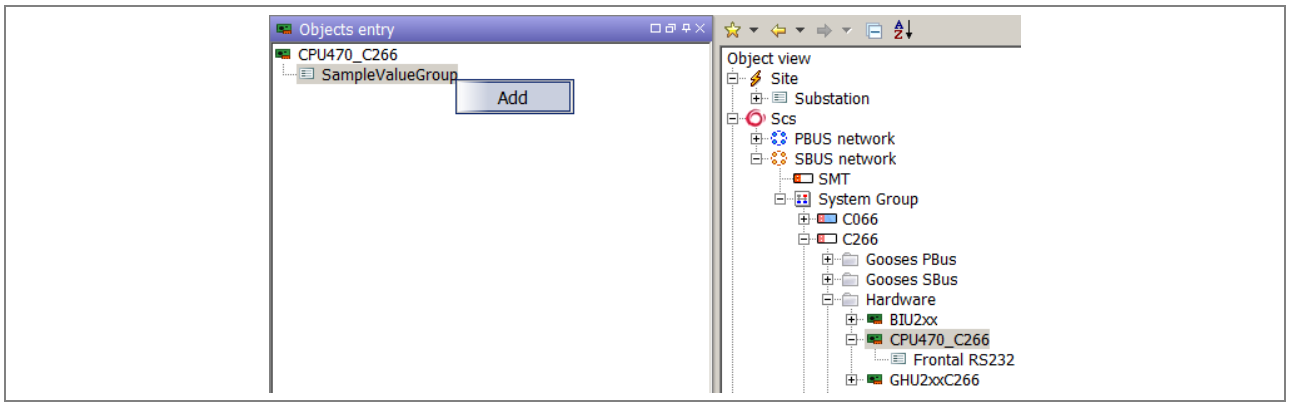


3 Select the SVCBs and set the **Index** attribute value (0 to 80) if the SVCB contains a reference (busbar) voltage SV. This index identifies the sample value control block in the PBUS SV list, which is used to manage topology changes for the synchrocheck function.

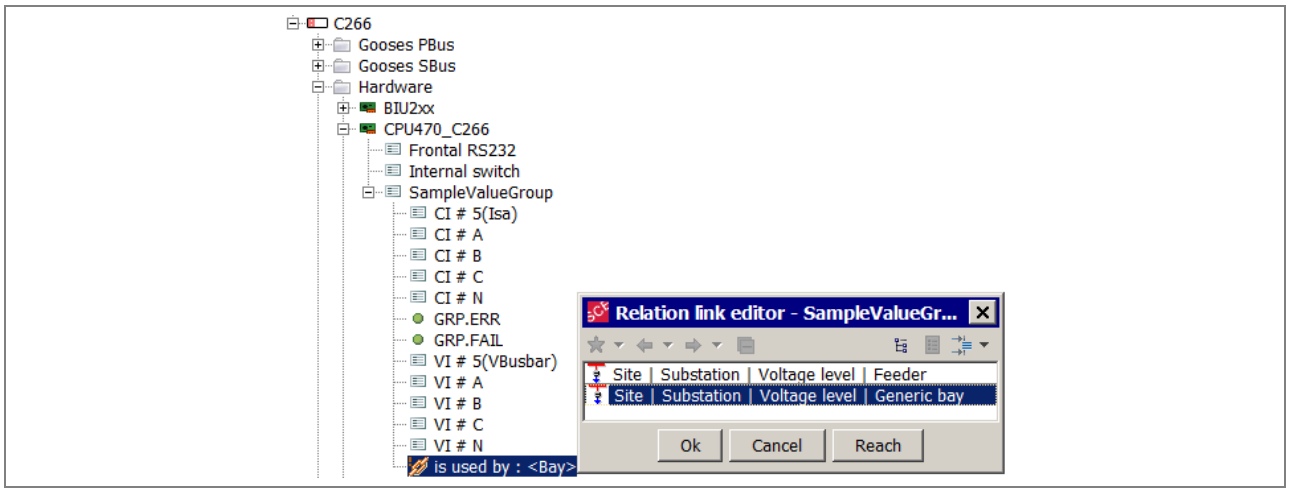
4 Create the required bay and link its relation **is managed by :** to the BCU

5 Check that the BCU's **CPU470_C266** is linked to the same **PBUS network** as the merging units providing the sampled values

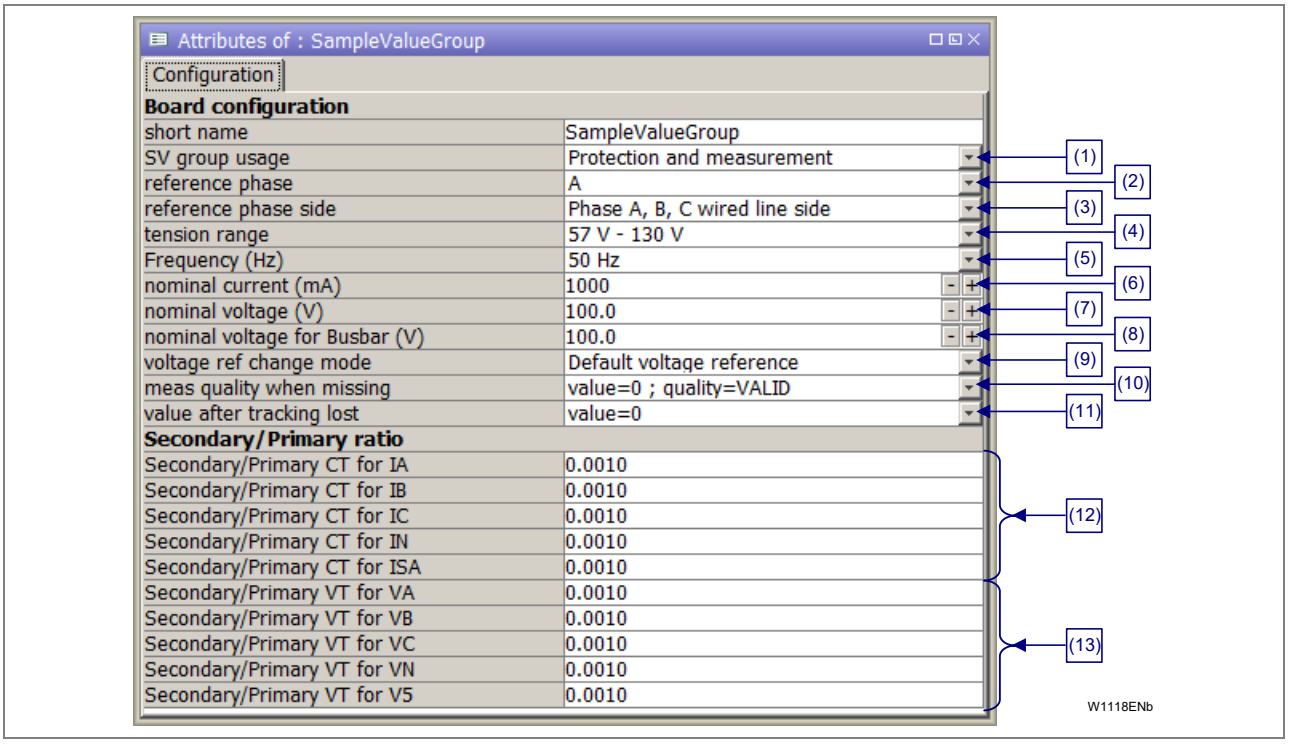
6 Add a sample value group to the BCU's **CPU470_C266**.



7 Link the relation **is used by : < bay >** to the electrical bay



8 Set the **SampleValueGroup** attributes:



Board configuration

(1) **SV group usage** (*Protection and measurement*, *Measurement*):

Note:
If 2 independent sampled value groups are configured on the same bay, one SV group must be set to Protection and measurement *and the other to* Measurement.

(2) **reference phase (Phase A or AB / Phase B or BC / Phase C or CA)**: Phase or phase pair used by the Synchrocheck function to compare the line and busbar voltages.

(3) **reference phase side (Phase A, B, C wired line side / Phase A, B, C wired busbar side)**

(4) **tension range** (*57 V - 130 V* / *220 V - 480 V*): voltage range of the merging unit's voltage inputs.

(5) **Frequency** (*50 Hz*, *60 Hz*): Rated frequency of the power system.

(6) **nominal current** (*1000 mA* / *5000 mA*): Rated secondary phase current

(7) **nominal voltage** (range [1 V, 500 V], step 1 V): Rated secondary three-phase voltage

(8) **nominal voltage for Busbar (V)** (range [1 V, 500 V], step 1 V): Rated secondary busbar voltage

(9) **voltage ref change mode** (*Default voltage reference* / *Current voltage reference*):

- *Default voltage reference*: as soon as the stated reference phase is valid again, the acquisition process locks onto it
- *Current voltage reference*: the acquisition process remains locked onto the phase that has a valid signal

(10) **meas quality when missing** (value=0; quality=VALID / quality=FAULTY)

- *value=0; quality=VALID*: when no signal is received, that absence is considered as a valid 0 value that the C26x transmits over the network: SCADA, HMI, GTW…
- *quality=FAULTY*: when no signal is received, that absence is considered as an invalid value and the C26x transmits the signal "self-check fault" over the network: SCADA, HMI, Gateway…

If the reference phase signal is absent, the values transmitted by the merging unit are set to invalid.

(11) **value after tracking lost (value=0; hold current value)**: Reserved for future use.

Secondary/Primary ratio

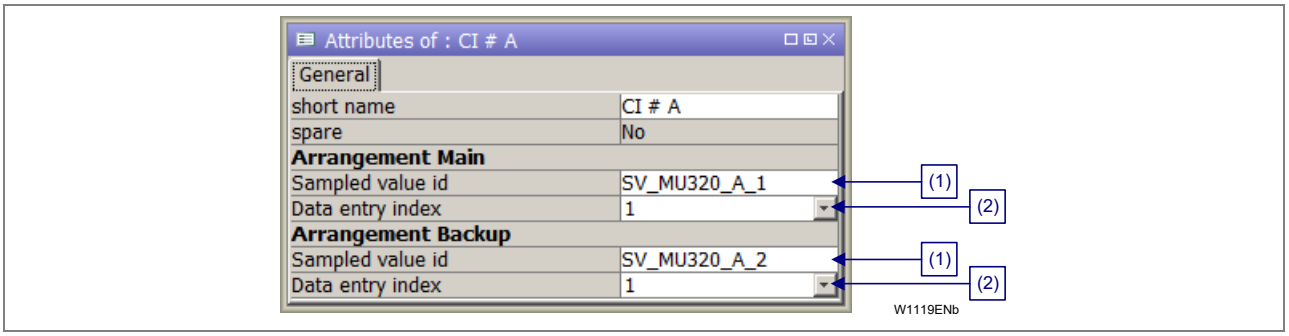
These attributes are used to set the instrument transformer ratios so as to convert the primary measurements transmitted by the merging unit into the secondary values processed by the CPU board.

(12) **Secondary/Primary CT for Ix** (range [0.00001, 1], step 0.00001): Instrument transformer ratios for currents.

(13) **Secondary/Primary VT for Vx** (range [0.00001, 1], step 0.00001): Instrument transformer ratios for voltages.

Note:
*All Merging Units presents in the same **SampleValueGroup** must have the same configuration ratios for voltages (VT) and currents (CT) (defined by the **Secondary/Primary ratios**)*

9 Configure the CI and VI inputs



For both arrangements of SVs if a backup arrangement is used, or just for **Arrangement Main** otherwise:

(1) **Sampled value id** (*Not_Used* or *sampled value id*): identifier for the sampled value frame, as entered in the field **sampled value id** of the merging unit's Sampled Value's attributes (double-click the field to display the selection list).

(2) **Data entry index** (*Not used*, *1*, *2*, *3*, *4*, *5*, *6*, *7*, *8*): channel number of the SV in each arrangement (standard SV frame: 1→ I_A, 2→ I_B, 3→ I_C, 4→ I_N, 5→ V_A, 6→ V_B, 7→ V_C, 8→V_N)
Values *1* to *8* are considered as *Not used* if the attribute **Sampled value id** is itself set to *Not_Used*.

Up to **10** Sample Values and their backups can be configured in each **SampleValueGroup**:

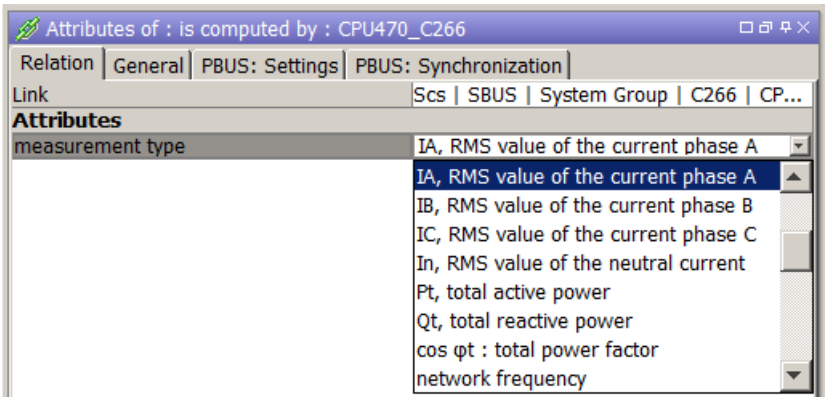
Label	Description	Default position in Sampled Value ID
CI # 5 (Isa)	Current value: optional High precision current value	4
CI # A	Current value: phase A	0
CI # B	Current value: phase B	1
CI # C	Current value: phase C	2
CI # N	Current value: Neutral	3
VI # 5 (VBusbar)	Reference Voltage value: BUSBAR side	9
VI # A	Voltage value: phase A	5
VI # B	Voltage value: phase B	6
VI # C	Voltage value: phase C	7
VI # N	Voltage value: Neutral	8



Caution:
If a synchrocheck function is used, the busbar voltage input (VI #5)
- must have its arrangement(s) configured,
- must not be wired to a sampled value representing one of the line voltages (the Sampled value id must be different).

10 Create the measurements under the electrical bay.

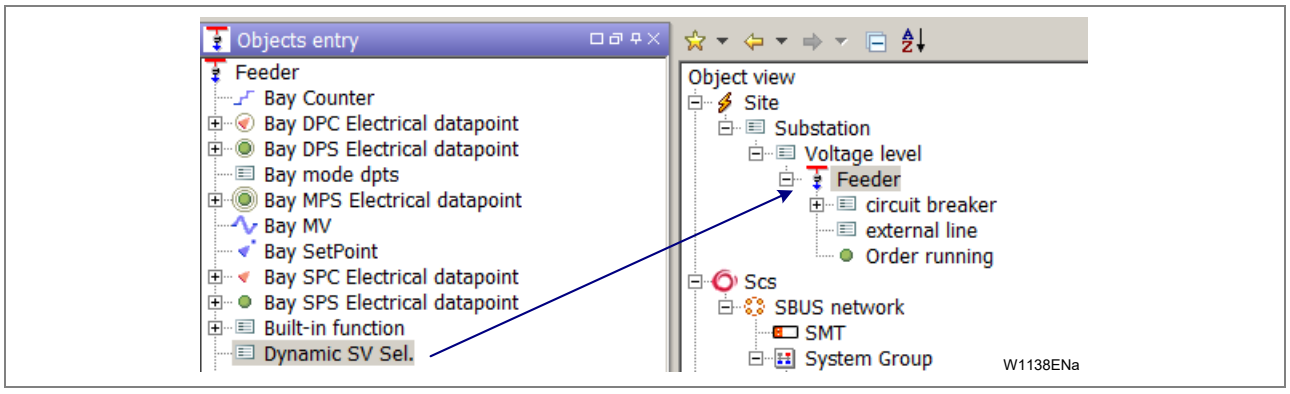
11 For each MV, add the relation **is computed by : CPU470_C266**, set it to the BCU, and then select the measurement to display in its attributes (smart tables cannot be used for process bus measurements).



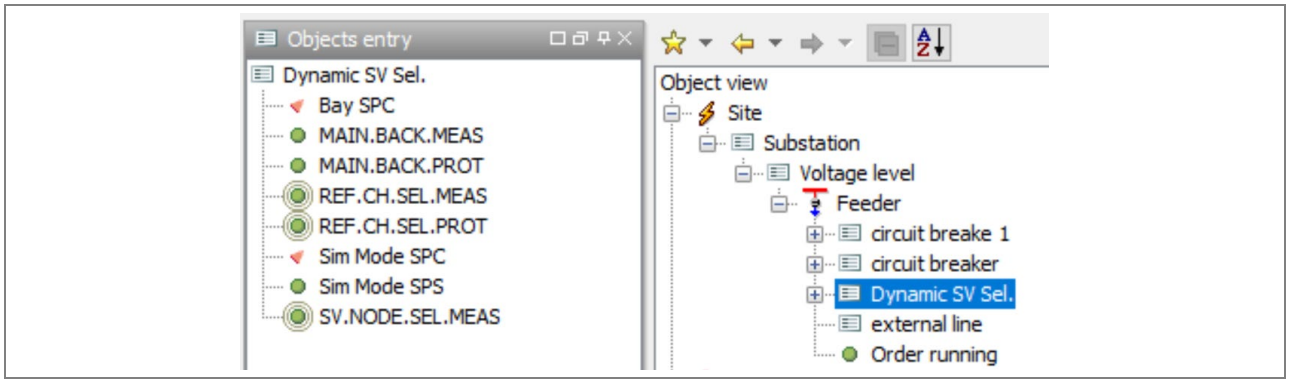
Dynamic sample value selection

In order to use dynamic sampled value selection, datapoints must be configured under the Electrical Bay connected to the merging units:

12 Add a **Dynamic SV Sel.** typed module.



The module is created with the compulsory *SV.NODE.SEL.PROT* MPS datapoint. In addition, optional datapoints can be added from the **Objects entry** window.



Datapoints	Description
MAIN.BACK.PROT (SPS)	Selection of the SampleValueGroup "protection & measurement" as active one
MAIN.BACK.MEAS (SPS)	Selection of the SampleValueGroup "measurement" as active one
Bay SPC (SPC)	Standard SPC, used for manual selection of a SampleValueGroup by linking it to the corresponding MAIN.BACK.xxxx SPS.
REF.CH.SEL.MEAS (MPS)	Selection of the SV index as BUSBAR voltage phase reference into the Merging Unit for "measurement" SampleValueGroup
REF.CH.SEL.PROT (MPS)	Selection of the SV index as BUSBAR voltage phase reference into the Merging Unit for "Protection" SampleValueGroup
SV.NODE.SEL.PROT (MPS)	Selection of the Merging Unit providing the svID for "protection & measurement" SampleValueGroup. This datapoint is compulsory.
SV.NODE.SEL.MEAS (MPS)	Selection of the Merging Unit providing the svID for "measurement" SampleValueGroup
Sim Mode SPC (SPS)	Manual control of simulation mode
Sim Mode SPS (SPS)	Feedback of simulation mode control

Merging unit redundancy

Add the *MAIN.BACK.xxxx* SPS. The state of this datapoint indicates which static SV arrangement is used, and in turn the merging unit(s) providing the SVs. It can be controlled by an automation or manually, using a standard *Bay SPC* datapoint.

Reference voltage change

Use the *SV.NODE.SEL.PROT* MPS to select the SVCB providing the reference voltage according to the present topology.

Phase selection

Use the *REF.CH.SEL.xxx* MPS to select the SV index providing the BUSBAR voltage phase reference.

Sample value simulation

Use the datapoint *Sim Mode SPC* and its feedback *Sim Mode SPS* to control whether a sample value simulator is being used (for testing/commissioning purposes).

Example

The example below describes a typical "double busbar" topology, with redundant DCS system for protections (5 svID available):

Static Arrangement MAIN (protection & measurement):

- LINE side: CI # 1, 2, 3, 4, 5 to VI # 1, 2, 3, 4, 5 are configured with voltage and current acquired by Merging Unit MU#1 (protection class)
- BUSBAR side: VI # 5 (Reference voltage) value is configured with voltage phase A, acquired by Merging Unit MU#9 (measurement class) connected at BUSBAR "BB1"
- I_{SA} (optional): CI # 5 (Isa) value is configured with current phase C, acquired by Merging Unit MU#2 (measurement class)

Static Arrangement BACKUP (protection & measurement):

- LINE side: CI # 1, 2, 3, 4, 5 to VI # 1, 2, 3, 4, 5 are configured with voltage and current acquired by Merging Unit "backup" MU#2 (protection class)
- BUSBAR side: same than MAIN configuration
- ISA (optional): same than MAIN configuration

The optional **Dynamic Arrangement** automation chooses the svID corresponding to the real time topology (BB1 or BB2) by selecting the right index (MU#7 or MU#9) into PBUS list.

The optional **Redundancy controller** shall control the MAIN or BACKUP arrangement selection.

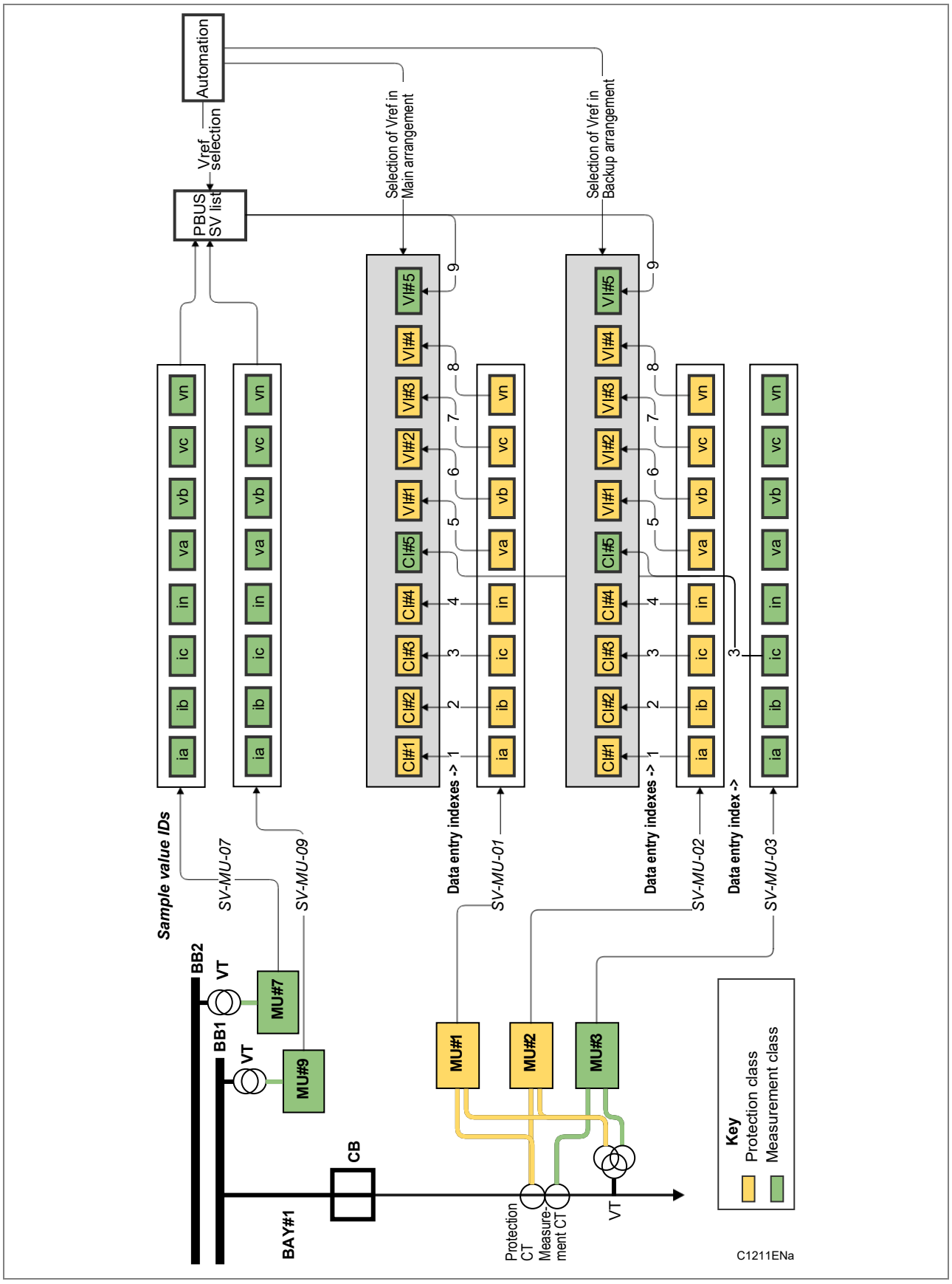
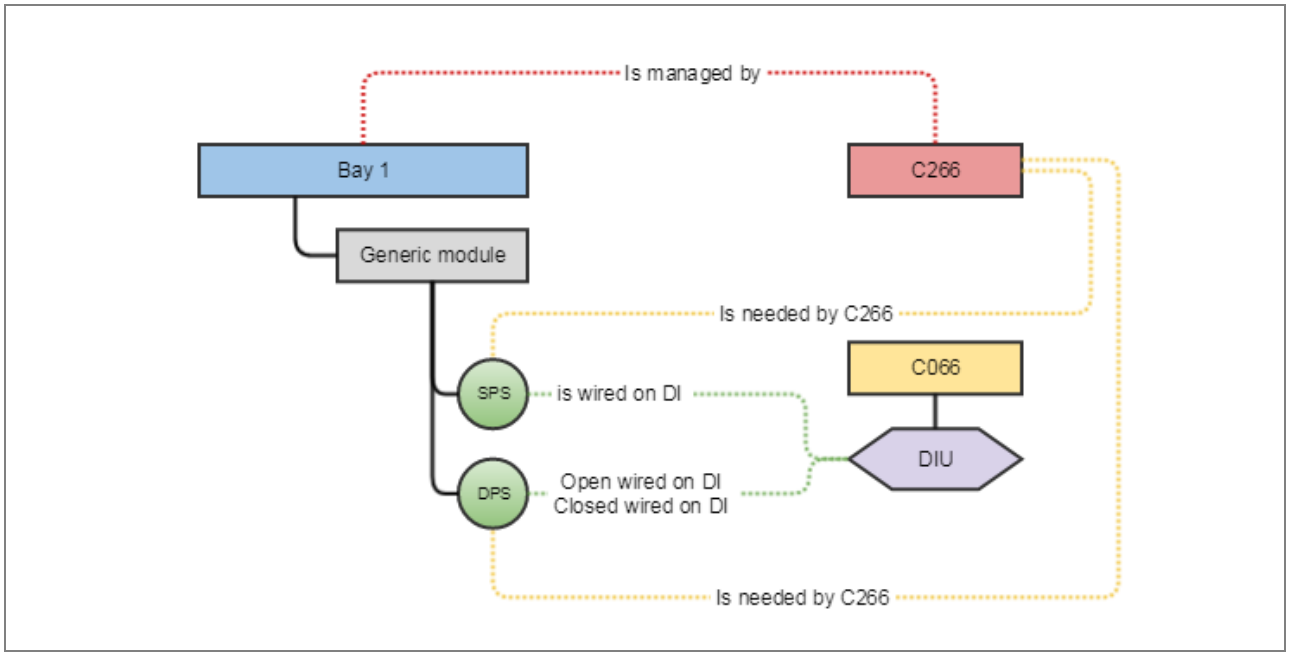


Figure 353: Static Arrangement Configuration example

6.3 DIGITAL INPUT CONFIGURATION

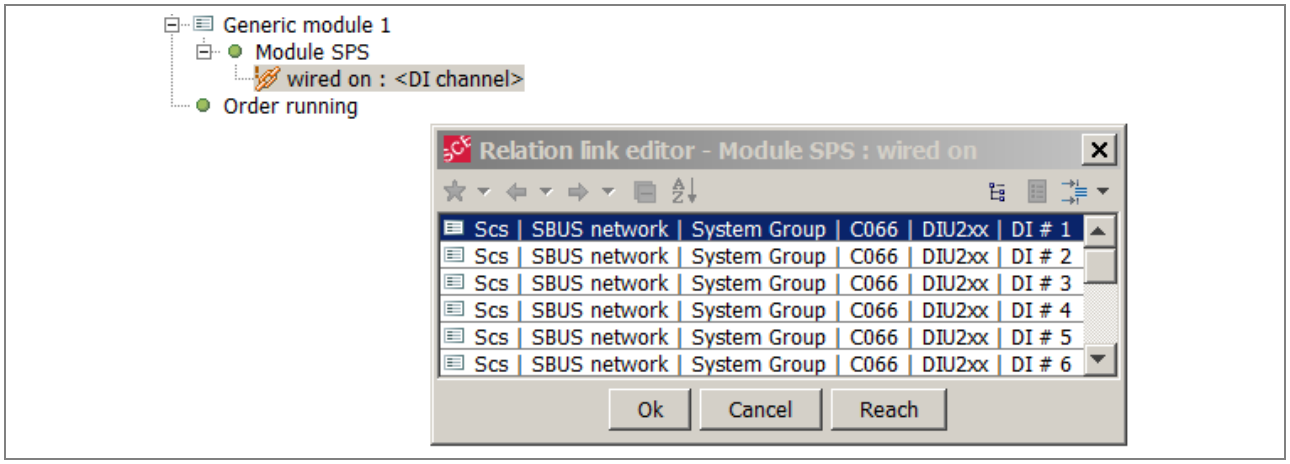
Wiring SPS and DPS datapoints to the SCU's digital input is similar to standard wiring to the BCU. However, in order for their configuration to be transmitted in the Goose frames received by the BCU, an extra relation "is needed by C266" must be added under the datapoints, as shown below.



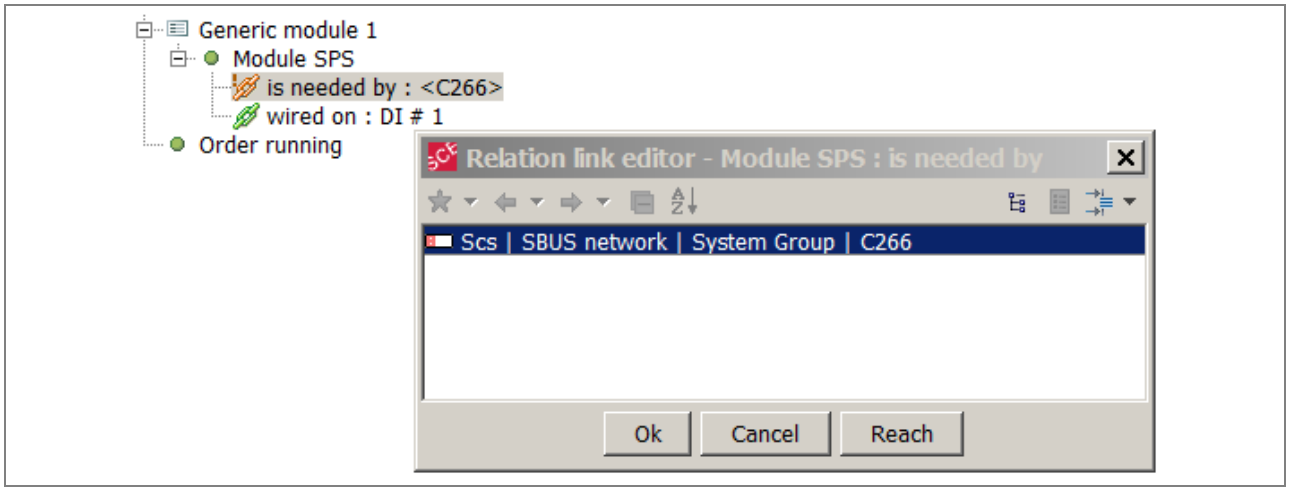
Configuration steps

1 Create the required module and add the DPS and/or SPS datapoint.

2 Wire this datapoint to the appropriate DI of the C066



3 Add and configure the relation **is needed by : <C266 >** to the wired datapoint.

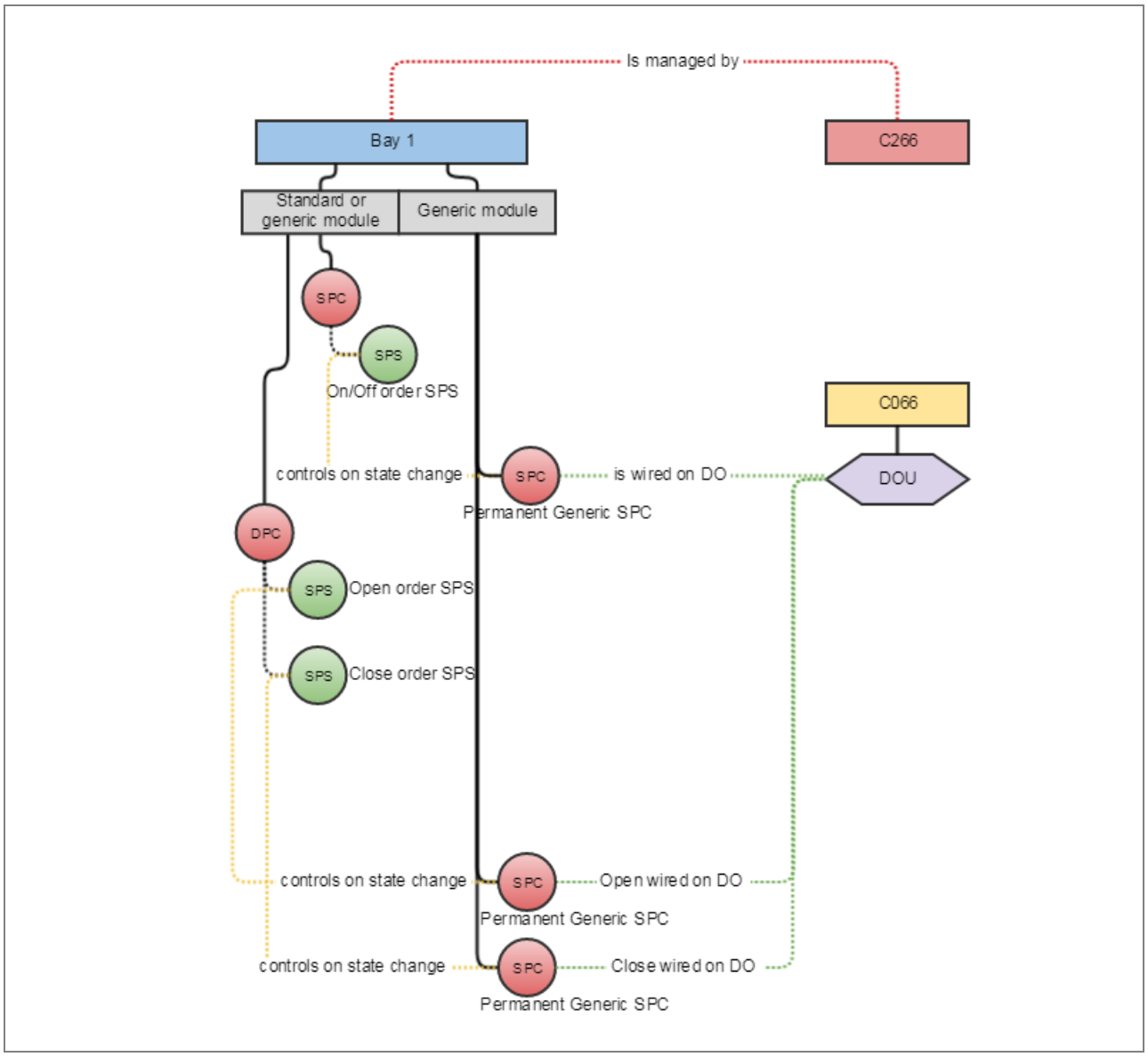


4 The datapoints transmitted in the GOOSE will be displayed in the "Goose PBus" folder under the **C066** after the next automatic addressing operation.

6.4 DIGITAL OUTPUT CONFIGURATION

6.4.1 SPC/DPC WITHOUT FEEDBACK

To wire an SPC or DPC to an SCU digital output, you need to interface 1 or 2 “virtual” SPC(s), as shown below.



Configuration steps

1 Add 1 or 2 "virtual" *Module SPC* datapoint(s) to a generic module.

   a Make sure their **activation mode** attributes are set to *Permanent*.

   b Wire them to the appropriate C066 digital outputs

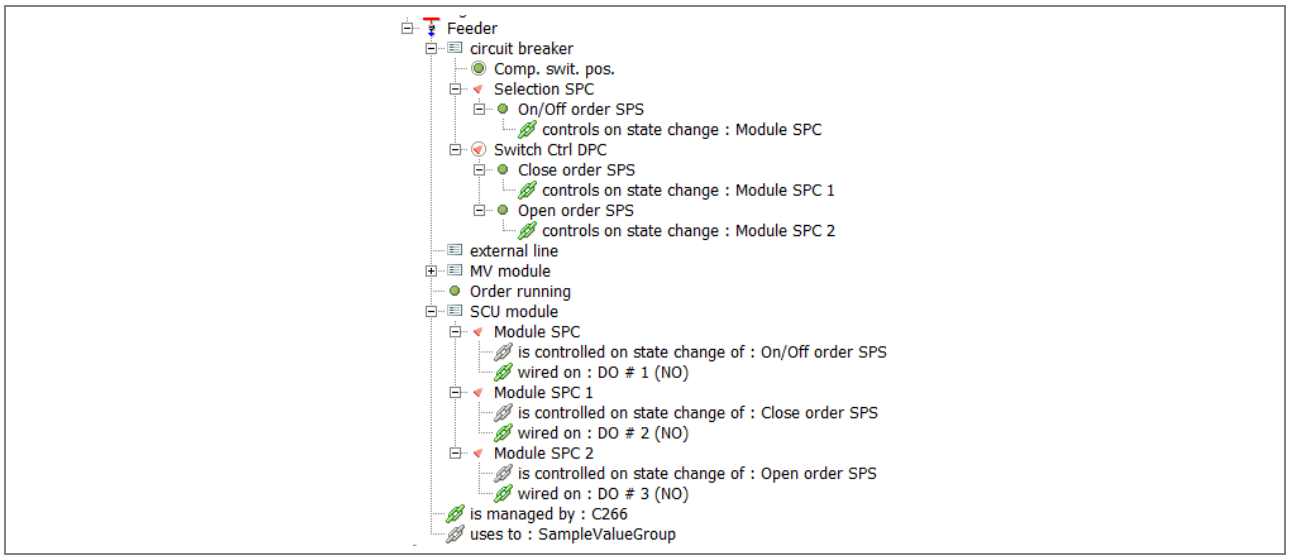
2 Add the electrical SPC or DPC datapoint to a standard or generic module.

   a Under a SPC, add *On/Off order SPS* (from the **Object entry** window’s group **SPS for xPC state**).

   b Under a DPC, add *Close order SPS* and *Open order SPS* (from the **Object entry** window’s group **SPS for xPC state**).

c Under each state SPS datapoint, add the relation **controls on state change : <xPC datapoint>**.

d Link this/these relation(s) to the corresponding SCU virtual SPC datapoint(s), as in the example shown below.

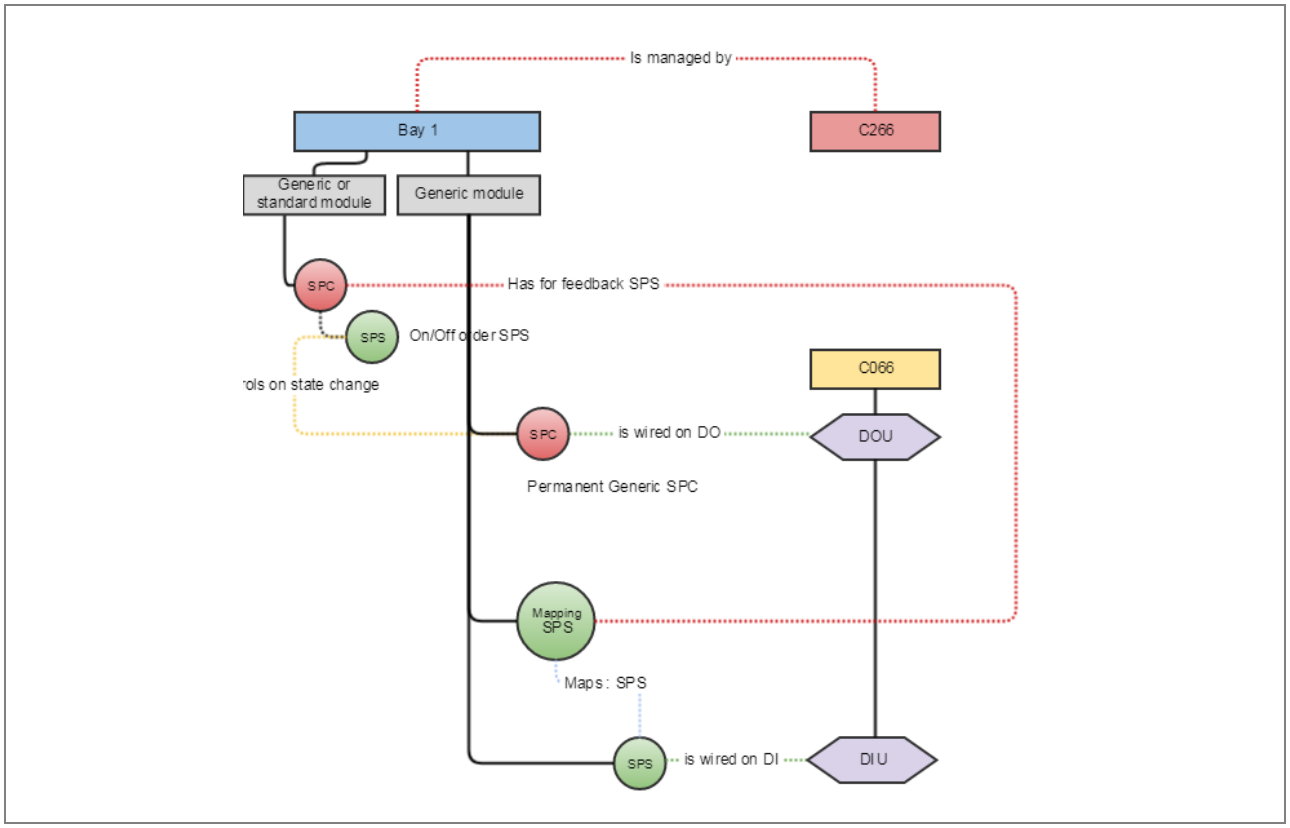


e For each relation, configure the attributes **'Reset' order value** and **'Set' order value**.

3 The datapoints transmitted in the GOOSE will be displayed in the **Goose PBus** folder under the **C266** after the next automatic addressing operation.

6.4.2 SPC WITH FEEDBACK

To wire an SPC's feedback SPS to an SCU's digital input, you need to interface a Mapping SPS between the SPC and the SPS wired to the DI, as shown in the diagram below.



Configuration steps

1 Add a "virtual" *Module SPC* datapoint to a generic module.

   a Make sure its **activation mode** attribute is set to *Permanent*.

   b Wire it to the appropriate C066's digital output

2 Add to the generic module

   - a *Mapping SPS* datapoint
   - a *Module SPS* datapoint

   a Wire the *Module SPS* datapoint to the appropriate C066's digital input

   b Under *Module SPS*: Add the relation **is mapped on : Mapping SPS Electrical datapoint** and link it to the *Mapping SPS* datapoint

3 Add the required electrical SPC datapoint to a standard or generic module.

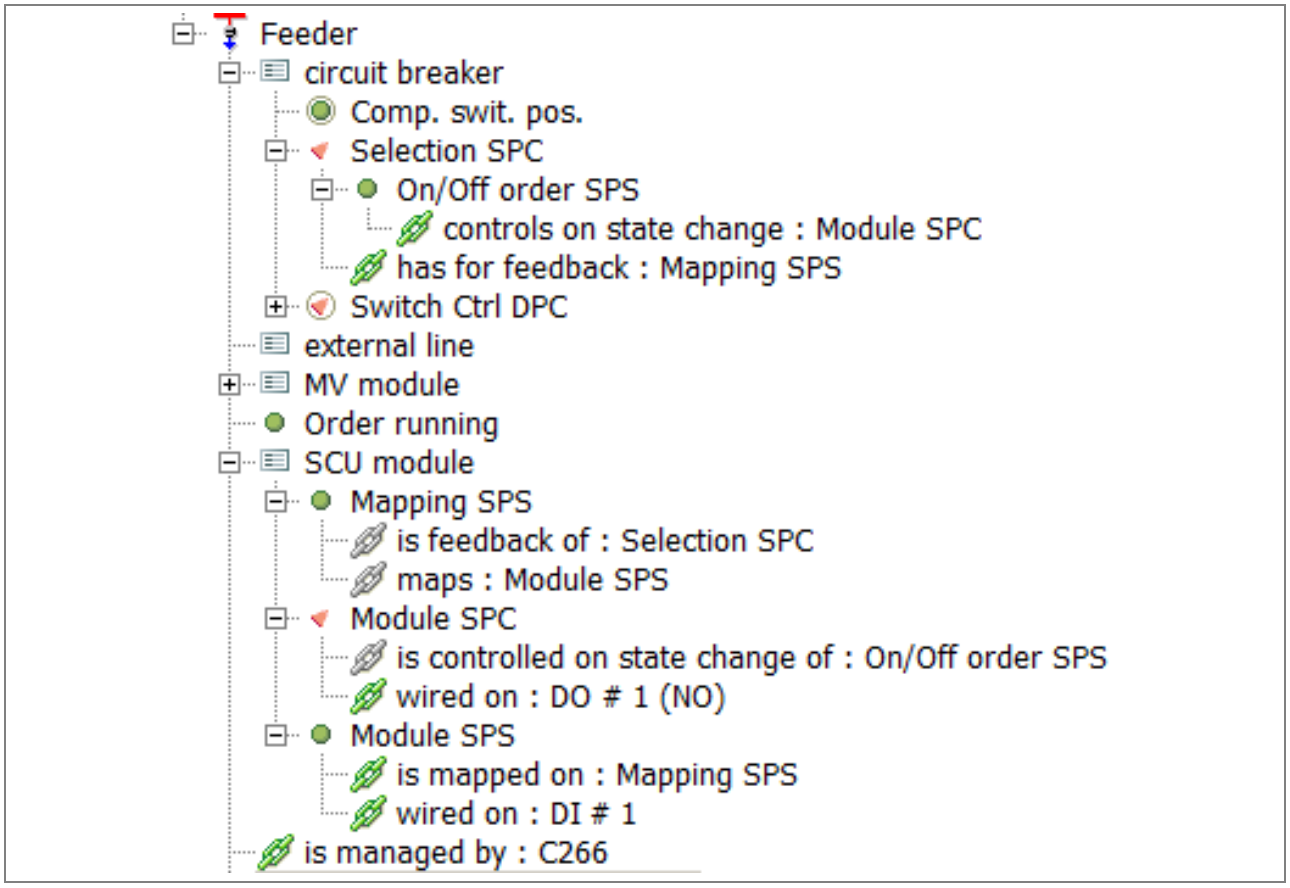
   a Under the electrical SPC datapoint, add *On/Off order SPS* (from the **Object entry** window's group **SPS for xPC state**).

   b Under the state SPS datapoint, add the relation **controls on state change : <xPC datapoint>**.

   c Link this relation to the corresponding wired virtual SPC datapoint.

   d Configure the relation's attributes **'Reset' order value** and **'Set' order value**.

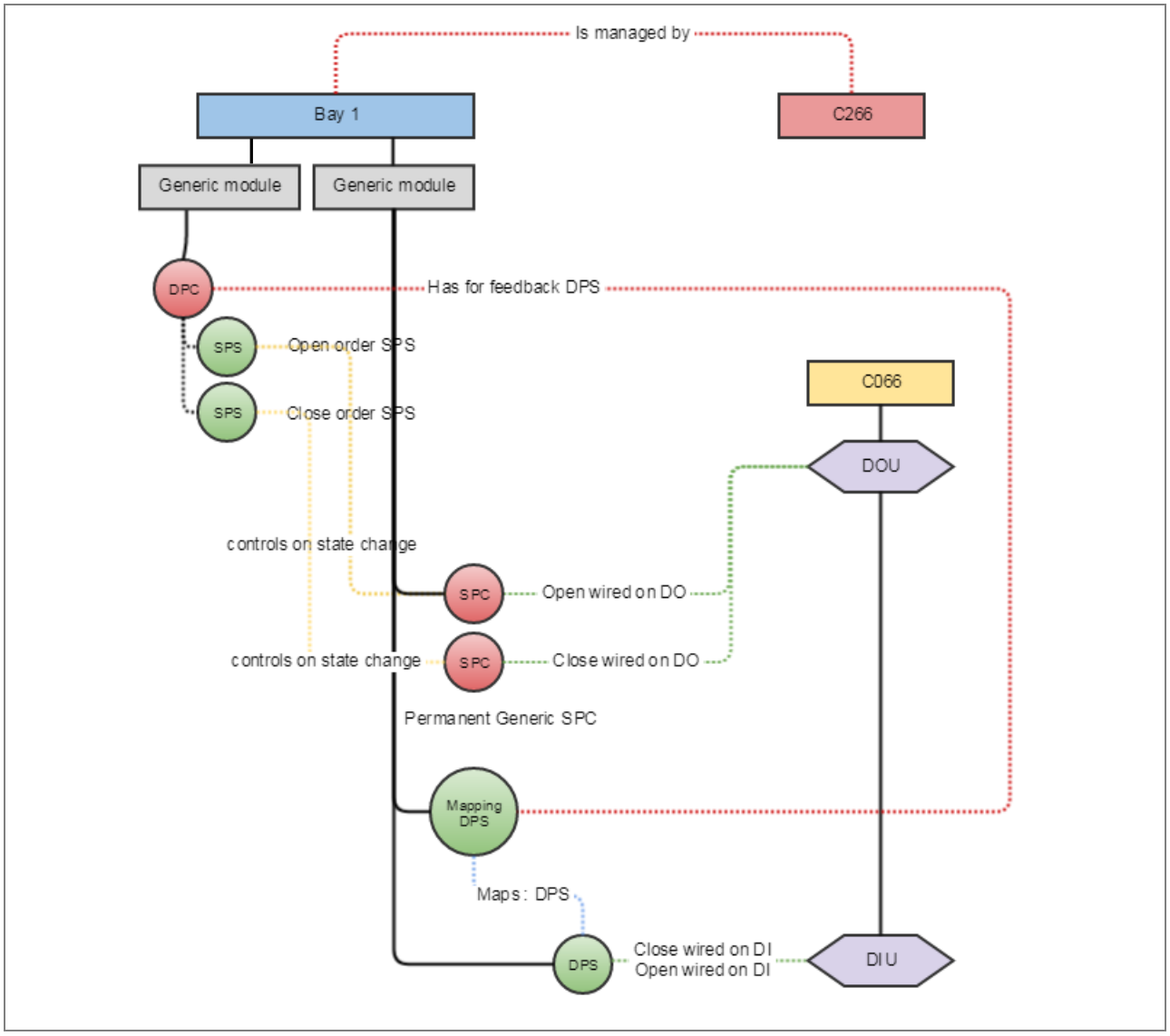
e Under the electrical SPC datapoint, add the relation **has for feedback : <SPS Electrical datapoint datapoint>**. And link that relation to the *Mapping SPS* datapoint.



4 The datapoints transmitted in the GOOSE will be displayed in the **Goose PBus** folders under the **C266** and the **C066** after the next automatic addressing operation.

6.4.3 DPC WITH FEEDBACK

To wire a DPC's feedback SPS to 2 SCU's digital inputs, you need to interface a Mapping DPS between the DPC and the SPS datapoints wired to the DIs, as shown in the diagram below.



Configuration steps

1 Add 2 "virtual" *Module SPC* datapoints to a generic module.

   a Make sure their **activation mode** attributes are set to *Permanent*.

   b Wire them to the appropriate C066's digital outputs

2 Add to the generic module

   - a *Mapping DPS* datapoint
   - a *Module DPS* datapoint

   a Wire the *Module DPS* datapoint to the 2 appropriate C066's digital inputs

   b Under *Module DPS*: Add the relation **is mapped on : Mapping DPS Electrical datapoint** and link it to the *Mapping DPS* datapoint

3 Add the required electrical DPC datapoint to a standard or generic module.

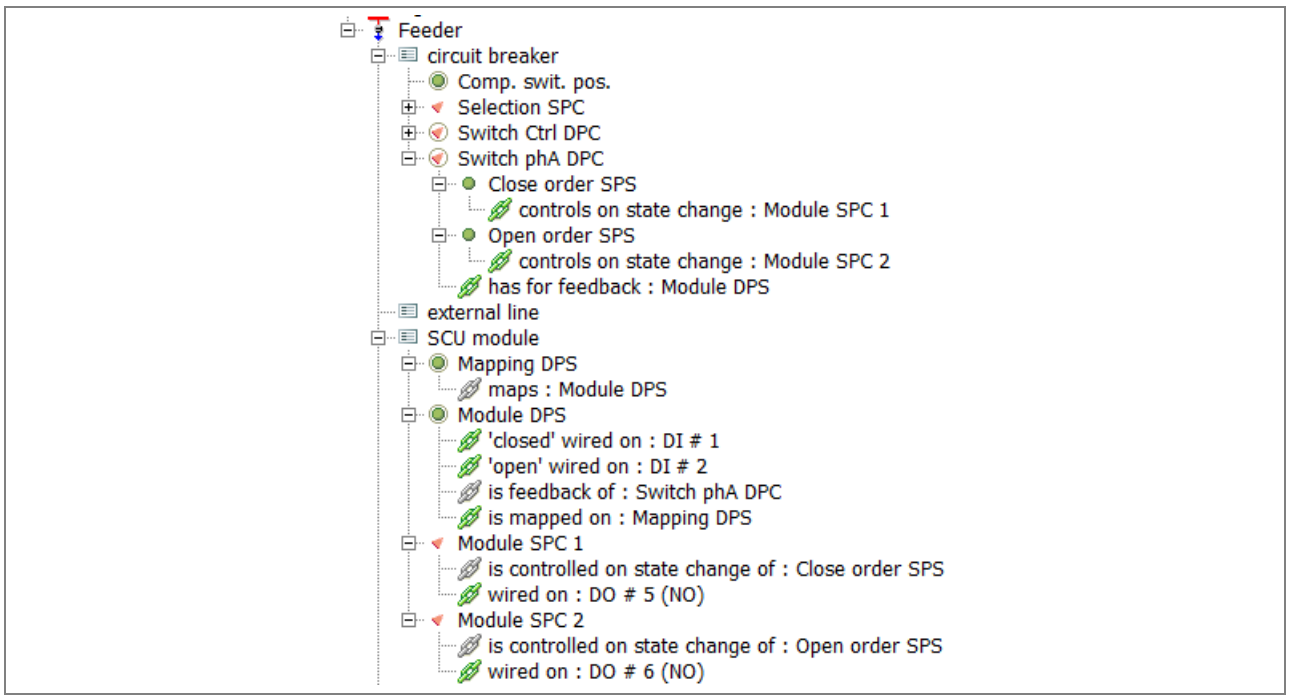
a Under the electrical DPC datapoint, add *Close order SPS* and *Open order SPS* (from the **Object entry** window's group **SPS for xPC state**).

b Under both state SPS datapoint, add the relation **controls on state change : <xPC datapoint>**.

c Link these relations to the 2 corresponding wired virtual SPC datapoints.

d Configure the relations' attributes **'Reset' order value** and **'Set' order value**.

e Under the electrical DPC datapoint, add the relation **has for feedback : <DPS Electrical datapoint datapoint>** and link that relation to the *Mapping DPS* datapoint.



4 The datapoints transmitted in the GOOSE will be displayed in the **Goose PBus** folders under the **C266** and the **C066** after the next automatic addressing operation.

7 DEFINING A C26X INTERFACE

7.1 SECURITY DISCLAIMER MESSAGES

For both the DS Agile C26x's front panel LHMI and the DS Agile CMT application, it is possible to enable and define security messages that the user will have to acknowledge before being able to connect to the DS Agile C26x.

These messages are enabled by default. The default English texts are:

LHMI

"Access to this system is limited to users authorized & trained as required by laws

Do not go further if you are not an explicitly authorized user"

CMT

"Access to this system is limited to specifically authorized users having received all trainings required by applicable laws, regulations, and by policies and procedures implemented by the legal entity hosting this system.

Unauthorized users may face criminal or civil liabilities and/or penalties. The use of this system may be recorded and monitored for system operations, security policy and intellectual property compliance related purposes and any information related to the use of this system may further be disclosed to third parties or law enforcement officials as necessary.

Disconnect now if you are not an authorized user or do not agree with the above terms."

7.1.1 DESCRIPTION AND LIMITS

LHMI

Two disclaimer texts can be defined for display on the C26x's front panel LHMI, one for each language managed by the LHMI.

- Maximum length for each line: 21 characters, including blank spaces.
- Maximum number of lines: 14.

CMT

One disclaimer text can be defined for display via the DS Agile CMT application.

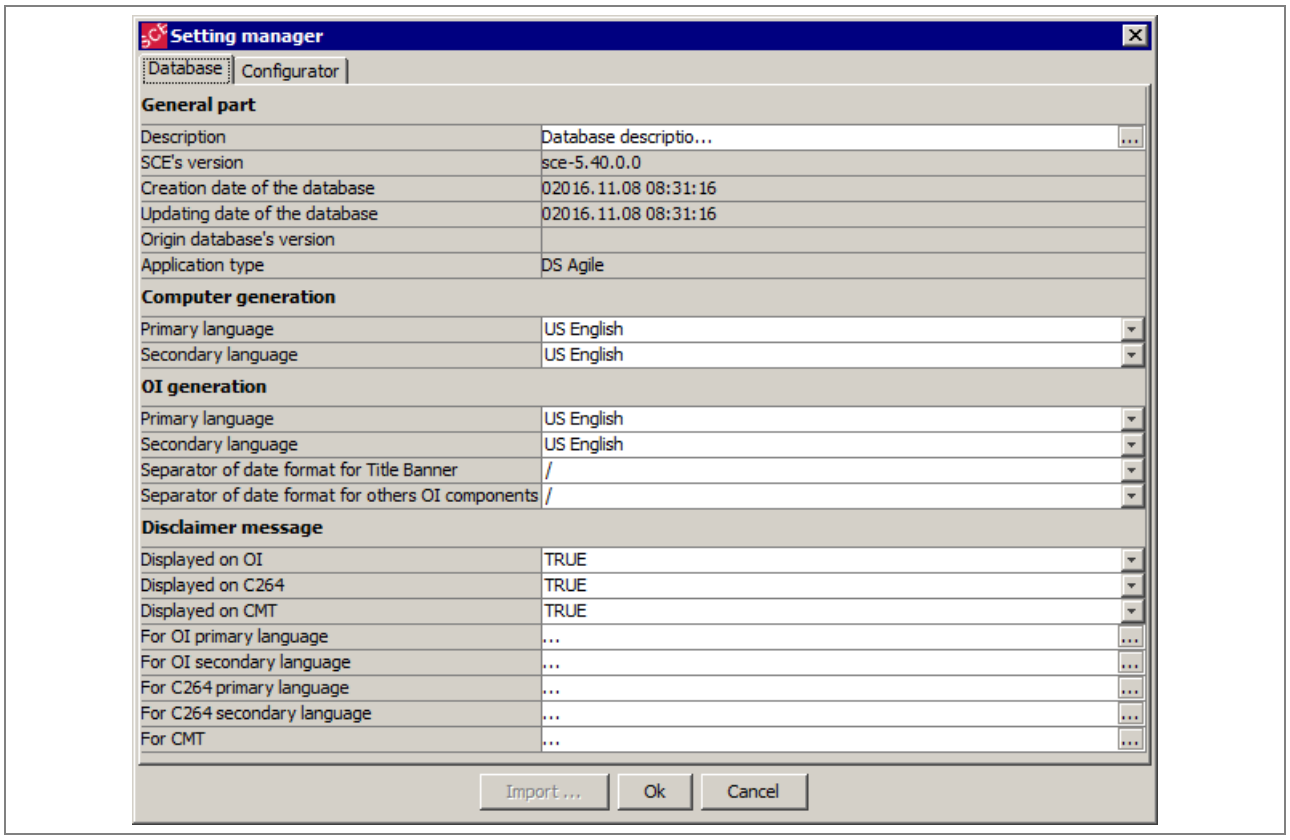
- Maximum length: 1000 characters, including blank spaces.

Note:
When the C26x is in Boot or in Maintenance mode, the CMT always displays the default disclaimer, whatever the database configuration.

7.1.2 CONFIGURATION

- In the **Tools** menu, select **Options...**
- Select the **Database** tab.

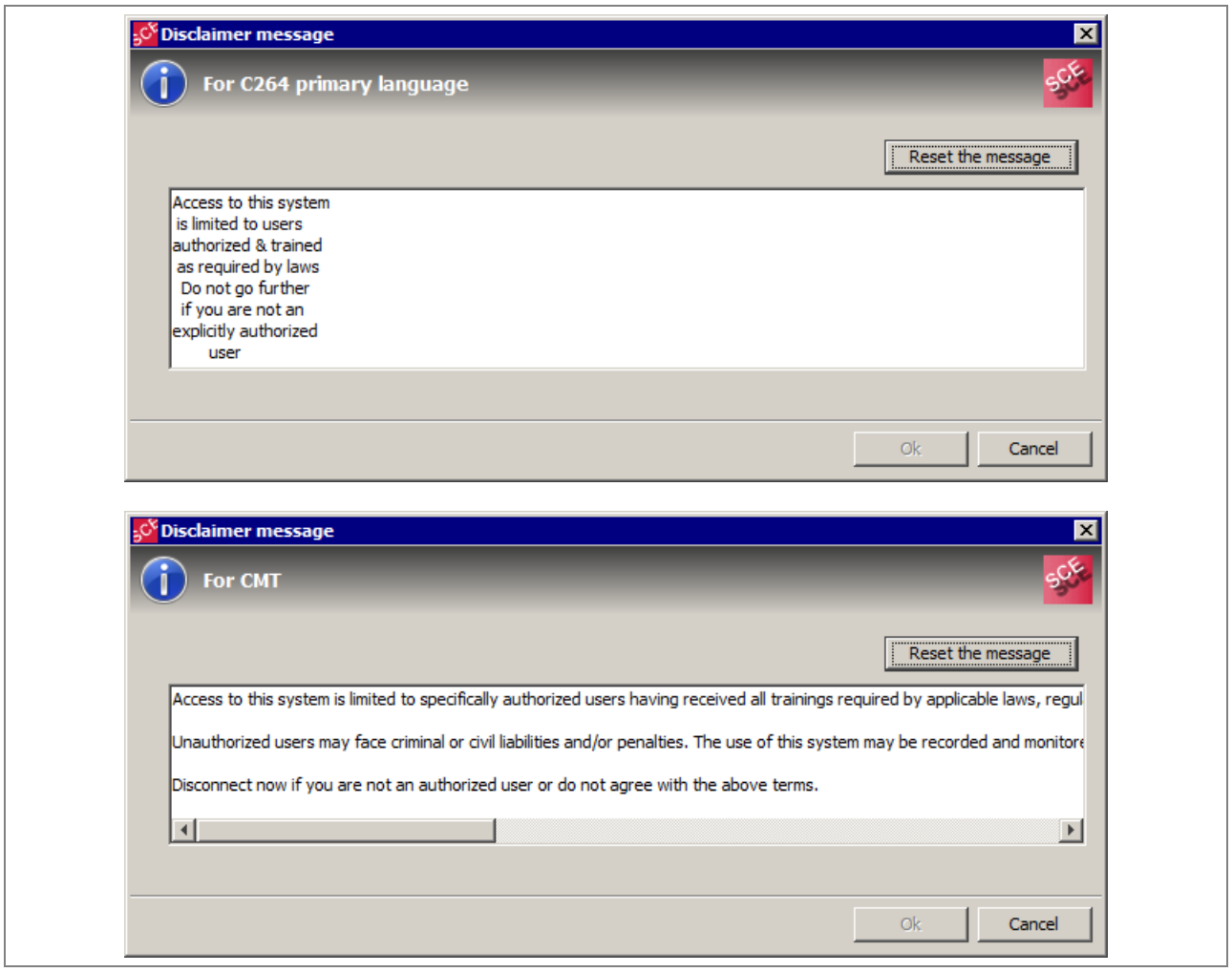
By default, both the C264 LHMI and the CMT disclaimers are enabled.



- Disable/enable disclaimers:
  - To disable the disclaimer for front panel LHMI connections, set **Displayed on C264** to *FALSE*. Set **Displayed on C264** back to *TRUE* to enable it again.
  - To disable the disclaimer for connections from the DS Agile CMT application, set **Displayed on CMT** to *FALSE*. Set **Displayed on CMT** back to *TRUE* to enable it again.

Notes:
*The setting for **Displayed on C264** also affects the browsing mode on the front panel LHMI:*
- If it is set to TRUE, the browsing mode is "secure", i.e. no access at all is possible without entering a valid login and password.
- If it is set to FALSE, read only access is allowed without having to log in. See chapter C26x/EN HI, Human Interface, for more details.

- Change disclaimer texts:
  - To access the edition window of each disclaimer text, click the button **[...]** at the right end of each line.



  - Edit the required texts according to the limits given above and click **Ok** when done.
  - To revert to the default text of any disclaimer, click **Reset the message** then **Ok**.

Although they are configured from the SCE's **Options** menu, these texts are added to the system configuration database, and become available once it is downloaded into the device.

Note:
In this system version, only the Primary language disclaimer is implemented for the C26x's LHMI. Changing the text for the secondary language has no effect.

Maximum disclaimer size

- CMT: 1000 characters
- LHMI: 24 lines, each line under 22 characters

7.2 LOCAL HMI DEFINITION

All types of C26x units can have a GHU300 board for led managing and possible local bay mimic panel animations in case of complete GHU300 board (see section *3.3.3.4 Attributes of a GHU3xx board*).

7.2.1 DEFINING A BITMAP TABLE

To define C26x bay mimics, bitmaps are used. Their definition is located at graphic root of the data modeling.

At C26x bay mimic definition level, objects only reference these bitmaps. So it is an easier way to propagate a bitmap change for instance to all objects that reference it.

At SCE level, bitmap object definition is extended to embed animation: up to 5 elementary static bitmaps can be grouped in a bitmap object:

- one (mandatory) for default representation
- one for ‘open’ (or reset) representation
- one for ‘closed’ (or set) representation
- one for ‘open withdrawn’ representation
- one for ‘closed withdrawn’ representation

Each representation corresponds to a filename containing the static bitmap definition.

To add a bitmap definition, select the Bitmap table level in the graphical topology add the Bitmap from the contextual **Objects entry** window.

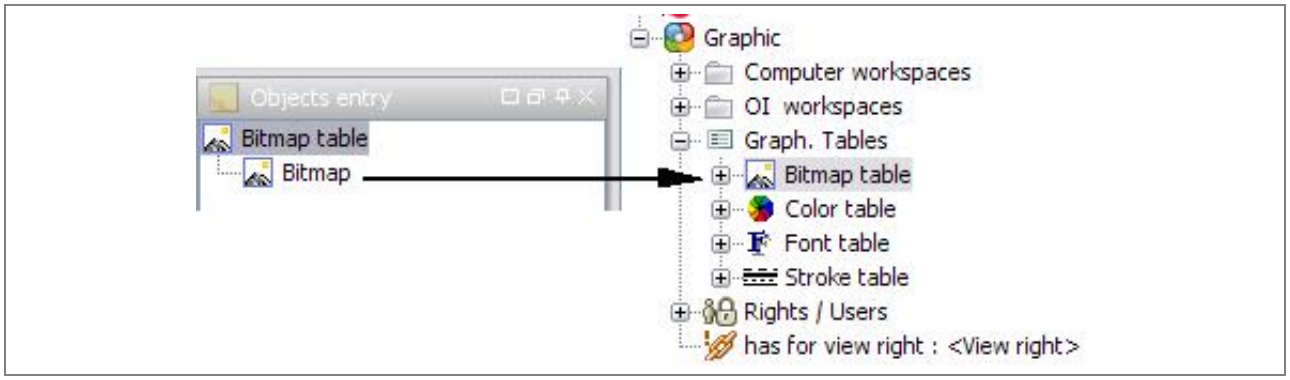


Figure 354: Adding a bitmap

Once added, bitmap attributes must be set at SCE level:

(1) **short name** and **long name**: used for internal SCE identification

(2) **reference index** (range [0, 150]: that must be unique for the set of defined bitmaps. This index will be used in bay mimic definition as described previously

(3) **type** (Single / 5-uple): single is used for static bitmap definition, 5-uple allows dynamic bitmap definition as described previously

(4) **file name by default**: corresponds to the filename containing the bitmap definition used for default representation

(5) **file name for 'open' state**: visible only if type is set to 5-uple: corresponds to the filename containing the bitmap definition used for open state representation

(6) **file name for 'closed' state:** visible if type is set to 5-uple: corresponds to the filename containing the bitmap definition used for closed state representation

(7) **file name for 'withdrawn open' state**: visible if type is set to 5-uple: corresponds to the filename containing the bitmap definition used for withdrawn open state representation

(8) **file name for 'withdrawn closed' state**: (visible if type is set to 5-uple): corresponds to the filename containing the bitmap definition used for withdrawn closed state representation

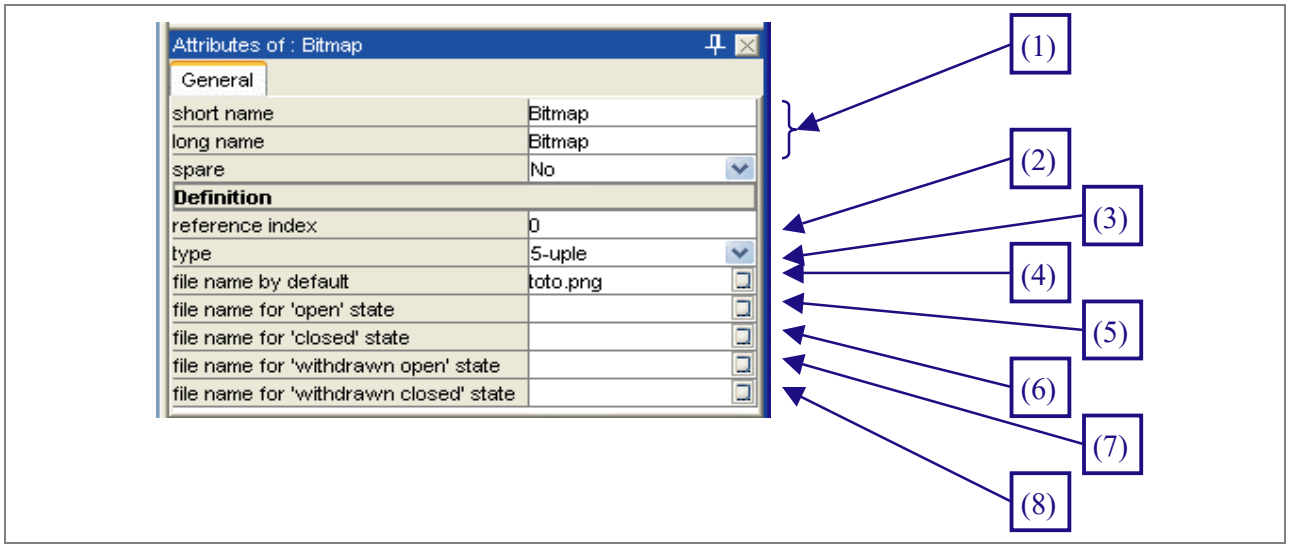


Figure 355: Setting the attributes of a bitmap

Attributes (7) and (8) can be omitted if breakers and switchgears represented in bay mimic are not concerned with withdrawn information.

To set a file name (attributes (4) to (8)) and define graphically a bitmap:

- select the attribute
- edit graphically a bitmap using the bitmap editor at SCE level
- save the graphical definition of the bitmap by giving a file name in bitmap editor

For details about bitmap editor usage refer to the *Graphic Menu* section in the Human Interface chapter of the SCE user manual.

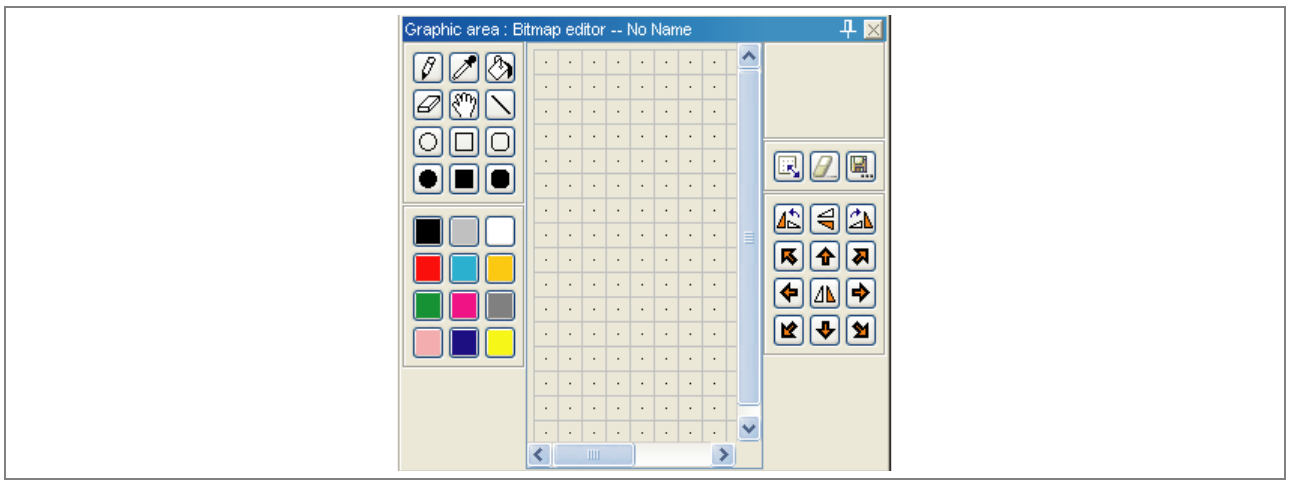


Figure 356: Using the Bitmap Editor

Color usage in bitmap editor is not significant for C26x monochrome LCD.

Configuration rules and checks

- The "reference index" attribute value of each "Bitmap" of the "Bitmap table" must be unique
- Depending on the "type" attribute value, 1 or 5 PNG file(s) can be linked to a Bitmap.
  For each one, the bitmap size must be ≤ 512 bytes

7.2.2 DEFINING A C26X WORKSPACE

Via a complete GHU300 board (see section *3.3.3.4 Attributes of a GHU3xx board*), each C26x with local HMI references a workspace that groups its bay mimic definitions. C26x workspaces cannot be shared by several C26x units because mimics are local to bays managed by a specific C26x.

Up to 24 bay mimics can be put in a C26x workspace, and up to 2 mimics can be linked to the same bay.

Usual labels are used by C26x Local HMI. They are located for all C26x units LHMI in one object grouping all translatable labels, located in “C26x workspaces” folder in Graphic topology.

7.2.2.1 SETTINGS LHMI LABELS

To modify a usual label used at C26x LHMI level, just select and update the corresponding attribute at LHMI labels object.

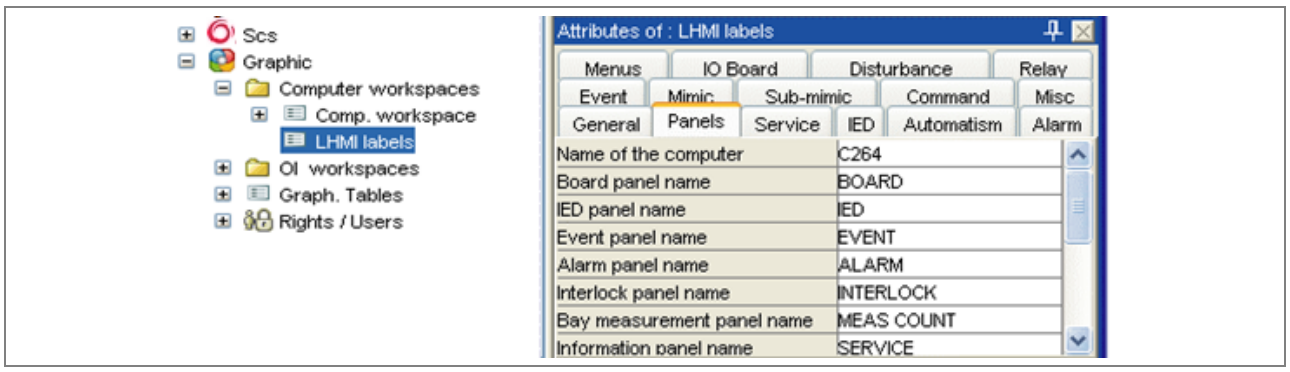


Figure 357: Settings LHMI labels

7.2.2.2 CREATING A WORKSPACE

To add a C26x workspace, select the Graphic level and add the Comp. workspace from the contextual **Objects entry** window.

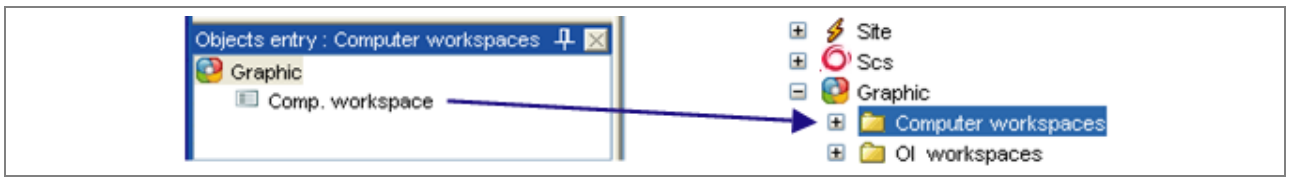


Figure 358: Adding a C26x workspace

Once added, the C26x workspace general features must be set at SCE level:

- Indicate which GHU300 board is concerned by created workspace by filling the relation **has for workspace** at concerned GHU board level (see section *3.3.3.4 Attributes of a GHU3xx board*).
- Setting the **short name** and **long name** (1) attributes of the workspace used for internal SCE identification,
- The attribute **local/remote password usage** (2) is not used.

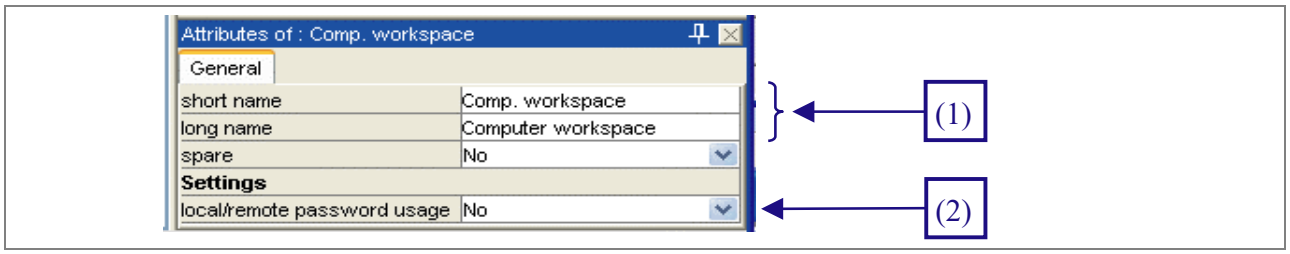


Figure 359: Setting the attributes of a C26x workspace

7.2.3 DEFINING A C26X BAY MIMIC

7.2.3.1 CREATING A C26X BAY MIMIC

To add a Bay mimic to a C26x, select the C26x workspace level and add the Bay mimic from the contextual **Objects entry** window.

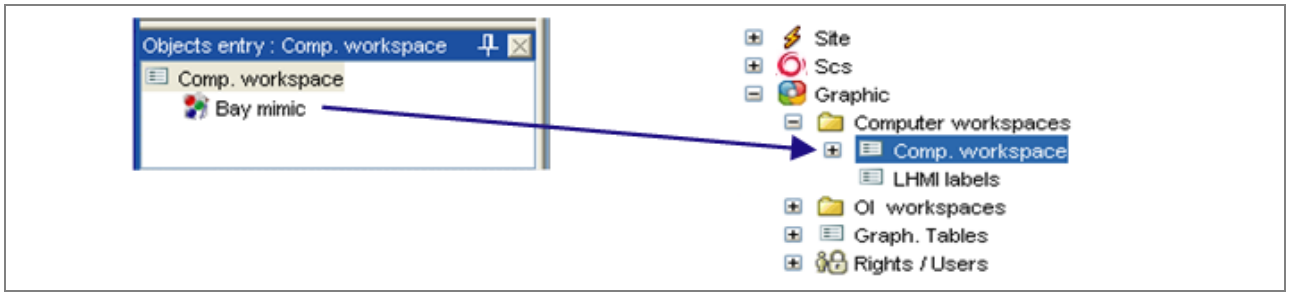


Figure 360: Adding a C26x Bay Mimic

Once added, bay mimic general attributes must be set at SCE level:

(1) **short name** of the bay mimic used for internal SCE identification.

(2) **bargraph representation** (none / Horizontal / Vertical): this attributes defines which type of bar graph is associated with an MV datapoint assigned to a bay mimic (see section *7.2.3.4 Assigning an MV to a bay mimic)*.

(3) **module name display** (*No* / *Yes*) this attribute defines if module short names are displayed at mimic level when a module is represented on bay mimic (see section *7.2.3.3 Defining dynamic part: pre-defined dynamic text, generic module representation, transformer representation).*

(4) Fill the relation **represents**, giving which bay is represented by the mimic (for details about bay see section *5.1.4 Defining a Bay*).

(5) f necessary, set the attribute **mimic rank** of the **represents** relation to correct value. This attribute is used when 2 mimics are configured to display an entire bay: as bay is split in 2 representations, the **mimic rank** attribute gives their display rank at C26x LHMI level (1 or 2).

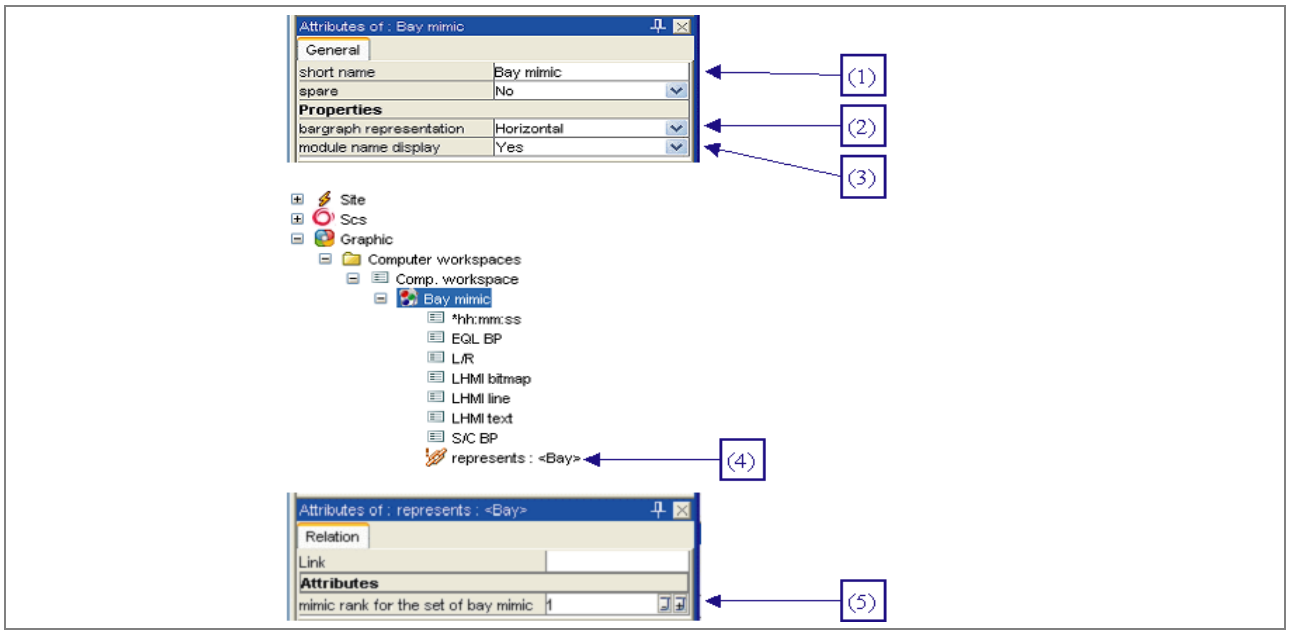


Figure 361: Setting the Bay Mimic features

When adding a bay mimic at workspace level, its core structure (canvas) is automatically created and displayed at SCE level, via bay mimic editor and in SCE tree browser. Its core structure consists of:

(1) Reserved zone for bay name display

(2) Reserved zone for bay local/remote display ((2') in tree browser)

(3) Reserved zone for 'interlocking bypass in progress' information ((3') in tree browser)

(4) Configurable zone for graphical representation of the bay (static and dynamic parts)

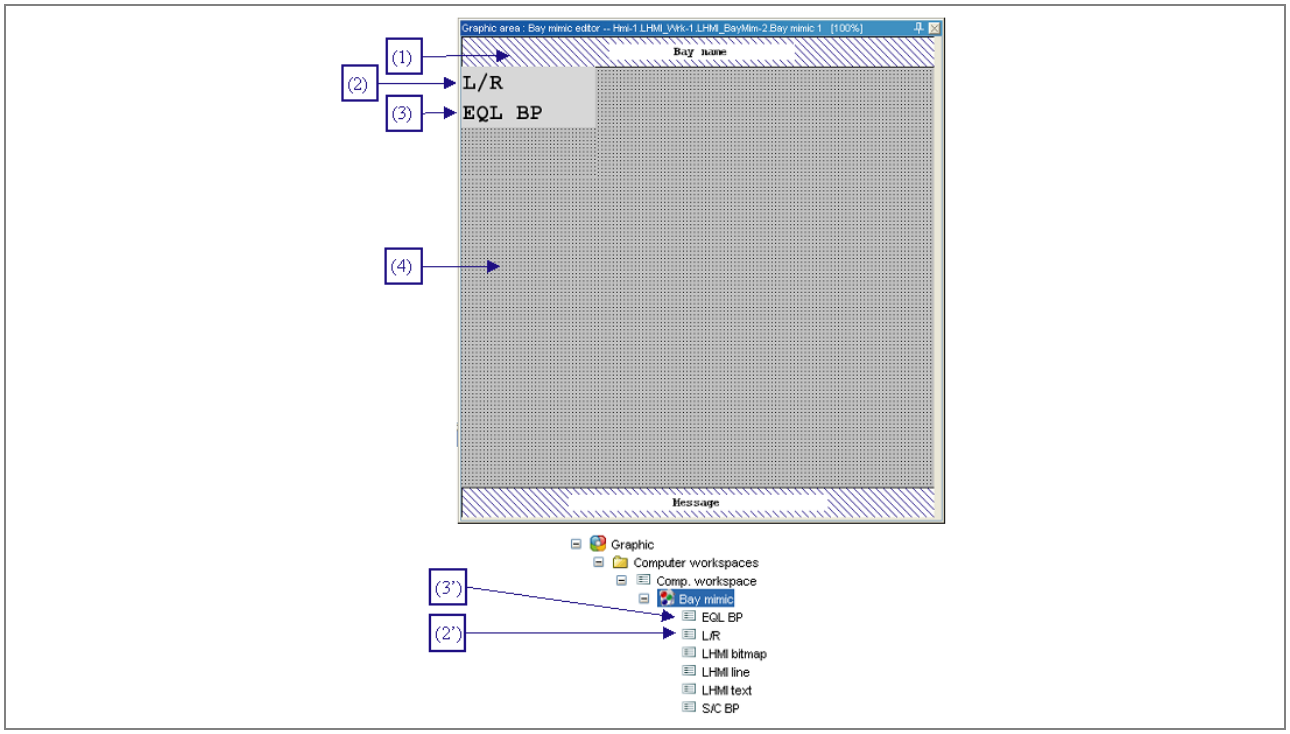


Figure 362: Core structure of a Bay Mimic

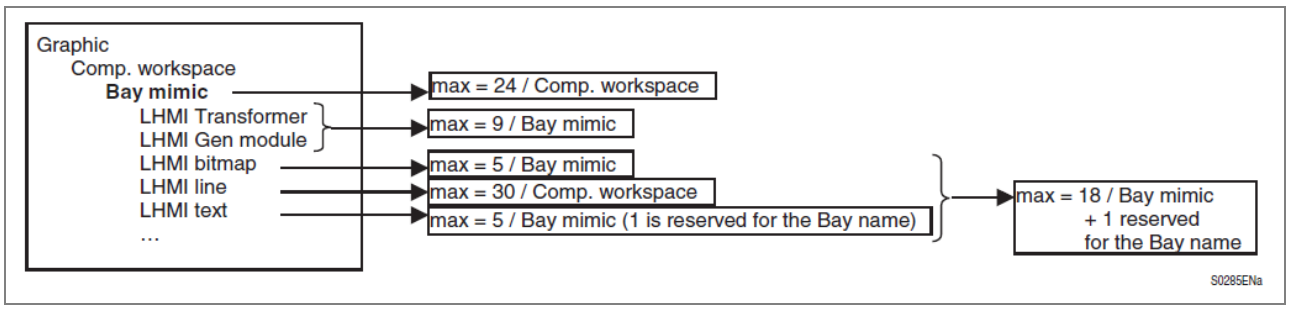
For more details about C26x LCD usage, refer to the Human Interface chapter of the C264 user manual.

The configurable zone of a bay mimic can be split in two parts:

- A static part with no real-time animation
- A dynamic part with real-time animated representations.

Configuration rules and checks

- The C26x managing a bay represented by a "Bay mimic" must be the same as the one linked to the "Comp. workspace" (computer workspace) of this "Bay mimic".
- A bay can be represented by 0, 1 or 2 "Bay mimic". Each **represents** relation has an attribute **mimic rank for the set of bay mimic.** In the case of 2 relations, each attribute value must be unique.
- For a Computer, the maximum count of managed bays (relation **is managed by**) which are linked to a "Bay mimic" (relation **represents**), is **12**.
- Limits of the count of symbols:



7.2.3.2 DEFINING THE STATIC PART: LINE, BITMAP, FIXED TEXT

The static part of a C26x bay mimic is described via graphical basic shapes:

- LHMI line: horizontal or vertical line with configurable thickness and length
- LHMI bitmap: bitmap that references a bitmap object in the bitmap table (see *7.2.1 Defining a bitmap*) where default representation is only taken into account
- Fixed text: multi-lingual fixed text

Once added, these elements automatically appear in the window of the bay mimic editor at SCE level.

Configuration rules and checks

- The coordinates (x, y) of a symbol must not be located outside the mimic area.

Adding a line

To add a line in a bay mimic diagram, select the Bay mimic level and add the line from the contextual **Objects entry** window:

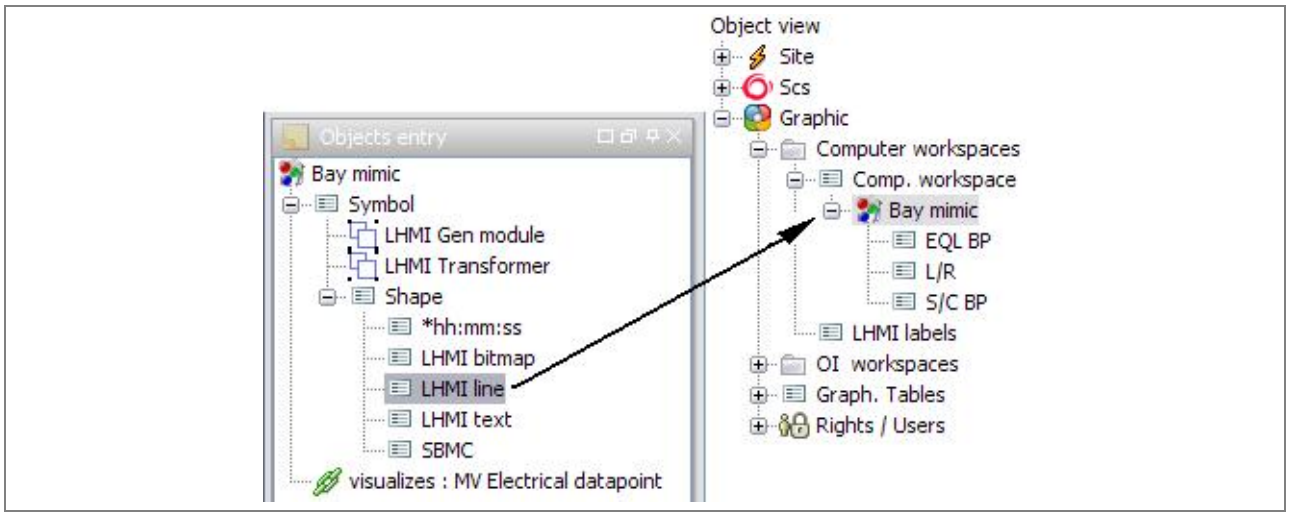


Figure 363: Adding a line to a C26x Bay Mimic

Once added, line attributes must be set:

(1) **short name** of the line used for internal SCE identification

(2) **x** (range [0, 127 pixels], step 1 pixel): abscissa

(3) **y** (range [0, 127 pixels], step 1 pixel): ordinate

(4) **length** (range [1 pixel, 127 pixels], step 1 pixel)

(5) **orientation** (*Horizontal* / *Vertical*)

(6) **thickness** (range [1 pixel, 8 pixels], step 1 pixel)

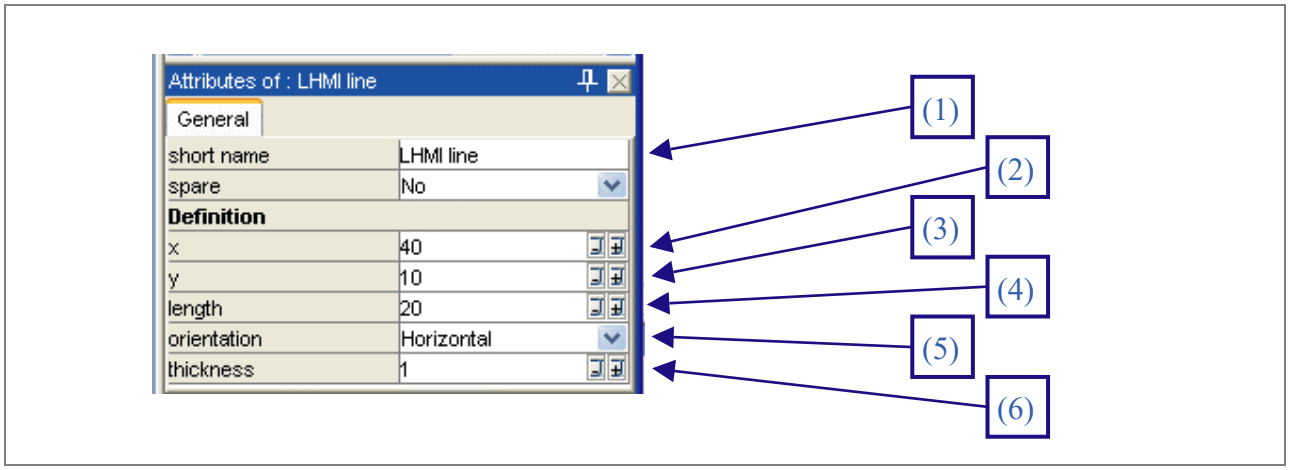


Figure 364: Setting the attributes of a line

Abscissa, ordinate, length and thickness of a LHMI line can be directly adjusted with the mouse in bay mimic editor (for detail, refer to the SCE user's manual)

Adding a bitmap

To add a bitmap image to a bay mimic diagram, select the Bay mimic level and add the bitmap from the contextual **Objects entry** window.

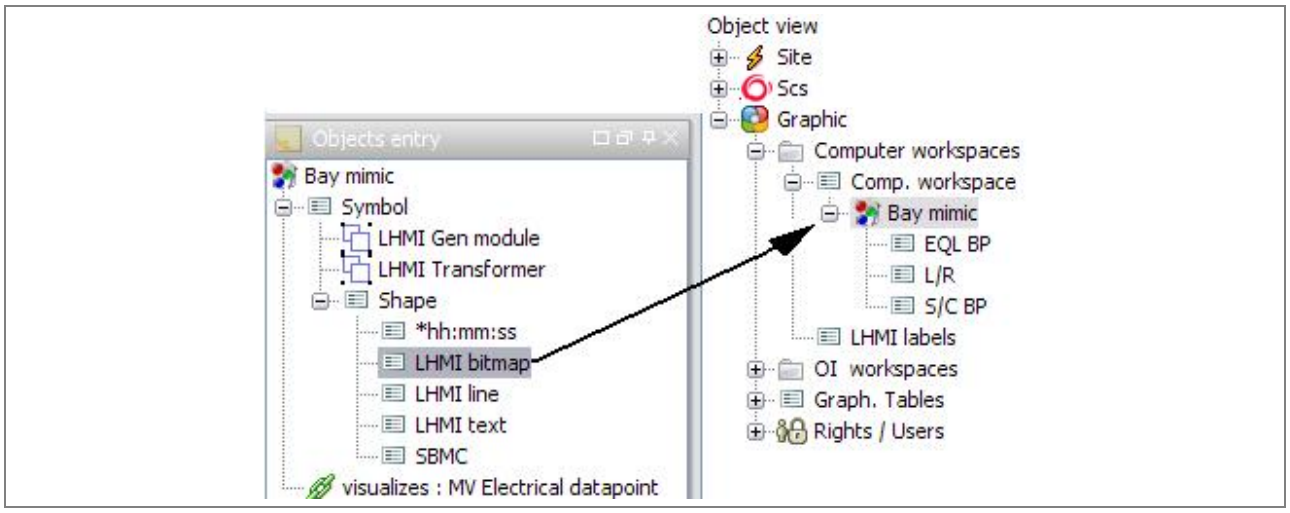


Figure 365: Adding a bitmap to a C26x Bay Mimic

Once added, bitmap attributes must be set:

(1) **short name** of the line used for internal SCE identification

(2) **x** (range [0, 127 pixels], step 1 pixel): abscissa

(3) **y** (range [0, 127 pixels], step 1 pixel): ordinate

(4) **bitmap reference**: corresponds to a link in the bitmap table (see section *7.2.1 Defining a bitmap table)*

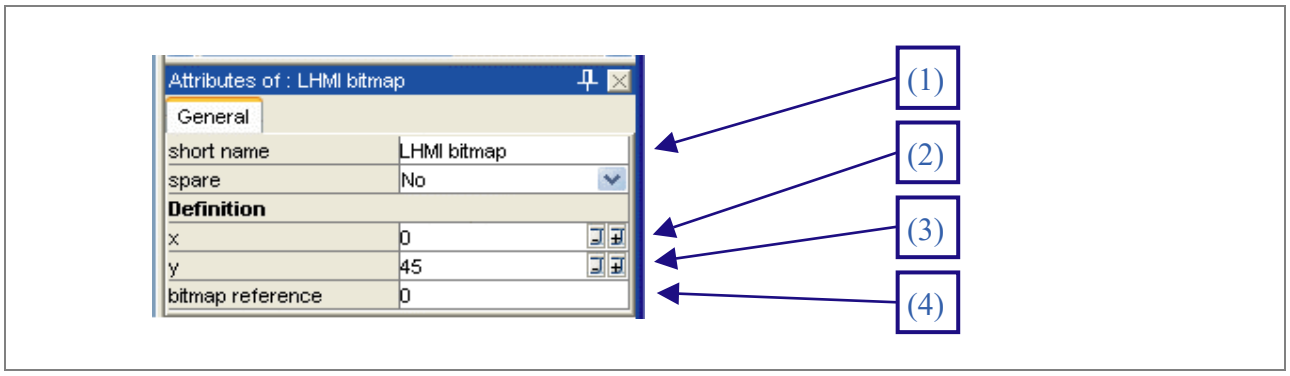


Figure 366: Setting the attributes of a bitmap

Abscissa and ordinate of a bitmap can be directly adjusted with the mouse in bay mimic editor (for detail, refer to SCE user manual)

Configuration rules and checks

- The link from an element to its bitmap is defined with the attribute "bitmap reference". The value of this attribute must refer to an existing bitmap in the "Bitmap table".

Adding a fixed text (plain text area)

To add a fixed text to a Bay mimic diagram, select the Bay mimic level and add the text from the contextual **Objects entry** window.

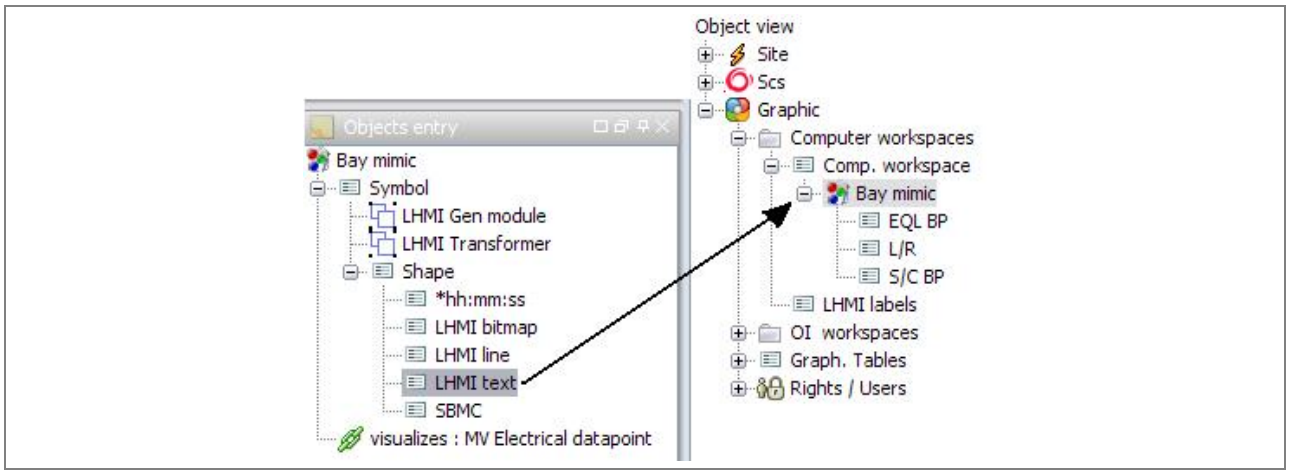


Figure 367: Adding a fixed text to a C26x Bay Mimic

Once added, fixed text attributes must be set at SCE level:

(1) **fixed text value**: text to display at mimic level

(2) **x** (range [0, 127 pixels], step 1 pixel): abscissa

(3) **y** (range [0, 127 pixels], step 1 pixel): ordinate

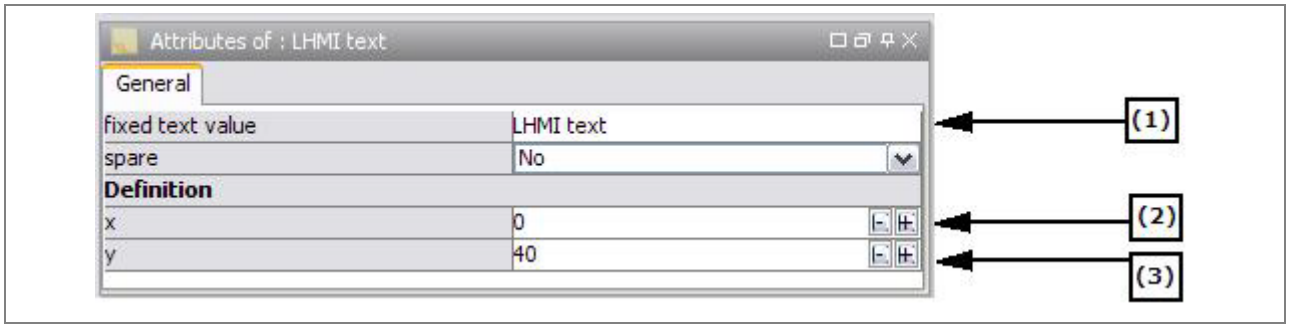


Figure 368: Setting the attributes of a bitmap

Abscissa and ordinate of a fixed text can be directly adjusted with the mouse in bay mimic editor (for detail, refer to SCE user manual). Text area length at bay mimic is automatically deduced from text value length (attribute (1)).

7.2.3.3 DEFINING DYNAMIC PART: PRE-DEFINED DYNAMIC TEXT, GENERIC MODULE REPRESENTATION, TRANSFORMER REPRESENTATION

To define dynamic part of C26x bay mimics, 3 types of objects are available:

- Pre-defined dynamic text, used:
  - to display local/remote and SBMC status of the bay
  - to manage interlock bypass during control sequence on the bay
  - to display time and synchronization status

Generic module representation: used to display module status, linked to a specific SPS or DPS electrical datapoint. Implicit link to possible xPC associated datapoint is given to C26x for command purpose at local HMI level, via the existence of the relation **is feedback of** between the xPS and the xPC.

- A generic module is composed of 2 sub-objects:
  - a name for display (mandatory)
  - a 'xPS muti-state' for dynamic module state display (mandatory), referencing a dynamic bitmap object in the bitmap table, and whose relation to a xPS datapoint (SPS or DPS) has to be filled up to precise animation datapoint
- Transformer representation: used to display transformer module; linked to an optional Tap Position Indicator. Transformer is composed of 5 sub-objects:
  - a name for display (mandatory)
  - a 'TPI muti-state' for transformer display (mandatory), referencing a dynamic bitmap object in the bitmap table, and whose relation to a TPI datapoint can be filled up to precise the concerned datapoint for the following animation
  - an optional 'current TPI value' object to display dynamically the current value of the TPI,
  - an optional 'max TPI value' object to display upper available value for the TPI
  - an optional 'min TPI value' object to display lower available value for the TPI

Adding time information

To add time information to a Bay mimic diagram, select the Bay mimic level and add the time field from the contextual **Objects entry** window.

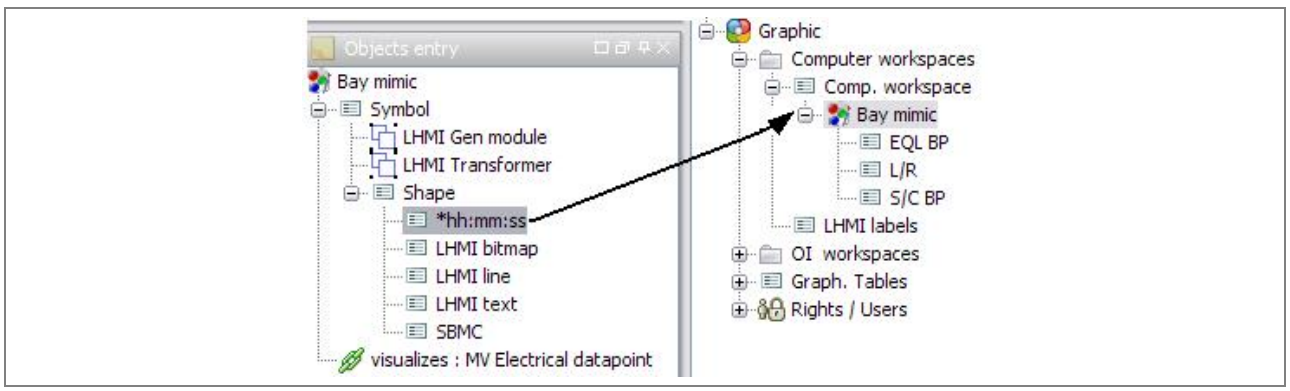


Figure 369: Adding time information to a C26x Bay Mimic

Once added, time information attributes must be set at SCE level:

(1) **short name** of the time information area used for internal SCE identification

(2) **x** (range [0, 127 pixels], step 1 pixel): abscissa

(3) **y** (range [0, 127 pixels], step 1 pixel): ordinate

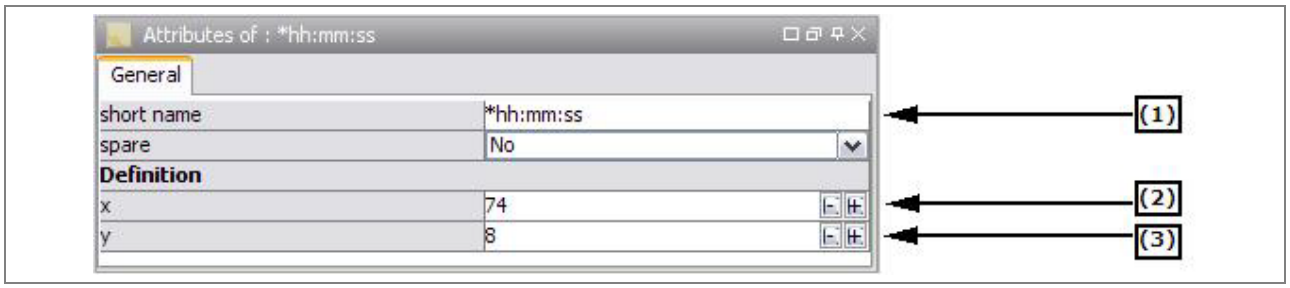


Figure 370: Setting the time information attributes

Abscissa and ordinate of time information can be directly adjusted with the mouse in bay mimic editor (for detail, refer to the Human Interface chapter of the SCE user manual).

Positioning the Local/Remote state or the Interlock bypass

When creating a bay mimic, the following objects are implicitly created in the mimic at a pre-defined location:

(1) Interlock bypass ‘button’

(2) Local/remote status

(3) not used

Depending on customer’s need, these data can be positioned at a different location:

- directly using mouse drag and drop in bay mimic editor
- by editing the abscissa and ordinate attributes of the object

Interlock bypass can be inhibited by setting the attribute Spare to Yes.

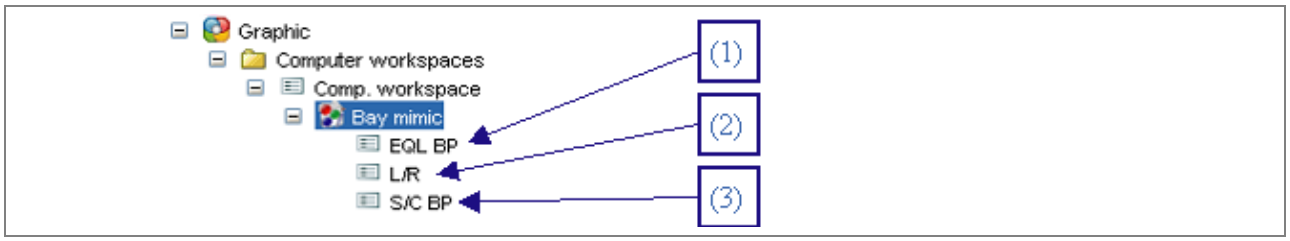


Figure 371: Positioning pre-defined text information in a Bay Mimic

Adding an SBMC indication

To add an SBMC indication to a Bay mimic diagram, select the Bay mimic level and add SMBC from the contextual **Objects entry** window.

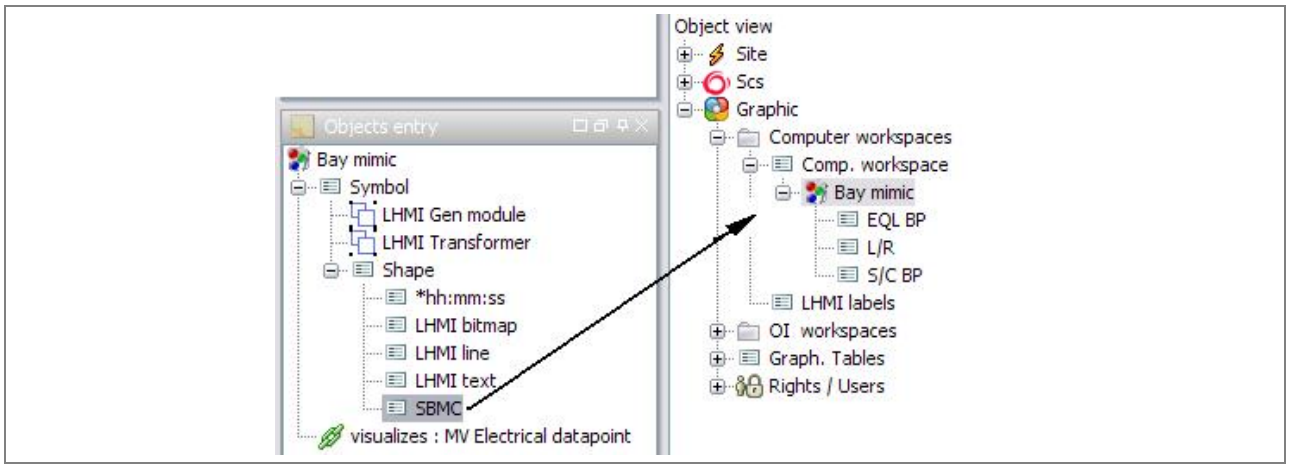


Figure 372: Adding an SBMC indication into a C26x Bay Mimic

Depending on customer's need, the SBMC indication can be positioned at any location in bay mimic:

- directly using mouse drag and drop in bay mimic editor
- by editing the coordinates of the object

Adding a generic module representation

In bay mimic, 'LHMI Gen module' is used for module dynamic representation. A 'LHMI Gen module' is a graphical group constituted of:

- the dynamic representation itself (LHMI Gen module), that is linked to SPS or DPS datapoint and to a dynamic bitmap in bitmap table
- the graphical name of the module (Name), always located on the right of the module representation

To add a generic module representation to a bay mimic diagram, select the Bay mimic level and add the generic module from the contextual **Objects entry** window.

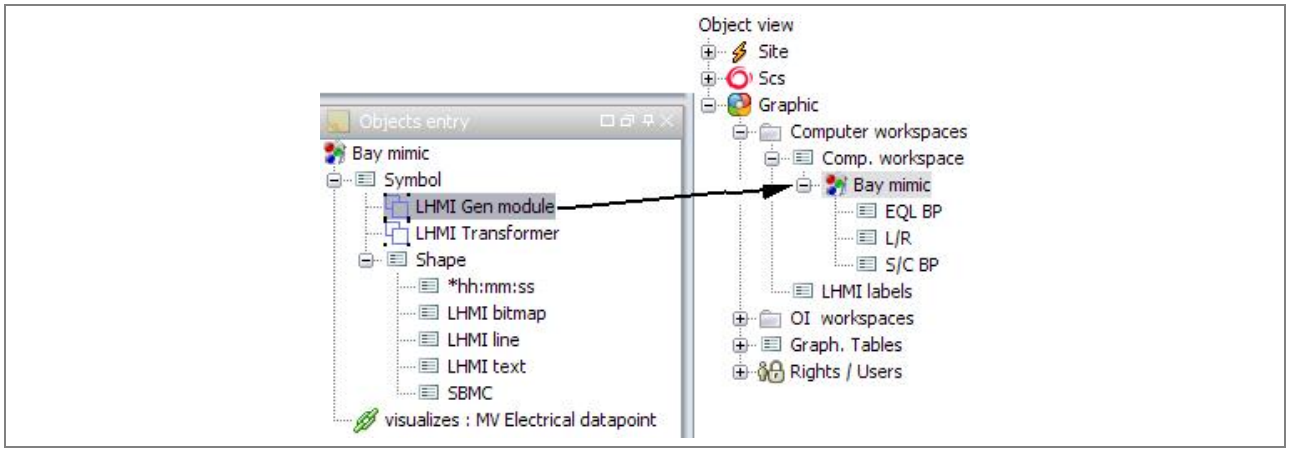


Figure 373: Adding a generic module to a C26x Bay Mimic

Once added, the representation features must be set at SCE level:

(1) **short name** of the representation used for internal SCE identification

(2) **x** (range [0, 127 pixels], step 1 pixel): abscissa

(3) **y** (range [0, 127 pixels], step 1 pixel): ordinate

(4) **control availability** (*No* / *Yes*): attribute to precise if control of the module can be directly done via bay mimic. This attribute is significant if SPS/DPS linked to the generic module representation (via (5) relation) is feedback of a control SPC or DPC. If so, control availability concerns this SPC/DPC

(5) Relation **is managed by** that must be filled to precise which SPS or DPS is used for bitmap animation

(6) **multi-bitmap reference**: corresponds to a link in the bitmap table (see section *7.2.1 Defining a bitmap table*)

(7) **module name value**: text displayed on LCD (up to 4 characters)

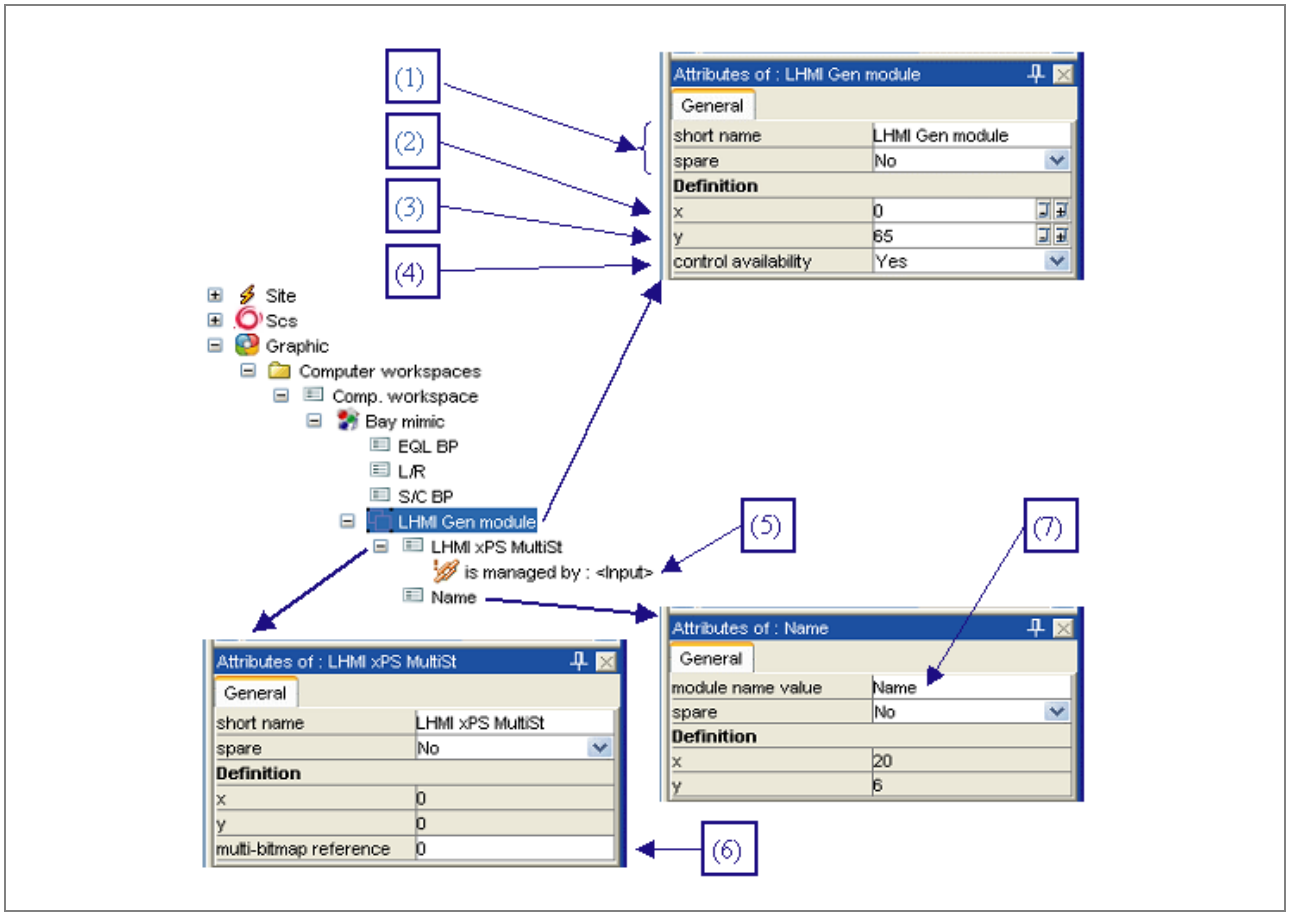


Figure 374: Setting the features of a generic module's representation

Coordinates (x and y) of a generic module can be directly managed using mouse in bay mimic editor (for detail, refer to SCE user manual).

Configuration rules and checks

- The link from an element to its bitmap is defined with the attribute: "bitmap reference". The value of this attribute must refer to an existing bitmap in the "Bitmap table".
- The "Bitmap" linked to a "LHMI xPS MultiSt" MultiState must be defined as follows:
  - its "type" attribute must be set to "5-uple" value
  - its first 3 file names { "file name by default", "file name for 'open' state", "file name for 'closed' state" } are mandatory and each one must be unique.
  Furthermore, if the MultiState is linked to an SPS or DPS datapoint of a module containing a "Withdrawn" SPS datapoint, through the **is managed by** relation, then the following constraints are added to the "Bitmap" definition:
  - its 2 file names { "file name for 'withdrawn open' state", "file name for 'withdrawn closed' state" } are both mandatory and each one must be unique.

Adding a transformer representation

In bay mimic, 'LHMI Transformer' is used for dynamic transformer representation. A 'LHMI transformer' is a graphical group constituted of:

- the dynamic representation itself (LHMI Gen module), that is linked to SPS or DPS datapoint and to a dynamic bitmap in bitmap table
- the graphical name of the module (Name), always located on the right of the module representation

To add a transformer representation to a bay mimic diagram, select the Bay mimic level and add the transformer from the contextual **Objects entry** window:

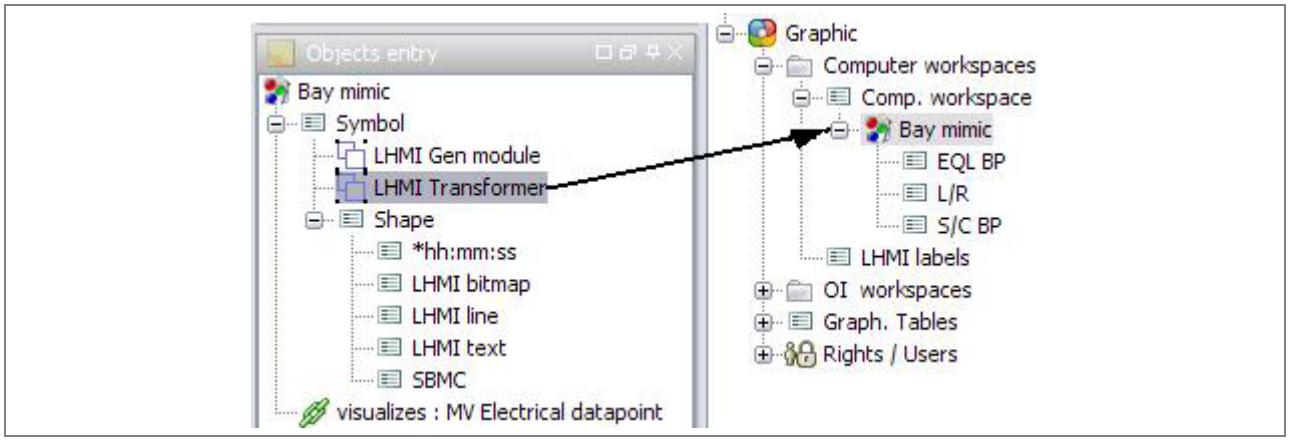


Figure 375: Adding a generic module to a C26x Bay Mimic

Once added, the representation features must be set:

(1) **short name** of the representation used for internal SCE identification.

(2) **x** (range [0, 127 pixels], step 1 pixel): abscissa

(3) **y** (range [0, 127 pixels], step 1 pixel): ordinate

(4) **control availability** (*No* / *Yes*): attribute to precise if control of the transformer can be directly done via bay mimic. This attribute is significant if Raise/Lower DPC control exists for Tap changer built-in function containing the TPI datapoint used for transformer animation (via (5) relation). If so, control availability concerns this DPC.

(5) Relation **is managed by** that must be filled to precise which TPI is used for transformer animation.

(6) **bitmap reference**: corresponds to a link in the bitmap table (see section *7.2.1 Defining a bitmap table*).

(7) **module name value**: name of the transformer: text displayed on LCD (up to 4 characters).

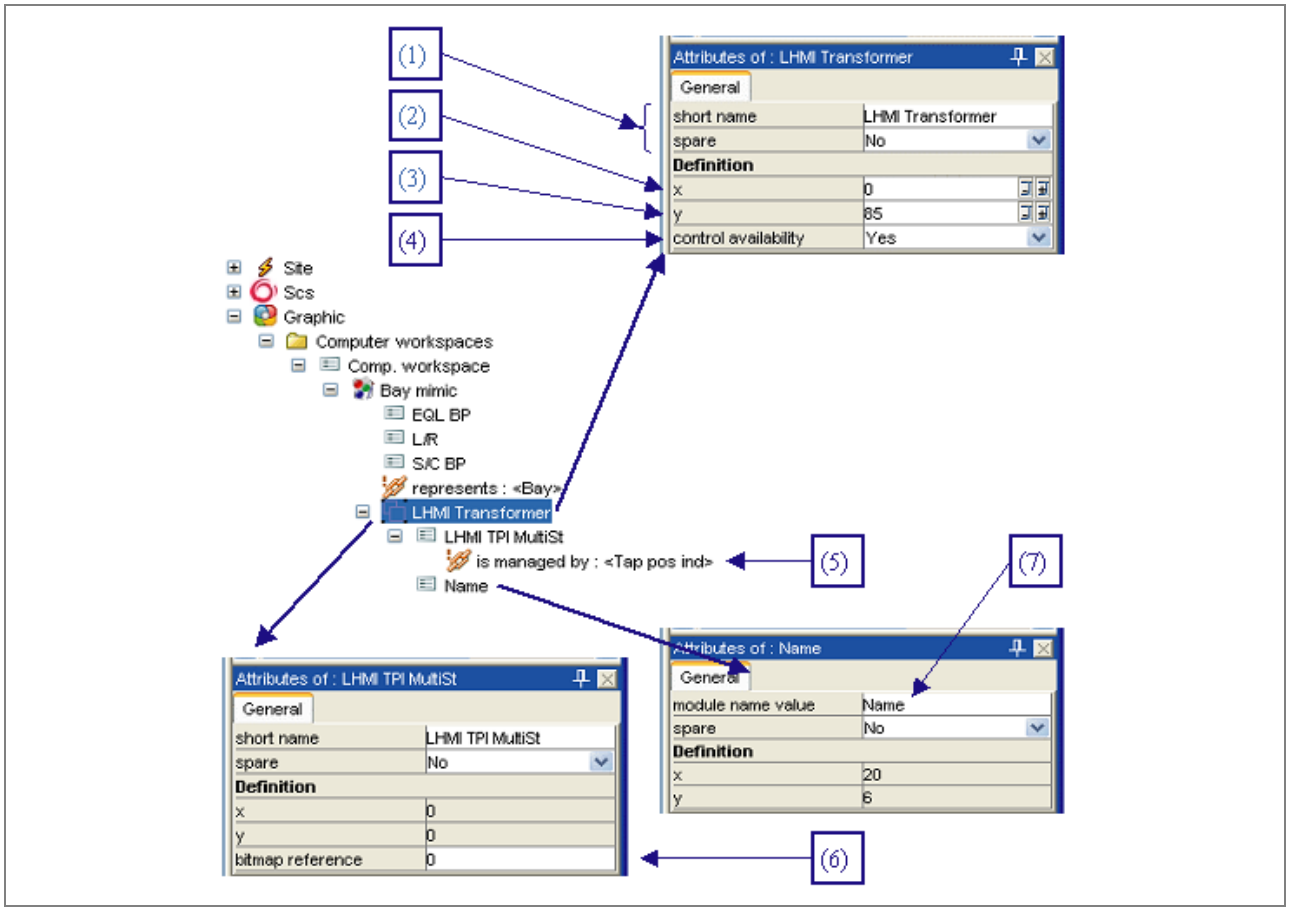


Figure 376: Setting the features of a transformer representation

Abscissa and ordinate of a transformer can be directly adjusted with the mouse in bay mimic editor (for detail, refer to SCE user's manual)

When adding a transformer representation, extra values about associated TPI datapoint can be placed in the bay mimic:

- Current TPI value (dynamic)
- Maximum TPI value
- Minimum TPI value

To add a such TPI information to a bay mimic diagram, select the Bay mimic level and add the TPI field(s) from the contextual **Objects entry** window:

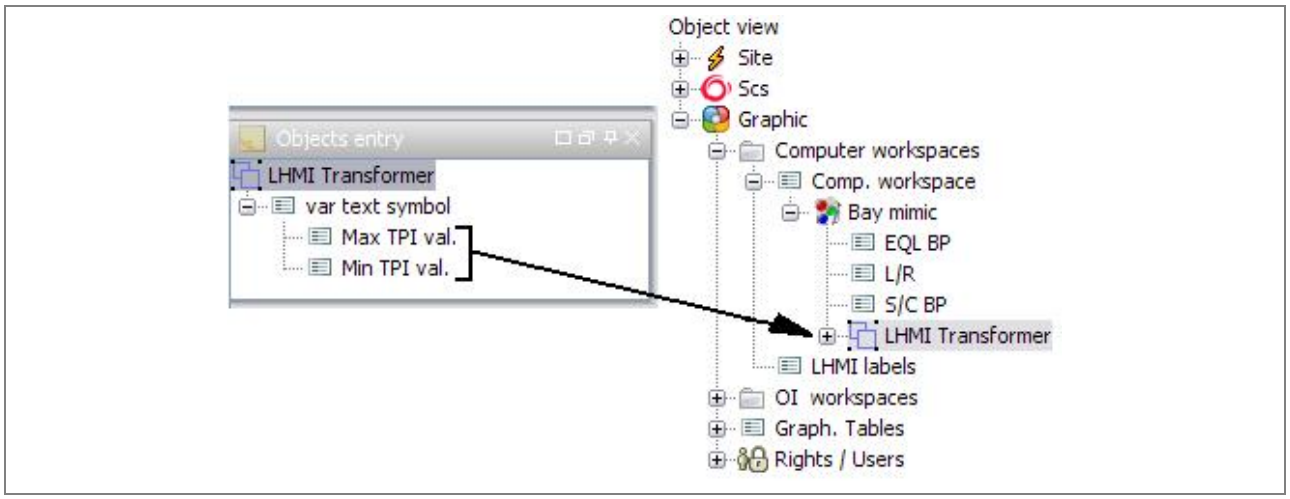


Figure 377: Adding a TPI indication to a C26x Bay Mimic

Once added, TPI information can be positioned at a different location:

- directly using mouse drag and drop in bay mimic editor
- by editing the X-coordinate and Y-coordinate attributes of the object

Configuration rules and checks

- The link from an element to its bitmap is defined with the attribute: "bitmap reference". The value of this attribute must refer to an existing bitmap in the "Bitmap table".

7.2.3.4 ASSIGNING AN MV TO A BAY MIMIC

An MV datapoint is assigned to a specific bay mimic by adding the relation **visualizes** at bay mimic level and filling it with the MV.

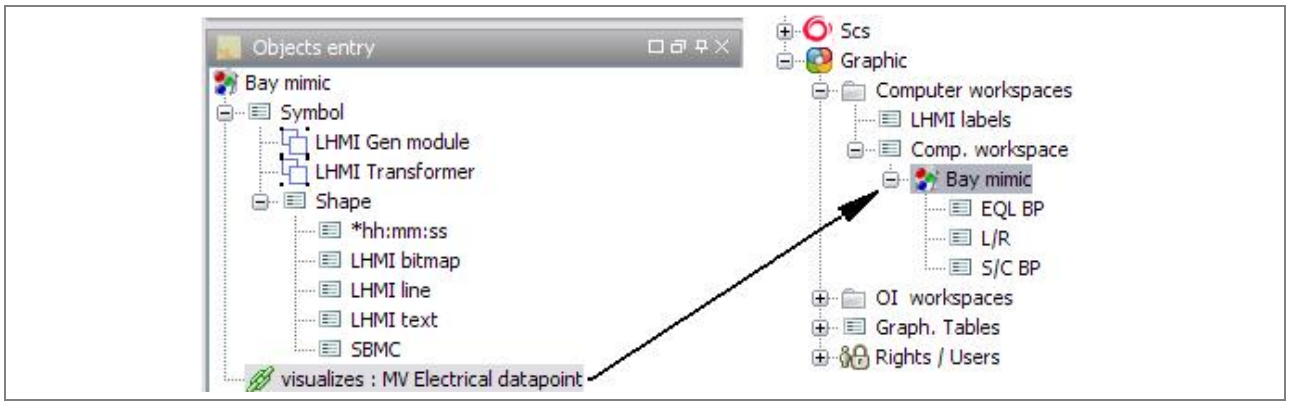


Figure 378: Assigning an MV datapoint to a Bay Mimic

Once the relation added and filled, its attributes **scale** must be set at SCE level:

- **scale** (120% / 200% / No bargraph), to precise which representation is used for the MV in the bay mimic

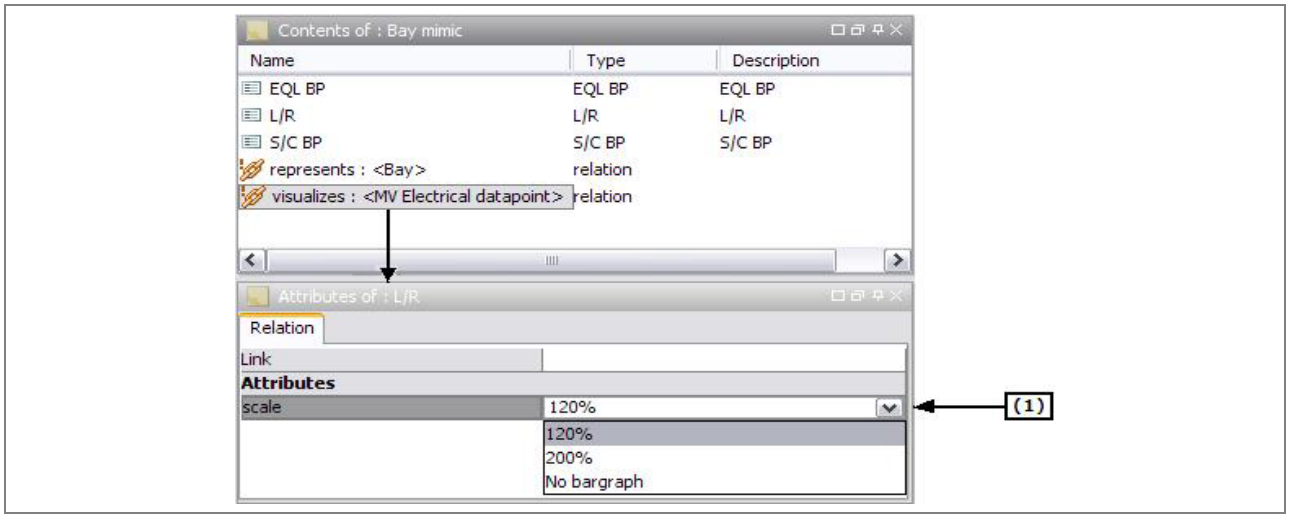


Figure 379: Setting an MV representation in a Bay Mimic

Configuration rules and checks

- An MV datapoint visualized in a "Bay mimic" (relation **visualizes**) must belong to the bay represented by the "Bay mimic" (relation "represents").
- For each visualized MV datapoint, the **transmission on event** attribute must be set neither to "Cyclic short period" value nor to "Cyclic long period" value to avoid overflow of the Bay mimic input buffer.

7.2.4 DISPLAYING A DATAPOINT STATE THROUGH AN LED

SPS and DPS datapoint status can be displayed via the LEDs of the GHU300 board by adding the relation **has state displayed on** at datapoint level (1). Only datapoints managed by the C26x can be displayed via the LEDs of its GHU300 board.

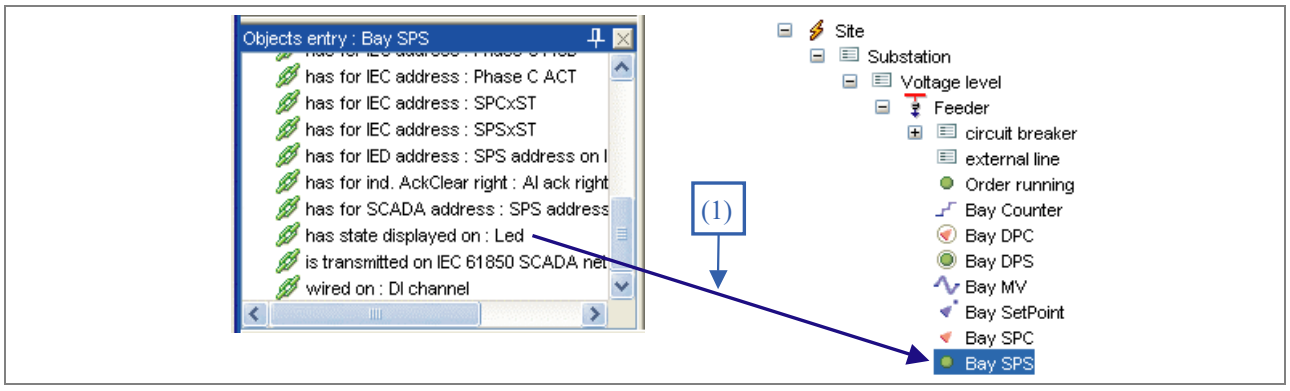


Figure 380: Displaying a datapoint state through an LED (example for a Bay SPS datapoint)

Once added at SPS (resp. DPS) level, select the associated led (link) and the attributes:

- **LED usage**: for displaying alarms / for displaying states
- **led behaviour for 'Closed' state**: *Off* / *On* / *Blinking slow* / *Blinking fast*
- **led behaviour for 'Open' state**: *Off* / *On* / *Blinking slow* / *Blinking fast*
- **led behaviour for 'Invalid' state**: *Off* / *On* / *Blinking slow* / *Blinking fast*
- **Status for Transient (SPS only)**: *On* / *Blinking slow*

The values are relevant only for the attributes that follow:

Led used Data point	For displayin state	For displaying alarm
SPS	Status for 'Set' Status for 'Reset' Status for 'Invalid'	Status for 'Transient'
DPS	Status for 'Closed' Status for ''Open' Status for 'Invalid'	–

Configuration and checks

- If the **HMI type** attribute is set to *Simple*, then **Led#5** must not be assigned (no relation link from **Led#5** to any datapoint) as it is reserved for the Local/Remote indication on that front panel.

8 DEFINING PROTECTION FUNCTIONS

Note: Protection and Automatism functions are only available if the DS Agile C26x is fitted with a TMU board.

Protection and automatism functions are respectively described in the **Protection Functions** section, available in the Functional Description chapter of the C264 user manual.

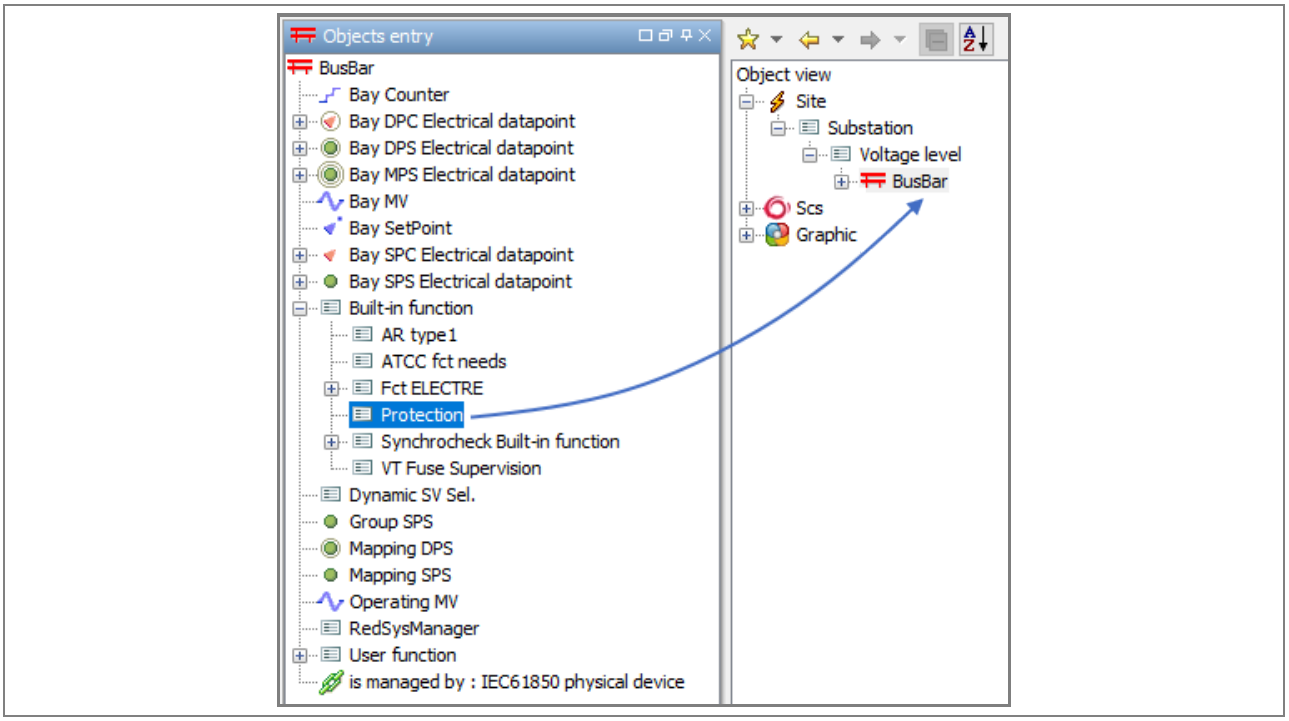
The following protection is available with DS Agile C26x units:

- Phase Overcurrent protection function (ANSI 50/51)
- Earth Fault (50N/50G/51N/51G/67N/67G)
- Circuit Breaker Failure

8.1 ADDING A PROTECTION FUNCTION

Adding a protection function is done in the SCE using the contextual “Object entry” panel at any bay level:

- In the **Object view** panel, expand the **Voltage level** node and select an electrical bay.
- In the **Objects entry** panel, expand the **Built-in function** node.
- Right-click on the **Protection** built-in function and click on **Add**.



- Under your electrical bay, in the **Object view** panel, click on **Protection**.
- In the **Objects entry** panel, right-click on the relevant protection type.

8.1.1 COMMON DATAPOINTS

When adding a Protection function, several mandatory datapoints are automatically created at function level and must be configured:

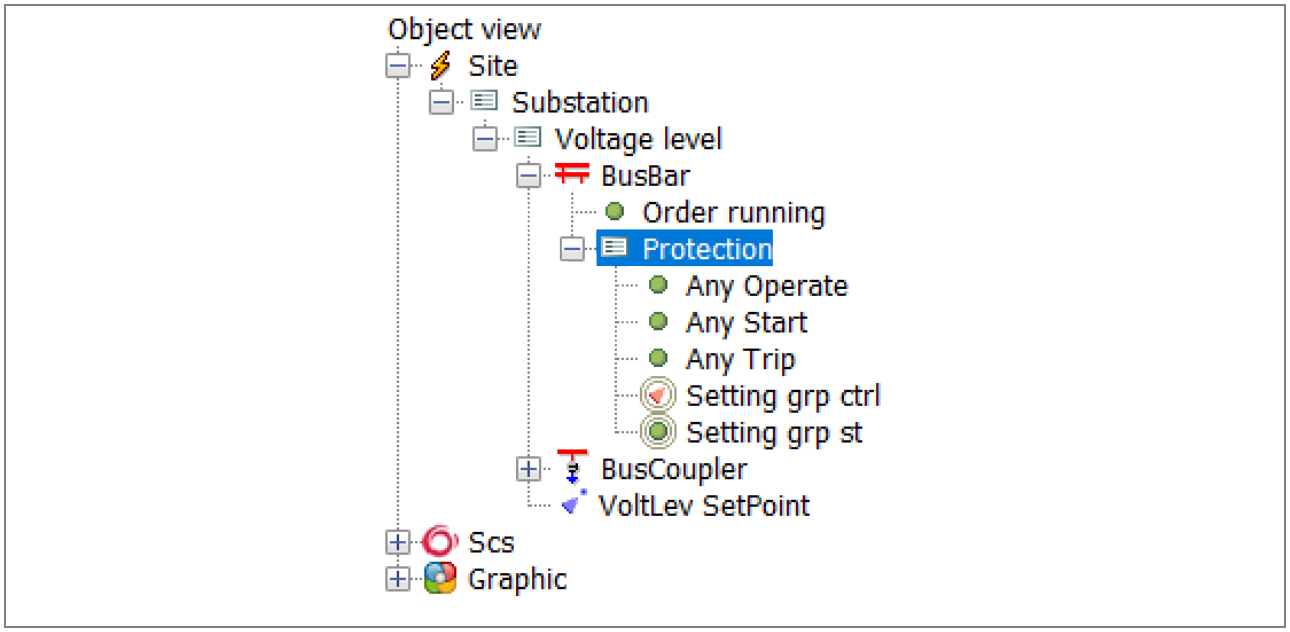


Figure 381: Default Protection datapoints

- **Any Operate**: this permanent SPS (general status) indicates an Operate (tripping) on at least one protection function. The IEC 61850 mapping of this datapoint is PTRC/ST/Op.general (ACT_ST_Gen). This SPS can be used either as:
  - **SPS group**. In this case, the “**Any Operate**" SPS is the synthesis of all "Operate" datapoints (group result) of protection functions configured in the "**Protection**" object. The "Any Operate" SPS is a SPS group with only attribute "operator type" set to "OR" (Read Only). As soon as one protection function/stage is added to the "Protection" object, all existing "Operate" datapoints are automatically linked to "Any Operate” SPS using the relation link "belongs to group".

    or
  - **Automation output**. In the case, the “**Any Operate**" SPS is the result of the automation output. The "Operator type" attribute is not used.
- **Any Start**: this permanent SPS (general status) indicates a Start on at least one protection function. The IEC 61850 mapping of this datapoint is PTRC/ST/Str.general (ACD_ST_Gen).
  This SPS can be used either as:
  - **SPS group**. In this case, the “**Any Start**" SPS is the synthesis of all "Start" datapoints (group result) of protection functions configured in the "**Protection**" object. The "Any Start" SPS is a SPS group with only attribute "operator type" set to "OR" (Read Only). As soon as one protection function/stage is added in "Protection" object, all existing "Start" datapoints are automatically linked to "Any Start" SPS using the relation link "belongs to group".

    or
  - **Automation output**. In the case, the “**Any Start**" SPS is the result of the automation output. The "Operator type" attribute is not used.

- **Any Trip**: this permanent SPS (general status) indicates that a Trip order is raised. The IEC 61850 mapping of this datapoint is PTRC/ST/Tr.general (ACT_ST_Gen).
  This SPS can be used either as:
  - **SPS group**. In this case, the “**Any Trip**" SPS is the mirror of "Any Operate" SPS. The "Any Trip" SPS is a SPS group with only attribute "operator type" set to "OR" (Read Only). As soon as one protection function is added to the "Protection" object, the "Any Operate" datapoint is automatically linked to "Any Trip” SPS using the relation link "belongs to group".

    or
  - **Automation output**. In the case, the “**Any Start**" SPS is the result of the automation output. The "Operator type" attribute is not used.

8.1.2 COMMON PROTECTION FUNCTION ATTRIBUTES

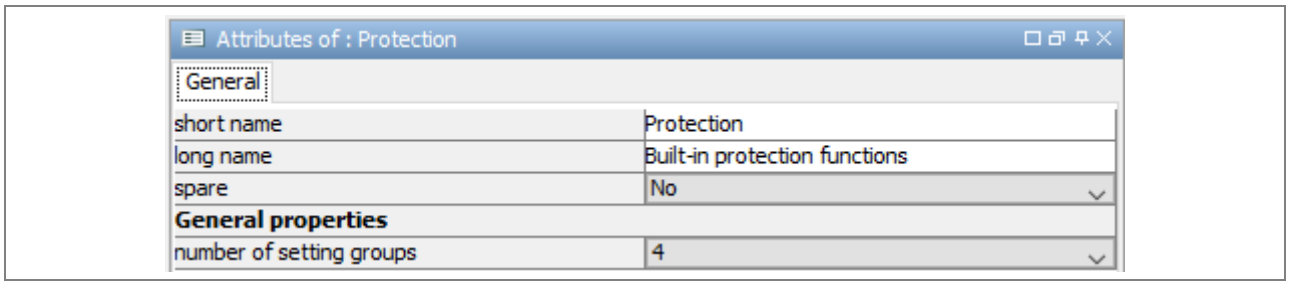


Figure 382: Protection attributes

(1) **short name** and **long name**: used for logging, alarms ... (can be modified).

(2) **spare**: (*Yes* / *No*)

(3) **number of setting groups**: defines the number of configurable setting groups for the protection function. Up to 4 settings groups can be configured.

8.1.3 SETTING GROUP MANAGEMENT

Up to 4 (four) setting groups can be configured in DS Agile SCE. Only configured setting groups can be managed via MiCOM S1 tool.

The setting group management is common to all protection functions.

To manage the activation of setting groups and know the active group status, respectively one MPC and one MPS are used at “Protection” level:

- **Setting grp ctrl**: this mandatory MPC enables a settings group. The IEC 61850 mapping of this datapoint is LLN0/CO/ActSetGr (ENC_Direct).
- **Setting grp st**: this mandatory MPS indicates the number of the active setting group. The IEC 61850 mapping of this datapoint is LLN0/ST/SetGrSt (ENS_ST)

Note: global settings cannot be changed from Micom S1. Protection setting groups being part of global settings can be changed from HMI only.

8.1.4 REPLICATING ONE PROTECTION SETTING GROUP TO ANOTHER

When several setting groups (up to 4) are defined at protection level (see section **Common Protection Function Attributes**), you can automatically copy the settings of one group to several groups using the "**Edit settings**" function available in the context menu of the **Overcurrent** object.

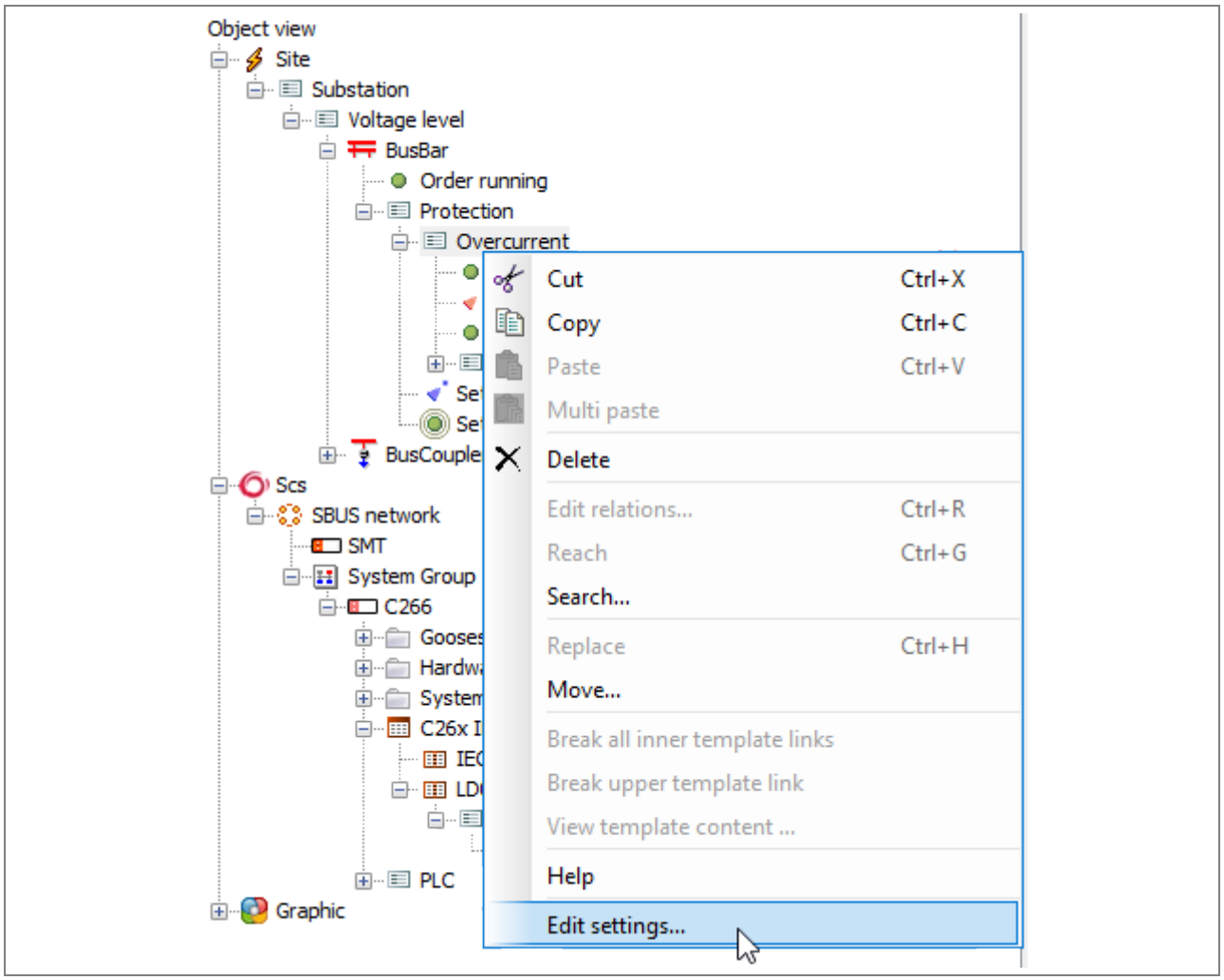


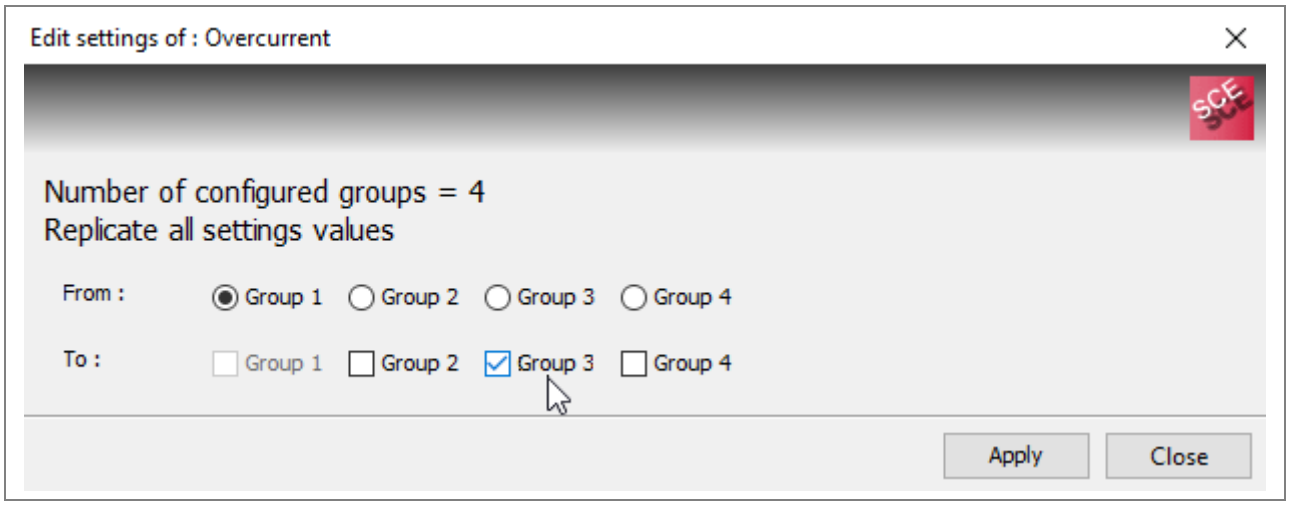
Figure 383: "Edit Settings" function from the Overcurrent right-click menu

Note: this function is greyed out if only one setting group is configured at "Protection" level.

Once the “**Edit settings**” function is started:

1 Select the source group from which you want to replicate all settings by ticking the appropriate radio button

2 Select the target group to which you want to copy all settings by ticking the appropriate check box



3 Click on **Apply** to validate your selection

4 Then, click on **Close** to close the dialog box.

8.2 [50/51/67] PHASE OVERCURRENT PROTECTION

Most electrical power system faults result in an overcurrent of one kind or another. Phase current faults are faults where fault current flows between two or more phases of a power system. The fault current may be between the phase conductors only or, between two or more phase conductors and earth.

The phase Overcurrent built-in function [50/51/67] embedded in the C264 can be configured with standard inverse curves or can be set to definite time.

An overcurrent function can be added at any bay level. Only one "**Overcurrent**" protection function can be configured per bay. The C264 can manage up to two "**Overcurrent**" protection functions when it controls two distinct bays.

Configuration

When adding an overcurrent built-in function - from the contextual **Objects entry** window ("**Protection**" built-in function), several mandatory datapoints are automatically created at function level and must be configured. They give information about the overcurrent context and statuses. They are managed by the C264 that runs the protection function.

A first "**Stage**" object is also added. It contains a set of parameters allowing the definition of "operate", "reset" and "block" conditions of the protection. Up to 6 independent stages containing their own settings (delay characteristics…) can be added to the function to control the tripping of the power grid's circuit breakers.

Each protection function has 4 setting groups that can be switched independently. The settings are independent for each stage, but for each stage, settings apply to all phases.

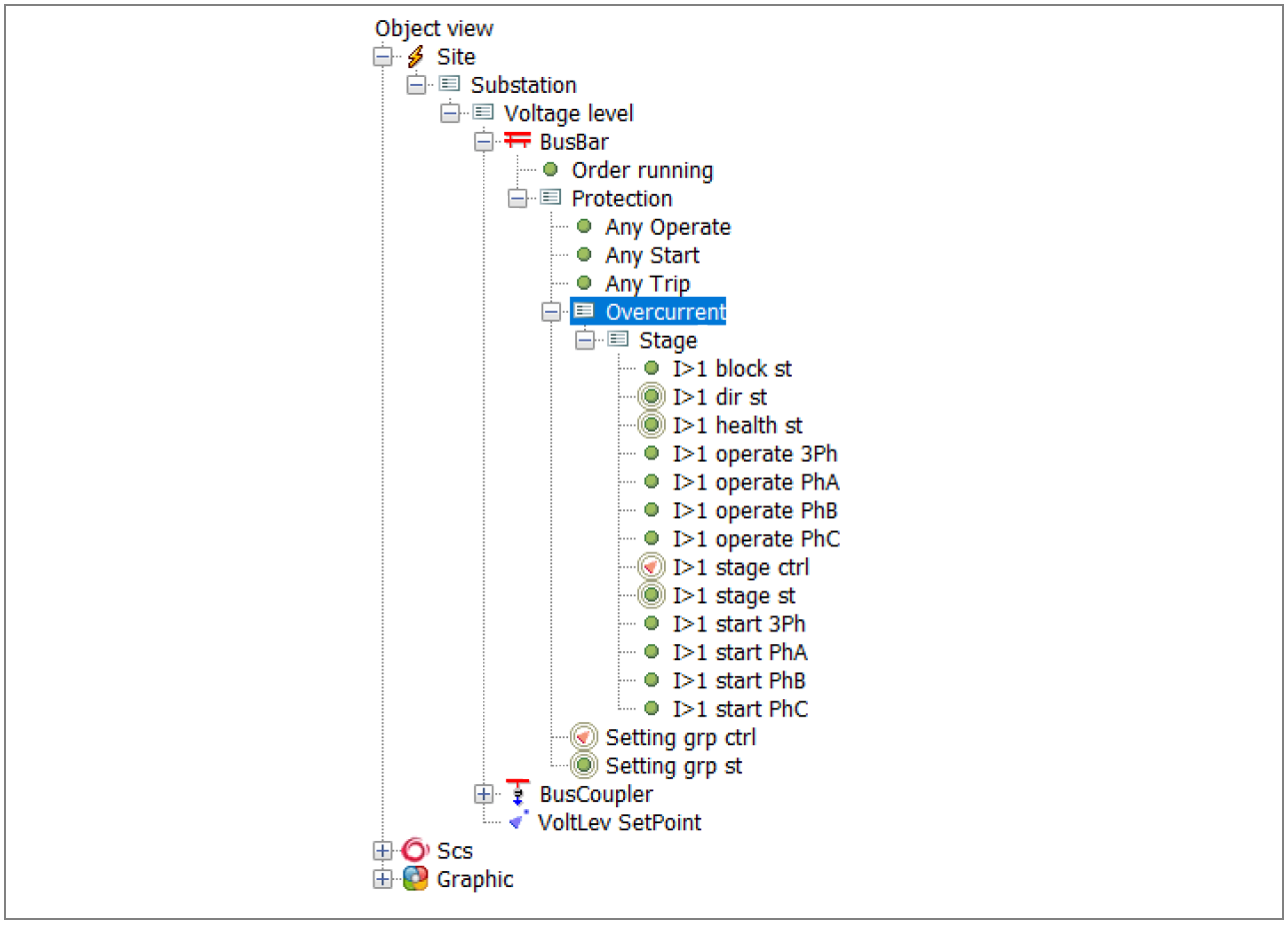


Figure 384: Default Overcurrent protection function datapoints

Note: as any other protection module:

- 4 groups are available and can be managed by a command and monitored by a status
- No trip is generated by this module, only operate, so trip must be linked to operate if needed through logic and/or configuration
- No events or alarms are generated by this module, so they must be linked with appropriate signals through logic and/or configuration
- No LED are directly managed by this module, so they must be linked with appropriate signals through logic and/or configuration
- CT/VT ratio used are those defined at global level

8.2.1 OVERCURRENT CONFIGURATION

8.2.1.1 ATTRIBUTES AND SETTINGS

General features of the Overcurrent protection function must be set at SCE level.

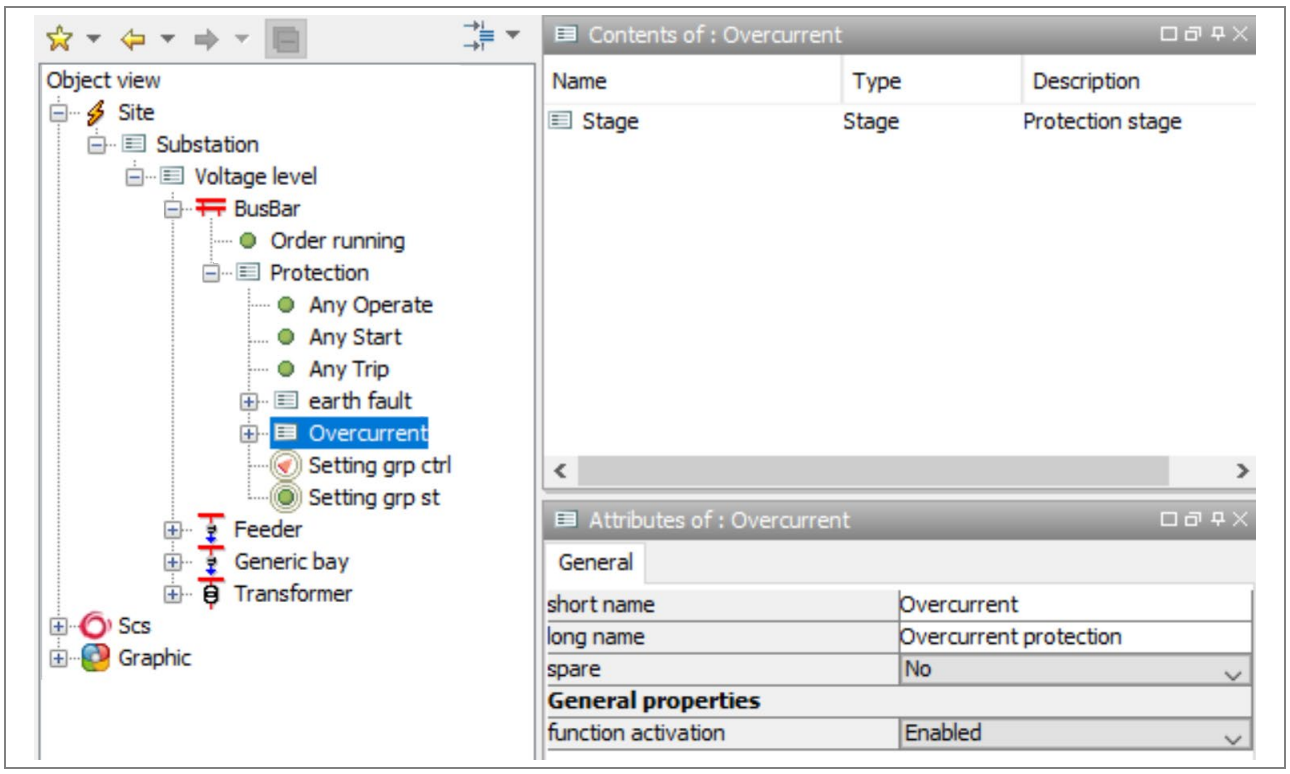


Figure 385: General Overcurrent attributes

(1) **short name** and **long name**: used for logging, alarms ... (can be modified).

(2) **spare** (*Yes* / *No*)

(3) **function activation** (*Enabled* / *Disabled*): Enables or disables the overcurrent protection function. This setting can be changed through Micom S1 tool.

8.2.1.2 ADDITIONAL DATAPOINTS

Optional datapoints can be added to the Overcurrent object, from the contextual **Objects entry** window. All IEC addresses of these datapoints are in the "PROTECTION" Logical Device.

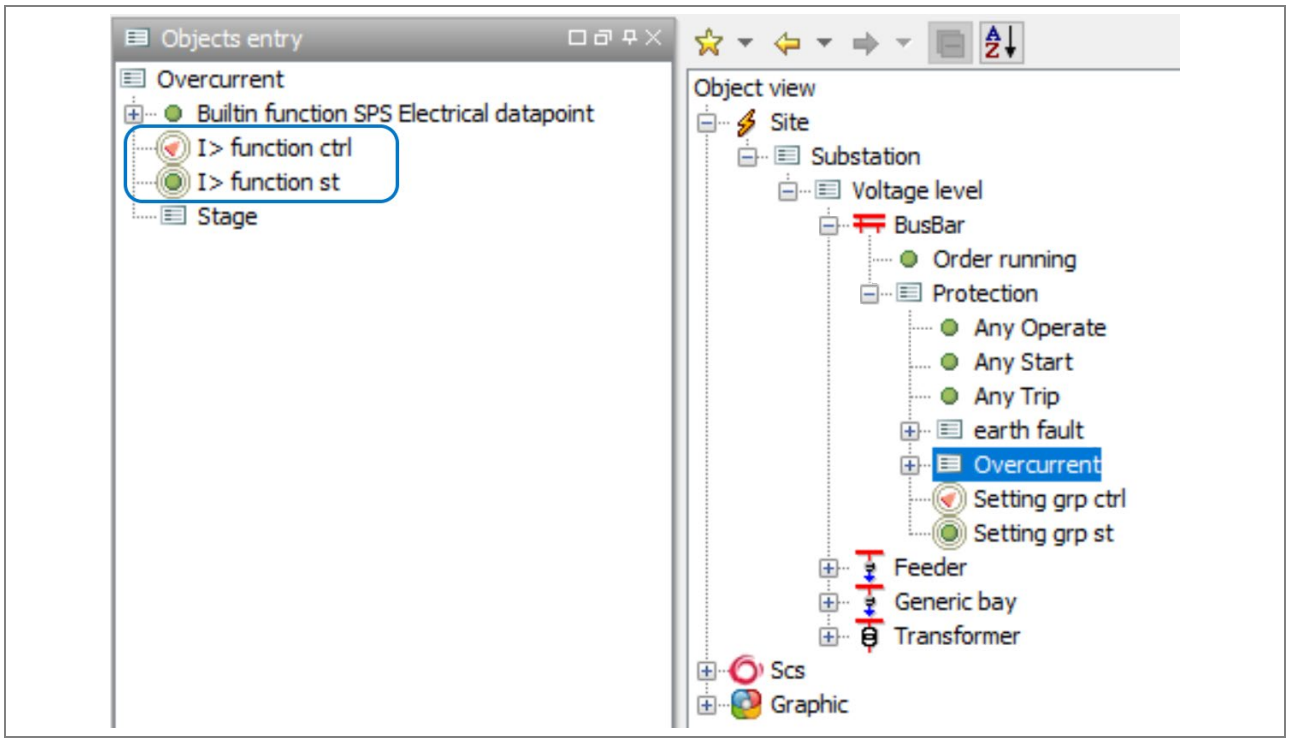


Figure 386: Optional Overcurrent datapoints

- **I> function ctrl**: this MPC enables or disables the Overcurrent protection function. Complete the relation “Has for feedback "I> function st" MPS. The IEC 61850 mapping of this datapoint is LLN0/CO/OcpMod (ENC_Direct).
- **I> function st**: This MPS (function output) indicates the status of this protection function, enabled or disabled. Complete the relation “Has to be feedback of "I> function ctrl" MPC.
  The IEC 61850 mapping of this datapoint is LLN0/ST/OcpMod (ENC_Orig_ST).
- **I> block st**: This SPS (function output) indicates the blocking status of this protection function.
  The IEC 61850 mapping of this datapoint is LLN0/ST/OcpBlk (SPS_ST).
- **I> inhibit**: This SPS (function input) allows to inhibit the function. Same behavior as if the function is Disabled.
- **I> VTS block**: This SPS (function input) is provided by Voltage Transformer Supervision when a failure appears.
- **I> AR block**: This SPS (function input) is provided by AR function when an auto-reclosing is in progress.

8.2.2 STAGE CONFIGURATION

8.2.2.1 MANDATORY DATAPOINTS

When adding a "Stage" object to an overcurrent built-in function, several mandatory datapoints must be configured to define the "operate", "reset" and "block" conditions of the overcurrent protection function. The

C264 provides six stages of segregated three-phase overcurrent protection, each with independent time delay characteristics.

The settings are independent for each stage, but for each stage, settings apply to all phases.

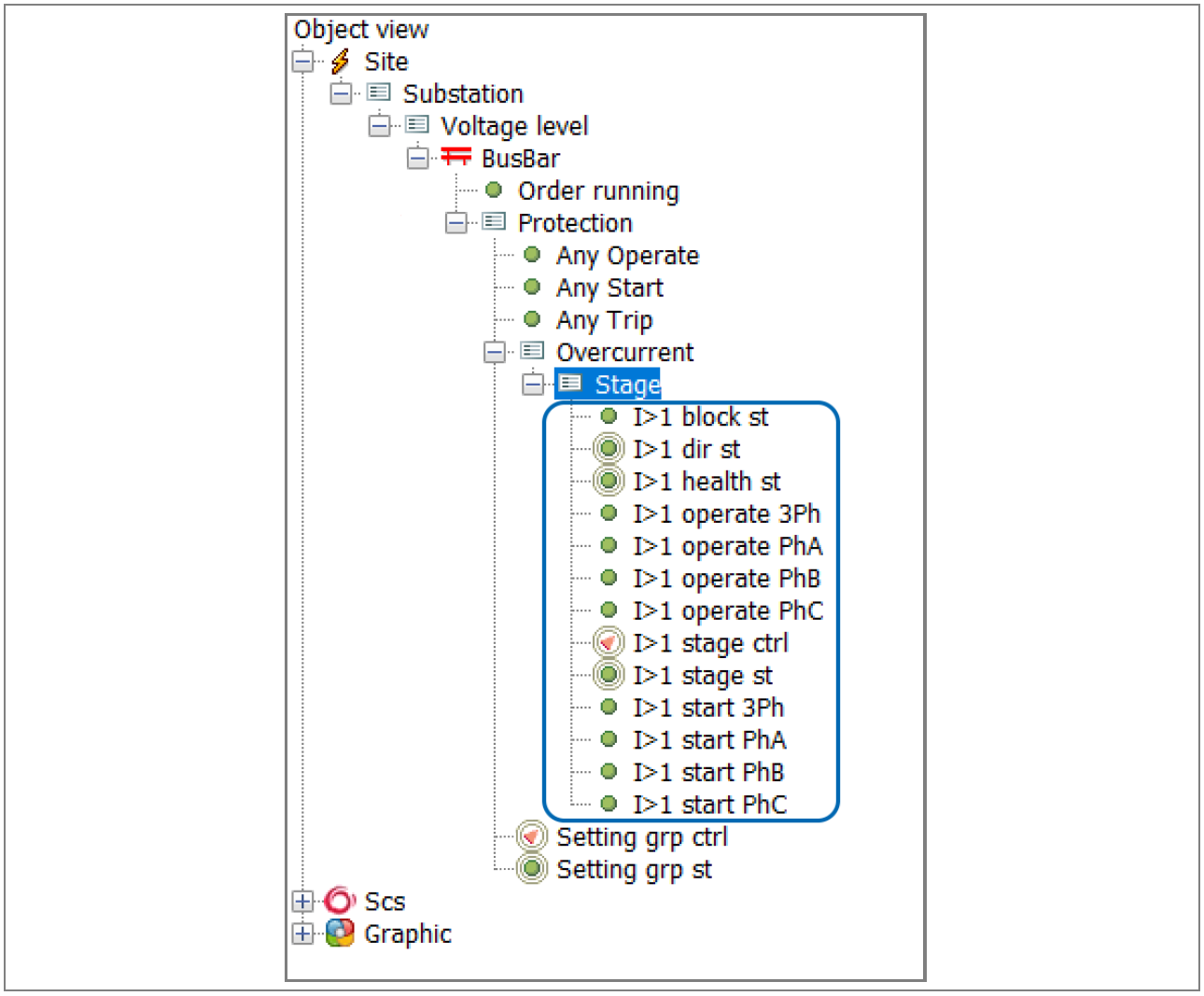


Figure 387: Mandatory Stage datapoints

- **I>x block st**: this permanent SPS (function output) indicates if the current stage is blocked or not. The IEC 61850 mapping of this datapoint is ocPTOCy/ST/Blk (SPS_ST).
- **I>x dir st**: this MPS (function output) indicates the directional status of this stage. The IEC 61850 mapping of this datapoint is ocPTOCy/ST/Str.dirGeneral (ACD_ST_PhsX).

- **I>x health st**: this MPS (function output) indicates the health status of the current stage. IEC 61850 mapping of this datapoint is ocPTOCy/ST/Health (ENS_ST).

  3 possible states:

  - **OK**
  - **Warning**: overcurrent is working in degraded mode. Overcurrent was configured as Directional, but voltage quality is bad and settings indicate working in non-directional mode
  - **Alarm**: overcurrent is out of service. Either current quality is bad, or overcurrent was configured as Directional, but VT quality is bad and settings indicate blocking overcurrent

- **I>x operate 3Ph**: this permanent SPS (function output) indicates a three-phase tripping of the protection (three-phase operate) for the current stage. The IEC 61850 mapping of this datapoint is ocPTOCy/ST/Op.general (ACT_ST_PhsX).

- **I>x operate PhA**: this permanent SPS (function output) indicates a protection trip (protection operate) on phase A for the current stage. The IEC 61850 mapping of this datapoint is ocPTOCy/ST/Op.phsA (ACT_ST_PhsX).

- **I>x operate PhB**: this permanent SPS (function output) indicates a protection trip (protection operate) on phase B for the current stage. The IEC 61850 mapping of this datapoint is ocPTOCy/ST/Op.phsB (ACT_ST_PhsX).

- **I>x operate PhC**: this permanent SPS (function output) indicates a protection trip (protection operate) on phase C for the current stage. The IEC 61850 mapping of this datapoint is ocPTOCy/ST/Op.phsC (ACT_ST_PhsX).

- **I>x stage ctrl**: this MPC enables or disables the current stage.
  The IEC 61850 mapping of this datapoint is ocPTOCy/CO/Mod (ENC_Direct).

- **I>x stage st:** this MPS (function output) indicates if the current stage is enabled or disabled. The IEC 61850 mapping of this datapoint is ocPTOCy/ST/Mod (ENC_Orig_ST).

- **I>x start 3P**: this permanent SPS (function output) indicates a three-phase start of the protection on the current stage. The IEC 61850 mapping of this datapoint is ocPTOCy/ST/Str.general (ACD_ST_PhsX).

- **I>x start PhA**: this permanent SPS (function output) indicates a start of protection on phase A, for the current stage. The IEC 61850 mapping of this datapoint is ocPTOCy/ST/Str.phsA (ACD_ST_PhsX).

- **I>x start PhB**: this permanent SPS (function output) indicates a start of protection on phase B, for the current stage. The IEC 61850 mapping of this datapoint is ocPTOCy/ST/Str.phsB (ACD_ST_PhsX).

- **I>x start PhC**: this permanent SPS (function output) indicates a start of protection on phase C, for the current stage. The IEC 61850 mapping of this datapoint is ocPTOCy/ST/Str.phsC (ACD_ST_PhsX).

8.2.2.2 ADDITIONAL DATAPOINTS

Optional SPS datapoints can be added to a stage from the contextual **Objects entry** window:

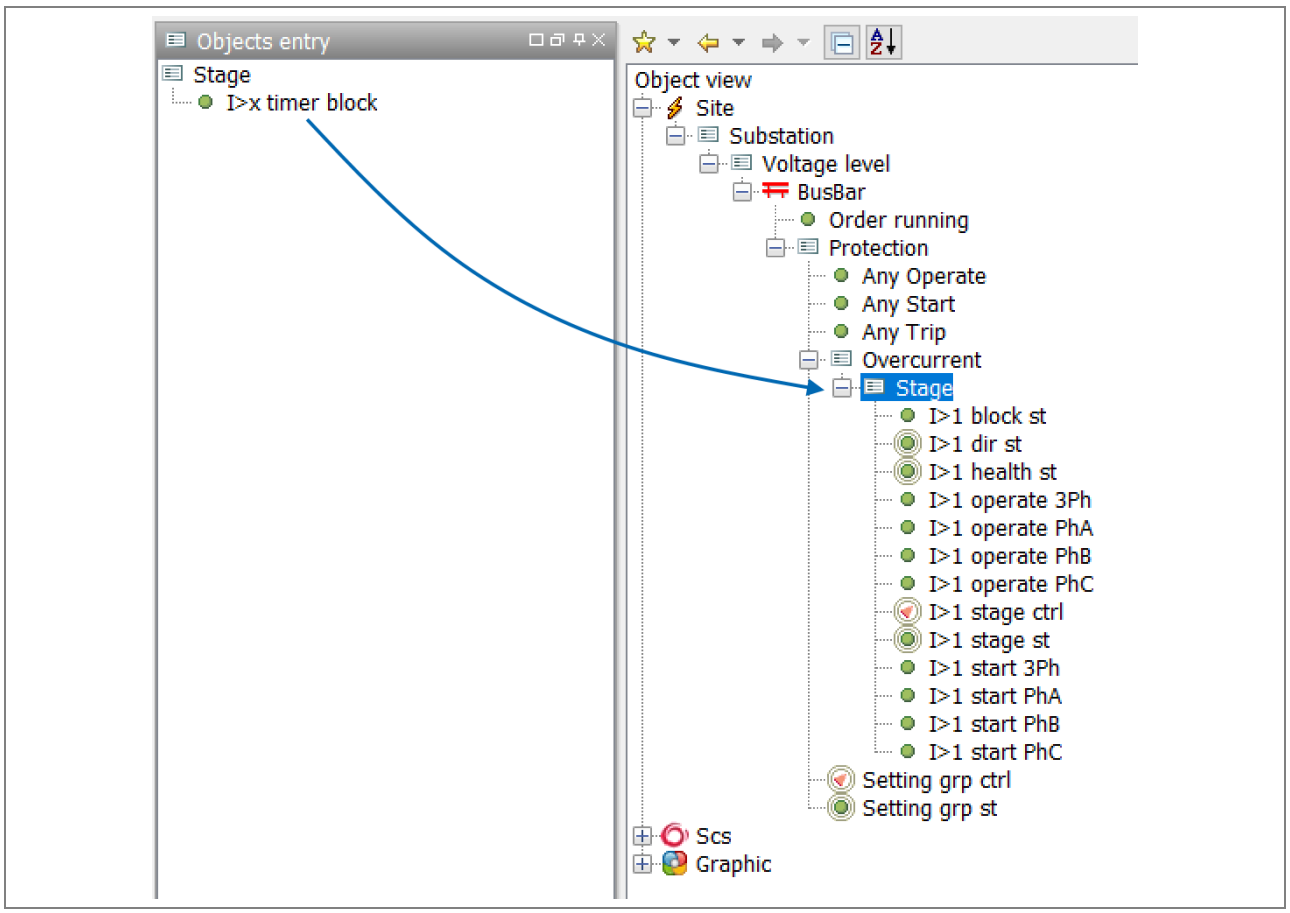


Figure 388: Optional Stage datapoints

- **I>x timer block**: permanent SPS (function input) is used to block the timer launched by the start signal, for the current stage.

8.2.2.3 STAGE ATTRIBUTES

The general attributes of a stage must be set at SCE level.

The "short name" attribute of each datapoint is prefixed by "I>x" by default.

- "**I>**" helps to identify a datapoint of the overcurrent protection function.
- "**x**" identifies the stage number (from 1 to 6 according to the value set in the "stage number" attribute).

Some stage attributes can be edited directly from MiCOM S1.

8.2.2.3.1 General Properties

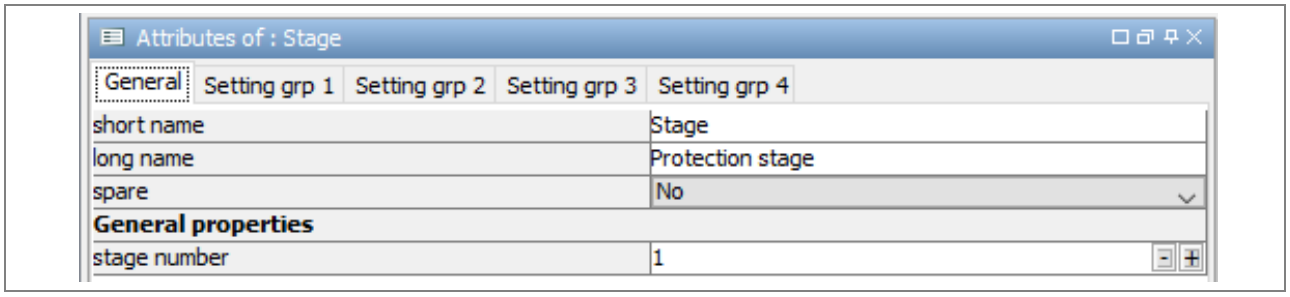


Figure 389: General Stage attributes and settings

(1) **short name** and **long name**: used for logging, alarms ... (can be modified).

(2) **Spare** (*Yes / No*)

(3) **stage number**: enter the number that will identify the stage of the function (from 1 to 6).

8.2.2.3.2 Setting grp x

For each setting group (up to 4), set the following attributes:

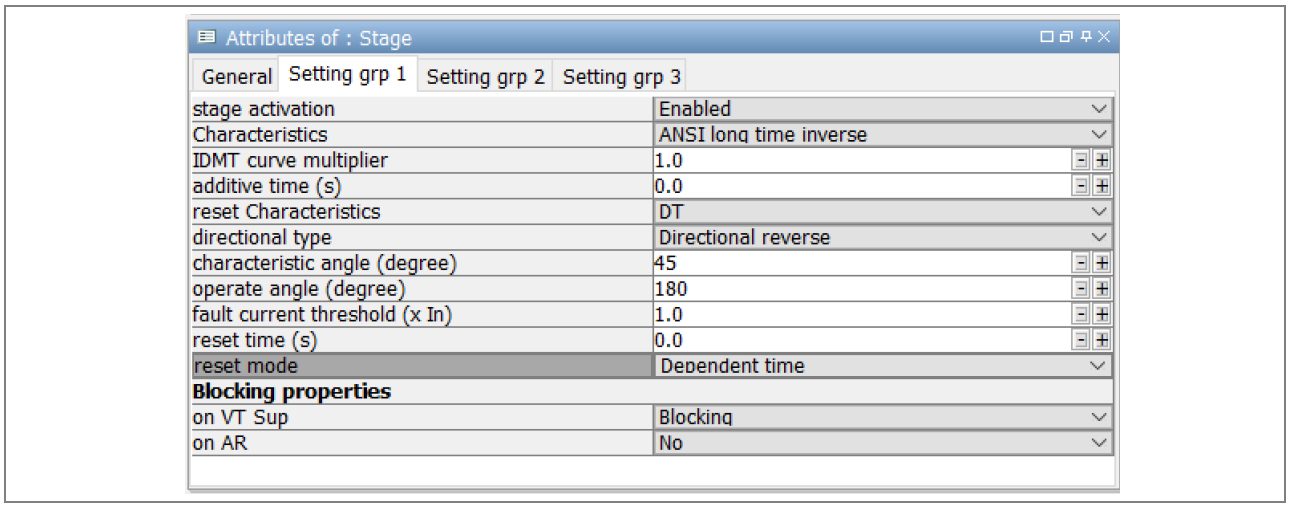


Figure 390: General setting for setting group

(1) **stage activation**: enables or disables this stage. This setting can be changed from Micom S1.

(2) **characteristics**: sets the operating mode of the stage (from Definite or dependent time or IDMT curves). This setting can be changed from Micom S1.
The available curves are:

- DT (default values)
- IEC standard inverse
- IEC very inverse
- IEC extremely inverse
- UK long time inverse
- UK rectifier
- Rapid inverse
- IEEE moderately inverse
- IEEE very inverse
- IEEE extremely inverse
- US inverse
- US short time inverse
- ANSI normal inverse
- ANSI short time inverse
- ANSI long time inverse
- ANSI very inverse
- ANSI extremely inverse

For more information about the equations applied according to chosen curve, please refer to the **Functional Description** chapter of the C264 user manual (section **Protection Function**).

(3) **IDMT curve multiplier** ([0,001, 10], step 0,001): this setting is available for stages with Definite time functionality (set in the "**characteristics**" attribute). It allows you to define the time multiplier when IDMT curve is used.
Also called:

- TMS for curves IEC & UK,
- TD for curves IEEE & US & ANSI,
- K(RI) for curve Rapid inverse.

This setting can be changed from MiCOM S1.

(4) **additive time** ([0, 10], step 0,01): defines an additional time, in second, according to the selected characteristic.

(5) **reset characteristics**: defines the reset characteristics:

- **DT**: the reset time is defined by user.
- **IDMT**: the reset time is defined from curve (only possible for IEC, IEEE, US & ANSI curves). For more information about the equations applied according to chosen curve, refer to the **Functional Description** chapter of the C264 user manual (section **Protection Function**).

This setting can be changed from MiCOM S1.

(6) **directional type**: defines the direction of fault to be considered. If fault current can flow in both directions through a protected location, you will need to use a directional overcurrent element to determine the direction of the fault, either directional forward or directional reverse or non directional. If calculated direction is different from configured direction, then start and operate signals will not pick-up. This setting can be changed from Micom S1**.**

(7) **characteristic angle (degree)** ([-180, 180], step 1): this setting depends on the Directional type attribute. It defines the characteristic angle in degree for optimum performance when the function works in Directional forward or Directional reverse mode. This setting must be equal to the phase angle of the negative sequence current with respect to the inverted negative sequence voltage, in order to be at the center of the directional characteristic. It can be changed from Micom S1.

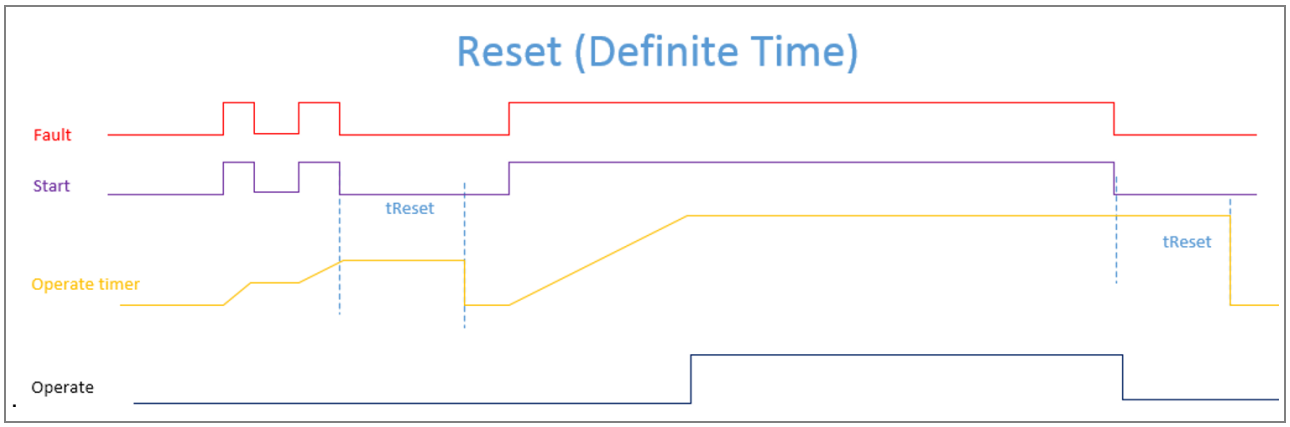
(8) **operate angle (degree)** ([0, 180], step 1): this setting depends on the Directional type attribute. It defines the opening angle (in degree) of the forward or reverse operate zone. It can also be set independently for each stage. This setting can be changed from Micom S1.

(9) **fault current threshold (x In)** ([0,01 ; 40], step 0,01): defines the pick-up current threshold. When this threshold is exceeded, a delay is started. This setting is expressed in factor of In (In being defined at TMU board level). This setting can be changed from Micom S1

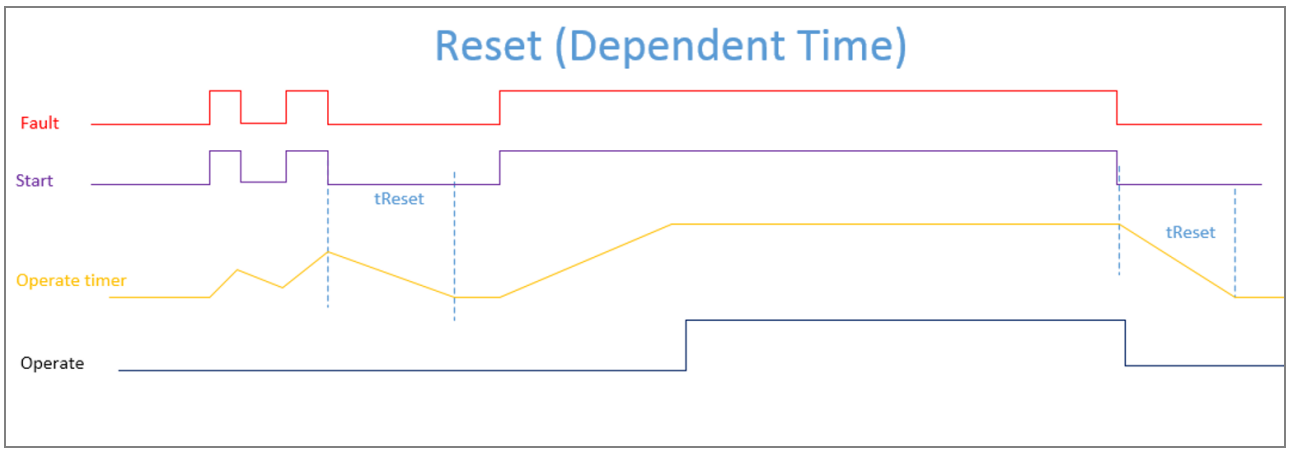
(10) **reset time (s)** ([0, 10], step 0,01): in the event of a fault condition (current > threshold) then a start delay is started. If the fault disappears (current < threshold) during time defined by this setting then start delay is reset. This setting depends on the reset characteristics attribute and is only visisible when set to DT. It can be changed from Micom S1.

(11) **reset mode**: select either Definite time or Dependent time (This setting can be changed from MiCOM S1)

- If **Definite time** is selected, the C264 goes back to its reset state after the delay defined in the Reset time seting. The operate timer is maintained during the reset condition:



- If **Dependent time** is selected, the C264 goes back to its reset state after the delay defined in the Reset time seting. The operate timer is decreased during the reset condition:



(12) **On VT Sup**: Voltage Transformer Supervision (VTS) can be used to block operation of directional overcurrent elements.
This setting depends on the **directional type** attribute and is only visisible when set to **Directional forward** or "**Directional reverse**. It defines – for the current stage - the behavior of the function when directional forward or reverse is selected, and a problem is detected on the Voltage Transformer (failure of the Voltage Transformer Supervision or a bad voltage quality).
Either the function is blocked by the appropriate stage or the stage is downgraded to non directional mode.
This setting can be changed from Micom S1.

(13) **On AR**: indicates whether the function is blocked by this stage when an auto-reclosing is in progress. This setting can be changed from Micom S1.

8.2.3 REPLICATE SETTING VALUES OF ONE SETTING GROUP TO ANOTHER

*Note: When several setting groups (up to 4) are defined at protection level (see section **Common Protection Function Attributes**), you can automatically duplicate the setting values of one setting group to one or several groups using the "**Edit settings**" function available in the context menu of the **Overcurrent** object. See section 8.1.4 Replicating one Protection Setting group to another.*

8.3 [50N/50G/51N/51G/67N] EARTH FAULT PROTECTION

Earth faults are overcurrent faults where the fault current flows to earth. Earth faults are the most common type of fault.

Earth fault protection (EF) is used for earth fault current that is :

- either measured directly from the system (measured),
- or derived internally from summing the three-phase currents (derived)

The “Earth Fault” built-in function [50N/50G/51N/51G/67N] embedded in the C264 controls the tripping of the circuit breakers of the power grid. The job of this protection is to protect the prower system from faults by isolating the faults as quickly as possible to limit the danger and prevent fault currents flowing through systems, which can cause severe damage to equipment and systems.

At the same time, to avoid unnecessary power cuts, only defective parts of the power grid are to be cut off.

The "Earth Fault" protection function provides four levels of protection against earth faults that can be switched independently. The settings are independent for each stage, but for each stage, settings apply to all phases.

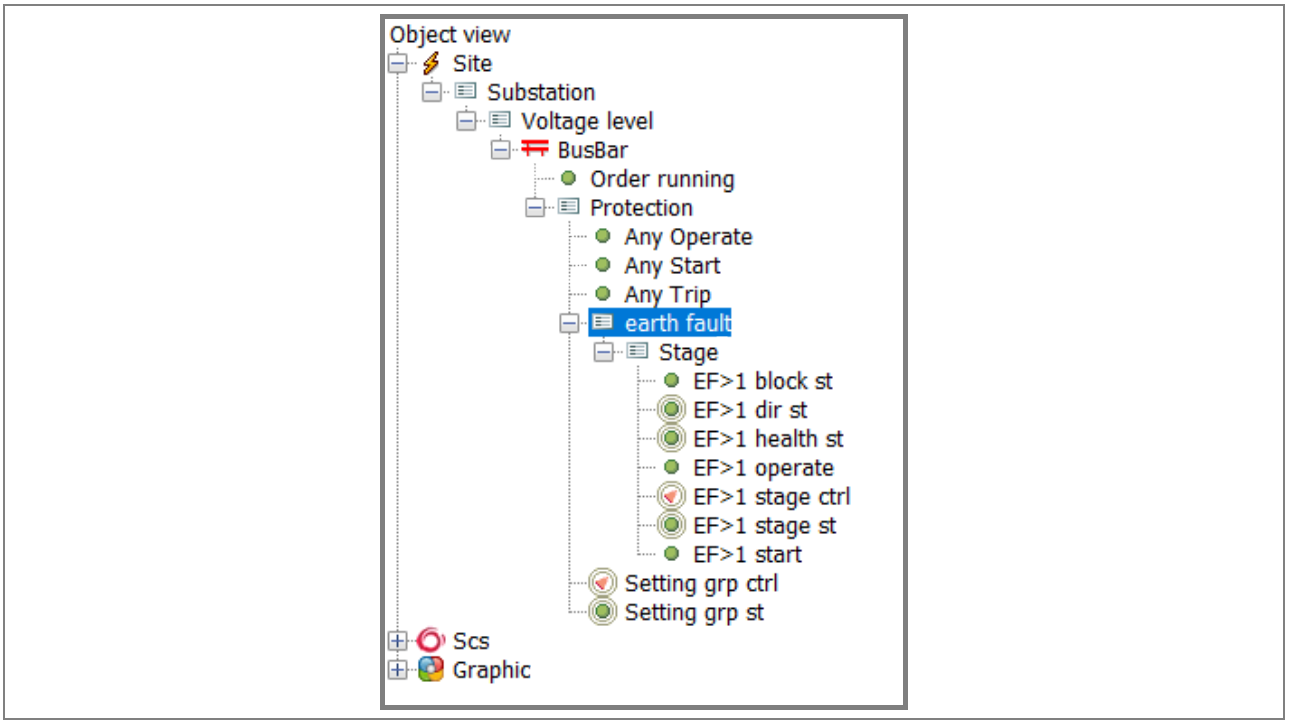


Figure 391: Default Earth Fault protection function datapoints

8.3.1 EARTH FAULT CONFIGURATION

8.3.1.1 ATTRIBUTES AND SETTINGS

Attributes and settings of the **Earth Fault** protection function must be set at SCE level. Some stage attributes can also be edited directly from MiCOM S1.

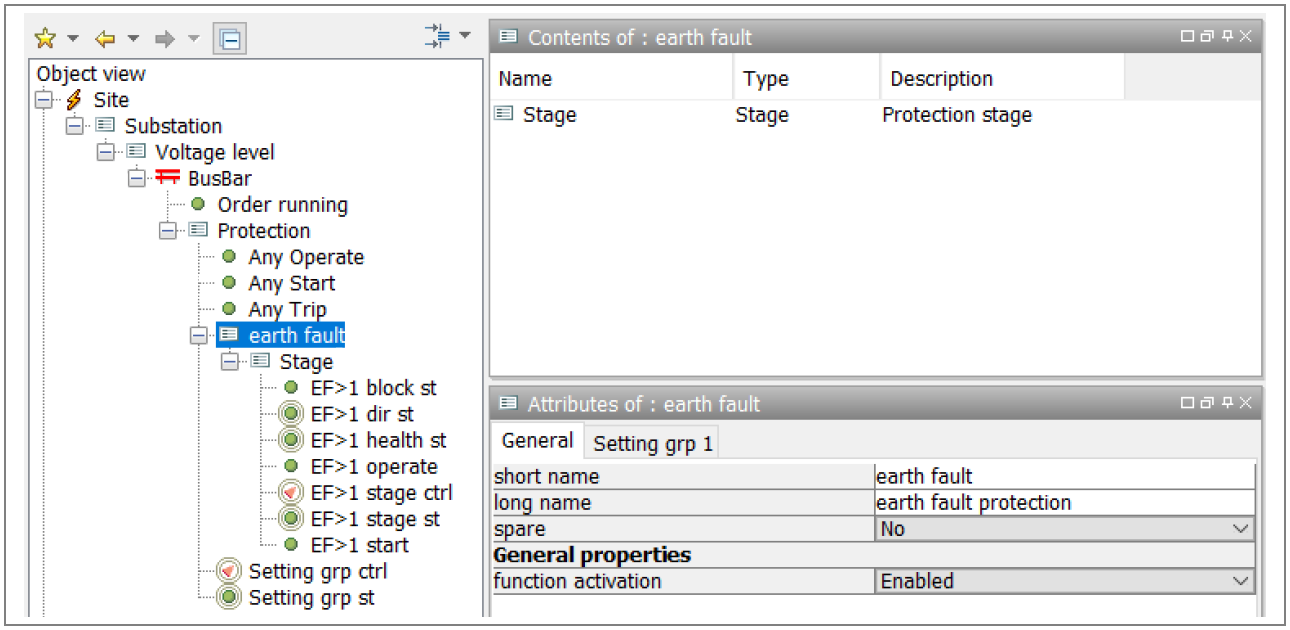


Figure 392: General Earth Fault attributes

(1) **short name** and **long name**: used for logging, alarms ... (can be modified).

(2) **spare** (*Yes* / *No*)

(3) **function status** (*Enabled* / *Disabled*): status of the Earth Fault protection function. The function can be enabled or disabled in the SCE or through Micom S1 tool.

Setting grp x

For each setting group (up to 4), set the following attributes.

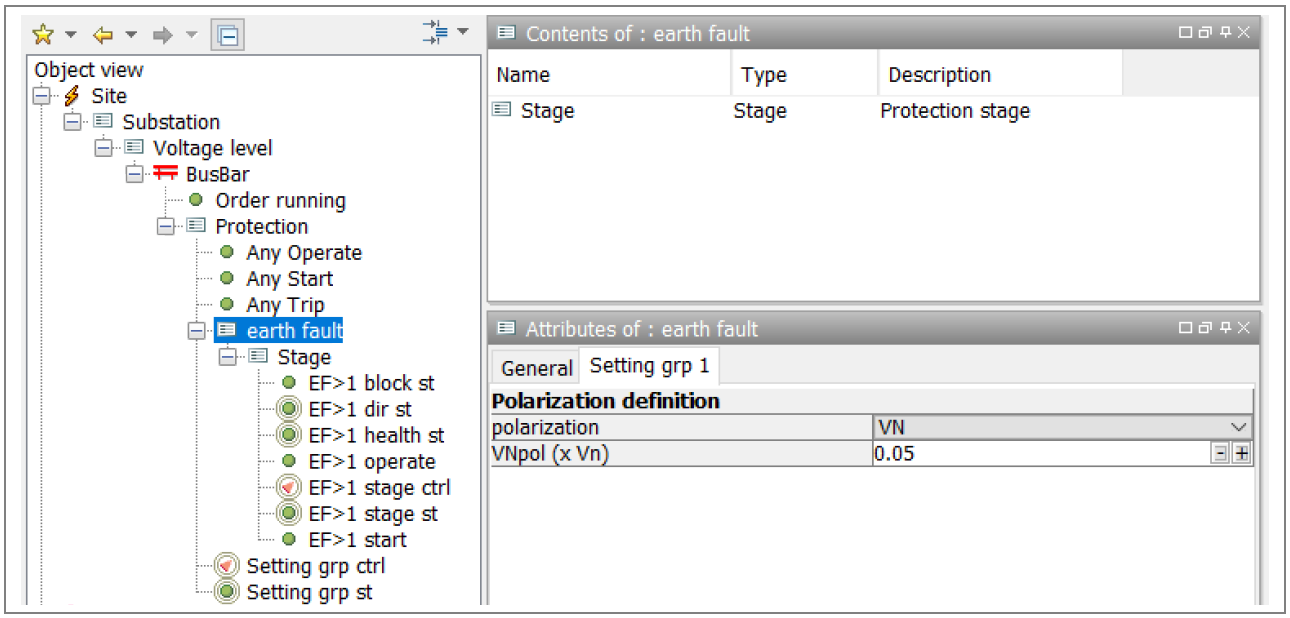


Figure 393: General setting for setting group

(1) **Polarization**: allows to choose the polarization vector for all stages. This setting can be changed from Micom S1.

- VN (default value)
- Negative phase sequence

(2) **VNpol (x Vn)** ([0,005, 0,8], step 0,005)**:** allows to define the polarization voltage threshold for the all stages to avoid taking into account acquisition noise. Factor of Vn. Depends on the "**Polarization**" attribute value. Only visible if equals to "**VN**". This setting can be changed from Micom S1.

(3) **V2pol (x Vn)** ([0,005, 0,25], step 0,005): allows to define the polarization voltage threshold for the all stages to avoid taking into account acquisition noise. Factor of Vn. Depends on the "**Polarization**" attribute value. Only visible if equals to "**Negative phase sequence**". This setting can be changed from MiCOM S1.

(4) **I2pol (x In)** ([0,08, 1], step 0,01): allows to define polarization current threshold for all stages to avoid taking into account acquisition noise. Factor of In. Depends on the of "**Polarization**" attribute value. Only visible if equals to "**Negative phase sequence**". This setting can be changed from MiCOM S1.

*Note: Up to four Setting groups can be configured in this view depending on the "**number of setting groups**" value set in the "Protection" object.*

8.3.1.2 ADDITIONAL DATAPOINTS

Optional datapoints can be added to the “Earth Fault” object, from the contextual **Objects entry** window:

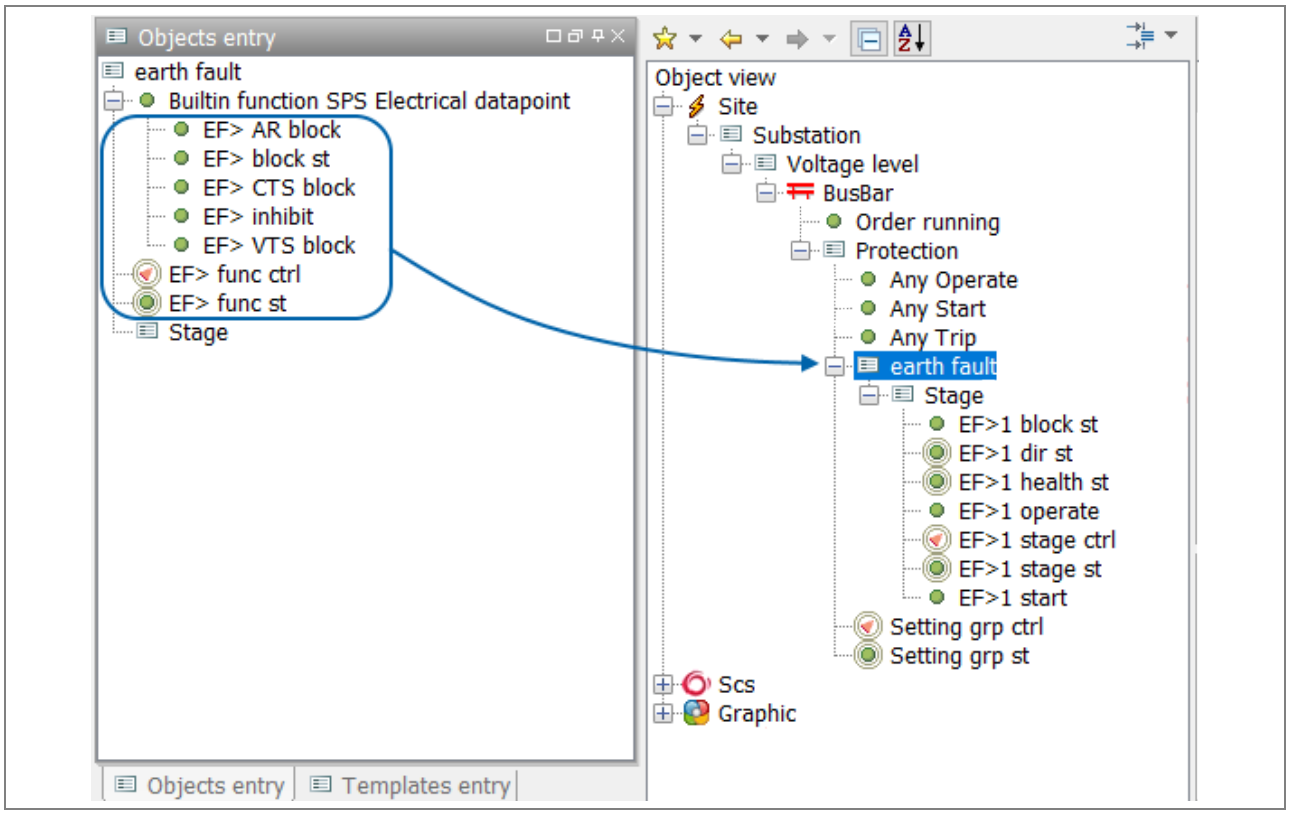


Figure 394: Optional “Earth Fault” datapoints

- **EF> AR block**: this SPS (function input) is provided by AR function when an auto-reclosing is in progress.
- **EF> block st:** this SPS (function output) indicates the blocking status of this protection function. The IEC 61850 mapping of this datapoint is LLN0/ST/EfpBlk (SPS_ST).
- **EF> CTS block**: this SPS (function input) is provided by Current Transformer Supervision when a failure appears.
- **EF> inhibit**: this SPS (function input) allows to inhibit the function (same behavior as if the function is Disabled).
- **EF> VTS block**: this SPS (function input) is provided by Voltage Transformer Supervision when a failure appears.
- **EF> func ctrl**: MPC used to enable or disable this protection function The IEC 61850 mapping of this datapoint is LLN0/CO/EfpMod (ENC_Direct).
- **EF> func st**: this MPS (function output) indicates the status of this protection function. The IEC 61850 mapping of this datapoint is LLN0/ST/EfpMod (ENC_Orig_ST).

8.3.2 STAGE CONFIGURATION

When an "**Earth fault**" protection function is added, one "**Stage**" sub-object is automatically created.

A "Stage" object gathers a set of parameters allowing the definition of "operate", "reset" and "block" conditions of the protection. It also has function input and output datapoints.

Up to four satges can be defined.

Each "Stage" object offers an independent set of parameters, but for each stage, the parameters apply to all phases.

For a stage, the "short name" attribute of each datapoint is prefixed by "EF>x" by default.

- "**EF>**" helps to identify a datapoint of the Earth Fault protection function.
- "**x**" identifies the stage number (from 1 to 4 according to the value set in the "stage number" attribute).

If this prefix is not changed by the user, this one is automatically updated according to the value of the "stage number" attribute.

8.3.2.1 ATTRIBUTES AND SETTINGS

Attributes and settings of the **Earth Fault** protection function must be set at SCE level. Some stage attributes can also be edited directly from MiCOM S1.

8.3.2.1.1 General Properties

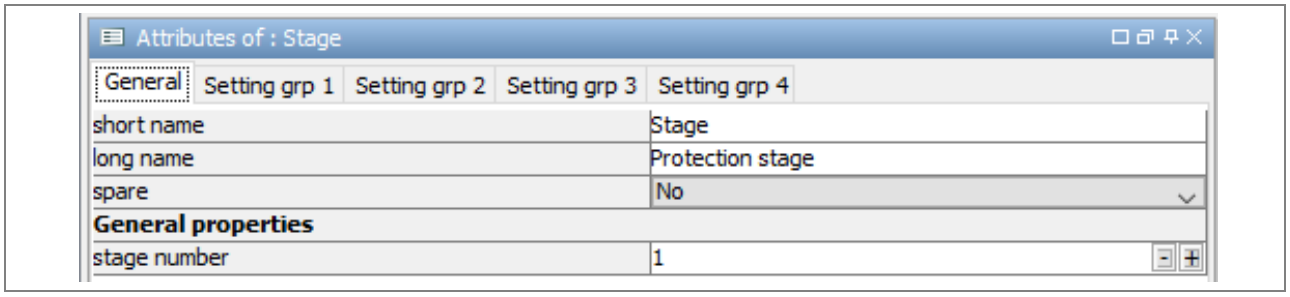


Figure 395: General Stage attributes and settings

(1) **short name** and **long name**: used for logging, alarms ... (can be modified).

(2) **Spare** (*Yes / No*)

(3) **stage number**: enter the number that will identify the stage of the function (from 1 to 4).

8.3.2.1.2 Setting grp x

Note: Up to four Setting groups can be configured in this view depending on the "number of setting groups" value set in the "Protection" object.

For each setting group (up to 4), set the following attributes:

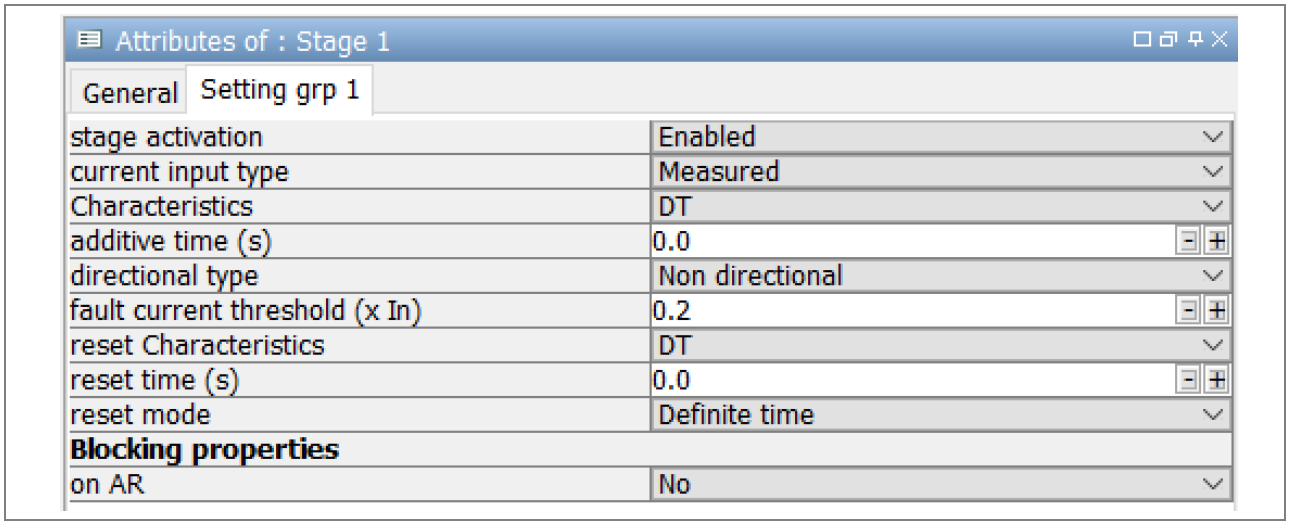


Figure 396: General setting for setting group

(1) **stage activation** (*Disabled / Enabled*): allows to enable or disable this stage. This setting can be changed from MiCOM S1. The IEC 61850 mapping of this datapoint is efPTOCy/SG/SetEna (SPG)

(2) **current input type** (*Measured / Derived*): type of current input used. This setting can be changed from MiCOM S1. The IEC 61850 mapping of this datapoint is efPTOCy/SG/NeutSrc (ENG).

(3) **characteristics**: sets the operating mode of the stage. This setting can be changed from Micom S1. The IEC 61850 mapping of this datapoint is efPTOCy/SG/TmACrv (CURVE).
The available curves are:

- DT (default value)
- IEC standard inverse
- IEC very inverse
- IEC extremely inverse
- UK long time inverse
- Rapid inverse
- IEEE moderately inverse
- IEEE very inverse
- IEEE extremely inverse
- US inverse
- US short time inverse
- IDG
- ANSI normally inverse

- ANSI short time inverse
- ANSI long time inverse
- ANSI very inverse
- ANSI extremely inverse
- EPATR B

For more information about the equations applied according to chosen curve, please refer to the **Functional Description** chapter of the C264 user manual (section **Protection Function**).

(4) **IDMT curve multiplier** ([0,01, 100], step 0,01): this setting is available for stages with Definite time functionality (set in the “characteristics” attribute). It allows the user to define the time multiplier when IDMT curve is used. This setting can be changed from MiCOM S1.

(5) **additive time** ([0, 200], step 0,01): defines an additional time, in second, according to the selected characteristic.

(6) **directional type:** defines the fault detection type:

- **Non directional**
- **Directional forward**
- **Directional reverse**

This setting can be changed from Micom S1**.**

(7) **characteristic angle (degree)** ([-180, 180], step 1): this setting depends on the **Directional type** attribute. It defines the characteristic angle in degree for optimum performance when the function works in **Directional forward** or **Directional reverse** mode. This setting must be equal to the phase angle of the negative sequence current with respect to the inverted negative sequence voltage, in order to be at the center of the directional characteristic. It can be changed from Micom S1.

(8) **operate angle (degree)** ([0, 180], step 1): this setting depends on the **Directional type** attribute. It defines the opening angle (in degree) of the forward or reverse operate zone. It can also be set independently for each stage. This setting can be changed from Micom S1.

(9) **fault current threshold (x In)** ([0,01 ; 40], step 0,01): defines the pick-up current threshold. When this threshold is exceeded, a delay is started. This setting is expressed in factor of In (In being defined at TMU board level). This setting can be changed from Micom S1.

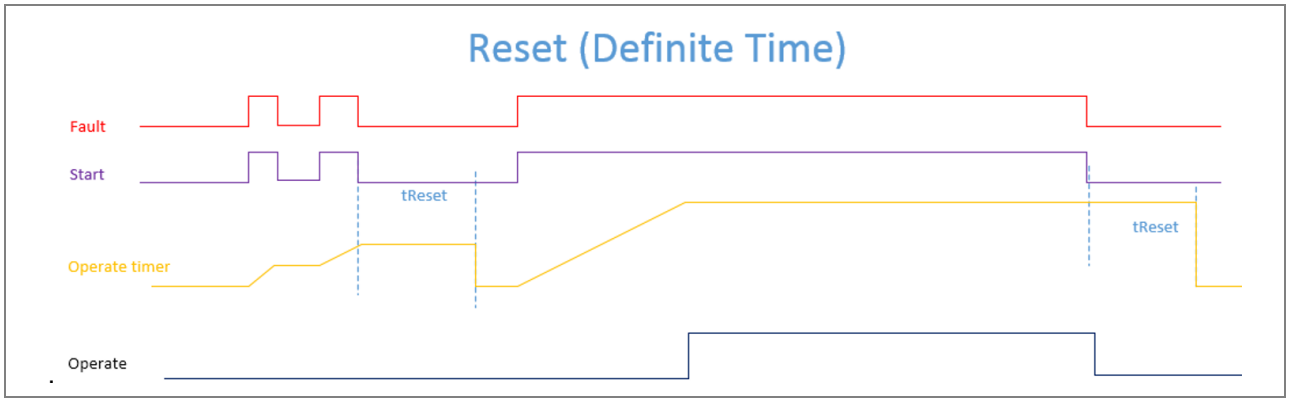
(10) **reset characteristics**: defines the reset characteristics. This setting can be changed from MiCOM S1.

- When the "**characteristics**" attribute value is "IEC ..." or "IEEE ..." or "US ..." or "ANSI ...", the available values are:
  - **DT**: the reset time is defined by user.
  - **IDMT**: the reset time is defined from curve (only possible for IEC, IEEE, US & ANSI curves). For more information about the equations applied according to chosen curve, refer to the **Functional Description** chapter of the C264 user manual (section **Protection Function**).
- When the "characteristics" attribute value is"DT" or "UK ..." or "Rapid inverse" or "IDG" or "EPATR B", the available values are:
  - **DT**: the reset time is defined by user.

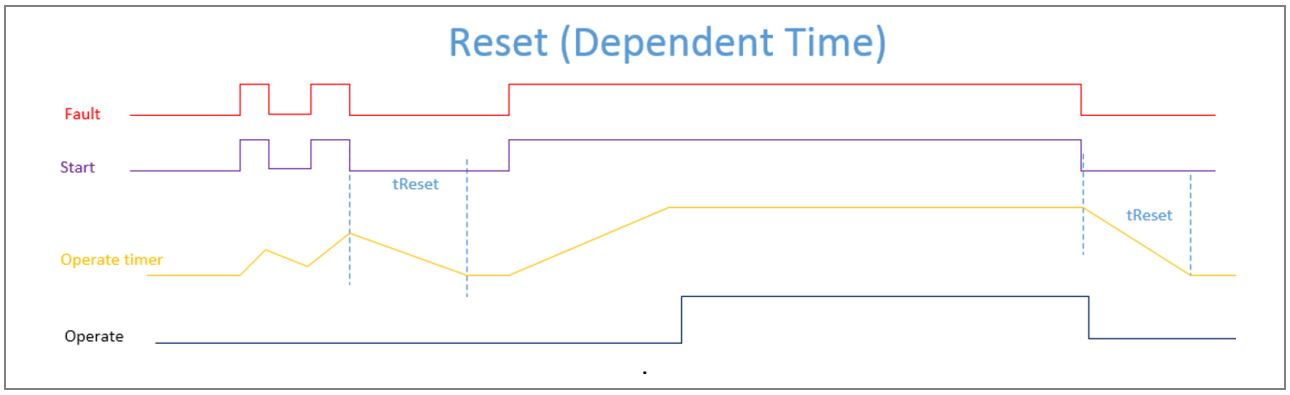
(11) **reset time (s)** ([0, 100], step 0,01): in the event of a fault condition (current > threshold) then a start delay is started. If the fault disappears (current < threshold) during time defined by this setting, then start delay is reset. This setting depends on the reset characteristics attribute and is only visisible when set to DT. It can be changed from Micom S1.

(12) **reset mode** *(Definite time / Dependent time)*: select either Definite time or Dependent time (This setting can be changed from MiCOM S1).

- If **Definite time** is selected, the C264 goes back to its reset state after the delay defined in the Reset time seting. The operate timer is maintained during the reset condition:



- If **Dependent time** is selected, the C264 goes back to its reset state after the delay defined in the Reset time seting. The operate timer is decreased during the reset condition:



(13) **On VT Error** *(Blocking / Non directional)*: Voltage Transformer Supervision (VTS) can be used to block operation of directional overcurrent elements. This setting depends on the **directional type** attribute and is only visisible when set to **Directional forward** or "**Directional reverse**. It defines – for the current stage - the behavior of the function when a problem is detected on the Voltage Transformer (failure of the Voltage Transformer Supervision or a bad voltage quality). Either the function is blocked by the appropriate stage or the stage is downgraded to non directional mode. This setting can be changed from Micom S1.

(14) **On AR** *(No / Yes)*: indicates whether the function is blocked by this stage when an auto-reclosing is in progress. This setting can be changed from Micom S1.

8.3.3 REPLICATE SETTING VALUES OF ONE SETTING GROUP TO ANOTHER

*Note: When several setting groups (up to 4) are defined at protection level (see section **Common Protection Function Attributes**), you can automatically duplicate the setting values of one setting group to one or several groups using the "**Edit settings**" function available in the context menu of the **Overcurrent** object. See section 8.1.4 Replicating one Protection Setting group to another.*

8.3.3.1 MANDATORY DATAPOINTS

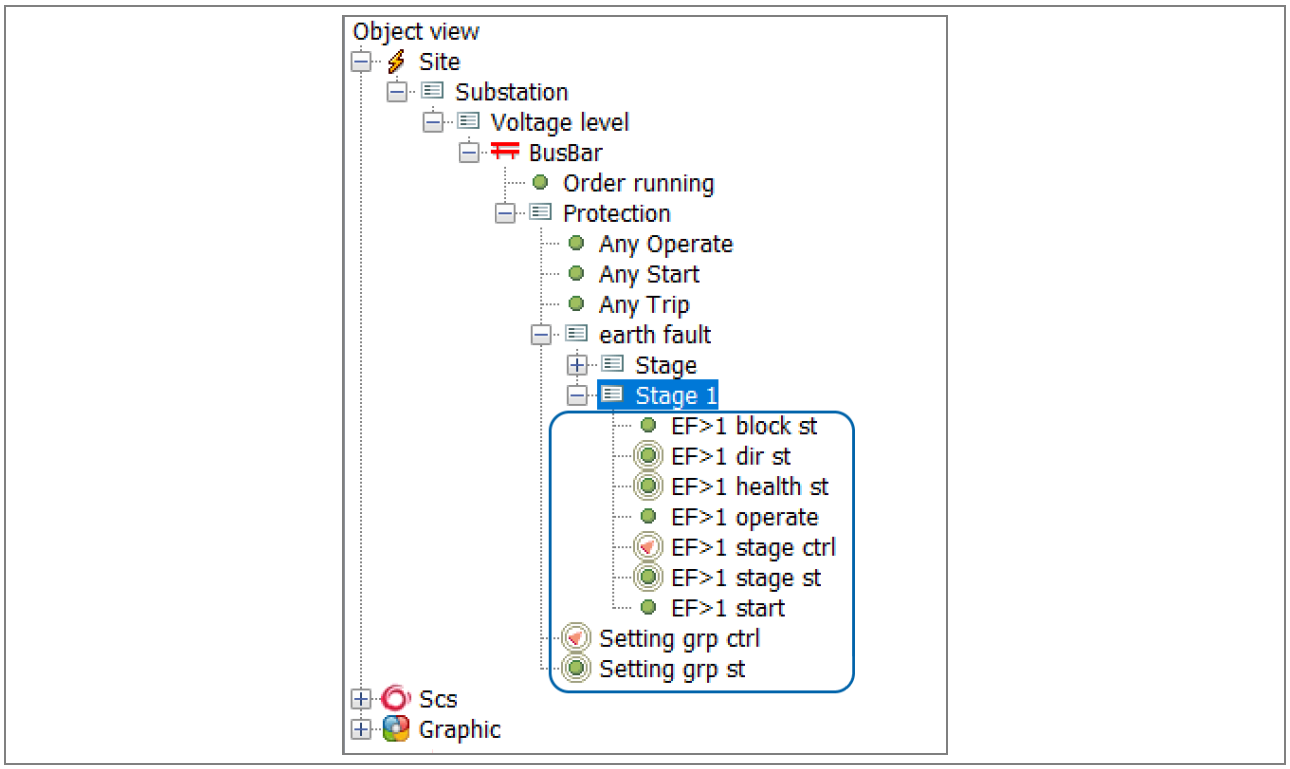


Figure 397: Mandatory Stage datapoints

- **EF>x block st**: this permanent SPS (function output) indicates if the current stage is blocked or not. The IEC 61850 mapping of this datapoint is efPTOCy/ST/Blk (SPS_ST).
- **EF>x dir st**: this MPS (function output) indicates the directional status of this stage. The IEC 61850 mapping of this datapoint is efPTOCy/ST/Str.dirGeneral (ACD_ST_Neut).
- **EF>x health st**: this MPS (function output) indicates the health of the current stage. The IEC 61850 mapping of this datapoint is efPTOCy/ST/Health (ENS_ST).
- **EF>x operate**: This SPS (function output) indicates for this stage, a protection operates. The IEC 61850 mapping of this datapoint is efPTOCy/ST/Op.general (ACT_ST_Neut).
- **EF>x stage ctrl**: this MPC enables or disables this stage. The IEC 61850 mapping of this datapoint is efPTOCy/CO/Mod (ENC_Direct).
- **EF>x stage st**: this MPS (function output) indicates the status of this stage. The IEC 61850 mapping of this datapoint is efPTOCy/ST/Mod (ENC_Orig_ST)
- **EF>x start**: this SPS (function output) indicates for this stage, a protection start. The IEC 61850 mapping of this datapoint is efPTOCy/ST/Str.general (ACD_ST_Neut).

8.3.3.2 ADDITIONAL DATAPOINTS

Optional datapoints can be added to the “**Earth fault**" object from the contextual **Objects entry** window.

All IEC addresses of these datapoints if used, are in the "PROTECTION" Logical Device.

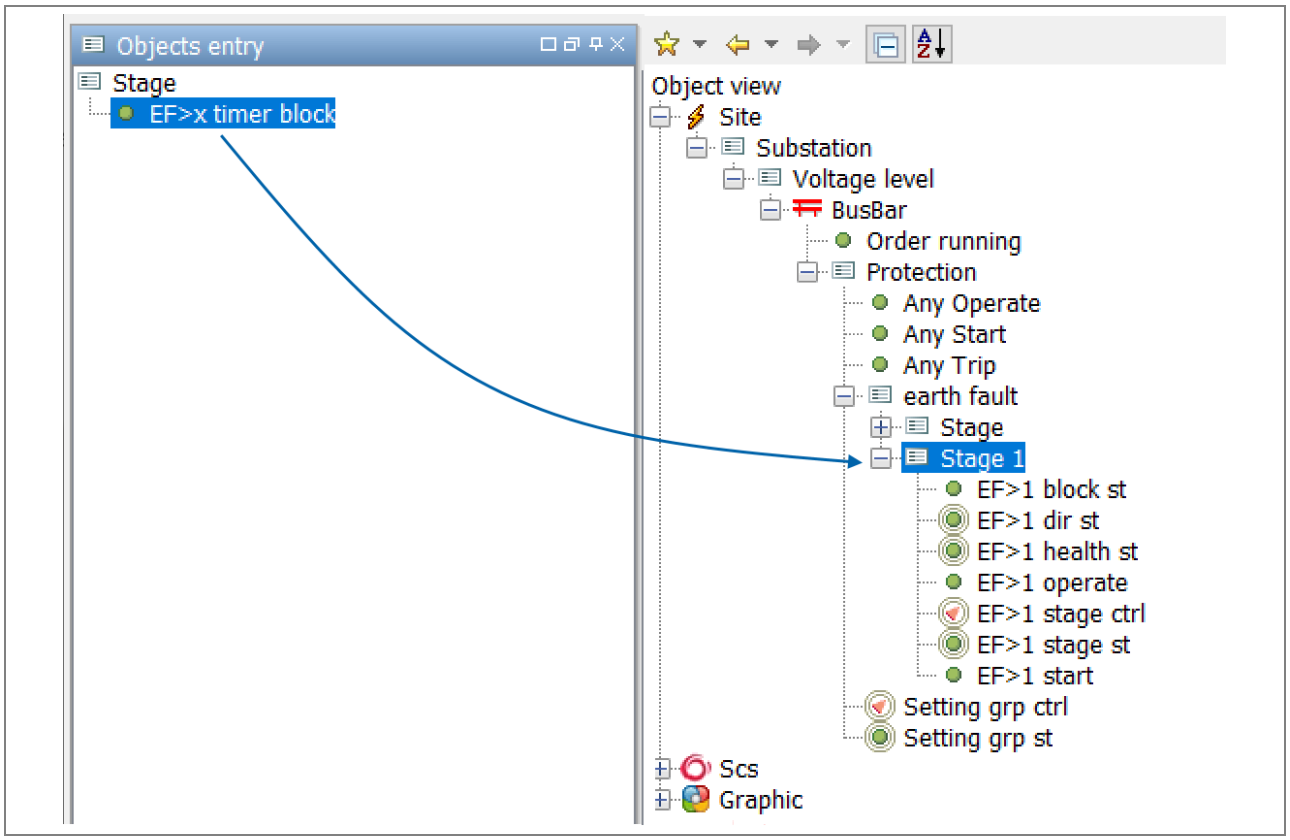


Figure 398: Optional “Earth fault” object

- **EF>x timer block**: this SPS (function input) is used to block the timer launched by the start signal, for the current stage.

8.4 [50BF] CIRCUIT BREAKER FAILURE PROTECTION

When a fault occurs, one or more protection devices will operate and issue a trip command to the relevant circuit breakers. Operation of the circuit breaker is essential to isolate the fault and prevent, or at least limit, damage to the power system. For transmission and sub-transmission systems, slow fault clearance can also threaten system stability.

The "Circuit Breaker Failure" function monitors the circuit breaker and establishes whether it has opened within a reasonable time. If the fault current has not been interrupted following a set time delay from circuit breaker trip initiation, the CBF function will operate, whereby the upstream circuit breakers are back-tripped to ensure that the fault is isolated.

To monitor CB, the Circuit Breaker Failure function can be initiated of two non-exclusive ways:

- Internally from internal operate signal,
- Externally from external trip of another device.

Configuration

C264 can manage **up to two "CB failure"** functions for the set of its bays.

A "**CB failure**" function must have at least one initiation mode defined. Two initiation modes are configurable, internal and/or external from respective objects.

When adding a **CB failure** function - from the contextual **Objects entry** window ("**Protection**" built-in function), several mandatory datapoints are automatically created at function level and must be configured.

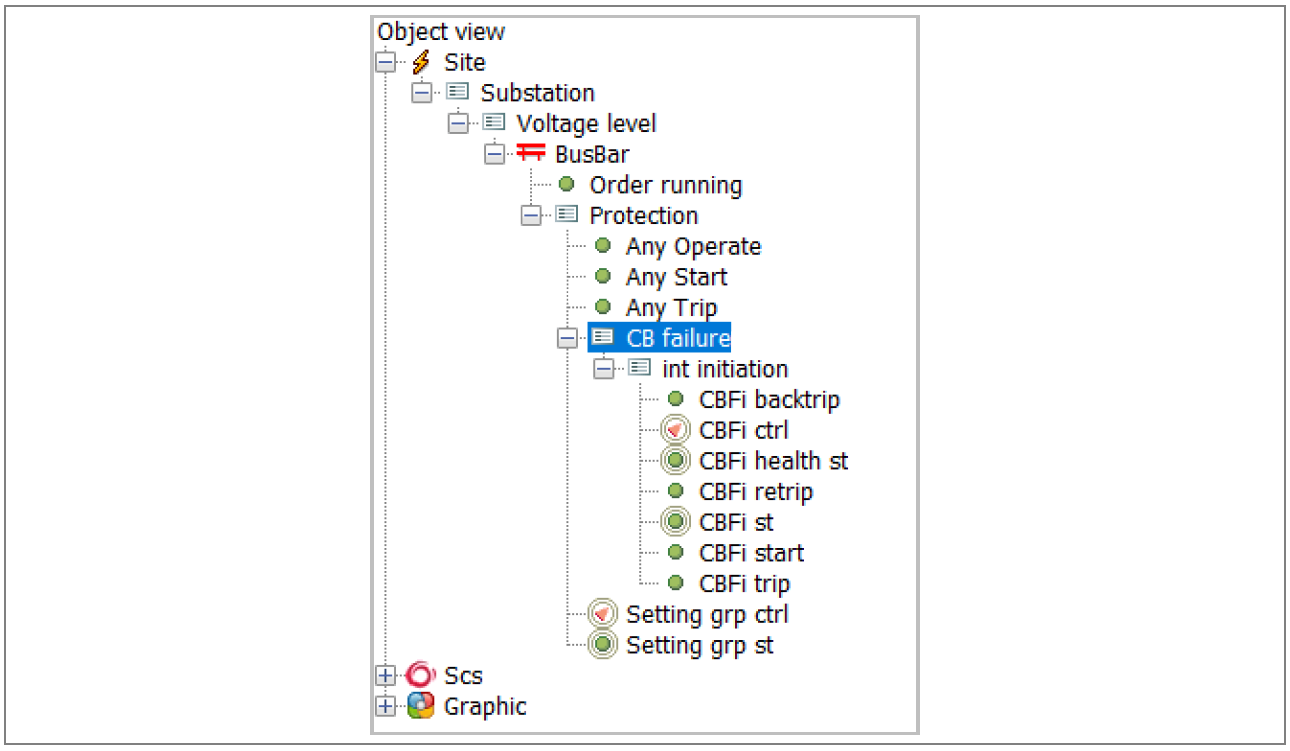


Figure 399: Default CB Failure protection function datapoints

8.4.1 CB FAILURE CONFIGURATION

8.4.1.1 ATTRIBUTES AND SETTINGS

General features of the Circuit Breaker Failure protection function must be set at SCE level:

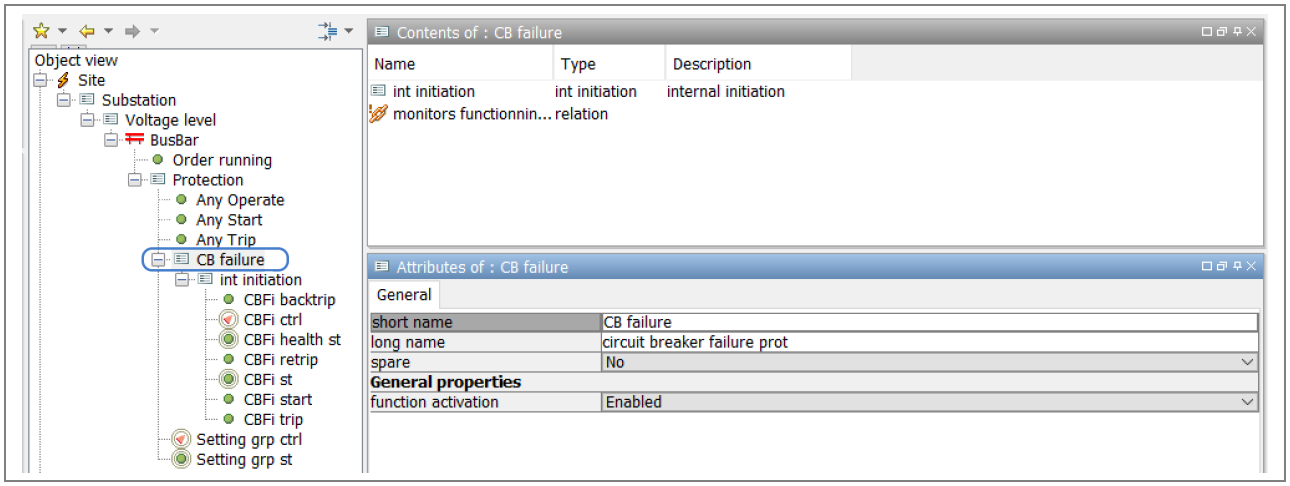


Figure 400: General CB Failure attributes

(1) **short name** and **long name**: used for logging, alarms ... (can be modified).

(2) **spare** (*Yes* / *No*)

(3) **function activation** (*Enabled* / *Disabled*): Enables or disables the CB Failure protection function. This setting can be changed through Micom S1 tool.

8.4.1.2 ADDITIONAL DATAPOINTS

Optional datapoints can be added to the “CB Failure” object, from the contextual **Objects entry** window:

All IEC addresses of these datapoints are in the "PROTECTION" Logical Device.

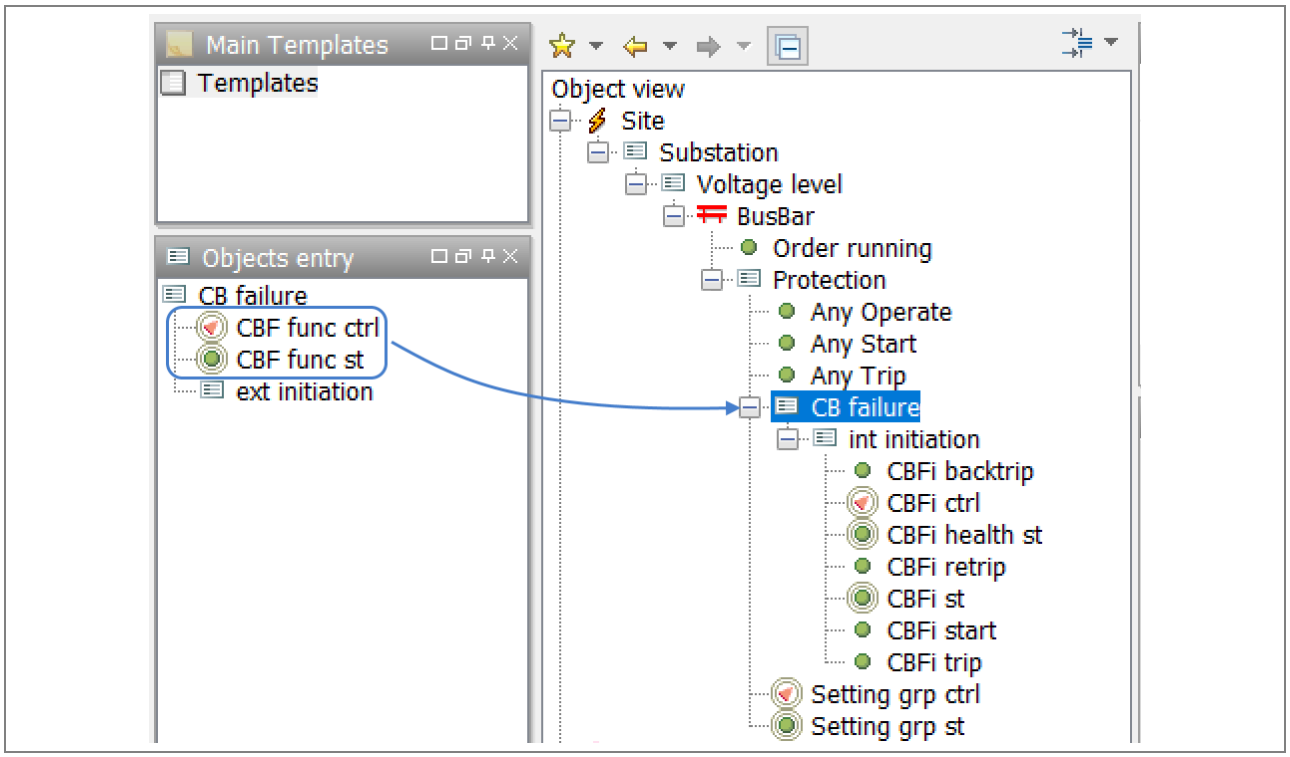


Figure 401: Optional Overcurrent datapoints

- **CBF func ctrl**: this MPC enables or disables the CB Failure protection function. Complete the relation “Has for feedback " CBF func st" MPS. The IEC 61850 mapping of this datapoint is LLN0/CO/BfpMod (ENC_Direct).
- **CBF func st**: This MPS (function output) indicates the status of this protection function (enabled or disabled). Complete the relation “CBF func ctrl" MPC.
  The IEC 61850 mapping of this datapoint is LLN0/ST/BfpMod (ENC_Orig_ST).

8.4.1.3 RELATIONS

A "CB failure" built-in function has a mandatory relation link with one circuit breaker module of the same bay.

This relation link allows to identify the monitored circuit breaker when several exist in the same bay.

From the "CB failure" built-in function, the name of this relation link is: "monitors functionning of"

From the "circuit breaker" module, the name of this relation link is: "is monitored by".

8.4.2 INTERNAL INITIATION (OPTIONAL)

By default, when a "CB failure" protection function is added to the configiration, one "Internal initiation" sub-object is automatically created.

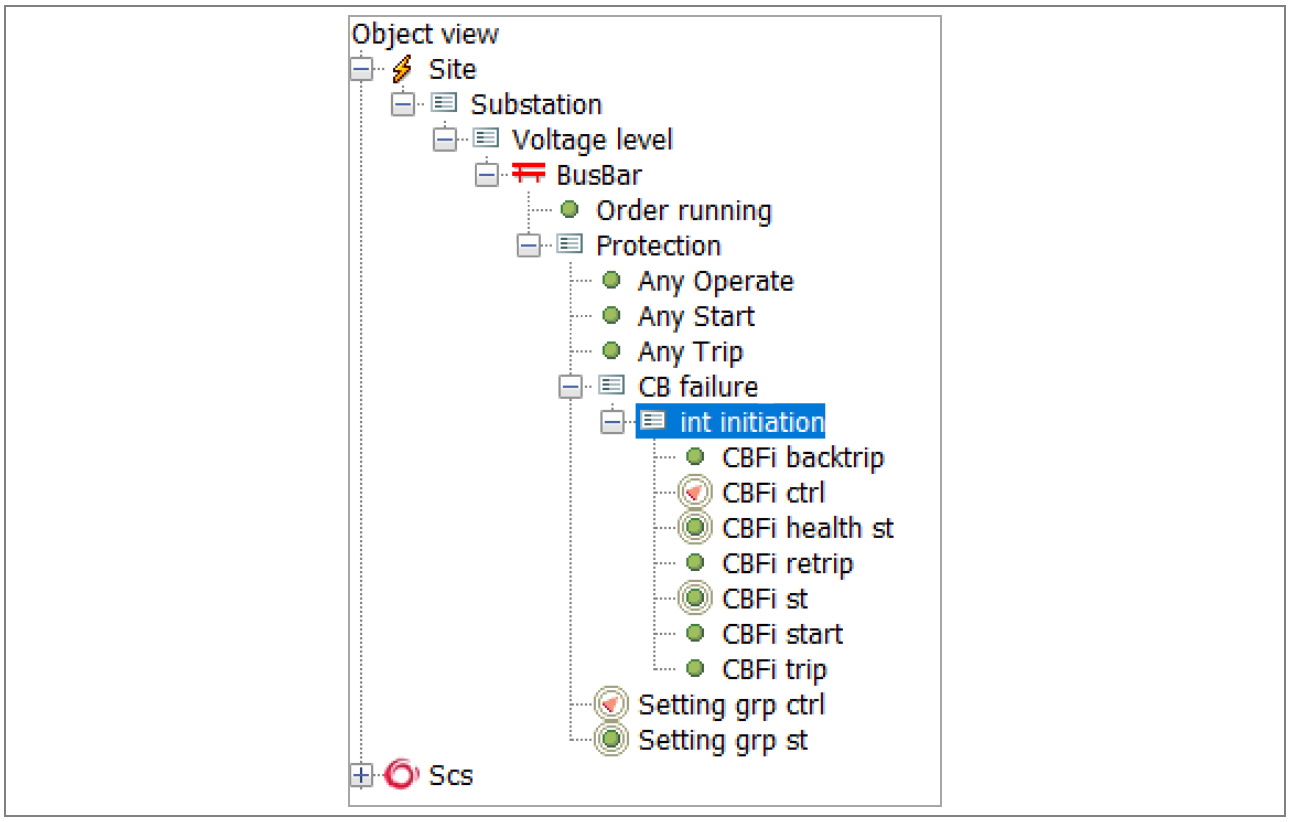


Figure 402: Internal initiation datapoints

8.4.2.1 ATTRIBUTES AND SETTINGS

General attributes and settings of the **Internal initiation** must be set at SCE level.

General

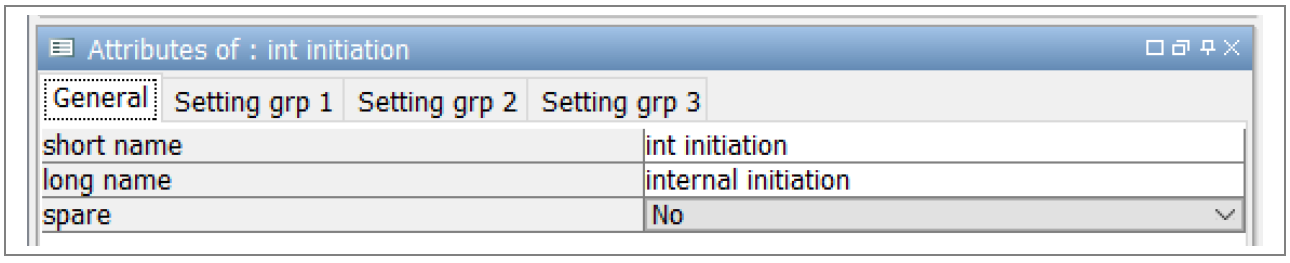


Figure 403: General attributes of the internal initiation mechanism

(1) **short name** and **long name**: used for logging, alarms ... (can be modified).

(2) **spare** (*Yes* / *No*)

Setting group x

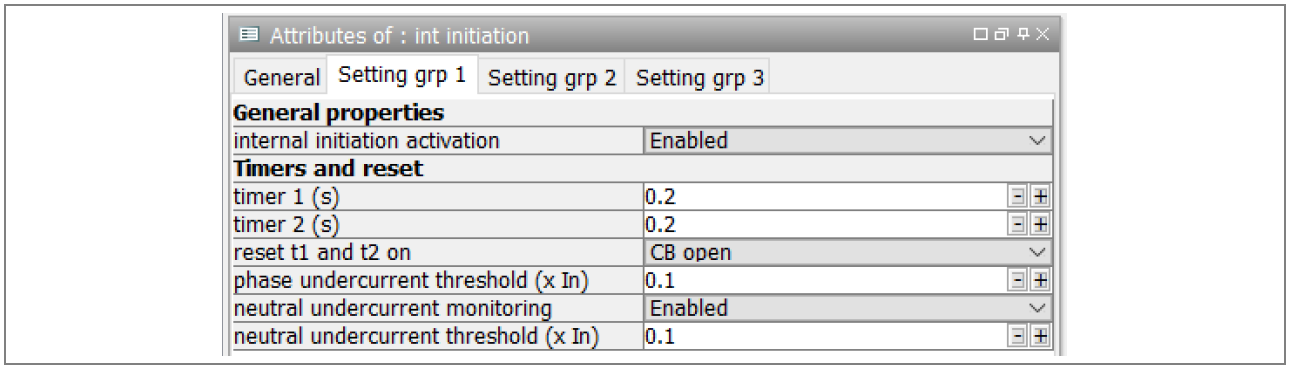


Figure 404: Attributes of the Internal Initiation Setting Group

(1) **internal initiation activation** (*Enabled* / *Disabled*): enables or disables the internal initiation mode in the SCE or through Micom S1.

(2) **timer 1** ([0, 50], step 0.01): sets the timer in seconds for retrip. This setting is visible if **internal initiation activation** is "Enabled". This setting can be changed from Micom S1.

(3) **timer 2** ([0, 50], step 0.01): sets the timer in seconds for a backtrip. This setting is visible if **internal initiation activation** is "Enabled". This setting can be changed from Micom S1.

(4) **reset t1 and t2 on** (*loss of current / CB open / loss of current and CB open*): defines the reset type of timers in case of internal initiation. This setting is visible if **internal initiation activation** is "Enabled". This setting can be changed from Micom S1.

(5) **phase undercurrent threshold (x In)** ([0.05, 4], step 0.01): defines the phase undercurrent threshold (in factor of In) for a protection reset in case of internal initiation. This setting is visible only if "reset t1 and t2 on" attribute is set to "loss of current" or "loss of current and CB open". This setting can be changed from Micom S1.

(6) **neutral undercurrent monitoring** (*Enabled* / *Disabled*): enables or disables the monitoring of undercurrent on neutral/earth in case of internal initiation. This setting is visible only if "reset t1 and t2 on" attribute is set to "loss of current" or "loss of current and CB open". This setting can be changed from Micom S1.

(7) **neutral undercurrent threshold (x In)** ([0.05, 4], step 0.01): defines the neutral/ground undercurrent threshold in factor of In for a protection reset in case of internal initiation. This setting is visible if “neutral undercurrent monitoring” is "Enabled". This setting can be changed from Micom S1.

8.4.2.2 MANDATORY DATAPOINTS

When adding a "CB Failure" protection function, mandatory datapoints of "**Internal initiation**" object must be configured. All IEC addresses of these datapoints are in the "PROTECTION" Logical Device.

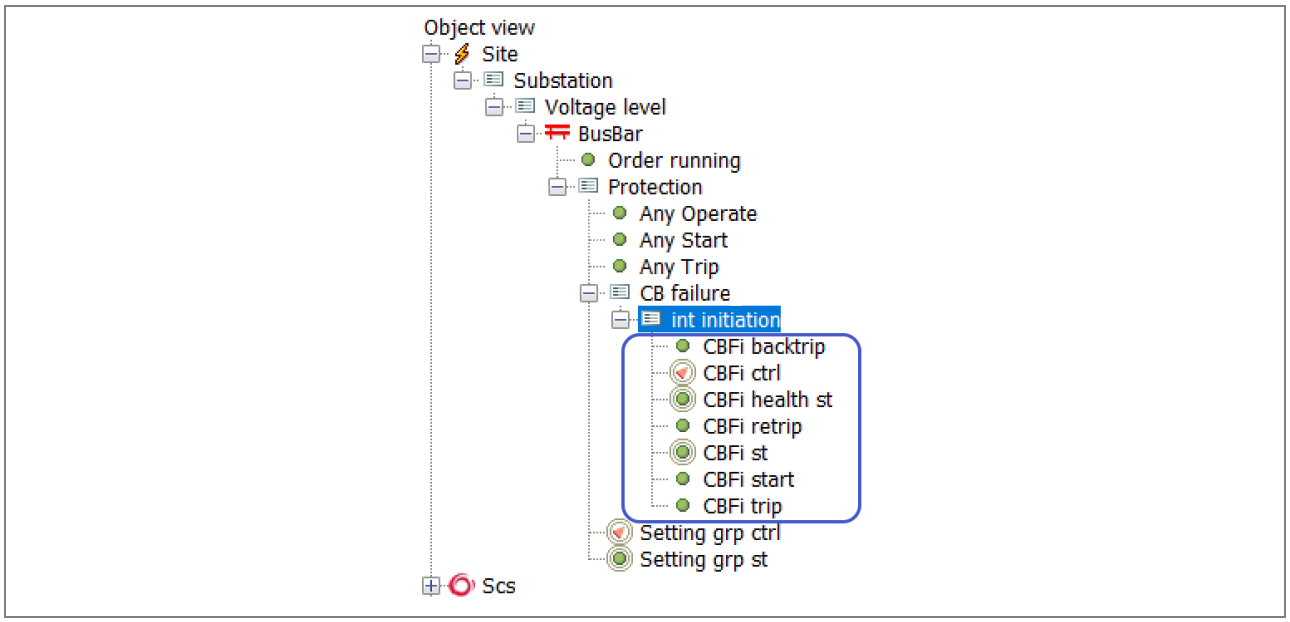


Figure 405: Mandatory "Internal initiation" datapoints

- **CBFi backtrip**: this SPS (function output) indicates an internal order of backtrip. The IEC 61850 mapping of this datapoint is *InRBRF/ST/OpEx.general (ACT_ST_Gen)*.
- **CBFi ctrl:** this MPC enables or disables the internal initiation of timers. Complete the relation “Has for feedback "CBFi st" MPS. The IEC 61850 mapping of this datapoint is *InRBRF/CO/Mod (ENC_Direct)*.
- **CBFi health st**: this MPS (function output) indicates the health status in case of internal initiation. The IEC 61850 mapping of this datapoint is *InRBRF/ST/Health (ENS_ST)*.
- **CBFi retrip**: this SPS (function output) indicates an internal order of retrip. The IEC 61850 mapping of this datapoint is *InRBRF/ST/OpIn.General (ACT_ST_Gen)*.
- **CBFi st**: this MPS (function output) indicates the status of internal initiation, enabled or disabled. Complete the relation “Has for feedback "CBFi ctrl" MPC. The IEC 61850 mapping of this datapoint is *InRBRF/ST/Mod (ENC_Orig_ST)*.
- **CBFi start**: this SPS (function output) indicates an internal start of the protection. The IEC 61850 mapping of this datapoint is *InRBRF/ST/Str.general (ACD_ST_Gen)*.
- **CBFi trip**: this SPS (function input) indicates an internal order of trip. This SPS can used **as an Automation output**. In the case, the "CBFi trip" represents the result of automatism output defined by user. "Operator type" attribute is not used here.

8.4.2.3 ADDITIONAL DATAPOINTS

Optional datapoints can be added to the “Internal initiation" object, from the contextual **Objects entry** panel. All IEC addresses of these datapoints are in the "PROTECTION" Logical Device.

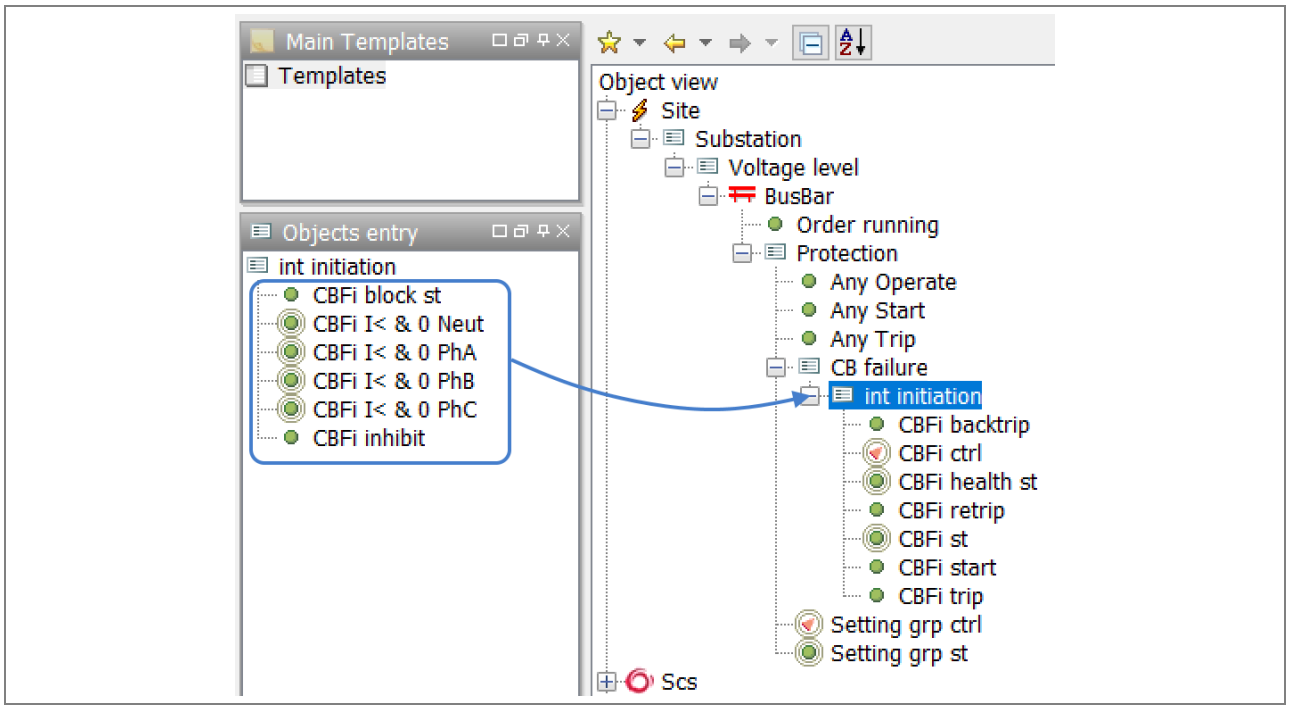


Figure 406: Optional "Internal initiation" datapoints

- **CBFi inhibit**: this SPS (function input) inhibits the function in internal mode. Same behavior as if function is Disabled.
- **CBFi block st**: this SPS (function output) indicates the blocking status in internal mode of this protection function. The IEC 61850 mapping of this datapoint is *InRBRF/ST/Blk (SPS_ST)*.
- **CBFi I< & 0 Neut**: this MPS (function output) indicates the status of neutral current in internal mode.
- **CBFi I< & 0 PhA**: this MPS (function output) indicates the status of phase A current in internal mode.
- **CBFi I< & 0 PhB**: this MPS (function output) indicates the status of phase B current in internal mode.
- **CBFi I< & 0 PhC**: this MPS (function output) indicates the status of phase C current in internal mode.

8.4.3 EXTERNAL INITIATION

The "External initiation" object is optional and can be added or removed by user. An "External initiation" object contains attributes/settings and datapoints for operation with external initiation.

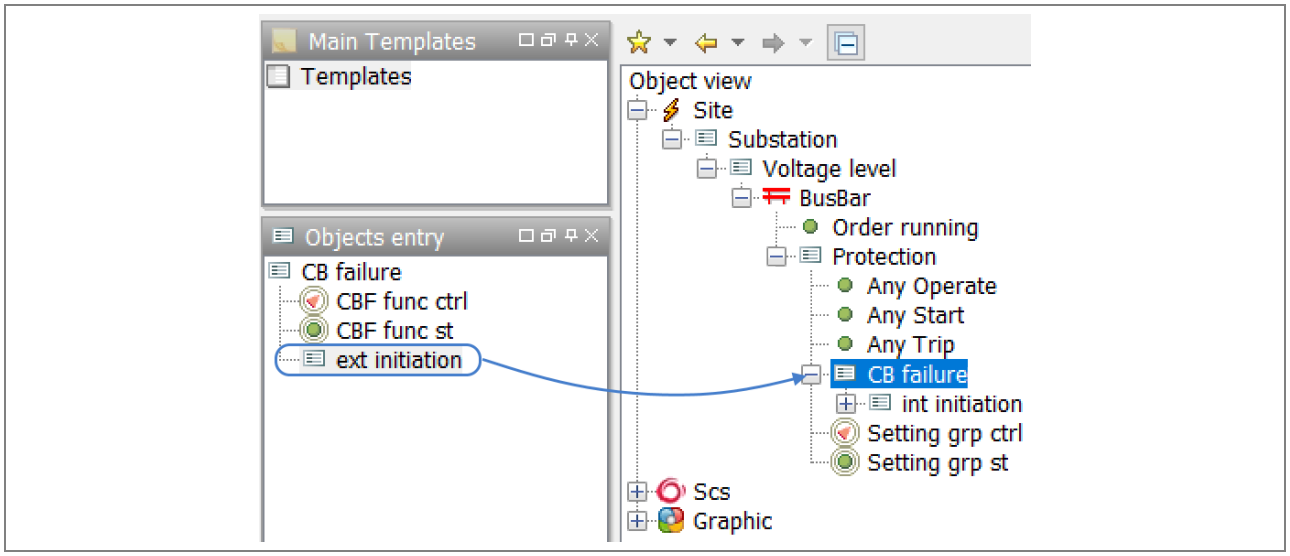


Figure 407: Optional "Internal initiation" datapoints

By default, when a "CB failure" object is used, the "External initiation" sub-object is not added automatically.

8.4.3.1 ATTRIBUTES AND SETTINGS

General features of the “External initiation" object must be set at SCE level.

General

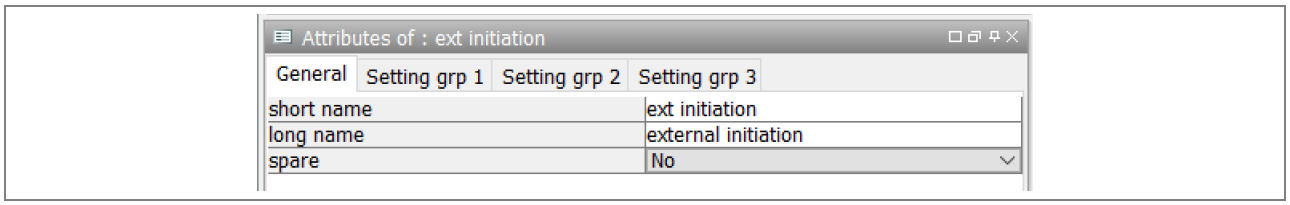


Figure 408: General CB Failure attributes

(1) **short name** and **long name**: used for logging, alarms ... (can be modified).

(2) **spare** (*Yes* / *No*)

Setting group x

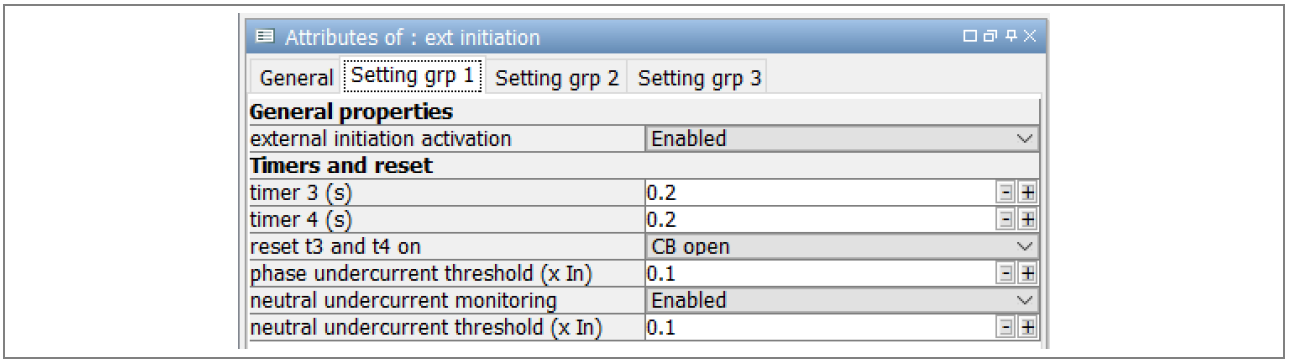


Figure 409: Attributes of the Internal Initiation Setting Group

(1) **external initiation activation** (*Enabled* / *Disabled*): enables or disables the external initiation mode in the SCE or through Micom S1.

(2) **timer 3** ([0, 50], step 0.01): sets the timer in seconds for a retrip. This setting is visible if **external initiation activation** is "Enabled". This setting can be changed from Micom S1.

(3) **timer 4** ([0, 50], step 0.01): sets the timer in seconds for a backtrip. This setting is visible if **external initiation activation** is "Enabled". This setting can be changed from Micom S1.

(4) **reset t3 and t4 on** (*loss of current / CB open / loss of current and CB open*): defines the reset type of timers in case of external initiation. This setting is visible if **external initiation activation** is "Enabled". This setting can be changed from Micom S1.

(5) **phase undercurrent threshold (x In)** ([0.05, 4], step 0.01): defines the phase undercurrent threshold (in factor of In) for a protection reset in case of external initiation. This setting is visible only if "reset t3 and t4 on" attribute is set to "loss of current" or "loss of current and CB open". This setting can be changed from Micom S1.

(6) **neutral undercurrent monitoring** (*Enabled* / *Disabled*): enables or disables the monitoring of undercurrent on neutral/earth in case of external initiation. This setting is visible only if "reset t3 and t4 on" attribute is set to "loss of current" or "loss of current and CB open". This setting can be changed from Micom S1.

(7) **neutral undercurrent threshold (x In)** ([0.05, 4], step 0.01): defines the neutral/ground undercurrent threshold in factor of In for a protection reset in case of external initiation. This setting is visible if “neutral undercurrent monitoring” is "Enabled". This setting can be changed from Micom S1.

8.4.3.2 MANDATORY DATAPOINTS

Mandatory datapoints must be configured when adding an "**External initiation**" object to the "CB Failure" protection function. All IEC addresses of these datapoints are in the "PROTECTION" Logical Device.

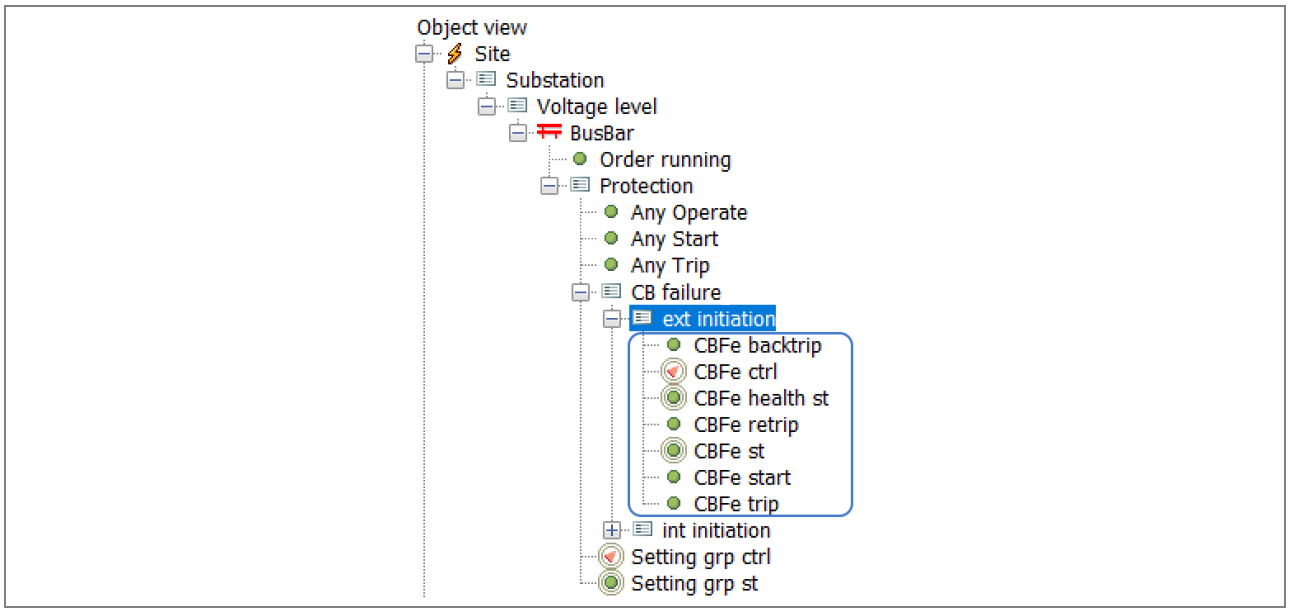


Figure 410: Mandatory "External initiation" datapoints

- **CBFe backtrip**: this SPS (function output) indicates an external order of backtrip. The IEC 61850 mapping of this datapoint is *ExRBRF/ST/OpEx.general (ACT_ST_Gen)*.
- **CBFe ctrl:** this MPC enables or disables the external initiation of timers. Complete the relation “Has for feedback "CBFe st" MPS. The IEC 61850 mapping of this datapoint is *ExRBRF/CO/Mod (ENC_Direct)*.
- **CBFe health st**: this MPS (function output) indicates the health status in external initiation. The IEC 61850 mapping of this datapoint is *ExRBRF/ST/Health (ENS_ST)*.
- **CBFe retrip**: this SPS (function output) indicates an external order of retrip. The IEC 61850 mapping of this datapoint is *ExRBRF/ST/OpIn.General (ACT_ST_Gen)*.
- **CBFe st**: this MPS (function output) indicates the status of external initiation of timers, enabled or disabled. Complete the relation “Has for feedback "CBFe ctrl" MPC. The IEC 61850 mapping of this datapoint is *ExRBRF/ST/Mod (ENC_Orig_ST)*.
- **CBFe start**: this SPS (function output) indicates an external start of the protection. The IEC 61850 mapping of this datapoint is *ExRBRF/ST/Str.general (ACD_ST_Gen)*.
- **CBFe trip**: this SPS (function input) indicates an external order of trip.

8.4.3.3 ADDITIONAL DATAPOINTS

Optional datapoints can be added to the “External initiation" object, from the contextual **Objects entry** panel. All IEC addresses of these datapoints are in the "PROTECTION" Logical Device

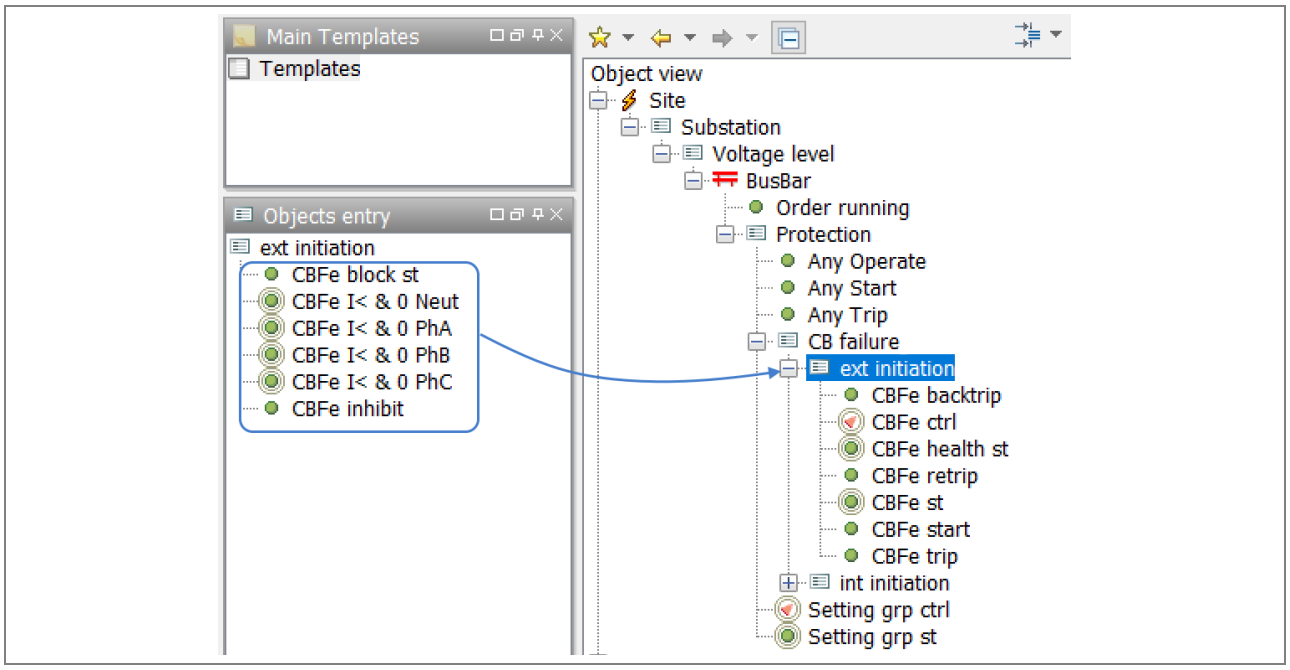


Figure 411: Optional "External initiation" datapoints

- **CBFe inhibit**: this SPS (function input) inhibits the function in external mode. Same behavior as if function is Disabled.
- **CBFe block st**: this SPS (function output) indicates the blocking status in external mode of this protection function. The IEC 61850 mapping of this datapoint is *ExRBRF/ST/Blk (SPS_ST)*.
- **CBFe I< & 0 Neut**: this MPS (function output) indicates the status of neutral current in external mode.
- **CBFe I< & 0 PhA**: this MPS (function output) indicates the status of phase A current in external mode.
- **CBFe I< & 0 PhB**: this MPS (function output) indicates the status of phase B current in external mode.
- **CBFe I< & 0 PhC**: this MPS (function output) indicates the status of phase C current in external mode.

8.4.4 LIMITS

- Only one "**CB failure**" function can be added per bay.
- A C264 can manage up to two "**CB failure**" functions when dealing with two physical bays.
- The "CBFi start" and "CBFe start" SPS datapoints of the "**CB failure**" function are not integrated into groups allowing the determination of "Any Start" ynthesis SPS at level "Protection".

SETTINGS

C26X/EN ST/E72B

Contents

1	**SCOPE OF THE DOCUMENT**	**3**
2	**TREE PANEL**	**4**
2.1	**Navigation**	**4**
2.2	**Tree panel parameters**	**4**
3	**MICOM S1**	**6**
3.1	**Operations**	**9**
3.1.1	Preliminary	9
3.1.2	Transferring a file from the C26x	9
3.1.3	Editing Online Parameters	9
3.1.4	Transferring new setting values	12
3.2	**Lists of parameters**	**14**
3.2.1	OP Parameters	14
3.2.2	Protection Config	15
3.2.3	Protection Group 1…N	16
3.2.4	Autorecloser (type 1) parameters	21
3.2.5	AVR parameters	22
3.2.6	Internal synchrocheck parameters	23
3.2.7	FBD parameters	28
3.3	**MiCOM S1 messages**	**29**
3.4	**Val file**	**30**

1 SCOPE OF THE DOCUMENT

This document is a chapter of the DS Agile C26x documentation. It describes the Settings -or on-line- parameters, which can be modified in runtime on DS Agile C26x units. The setting is done through the LHMI. It is only available with a GHU300 or a GHU301 front panel.

A number of parameters related to user functions can be done on-line from a PC.

2 TREE PANEL

2.1 NAVIGATION

The tree panel is accessible from bay panels by selecting the key  .

All data points are grouped into features and folders. To access a given feature the operator should navigate the panels using the arrow keys. Each panel shows the folders hierarchy.

 switch to neighbouring folder

 selects and expands the folder switching to its first item

 goes up to parent folder

At the bottom of the hierarchy, the folder is the single point of information, control or parameter. Edit mode allows the operator to change values.

 grants access to Edit mode for level 2 password input

 cancels edition and the data point modification

The most commonly used settings and controls are selected into a list. To browse the list the operator navigates using the arrow keys. The modification/control sequence is cancelled by  . The selection is confirmed by  .

2.2 TREE PANEL PARAMETERS

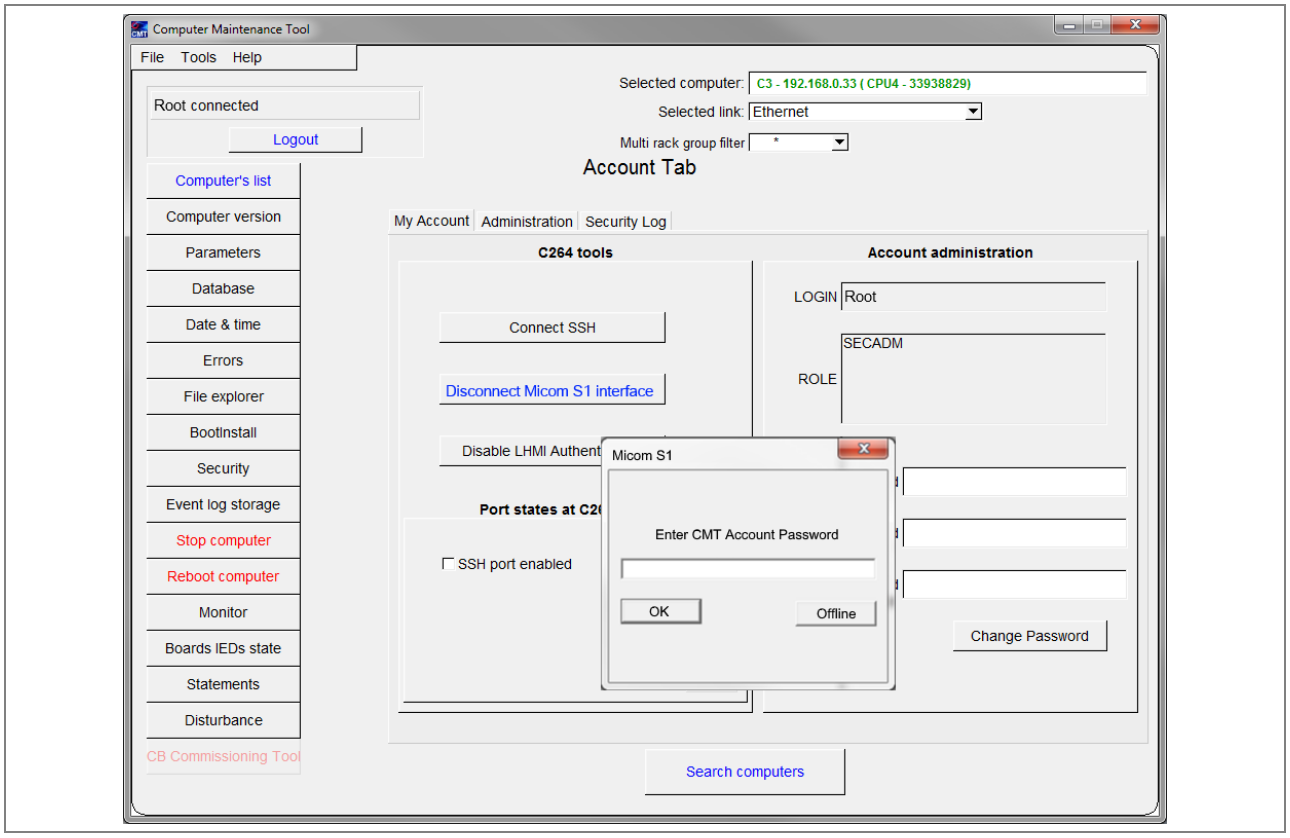
MENU TREE	Available Values Or [min;max] (step)(unit)	Description
COMMAND		
MAIN		
- RESET OP HOURS	RESET	Reset the number of the C26x operating hours
- CHANGE MODE OP	OPERAT, MAINT, TEST	Change the C26x mode into active, maintenance or test mode
- GLB ACK ALARM	ACK	Acknowledge all C26x alarms
- GLB CLR ALARM	CLEAR	Clear all acknowledged and reset alarms
- DATE	DATE	Change the date. Accepted if the C26x is not synchronised
- TIME	TIME	Change the time. Accepted if the C26x is not synchronised. The time format is hh: mn: sec
- DB SWITCH	YES	Switch between active and standby databases
- LANGUAGE	LG1, LG2	Switch between languages 1 & 2
COUNTER		
Counter 1 … Counter N		List of available counters
- COUNTER value	Counter value	Change the value of the counter

MENU TREE	Available Values Or [min;max] (step)(unit)	Description
CONFIG		
COMPUTER		
MAIN		
- IP ADDRESS	xxx.xxx.xxx.xxx	Set the C26x IP address
BAY		
Bay 0 Bay 1 Bay N		
COMM. PORT		
Com 1 … Com 4		
- BAUDRATE	baudrate *	Baudrate of the communication port among: N50,100,200,300,600,1200,2400,4800,9600,19200,38400, 56000.
- NB STOP BIT	1, 2	Number of stop bits
- NB BIT PER CHAR	7, 8	Number of bits per character
- PARITY	odd, even, none	Parity
HMI		
MAIN		
- EXIT MT TIME	[5;300](1)(s)	Time after which the Menu tree is automatically left if there is no pressed button
- BACK LIGHT DELAY	[5;300](1)(s)	Time after which the back light disappears if there is no pressed button
- SELECT EXIT TIME	[5;300](1)(s)	Maximum time between selection and execution orders
- PASSWORD	XXXX	Password: needed to modify parameters
- BYPASS DELAY	[20;120](1)(s)	Time after which a bypass is automatically deselected
BAY		
Bay 0 … Bay N		
- DISPLAY DEV NAME	YES, NO	Flag to validate or inhibit the display of the Name of Devices in the Bay Panel

3 MICOM S1

The MiCOM S1 can be started in online or offline mode.

When started via DS Agile CMT (from the **Security** tab), a login popup prompts the user to enter the CMT account password. The user may enter his/her credentials and click on **OK** to get MiCOM S1 opened in “online” mode or click on the **Offline** button to access MiCOM S1 in "offline" mode.



When started from the MS Windows© task or via the 

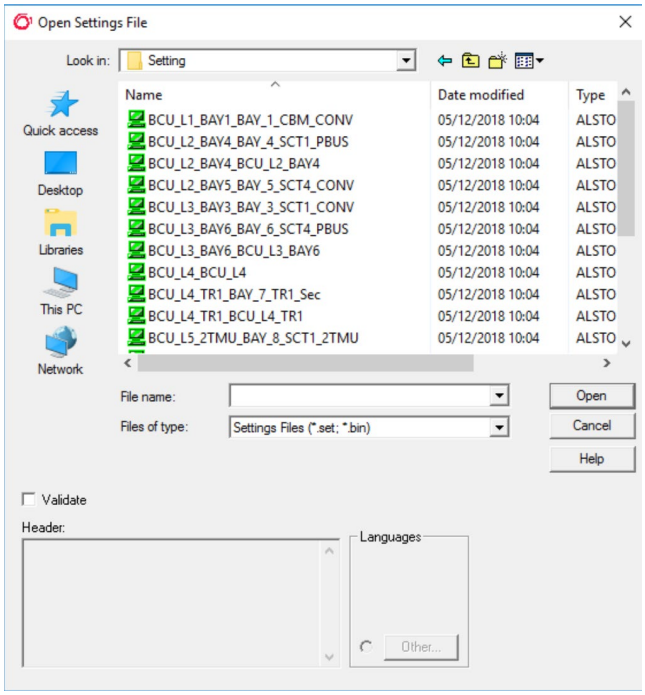
desktop icon, MICOM S1 is automatically launched in “Offline” mode.

The different application functions are accessed from the menu bar:

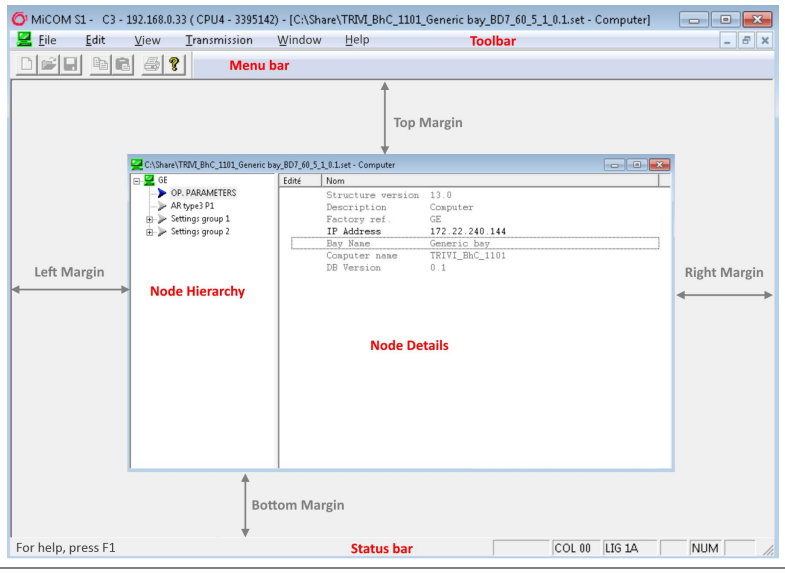
1 To open a setting file, click on **File ➡ Open ➡ Settings File**.

  Each setting files (*.set) are stored in the default directory **/flash/settings/**. The access path to this directory is set in the registry.

2 Each *.set is named with the C264 identifier and the bay name *[BCU-name]_[BAY-name.set]*. Search for the desired *.set file and then, click on **Open**:



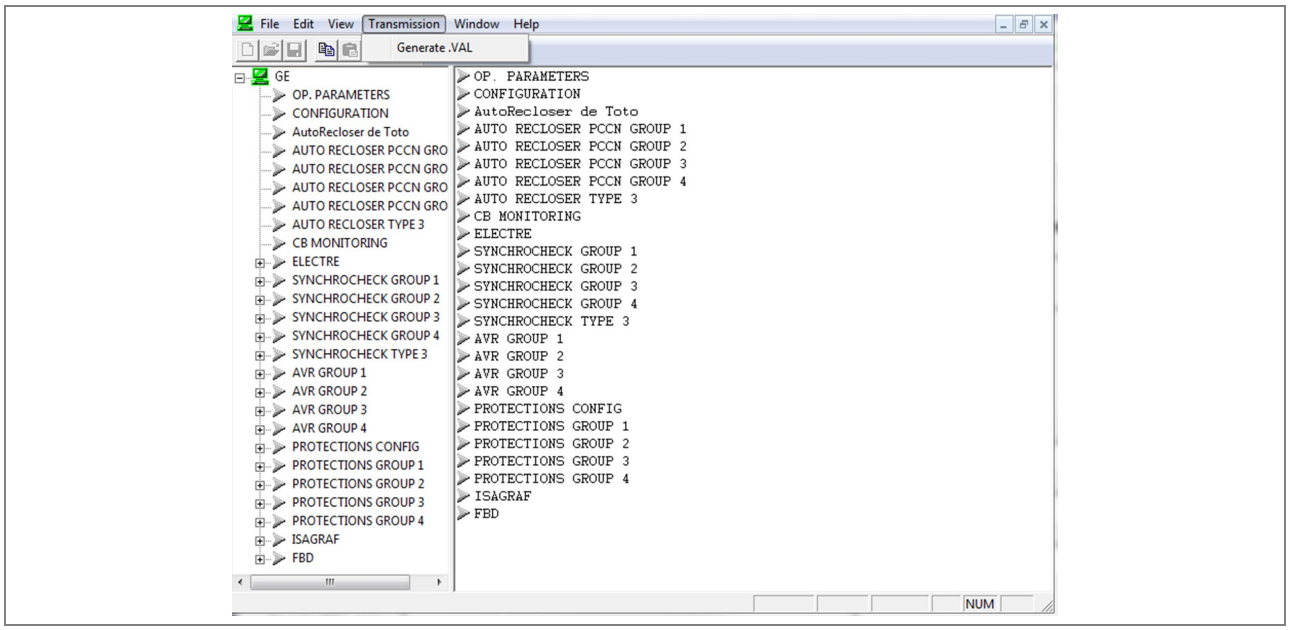
A resizable window embeds in the application windows in accordance with the four margins set in **File ➡ Page Setup**:



Once a setting file is opened, the main menu is updated with the new actions available for the operator.

- before getting or opening a file: **File**, **View**, **Help**. The **View** menu enables the operator to mask the toolbar and the status bar, and to expand/collapse a selected node.
- in addition, when a file is loaded: **Edit**, **Transmission**, **Window**.

When MICOM S1 is in “Offline” mode, the **Transmission** tab displays a different option. “Generate. VAL” is displayed instead of “Send settings” and “get settings”. In this mode, the user cannot connect to any C264 but prepare the setting files.



In MiCOM S1, parameters are grouped and organized in a tree-like hierarchy; the hierarchy can be expanded to display the parameters.

Once a group of settings is selected, various “editable” values appear at the right of the window.

Accessing these parameter values is “protected” as per configuration. Depending on access rights, a setting is editable or not and is greyed out.

In case of multibay, settings files are split.

For example, a BCU named **BCU_A** which contains 2 bays with build-in function named **Bay1** and **Bay2:**

- All settings used in FBD or Isagraf will be managed in **BCU_A.set** (Isagraf and FBD are compiled on BCU PLC and it is not possible to define the related bay)
- All setting used in build-in function of **Bay1** will be managed in **BCU_A_Bay1.set**
- All setting used in build-in function of **Bay1** will be managed in **BCU_A_Bay2.set****

3.1 OPERATIONS

3.1.1 PRELIMINARY

- Open the ***.set** file and check the C264 name in the **Operational Parameters** node to make sure you have opened the right file:
- If needed, create a new register key named “VERSION” and located under:

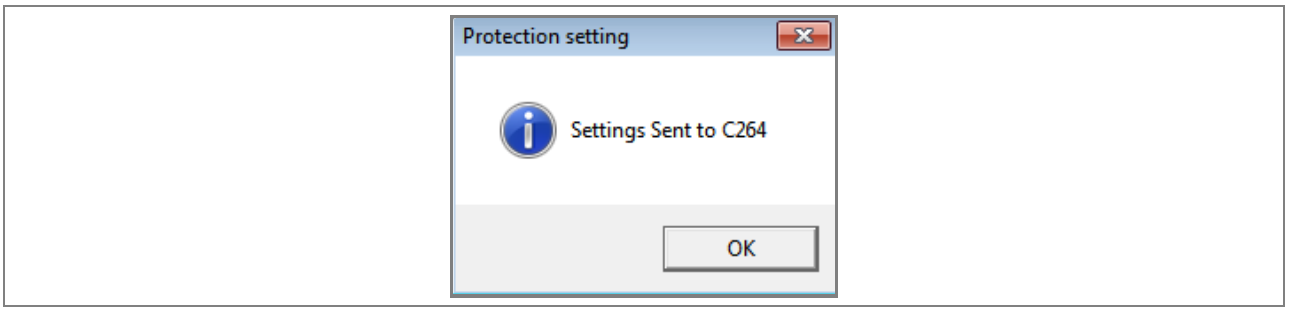
  `HKEY_LOCAL_MACHINE\Software\Wow6432Node\DCS\MICOM S1\Settings\`

  The value of this key can be 0 or 1. The default value is 1.

3.1.2 TRANSFERRING A FILE FROM THE C26X

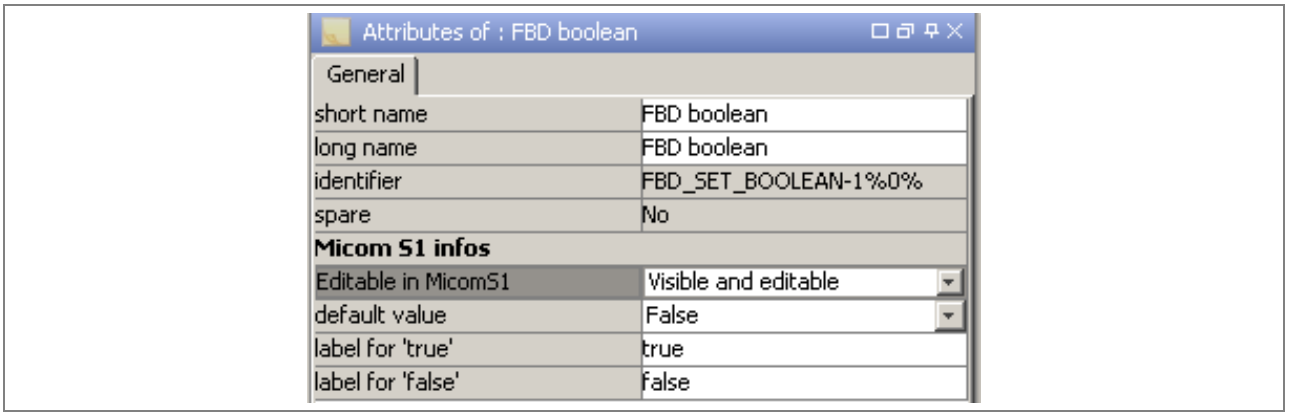
The .val file is transferred to the C26x. When data transmission is finished, the C26x sends an acknowledgement message. This message allows to read the .val received. The .val file is converted to .set and the current *.set is updated.

- Use the menu **Transmission ➡ Get Settings** and wait for the acknowledgment:

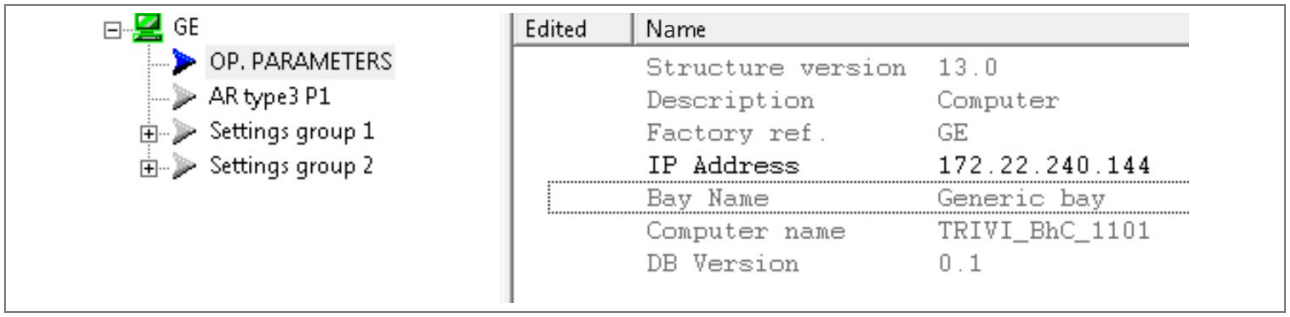


3.1.3 EDITING ONLINE PARAMETERS

The online visibility and possibility of setting are attributes configured in SCE:



Read-only parameters are greyed out in MiCOM S1 while editable parameters are shown in black:

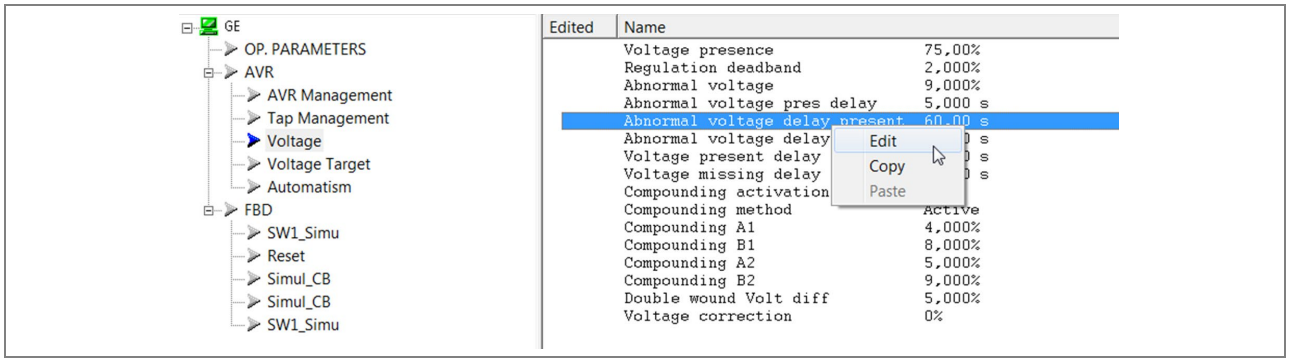


*Note: The "**IP address**" of the C264 may be configured as an "editable" or read-only field in the **File** menu/**Properties** dialog of the SCE. If this field is set to TRUE in the SCE, then when opening the C264 configuration file offline from MiCOM S1, the "**IP Address**" field will appear as editable. Please note that no check is done in MiCOM S1 to verify the validity of the IP address entered.*

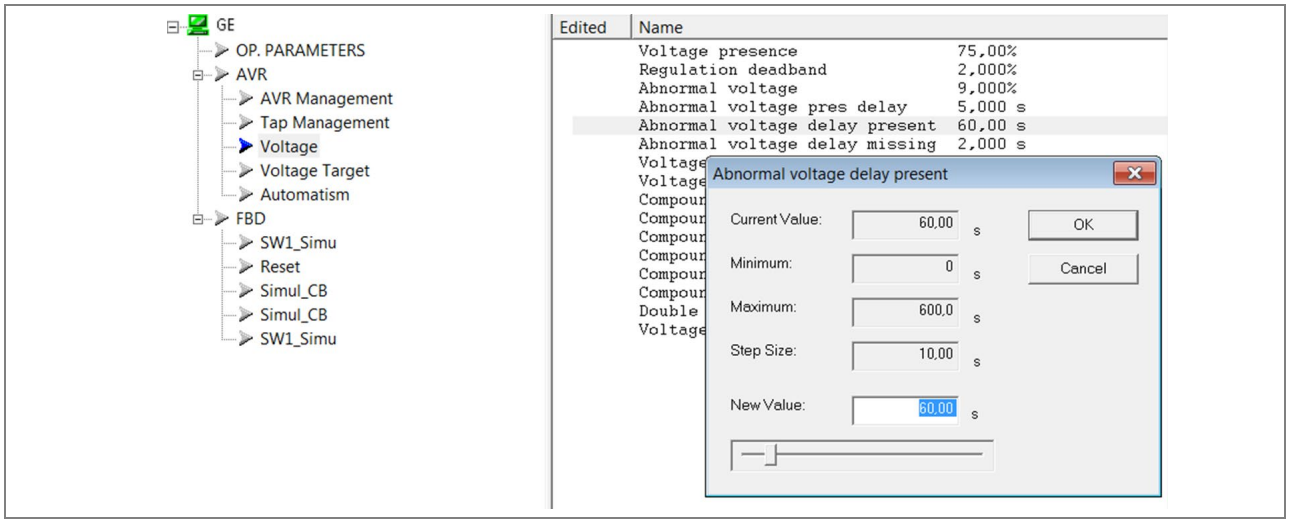
*When MiCOM S1 is used online (i.e connected to a C264), the "**IP address**" cannot be modified.*

To edit a setting:

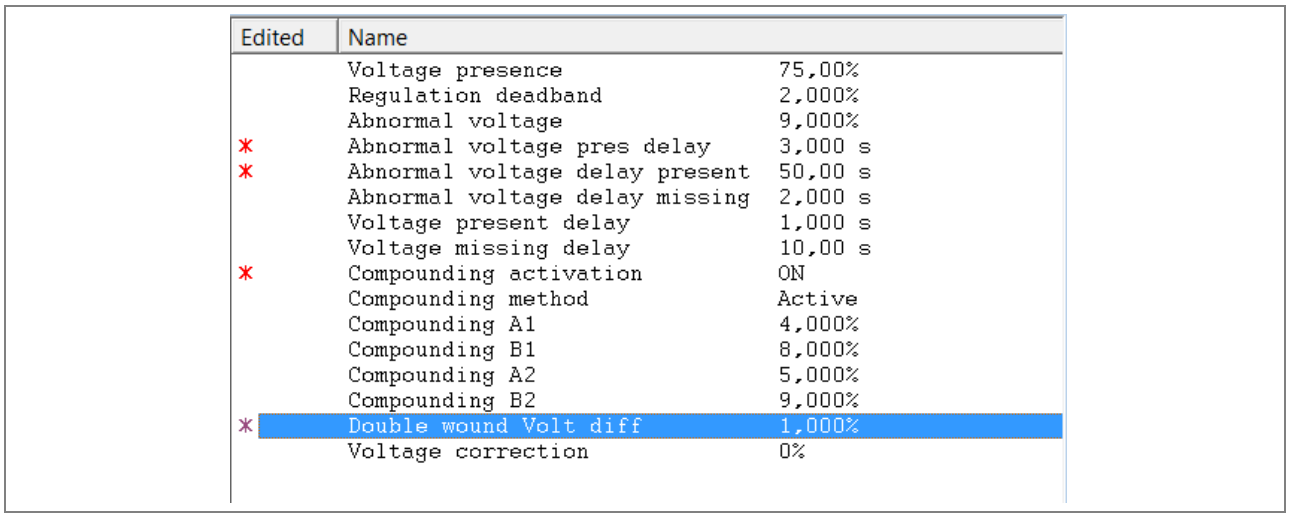
- Double click or right-click on the parameters and select **Edit**, as shown in below figures:



- Select the new value using the slider or the list or the spin buttons:



- After setting, a red star shows in the **Edited** column:



Edited	Name	
	Voltage presence	75,00%
	Regulation deadband	2,000%
	Abnormal voltage	9,000%
*	Abnormal voltage pres delay	3,000 s
*	Abnormal voltage delay present	50,00 s
	Abnormal voltage delay missing	2,000 s
	Voltage present delay	1,000 s
	Voltage missing delay	10,00 s
*	Compounding activation	ON
	Compounding method	Active
	Compounding A1	4,000%
	Compounding B1	8,000%
	Compounding A2	5,000%
	Compounding B2	9,000%
*	Double wound Volt diff	1,000%
	Voltage correction	0%

3.1.4 TRANSFERRING NEW SETTING VALUES

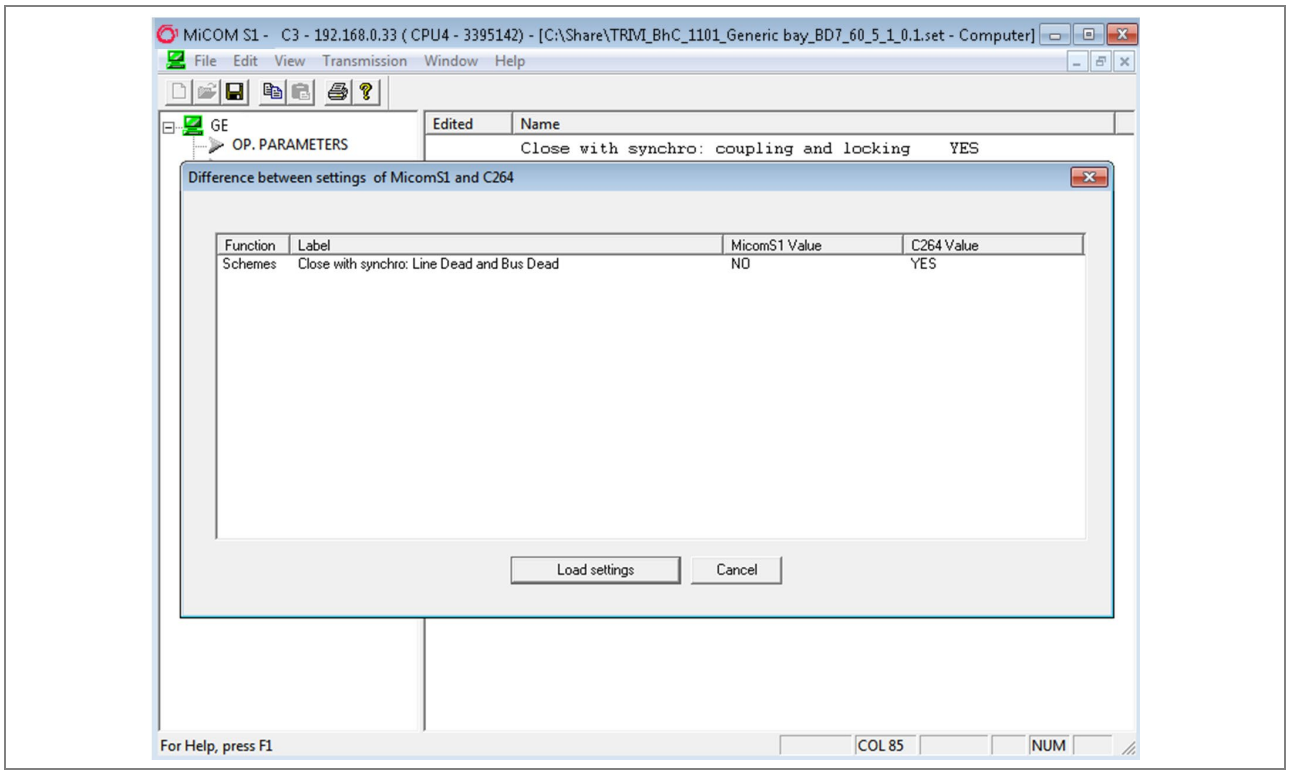
To transfer the settings file, click on **Transmission ➡ Set Settings**.

Before uploading the *.set file, MiCOM S1 compares the parameters already loaded in the C264 to those contained in the file you which to transfer.

- If no difference has been detected, MiCOM S1 will notify the user;
- if differences have been found, e.g. settings have changed, MiCOM S1 returns a comparison report containing the differences between the two files.

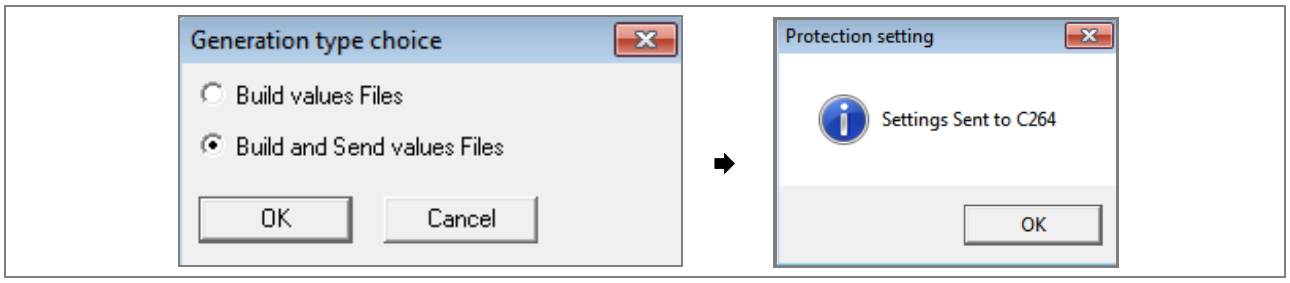
  The report indicates the following fields:

  - Function Name,
  - Setting label,
  - Setting value entered in MiCOM S1,
  - Setting value present on the C264.



After you have reviewed the differences, either click on:

- **Cancel** to stop the process
- **Load Settings** if you wish to send parameters to the C264. A popup prompts you to select how the setting file shall be generated. Select one of the following option:
  - **Build values Files**: the application indicates that a .val file is available; this allows to checkout the file before sending (see 3.6)
  - **Build and Send values files**: C26x fetches the file and acknowledges it positively or negatively



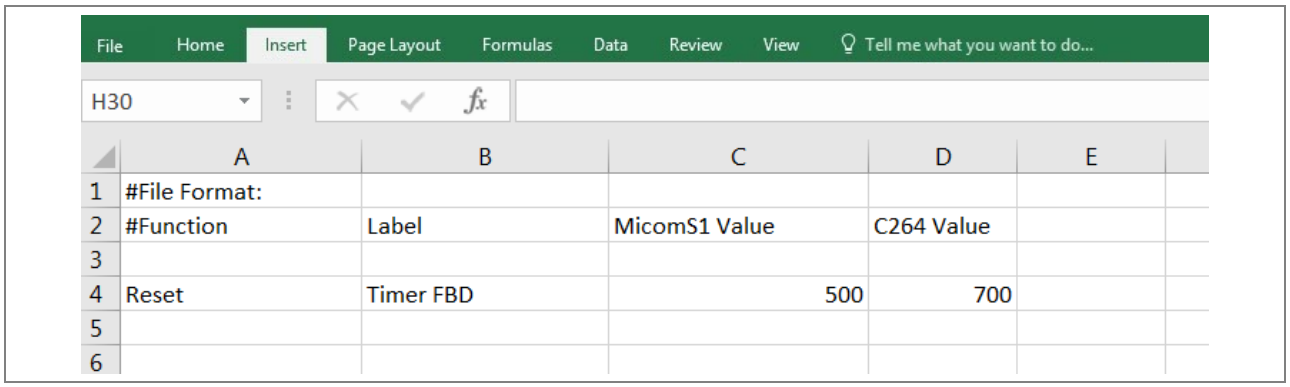
Once the setting file has been uploaded successfully to the C264, the comparison result is saved as an *.csv file in the folder where the setting file to be sent was located.

The filename is SETFILENAME_YYYYMMDD_HHMMSS.csv

Where:

- **SETFILENAME** is the setting file name (in the format [BCU-name]_[BAY-name.set])
- **YYYYMMDD** is the day when the result file was generated
- **HHMMSS** is the hour when the result file was generated

The comparison result file can be edited using Microsoft Excel ©:



	A	B	C	D	E
1	#File Format:				
2	#Function	Label	MicomS1 Value	C264 Value	
3					
4	Reset	Timer FBD	500	700	
5					
6					

The comparison result file is not saved if no difference is found between the setting file of the C266 and that of MS1 or if an error occurred when loading the file to the C264 (for instance, if an automation is in progress).

3.2 LISTS OF PARAMETERS

The parameters list includes if applicable:

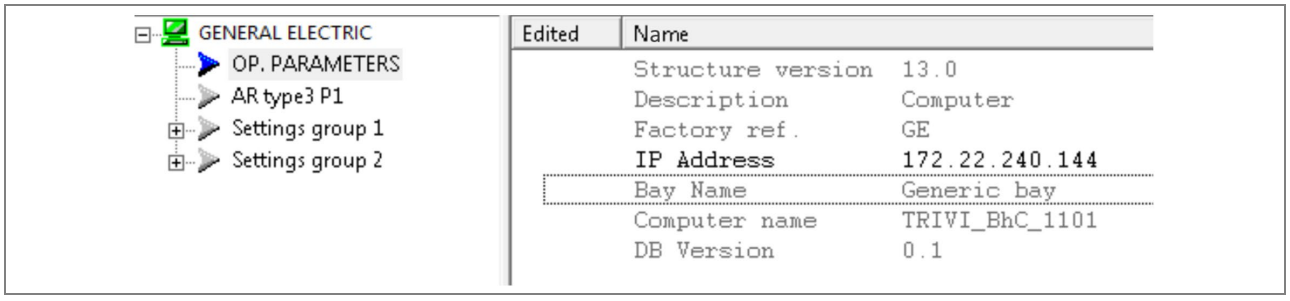
- OP
- Protection Config
- Protection Group 1
- Protection Group N
- AVR
- Auto-Recloser bay 1
- Auto-Recloser bay N
- Synchrocheck
- ISaGRAF Automatism 1
- ISaGRAF Automatism N
- PSL Automatism 1
- PSL Automatism M

Built-in functions such as ISaGRAF, PSL automatism (FBD …), AVR and Auto-Recloser are configured in SCE. It is possible to set the following functions:

- Automates' built-in as autorecloser, AVR (if applicable), synchrocheck (if applicable), protective function implemented for DS Agile
- ISaGRAF: (float or integer threshold & Boolean)
- Two kinds of parameters in FBD: The timeout used for (Ton / Toff) and the parameter (Boolean) validation

3.2.1 OP PARAMETERS

- Structure version: number of the data structure of settings used by the SCE to generate all the .set files with respect to a DB. It represents the template of all the settings that can be configured from the SCE. The C264 checks this number to be sure that structure of settings files loaded in the C264 matches the C264 software version.
  - The structure version remains the same between two databases generated with the same SCE.
  - The structure version changes only if the structure of settings has changed (for instance when a new feature with new settings is implemented in the SCE).



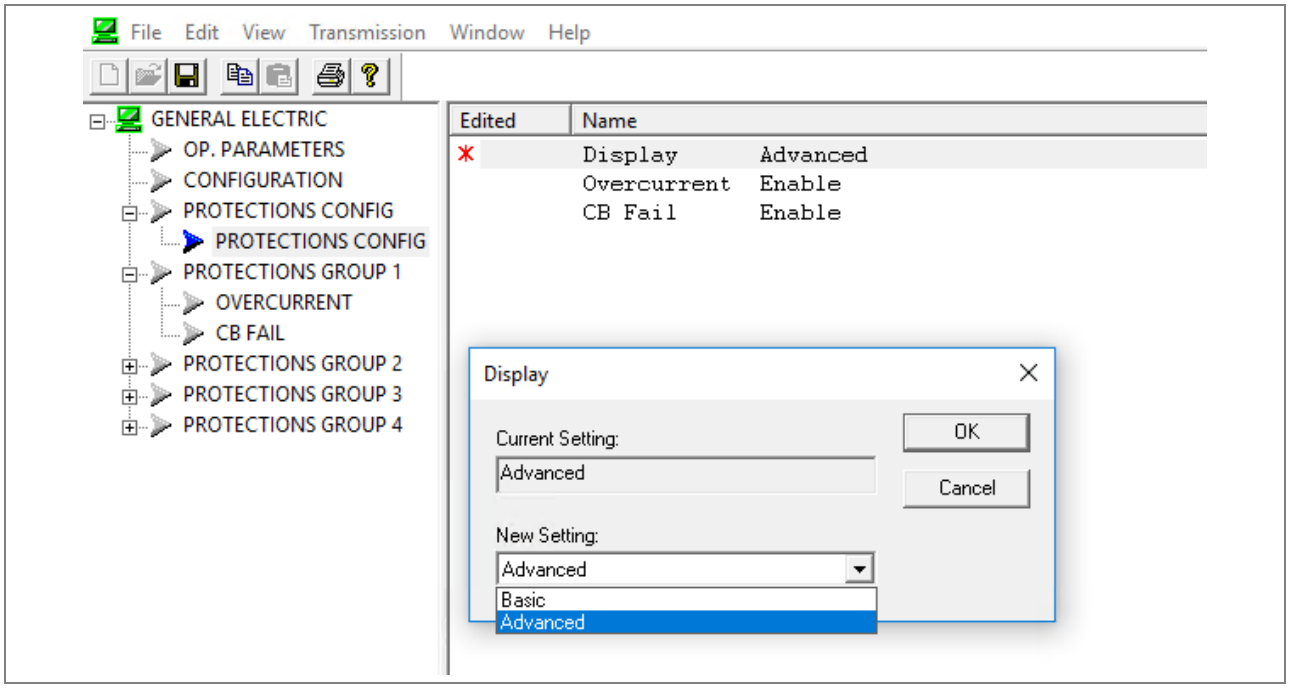
3.2.2 PROTECTION CONFIG

The C26x provides protection functions.

The Overcurrent and the Circuit breaker failure protection settings can be modified via MiCOM S1.

The protection setting display mode is set to **Basic** by default.

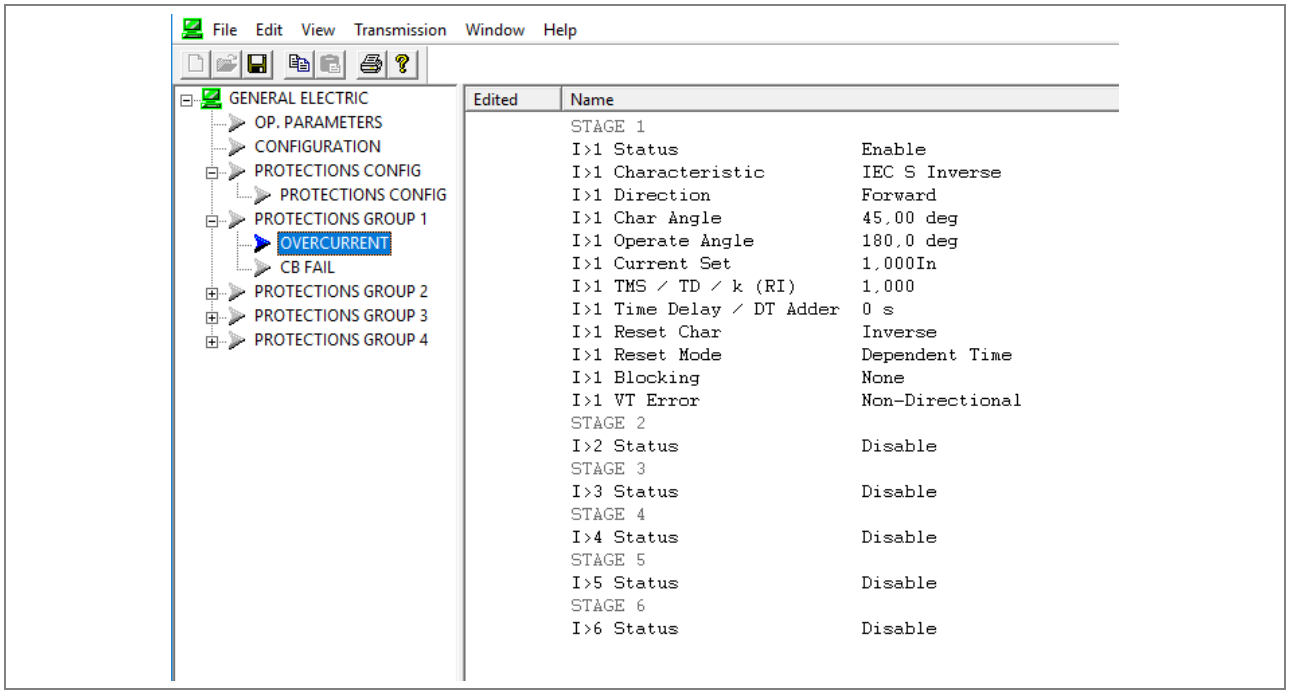
- Double click or right-click on **Display** and select **Advanced** to see all available protection parameters (see next section for details):



- **Overcurrent**: Enable/disable the Overcurrent protection (Enable by default)
- **CB Fail**: Enable/disable the Overcurrent protection (Enable by default)

3.2.3 PROTECTION GROUP 1…N

When the **Display** parameter (in the **Protection Config** node) is set to **Advanced**, the following protection settings appear in the **Protection Group**.

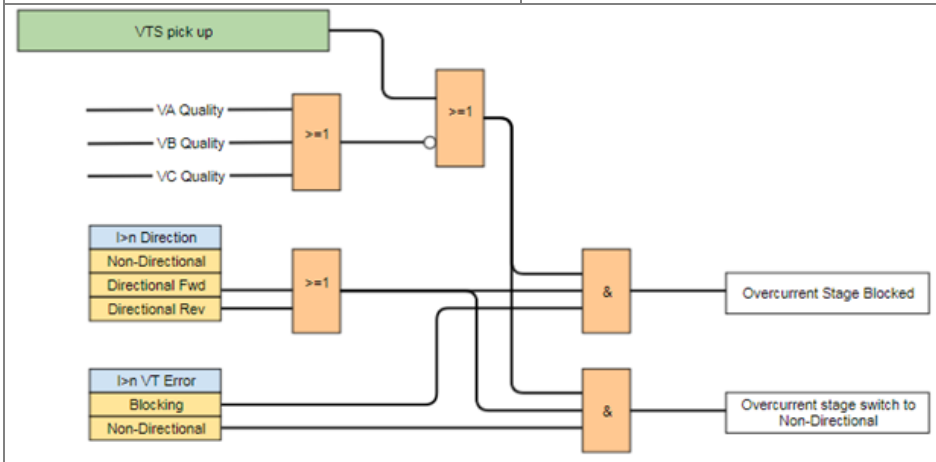


3.2.3.1 OVERCURRENT SETTINGS

*Note: In the table below, n represents one stage (from n1 to n6) according to configuration. Refer to the **Functional Description** chapter for additional information about the Overcurrent protection function and settings.*

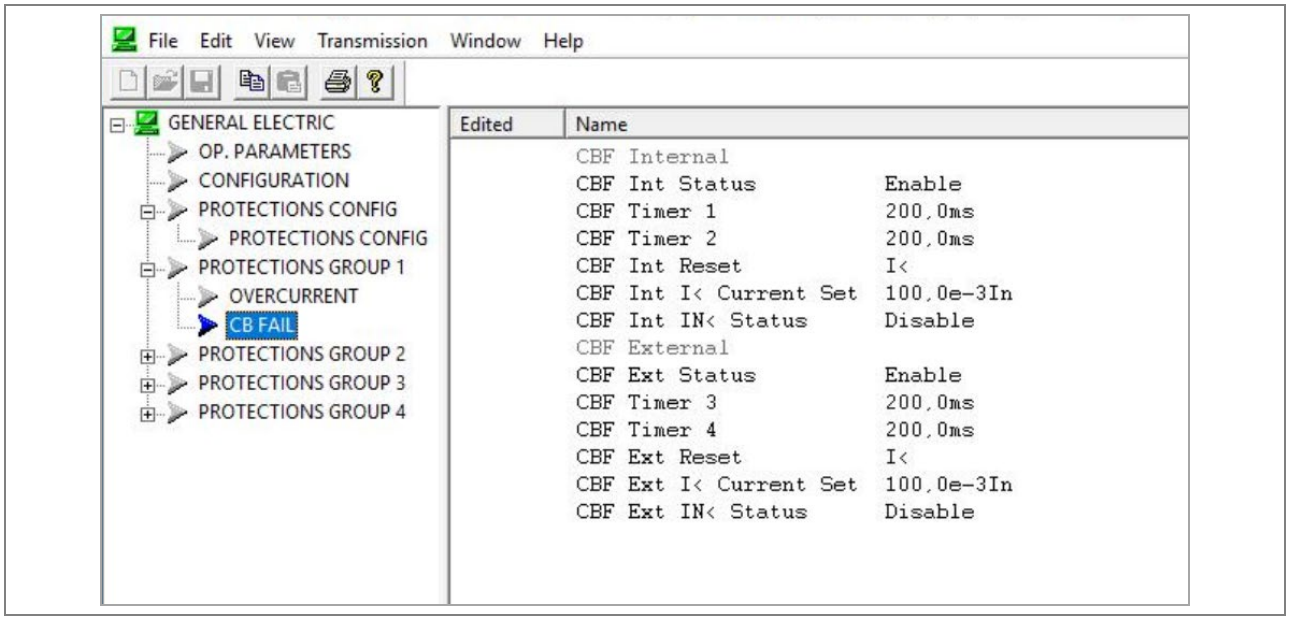
Setting	Description	Range
I>n Status	Enables/disables the Phase overcurrent stage.	• **Enable** (default value), • **Disable**
I>n Characteristic	Sets the characteristic (DT or IDMT) of the stage.	• **DT** (default value) • **IEC standard inverse** • **IEC very inverse** • **IEC extremely inverse** • **UK long time inverse** • **UK rectifier** • **Rapid inverse** • **IEEE moderately inverse** • **IEEE very inverse** • **IEEE extremely inverse** • **US inverse** • **US short time inverse** • **ANSI normal inverse** • **ANSI short time inverse** • **ANSI long time inverse** • **ANSI very inverse** • **ANSI extremely inverse**

I>n Direction	Defines the direction of fault to be considered. If the calculated direction is different from configured direction, then start and operate signals will not pick-up.	• **Non-Directional** (default value) • **Directional Fwd** • **Directional Rev**
I>n Char Angle	Defines the characteristic angle for the directional element. This setting is only shown in **Advanced** display mode.	From -180 to 180°, in steps of 1° Default: 45°
I>n Operate Angle	Defines the opening angle of the forward or reverse operate zone. This setting is only shown in **Advanced** display mode.	From 0 to 180° in steps of 1° Default: 180°
I>n Current Set	Sets the pick-up threshold of Phase TOC stage. This setting associated with time setting has to be defined in accordance with hardware capacity of the device. Visible if ("I>n Status=Enable")	From 0.05 to 40.00 x In in steps of 0.01 x In Default: 1.00 x In
I>n Time Delay / DT Adder	This setting is a factorization of 2 settings: • **Time Delay**, to define a time delay for DT characteristic • **DT Adder**, to add an additional fixed time delay to an IDMT Operate characteristic.	0 to 10s in steps of 0.01s Default: 1s
I>n TMS / TD / k(RI)	This setting is a factorization of 3 settings: • **TMS**, Time Multiplier Setting to adjust operate time of IEC or UK IDMT characteristic • **TD**, Time Multiplier Setting to adjust operate time of IEEE or US IDMT characteristic • k(RI), Time Multiplier Setting to adjust operate time of RI characteristic.	0.001 to 10s in steps of 0.001s Default: 1s
I>n Reset Char	This setting is a selection of a Definite Time (DT) or Inverse reset time for IEEE/US curves. • If DT reset is selected, the Phase TOC stage will reset after a time delay provided by “I>n tReset” setting. • If Inverse reset is selected, the time to reset is calculated based on the reset equation for the selected inverse curve	• Inverse (default value), • DT
I>n Reset Mode	This setting is based on IEC 60255-151 reset characteristics. • If Definite Time is selected, the relay shall return to its reset state after a user-defined reset time delay, i.e., Reset Time. During the reset time, the element shall retain its state value. • If Dependent Time is selected, the relay shall return to its reset state after a user-defined reset time delay, i.e., Reset Time. During the reset time, the timer will be decremented.	• Definite Time, • Dependent Time (default value)
I>n tReset	This setting defines the Reset time for the Definite Time Reset characteristic	From 0 to 10s in steps of 0.01s Default: 0s

I>n Blocking	Block will reset the pickup operand, if element is not operated. If element is operated, it does not have any effect	• None (default value), • AR
I>n VT Error	This setting defines the behavior of OC stage when Directional is selected and a problem occur on a VT. Two possible causes to detect VT issues are: VTS pick up and bad voltage quality	Block (default value), Non-Directional
		

3.2.3.2 CB FAIL SETTINGS

*Note: Refer to the **Functional Description** chapter for additional information about the CB failure protection implementation and settings.*



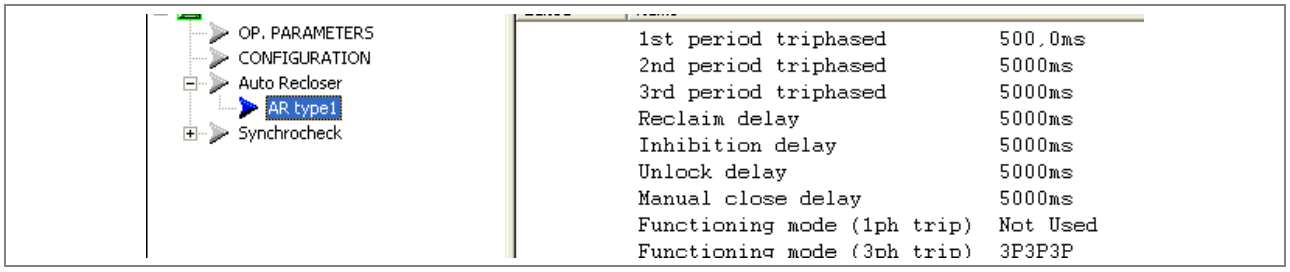
Setting	Description	Range
CBF Int Status	Enables/disables the Internal Circuit Breaker Failure protection	• Enable (default value), • Disable
CBF Timer 1	Defines the time before to raise an internal retrip signal Visible if "CB Fail" = Enable	From 0.00 to 50.00s in steps of 0.01s Default: 0.20s
CBF Timer 2	Defines the time before to raise an internal backtrip signal Visible if "CB Fail" = Enable	From 0.00 to 50.00s in steps of 0.01s Default: 0.20s
CBF Int Reset	Defines the condition to reset the circuit breaker fail protection initiated by internal condition. • If this setting is set to "I<" or "I< & CB Open" and "Int IN< Status" is enabled, both undercurrent (phase and ground) have to be detected to reset CB Fail. • If this setting is set to "I<" or "I< & CB Open" and "Int IN< Status" is disabled, only phase undercurrent has to be detected to reset CB Fail. Visible if "CB Fail" = Enable	• I< (default value) • CB Open • I< & CB Open
CBF Int I< Current Set	Defines the threshold for phase undercurrent used to reset circuit breaker fail protection initiated by internal condition Visible if "Int CBF Reset" <> CB Open	From 0.05 to 4.00 x In in steps of 0.01 x In Default: 0.10 x In
CBF Int IN< Status	Enables/disables monitoring of ground current. This monitoring should be used only with measured current. Visible if "CB Fail" = Enable	• Enable • Disable (default value)

Setting	Description	Range
CBF Int IN< Current Set	Defines the threshold for ground undercurrent used to reset circuit breaker fail protection initiated by internal condition Visible if ("Int CBF Reset" <> CB Open) and (Int IN< Status = enable)	From 0.05 to 4.00 x In in steps of 0.01 x In Default: 0.10 x In

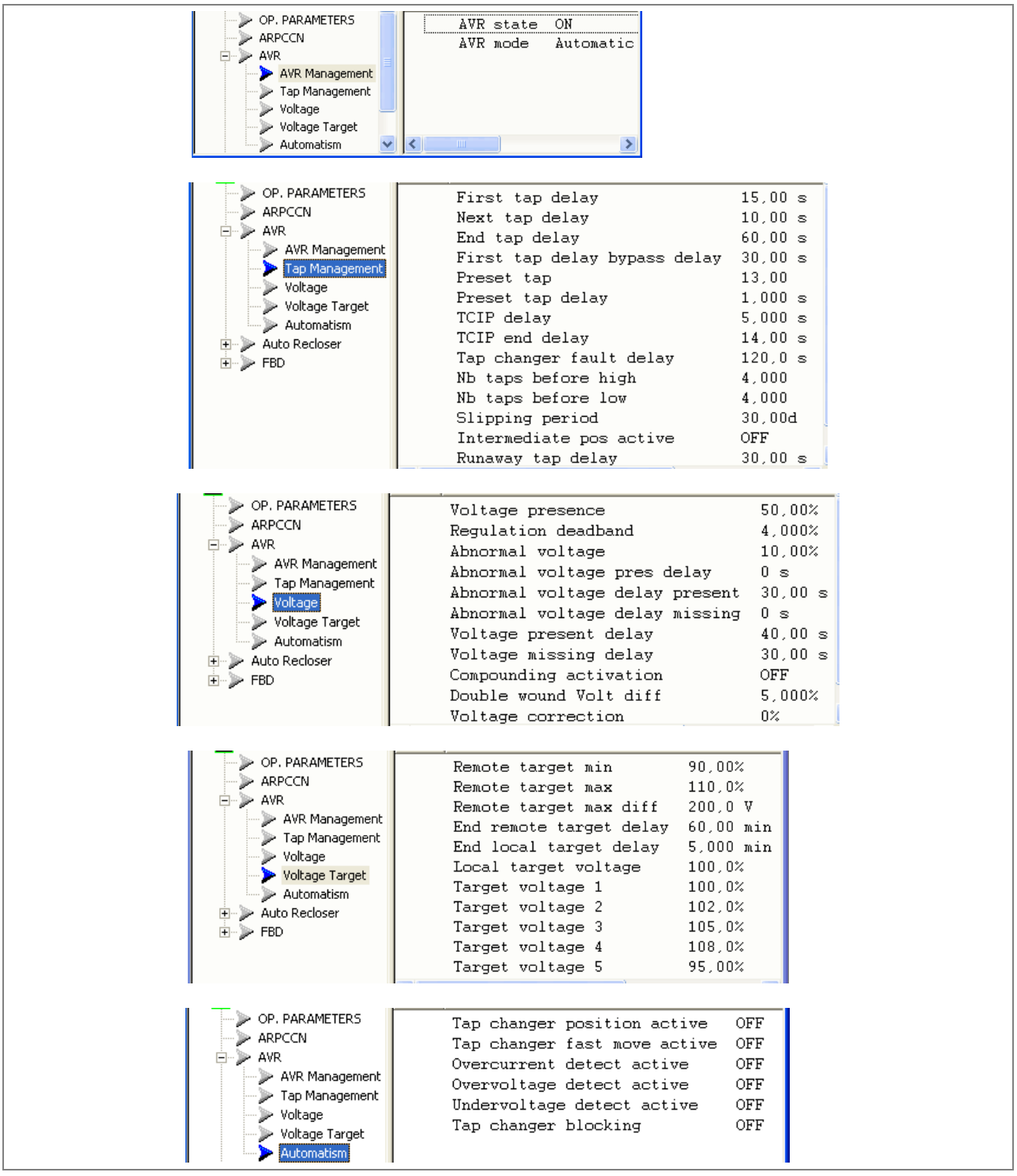
Setting	Description	Range
CBF Ext Statuse	Enables/disables the External Circuit Breaker Failure protection	• Enable (default value), • Disable
CBF Timer 3	Defines the time before to raise an external retrip signal Visible if "CB Fail" = Enable	From 0.00 to 50.00s in steps of 0.01s Default: 0.20s
CBF Timer 4	Defines the time before to raise an external backtrip signal Visible if "CB Fail" = Enable	From 0.00 to 50.00s in steps of 0.01s Default: 0.20s
CBF Ext Reset	Defines the condition to reset the circuit breaker fail protection initiated by external condition. • If this setting is set to "I<" or "I< & CB Open" and "Ext IN< Status" is enabled, both undercurrent (phase and ground) have to be detected to reset CB Fail. • If this setting is set to "I<" or "I< & CB Open" and "Ext IN< Status" is disabled, only phase undercurrent has to be detected to reset CB Fail. Visible if "CB Fail" = Enable	• I< (default value) • CB Open • I< & CB Open
CBF Ext I< Current Set	Defines the threshold for undercurrent used to reset circuit breaker fail protection initiated by external condition. Visible if "Ext CBF Reset" <> CB Open	From 0.05 to 4.00 x In in steps of 0.01 x In Default: 0.10 x In
CBF Ext IN< Status	Enable/disable monitoring of ground current. This monitoring should be used only with measured current. Visible if "CB Fail" = Enable	• Enable • Disable (default value)
CBF Ext IN< Current Set	Defines the threshold for ground undercurrent used to reset circuit breaker fail protection initiated by external condition Visible if ("Ext CBF Reset" <> CB Open) and (Ext IN< Status = enable)	From 0.05 to 4.00 x In in steps of 0.01 x In Default: 0.10 x In

3.2.4 AUTORECLOSER (TYPE 1) PARAMETERS

- Ist period triphased time min = 100, max = 60000, step = 10
- 2nd period triphased time min = 1000, max = 3600000, step = 10
- 3rd period triphased time min = 1000, max = 3600000, step = 1000
- Reclaim delay time min = 1000, max = 600000, step = 1000
- Inhibition delay min = 1000, max = 3600000, step = 1000
- Unlock delay min = 1000, max = 600000, step = 1000
- Manual close delay min = 1000, max = 600000, step = 1000
- Functioning mode (1 ph trip) types = 1P, 1P-3P, 1P-3P-3P, 1P-3P-3P-3P
- Functioning mode (3 ph trip) types = 3P, 3P-3P, 3P-3P-3P, 3P-3P-3P-3P



3.2.5 AVR PARAMETERS



To view the range allowed for each parameter, refer to the chapter C26x/EN AP.

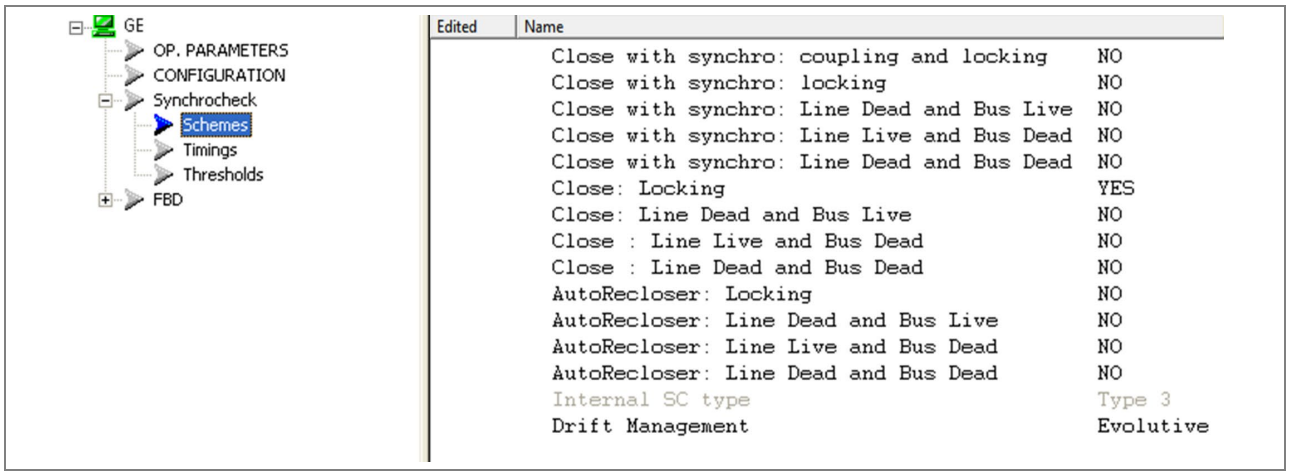
3.2.6 INTERNAL SYNCHROCHECK PARAMETERS

3.2.6.1 STANDARD TOPOLOGY (TYPE 4)

Note:
Not all the settings below are available or effective for all the S/C types. See Functional Description *chapter (*C26x/EN FT*) for details.*

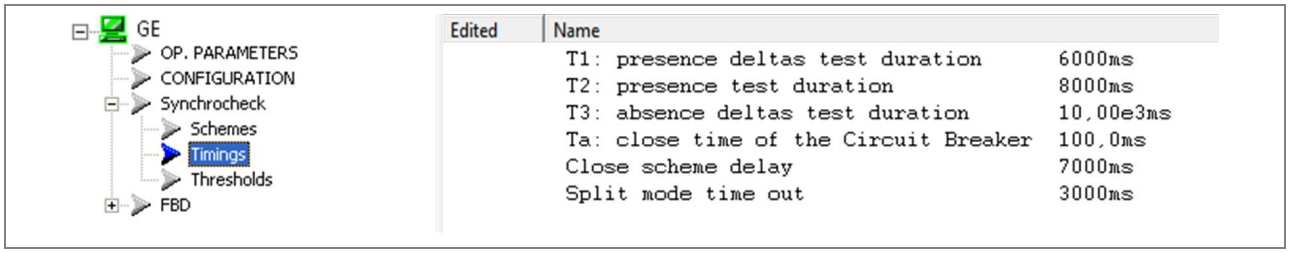
Schemes

- Close with synchro: Coupling and locking = YES/NO
- Close with synchro: Locking = YES/NO
- Close with synchro: Line Dead and Bus Live = YES/NO
- Close with synchro: Line Live and Bus Dead = YES/NO
- Close with synchro: Line Dead and Bus Dead = YES/NO
- Close: Locking = YES/NO
- Close: Line Dead and Bus Live = YES/NO
- Close: Line Live and Bus Dead = YES/NO
- Close: Line Dead and Bus Dead = YES/NO
- Autorecloser Locking = YES/NO
- Autorecloser Line Dead and Bus Live: = YES/NO
- Autorecloser Line Live and Bus Dead: = YES/NO
- Autorecloser Line Dead and Bus Dead = YES/NO
- Internal SC type = Type 1/Type 2/Type 3/Type 4 (not settable)
- Drift Management = Evolutive/Exclusive/Split (not settable)



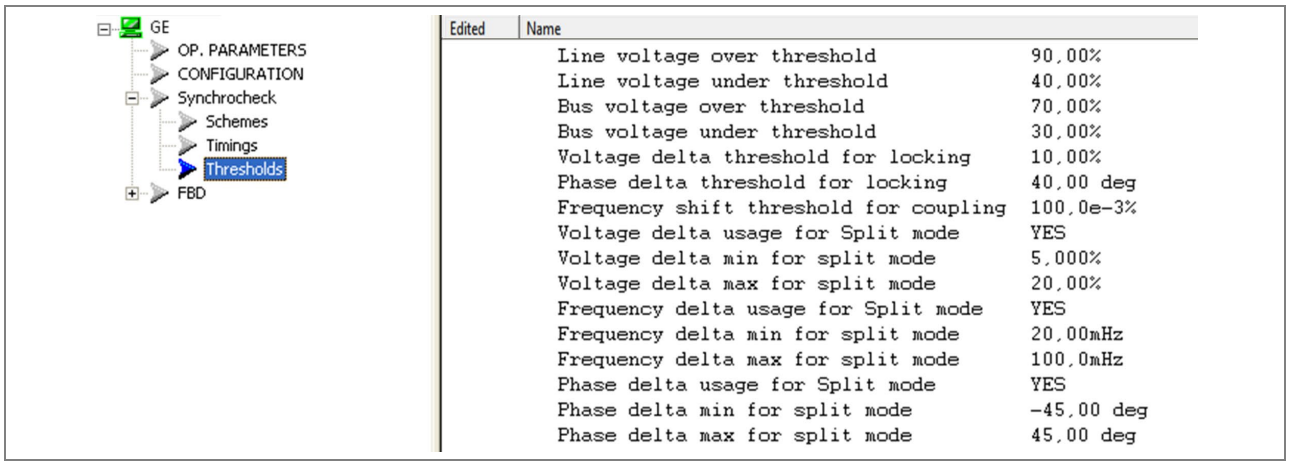
Timings

- T1: presence deltas test duration: min = 20 ms, max = 10000 ms, step = 10 ms
- T2: presence test duration: min = 200 ms, max = 10000 ms, step = 20 ms
- T3: absence deltas test duration: min = 200 ms, max = 10000 ms, step = 20 ms
- Ta: close time of circuit breaker: min = 0 ms, max = 1000 ms, step = 10 ms
- Delay for coupling: min = 1 s, max = 3600 s, step = 1 s
- Close with synchro scheme delay: min = 200 ms, max = 10000 ms, step = 10 ms
- Close scheme delay: min = 200 ms, max = 10000 ms, step = 10 ms
- Autorecloser scheme delay: min = 200 ms, max = 10000 ms, step = 10 ms
- Split mode time out: min = 0 ms, max = 10000 ms, step = 100 ms
- Control rejection time out: min = 0 s, max = 60 s, step = 1 s



Thresholds

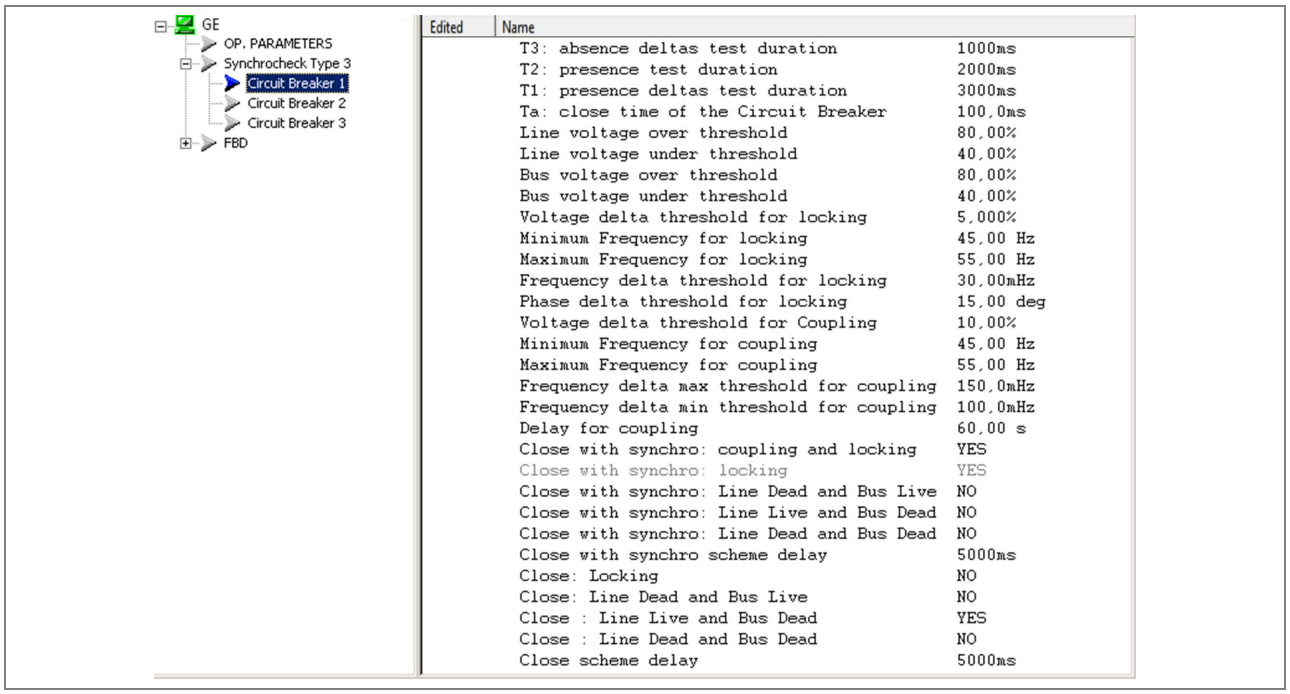
- Line voltage over threshold: min = 0, max = 100 % Vn, step = 1 % Vn
- Line voltage under threshold: min = 0, max = 100 % Vn, step = 1 % Vn
- Bus voltage over threshold: min = 0, max = 100 % Vn, step = 1 % Vn
- Bus voltage under threshold: min = 0, max = 100 % Vn, step = 1 % Vn
- Voltage delta threshold for locking: min = 0, max = 100 % Vn, step = 1 % Vn
- Minimum frequency for locking: min = 45.5 Hz, max = 59.5 Hz, step = 0.1 Hz
- Maximum frequency for locking: min = 50.5 Hz, max = 66 Hz, step = 0.1 Hz
- Frequency delta threshold for locking: min = 0, max = 1 Hz, step = 0.01 Hz
- Phase delta threshold for locking: min = 0, max = 90°, step = 1°
- Frequency shift threshold for locking: min = 0.02 Hz, max = 0.1 Hz, step = 0.01 Hz
- Voltage delta threshold for coupling: min = 0, max = 100 % Vn, step = 1 % Vn
- Minimum frequency for coupling: min = 45.5 Hz, max = 59.5 Hz, step = 0.1 Hz
- Maximum frequency for coupling: min = 50.5 Hz, max = 66 Hz, step = 0.1 Hz
- Minimum frequency delta threshold for coupling: min = 0, max = 1 Hz, step = 0.01 Hz
- Maximum frequency delta threshold for coupling: min = 0, max = 1 Hz, step = 0.01 Hz
- Phase delta threshold for coupling: min = 0, max = 90°, step = 1°
- Frequency shift threshold for coupling: min = 0.02 %, max = 0.1 %, step = 0.01 %
- Voltage delta usage for Split mode: NO/YES
- Voltage delta min for split mode: min = 0, max = 100 % Vn, step = 1 % Vn
- Voltage delta max for split mode: min = 0, max = 100 % Vn, step = 1 % Vn
- Frequency delta usage for Split mode: NO/YES
- Frequency delta min for split mode: min = 0, max = 1 Hz, step = 0.01 Hz
- Frequency delta max for split mode: min = 0, max = 1 Hz, step = 0.01 Hz
- Phase delta usage for Split mode: NO/YES
- Phase delta min for split mode: min = -180, max = 0°, step = 1°
- Phase delta max for split mode: min = 0, max = 180°, step = 1°
- Over Voltage threshold: min = 100 % Vn, max = 150 % Vn, step = 1 % Vn


GE
OP. PARAMETERS
CONFIGURATION
Synchrocheck
Schemes
Timings
Thresholds
FBD
Edited
Name
Line voltage over threshold 90,00%
Line voltage under threshold 40,00%
Bus voltage over threshold 70,00%
Bus voltage under threshold 30,00%
Voltage delta threshold for locking 10,00%
Phase delta threshold for locking 40,00 deg
Frequency shift threshold for coupling 100,0e-3%
Voltage delta usage for Split mode YES
Voltage delta min for split mode 5,000%
Voltage delta max for split mode 20,00%
Frequency delta usage for Split mode YES
Frequency delta min for split mode 20,00mHz
Frequency delta max for split mode 100,0mHz
Phase delta usage for Split mode YES
Phase delta min for split mode -45,00 deg
Phase delta max for split mode 45,00 deg

3.2.6.2 BREAKER-AND-A-HALF TOPOLOGY (TYPE3)

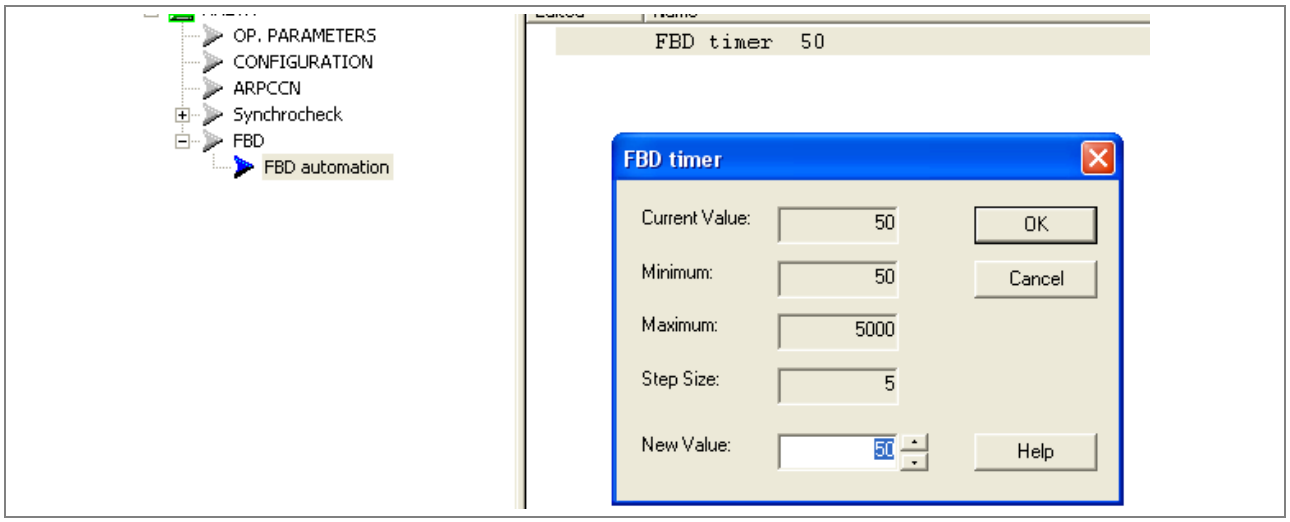
Circuit Breaker x (x = 1, 2 or 3)

- T3: absence deltas test duration: min = 200 ms, max = 10000 ms, step = 20 ms
- T2: presence test duration: min = 200 ms, max = 10000 ms, step = 20 ms
- T1: presence deltas test duration: min = 20 ms, max = 10000 ms, step = 10 ms
- Ta: close time of the Circuit Breaker: min = 0 ms, max = 1000 ms, step = 10 ms
- Line voltage over threshold: min = 0, max = 100 % Vn, step = 1 % Vn
- Line voltage under threshold: min = 0, max = 100 % Vn, step = 1 % Vn
- Bus voltage over threshold: min = 0, max = 100 % Vn, step = 1 % Vn
- Bus voltage under threshold: min = 0, max = 100 % Vn, step = 1 % Vn
- Voltage delta threshold for locking: min = 0, max = 100 % Vn, step = 1 % Vn
- Minimum Frequency for locking: min = 45.5 Hz, max = 59.5 Hz, step = 0.1 Hz
- Maximum Frequency for locking: min = 50.5 Hz, max = 66 Hz, step = 0.1 Hz
- Frequency delta threshold for locking: min = 0, max = 1 Hz, step = 0.01 Hz
- Phase delta threshold for locking: min = 0, max = 90°, step = 1°
- Voltage delta threshold for Coupling: min = 0, max = 100 % Vn, step = 1 % Vn
- Minimum Frequency for coupling: min = 45.5 Hz, max = 59.5 Hz, step = 0.1 Hz
- Maximum Frequency for coupling: min = 50.5 Hz, max = 66 Hz, step = 0.1 Hz
- Frequency delta max threshold for coupling: min = 0, max = 1 Hz, step = 0.01 Hz
- Frequency delta min threshold for coupling: min = 0, max = 1 Hz, step = 0.01 Hz
- Delay for coupling: min = 1 s, max = 3600 s, step = 1 s
- Close with synchro: coupling and locking: YES/NO
- Close with synchro: locking: YES/NO
- Close with synchro: Line Dead and Bus Live: YES/NO
- Close with synchro: Line Live and Bus Dead: YES/NO
- Close with synchro: Line Dead and Bus Dead: YES/NO
- Close with synchro scheme delay: min = 0.2 s, max = 10 s, step = 0.01 s
- Close: Locking: YES/NO
- Close: Line Dead and Bus Live: YES/NO
- Close: Line Live and Bus Dead: YES/NO
- Close: Line Dead and Bus Dead: YES/NO
- Close scheme delay: min = 0.2 s, max = 10 s, step = 0.01 s

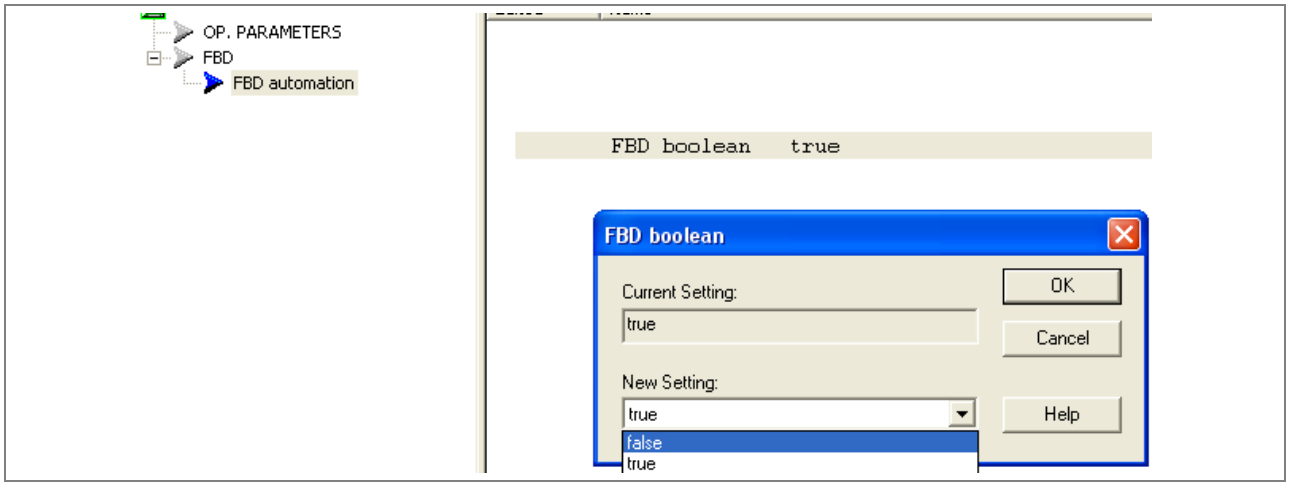


3.2.7 FBD PARAMETERS

FBD Timer:



FBD Boolean: True/false



3.3 MICOM S1 MESSAGES

Receipt value	MiCOM S1 messages
0	Setting done
1	Incorrect C26x DB Version revision
2	Number of protections incoherent with DB
3	No setting file in the C26x
4	FTP server problem. Verify that the FTP client is launched & try again
5	C26x internal error
6	C26x incorrect number
7	Setting impossible, command running
8	Error IED address
9	Incompatible data structure
10	IED setting failed
11	Compatibility error between C26x and SCE
12	Number of columns of the .VAL file incorrect
13	Error: label too long
14	Error PROTECTIONS C26x: Value not between MIN and MAX
15	Error ELECTRE d: Value not between MIN and MAX
16	Error FBD: Value not between MIN and MAX
17	Error ISaGRAF: Value not between MIN and MAX
18	Error AUTO RECLOSER: Value not between MIN and MAX
19	Error AUTO RECLOSER PCCN: Value not between MIN and MAX
20	Error SYNCHROCHECK: Value not between MIN and MAX *
21	Error AVR: Value not between MIN and MAX
22	Error PROTECTIONS C26x: Verification phase incorrect
23	Error ELECTRE d: Verification phase incorrect
24	Error FBD: Verification phase incorrect
25	Error ISaGRAF: Verification phase incorrect

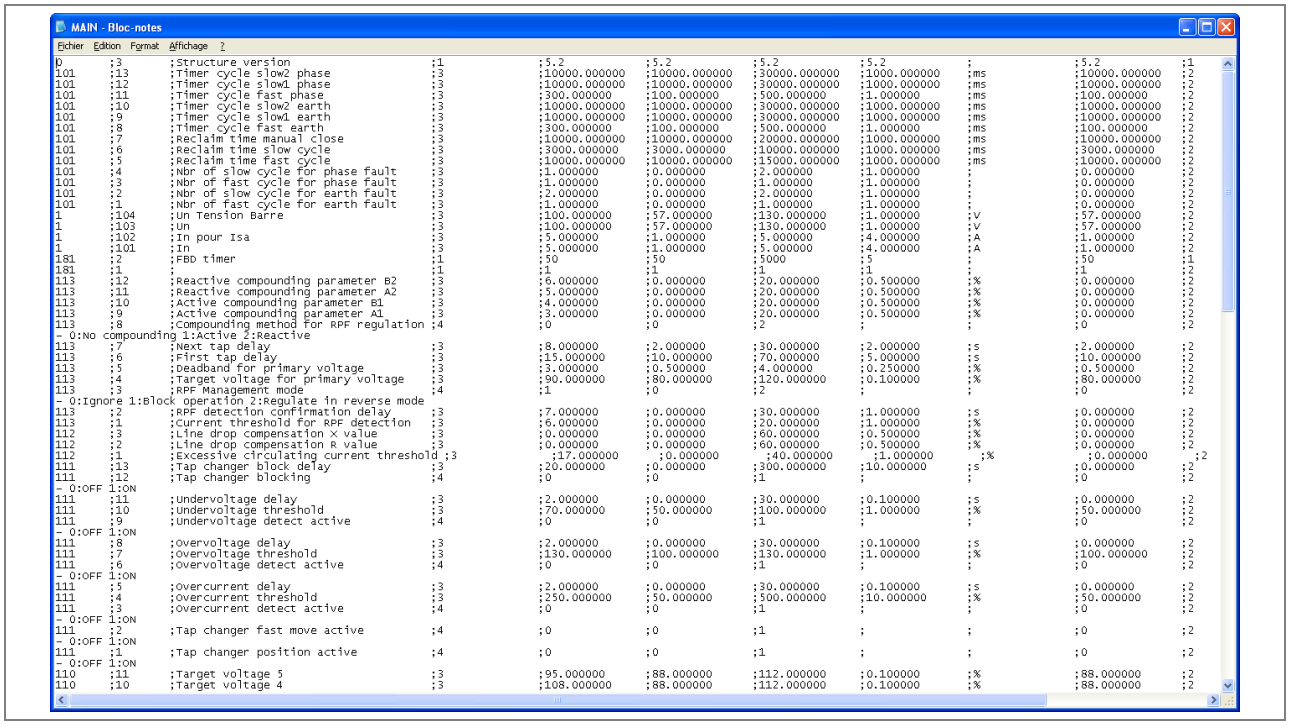
Receipt value	MiCOM S1 messages
26	Error AUTO RECLOSER: Verification phase incorrect
27	Error AUTO RECLOSER PCCN: Verification phase incorrect
28	Error SYNCHROCHECK: Verification phase incorrect
29	Error AVR: Verification phase incorrect
30	Error: File OK but a problem occurred during file copy
31	Error: Setting file for CPU270 board sent to a CPU260 board (obsolete)
32	Error in file checksum
33	Error: MiCOM S1 task not present
34	Error: Trip in progress A MiCOM S1 session is already used

* This message might pop up without any reason. To make sure there is no reason, extract the .set file from the zip archive and open it directly in MiCOM S1and repeat the transfer.

3.4 VAL FILE

The .val files are ASCII files generated on the desktop using the menu Transmission>Set settings. They can be opened using a text editor and saved for records.

Example:




```
0       ;3      ;Structure version                      ;1      ;5.2            ;5.2            ;5.2            ;5.2            ;               ;5.2            ;1
101     ;13     ;Timer cycle slow2 phase                ;3      ;10000.000000   ;10000.000000   ;30000.000000   ;1000.000000    ;ms             ;10000.000000   ;2
101     ;12     ;Timer cycle slow1 phase                ;3      ;10000.000000   ;10000.000000   ;30000.000000   ;1000.000000    ;ms             ;10000.000000   ;2
101     ;11     ;Timer cycle fast phase                 ;3      ;300.000000     ;100.000000     ;500.000000     ;1.000000       ;ms             ;100.000000     ;2
101     ;10     ;Timer cycle slow2 earth                ;3      ;10000.000000   ;10000.000000   ;30000.000000   ;1000.000000    ;ms             ;10000.000000   ;2
101     ;9      ;Timer cycle slow1 earth                ;3      ;10000.000000   ;10000.000000   ;30000.000000   ;1000.000000    ;ms             ;10000.000000   ;2
101     ;8      ;Timer cycle fast earth                 ;3      ;300.000000     ;100.000000     ;500.000000     ;1.000000       ;ms             ;100.000000     ;2
101     ;7      ;Reclaim time manual close              ;3      ;10000.000000   ;10000.000000   ;20000.000000   ;1000.000000    ;ms             ;10000.000000   ;2
101     ;6      ;Reclaim time slow cycle                ;3      ;3000.000000    ;3000.000000    ;10000.000000   ;1000.000000    ;ms             ;3000.000000    ;2
101     ;5      ;Reclaim time fast cycle                ;3      ;10000.000000   ;10000.000000   ;15000.000000   ;1000.000000    ;ms             ;10000.000000   ;2
101     ;4      ;Nbr of slow cycle for phase fault      ;3      ;1.000000       ;0.000000       ;2.000000       ;1.000000       ;               ;0.000000       ;2
101     ;3      ;Nbr of fast cycle for phase fault      ;3      ;1.000000       ;0.000000       ;1.000000       ;1.000000       ;               ;0.000000       ;2
101     ;2      ;Nbr of slow cycle for earth fault      ;3      ;2.000000       ;0.000000       ;2.000000       ;1.000000       ;               ;0.000000       ;2
101     ;1      ;Nbr of fast cycle for earth fault      ;3      ;1.000000       ;0.000000       ;1.000000       ;1.000000       ;               ;0.000000       ;2
1       ;104    ;Un Tension Barre                       ;3      ;100.000000     ;57.000000      ;130.000000     ;1.000000       ;V              ;57.000000      ;2
1       ;103    ;Un                                     ;3      ;100.000000     ;57.000000      ;130.000000     ;1.000000       ;V              ;57.000000      ;2
1       ;102    ;In pour Isa                            ;3      ;5.000000       ;1.000000       ;5.000000       ;4.000000       ;A              ;1.000000       ;2
1       ;101    ;In                                     ;3      ;5.000000       ;1.000000       ;5.000000       ;4.000000       ;A              ;1.000000       ;2
181     ;2      ;FBD timer                              ;1      ;50             ;50             ;5000           ;5              ;               ;50             ;1
181     ;1      ;                                       ;1      ;1              ;1              ;1              ;1              ;               ;1              ;2
113     ;12     ;Reactive compounding parameter B2      ;3      ;6.000000       ;0.000000       ;20.000000      ;0.500000       ;%              ;0.000000       ;2
113     ;11     ;Reactive compounding parameter A2      ;3      ;5.000000       ;0.000000       ;20.000000      ;0.500000       ;%              ;0.000000       ;2
113     ;10     ;Active compounding parameter B1        ;3      ;4.000000       ;0.000000       ;20.000000      ;0.500000       ;%              ;0.000000       ;2
113     ;9      ;Active compounding parameter A1        ;3      ;3.000000       ;0.000000       ;20.000000      ;0.500000       ;%              ;0.000000       ;2
113     ;8      ;Compounding method for RPF regulation  ;4      ;0              ;0              ;2              ;               ;               ;0              ;2
- 0:No compounding 1:Active 2:Reactive
113     ;7      ;Next tap delay                         ;3      ;8.000000       ;2.000000       ;30.000000      ;2.000000       ;s              ;2.000000       ;2
113     ;6      ;First tap delay                        ;3      ;15.000000      ;10.000000      ;70.000000      ;5.000000       ;s              ;10.000000      ;2
113     ;5      ;Deadband for primary voltage           ;3      ;3.000000       ;0.500000       ;4.000000       ;0.250000       ;%              ;0.500000       ;2
113     ;4      ;Target voltage for primary voltage     ;3      ;90.000000      ;80.000000      ;120.000000     ;0.100000       ;%              ;80.000000      ;2
113     ;3      ;RPF Management mode                    ;4      ;1              ;0              ;2              ;               ;               ;0              ;2
- 0:Ignore 1:Block operation 2:Regulate in reverse mode
113     ;2      ;RPF detection confirmation delay       ;3      ;7.000000       ;0.000000       ;30.000000      ;1.000000       ;s              ;0.000000       ;2
113     ;1      ;Current threshold for RPF detection    ;3      ;6.000000       ;0.000000       ;20.000000      ;1.000000       ;%              ;0.000000       ;2
112     ;3      ;Line drop compensation X value         ;3      ;0.000000       ;0.000000       ;60.000000      ;0.500000       ;%              ;0.000000       ;2
112     ;2      ;Line drop compensation R value         ;3      ;0.000000       ;0.000000       ;60.000000      ;0.500000       ;%              ;0.000000       ;2
112     ;1      ;Excessive circulating current threshold ;3     ;17.000000      ;0.000000       ;40.000000      ;1.000000       ;%              ;0.000000       ;2
111     ;13     ;Tap changer block delay                ;3      ;20.000000      ;0.000000       ;300.000000     ;10.000000      ;s              ;0.000000       ;2
111     ;12     ;Tap changer blocking                   ;4      ;0              ;0              ;1              ;               ;               ;0              ;2
- 0:OFF 1:ON
111     ;11     ;Undervoltage delay                     ;3      ;2.000000       ;0.000000       ;30.000000      ;0.100000       ;s              ;0.000000       ;2
111     ;10     ;Undervoltage threshold                 ;3      ;70.000000      ;50.000000      ;100.000000     ;1.000000       ;%              ;50.000000      ;2
111     ;9      ;Undervoltage detect active             ;4      ;0              ;0              ;1              ;               ;               ;0              ;2
- 0:OFF 1:ON
111     ;8      ;Overvoltage delay                      ;3      ;2.000000       ;0.000000       ;30.000000      ;0.100000       ;s              ;0.000000       ;2
111     ;7      ;Overvoltage threshold                  ;3      ;130.000000     ;100.000000     ;130.000000     ;1.000000       ;%              ;100.000000     ;2
111     ;6      ;Overvoltage detect active              ;4      ;0              ;0              ;1              ;               ;               ;0              ;2
- 0:OFF 1:ON
111     ;5      ;Overcurrent delay                      ;3      ;2.000000       ;0.000000       ;30.000000      ;0.100000       ;s              ;0.000000       ;2
111     ;4      ;Overcurrent threshold                  ;3      ;250.000000     ;50.000000      ;500.000000     ;10.000000      ;%              ;50.000000      ;2
111     ;3      ;Overcurrent detect active              ;4      ;0              ;0              ;1              ;               ;               ;0              ;2
- 0:OFF 1:ON
111     ;2      ;Tap changer fast move active           ;4      ;0              ;0              ;1              ;               ;               ;0              ;2
- 0:OFF 1:ON
111     ;1      ;Tap changer position active            ;4      ;0              ;0              ;1              ;               ;               ;0              ;2
- 0:OFF 1:ON
110     ;11     ;Target voltage 5                       ;3      ;95.000000      ;88.000000      ;112.000000     ;0.100000       ;%              ;88.000000      ;2
110     ;10     ;Target voltage 4                       ;3      ;108.000000     ;88.000000      ;112.000000     ;0.100000       ;%              ;88.000000      ;2
```

Each line (maximum size: 256 characters) represents a setting.

Each setting is made of 7 fields:

- name (character string)
- type of the parameter (1, 2 or 3) where:
  - 1 is for INT32
  - 2 is for UINT32
  - 3 is for REAL32
- value (based on the type)
- minimum value (based on the type)
- maximum value (based on the type)
- step (based on the type)
- unit
- default value (based on the type)

The maximum size of a field is 32 characters.

Each member of the parameter record is delimited by “;”.

Comments can be added to the file using the character #.

All the lines starting with #, ' ' , LF or CR are ignored.

HUMAN INTERFACE

C26X/EN HI/E72D

Contents

1	**SCOPE OF THE DOCUMENT**	**3**
2	**FRONT PANEL**	**4**
2.1	**Overview**	**4**
2.2	**LED behaviour**	**5**
2.2.1	First LEDs	5
2.2.2	Other LEDs	6
2.2.3	LED Chaser (“Highlighted Mode”)	7
2.3	**Configuration data**	**7**
2.3.1	General display management	8
2.3.2	Language support	9
2.3.3	Time and date display	9
2.3.4	Service information panel	10
2.3.5	Login Panel	11
2.3.6	Disclaimer Banner	11
2.3.7	Board panel	15
2.3.8	External device panel	17
2.3.9	Display of binary input information	19
2.3.10	Display of binary output information	20
2.3.11	Bay panels	21
2.3.12	Alarm panel (optional)	28
2.3.13	AVR panel (optional)	30
2.3.14	Event panel	33
2.3.15	Fault panel	34
2.3.16	Disturbance record panel	35
2.3.17	Menu tree	36
2.3.18	Controls	38
3	**COMPUTER MAINTENANCE TOOL**	**45**
4	**LOG PRINTING**	**46**
4.1	**Inputs**	**46**
4.2	**Outputs**	**46**

1 SCOPE OF THE DOCUMENT

This document is a chapter of the DS Agile C26x documentation. It describes the User Interfaces (coded HI for Human Interface) of this device:

- Front Panel Local HMI (or LHMI)
- Computer Maintenance Tool (CMT)

2 FRONT PANEL

2.1 OVERVIEW

The DS Agile C26x front panel exists in two versions:

- A simple FP with LEDs, L/R key and the serial link (GHU31x)
- A graphical FP with LEDs, L/R key, the Local Control Display and the serial link (GHU30x)

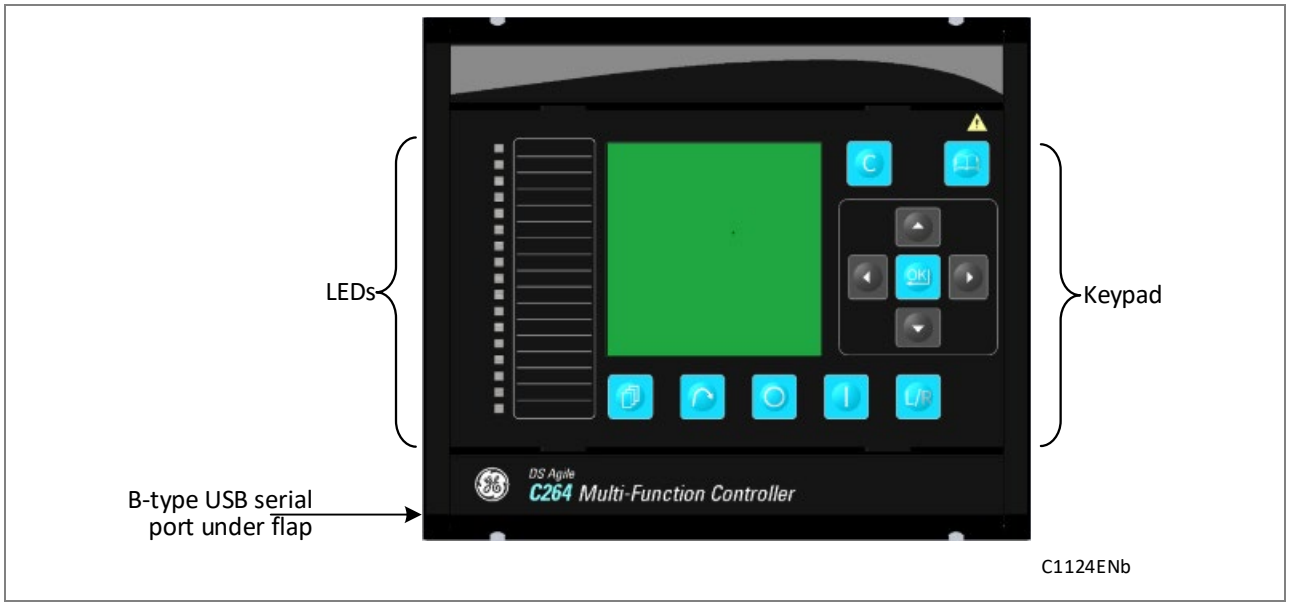


Figure 1: DS Agile C26x 40TE front panel (GHU300)

The graphic panel allows:

- Control of:
  - circuit breakers (open, close)
  - disconnecting switches (open, close)
  - transformers (raise, lower, go to min, go to max)
  - generic commands (start, stop or open/close)
  - setpoints
  - bay mode (local/remote)
  - C26x mode (operational, test/blocked, maintenance)
  - counters value
- Switching databases
- Changing the settings (menu tree)
- Alarm acknowledgement and clearing
- Datapoint suppression

- Display of:
  - Module positions
  - Alarm list
  - Disturbance records
  - Configuration
  - Events list
  - Fault list
  - Measurements, counters and TPI
  - Physical binary input/output states
  - Status information
  - Bay mode (local/remote, SBMC)
  - Bypass indications
  - Setting points
  - Board states
  - IED states
- Activating LEDs according to datapoint status

2.2 LED BEHAVIOUR

There are 17 LEDs available:

- 16 LEDs are managed by the firmware
- 1 LED is directly connected to the internal power rail

2.2.1 FIRST LEDS

The first 5 LEDs indicate the DS Agile C26x status information. The LEDs indicate from top to down:

LED id	Colour	LED on	LED slow blinking	LED fast blinking	LED off
1	Red	There is at least one major fault (hardware, database) (1)	There is at least 1 minor fault (I/O board, communication to IEDs, …) (2)	Not used	No fault
2	Amber	All alarms are acknowledged, but one alarm at least is still active (3)	All alarms displayed in the alarm panel are inactive & acknowledged	At least 1 not acknowledged alarm displayed in the alarm panel	No alarm
3	Amber	C26x in operational mode	C26x in maintenance mode	C26x in test/blocked mode	C26x rebooting
4	Green	Power on	Not used	Not used	Power off
5 (4)	Red	All bays managed by the C26x are in LOCAL mode	Bays managed by the C26x are not in the same control mode	Not used	All bays managed by the C26x are in REMOTE mode

(1) Major fault: DS Agile C26x not available due to internal failure (database error, CPU board failure, etc…).

(2) A minor fault is a fault causing only the non-availability of a part of the functionality.

(3) When the alarm disappears, the LED automatically returns to OFF.

(4) Assigned by C26x only for front panel without LCD: GHU3x1 or for an extension C26x.

2.2.2 OTHER LEDS

Other LEDs' default assignment:

- LED 7: DIU board fault
- LED 8: AIU board fault
- LED 9: DOU or HBU board fault
- LED 10: CCU board fault
- LED 11: AOU board fault
- LED 12: At least one IED is disconnected

Summary table

<table>
<tr><th rowspan="3">LED</th><th colspan="3">Single rack architecture</th></tr>
<tr><th colspan="3">C26x</th></tr>
<tr><th colspan="2">Graphic Panel</th><th>Simple Panel</th></tr>
<tr><td>1</td><td colspan="2" rowspan="3">Assigned by C26x</td><td rowspan="3">Assigned by C26x</td></tr>
<tr><td>2</td></tr>
<tr><td>3</td></tr>
<tr><td>4</td><td colspan="3">Linked to power supply</td></tr>
<tr><td>5</td><td rowspan="13">Freely assignable</td><td>Not used</td><td>Local/Remote</td></tr>
<tr><td>6</td><td rowspan="8">Freely assignable</td><td>Not used</td></tr>
<tr><td>7</td><td rowspan="6">Pre-defined</td><td rowspan="6">Pre-defined</td></tr>
<tr><td>8</td></tr>
<tr><td>9</td></tr>
<tr><td>10</td></tr>
<tr><td>11</td></tr>
<tr><td>12</td></tr>
<tr><td>13</td><td rowspan="5">Not used</td><td rowspan="5">Not used</td></tr>
<tr><td>14</td></tr>
<tr><td>15</td></tr>
<tr><td>16</td></tr>
<tr><td>17</td></tr>
</table>

2.2.3 LED CHASER (“HIGHLIGHTED MODE”)

A unit can be made easier to locate physically using a command that starts a LED chaser effect on its front panel: this “highlighted” mode is purely visual; it has no effect on the unit’s operation.

Note: The LED chaser is not available while the unit is in Maintenance or Halt mode.

The command is available if the optional *Device id* SPC has been added to the System info group of the unit in the configuration. Set the control *Device id* to *ON* to activate the highlighted mode, and to *OFF* to deactivate it from aView or another IEC 61850 remote station. Its activation is indicated in aView by the *Status device id* SPS appearing as *SET*.

Locally, the 13 freely assignable LEDs are lit 3 by 3, scrolling from bottom to top in a loop while the highlighted mode is active. To deactivate the highlighted mode, press the key **LED test** on a simple front panel or **L/R** on a graphical front panel.

When the highlighted mode is deactivated, the LEDs return to their previously stored states.

2.3 CONFIGURATION DATA

The behaviour of the user-configurable LEDs is defined in the C26x Database.

When using a simple LHMI, the 11 user-configurable LEDs give the status of the associated BI. Each BI state is displayed using the ON / OFF / BLINKING led state.

When using a graphical LHMI (with LCD), the 13 user-configurable LEDs can be configured to have 2 different behaviours:

1 give the status of the associated BI. Each BI state is displayed using the ON / OFF / BLINKING led state (same way as with a Simple LHMI),

2 provide a way to manage BIs as alarms.

Behaviour #2 is detailed below:

- if the BI is “transient”:
  - if the BI is SET, the associated LED is ON or Blinking Slow (depends of the DB),
  - after pressing the key C, the LED’s state goes OFF.
- if the BI is “permanent”:
  - if the BI is SET, the associated LED is Blinking Slow,
  - after pressing the key C, the LED goes ON,
  - if the BI is RESET, the associated LED remains Blinking if the key C has not been pressed or is OFF if it has.

Notes:
- The key C is used for the navigation in the menu tree. Therefore, alarm acknowledgement is not allowed from the menu tree.
- The alarm acknowledgement function is not available with the simple panel (no C key available).

The 11 other LED’s are freely configurable: they can be attached to a datapoint. Furthermore, the datapoint state is displayed through a led state: on, off, slow blinking, fast blinking.

For a Single Point, the Set / Reset / Invalid (i.e. all other states) can be attached to a LED. For a Double Point, the Open / Close / Invalid (i.e. all other states) can be attached to a LED.

2.3.1 GENERAL DISPLAY MANAGEMENT

The local HMI is composed of several “panels” and one “menu tree”. The panels allow displaying information and issuing control commands whilst the menu tree is used to display and modify the DS Agile C26x unit's settings.

During the menu navigation, the key C is used to return to the previous panel and has no effect on LED management.

The key is used to display the next panel.

From each panel, the key OK allows access to the menu tree, except from the **Settings** panel.

The keys and allow access to the various panels in a group.

List of panels

- **Service** panel, **Board** panel and **IED** panel: General device information (serial number, software version, version and state of both databases in memory, operating hours, operating mode and redundancy mode), list and states of the boards present in the device, and states of external IEDs connected to the device.
- Binary **Inputs** panel and Binary **Outputs** panel (information on the digital input and output states): available in active and in maintenance mode, except if there is no database present.
- **Bay** panels: One or two panels for each bay with sub-panels for:
  - measurement, counter and TPI
  - single, double and multiple datapoints status
  - controls
- **Alarm** panel: Displays the alarm list and allow acknowledgement and clearing of alarms.
- **Event** panel: Displays the event list.
- **Fault** panel: Displays the fault list.
- **Disturbance** panel: Displays the header of the disturbance file.
- **Login** panel: Allows the user to log in and out of the DS Agile C26x front panel interface. It is displayed upon the first key stroke when no session is active.

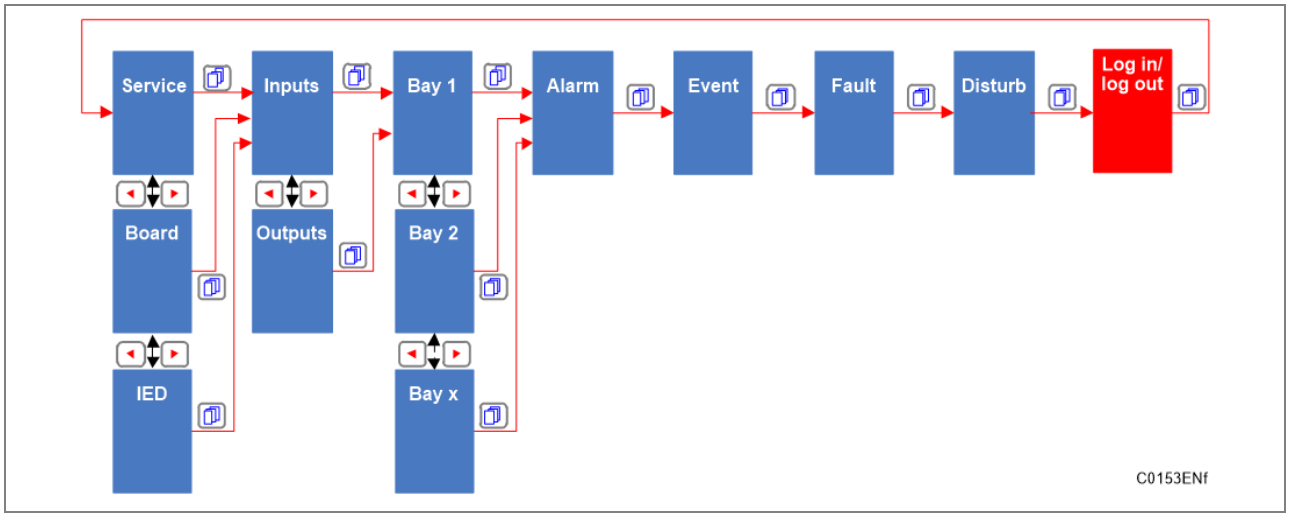


Figure 2: Panel browsing

Notes:
The default panels (after start-up and after an inactivity time-out) are defined during the configuration process: ***Service*** *Panel,* ***Fault*** *Panel or one of the* ***Bay*** *Panels.*

Pressing the key  *from any panel will return the display to the* ***Service*** *Panel.*

2.3.2 LANGUAGE SUPPORT

The display on the LCD supports 2 language versions, selected during the configuration process.
A parameter in the menu tree allows switching between both language versions.

2.3.3 TIME AND DATE DISPLAY

The front panel HMI displays the time, date and time synchronisation state of the unit.

Time: time of day is displayed in all the panels of the LCD. For each panel, time of day is displayed in the first line of the panel.

The display format of the time is **THH:MM:SS** where T is the time synchronisation state (* or nothing), HH the hour (0 to 23), MM the minutes (00 to 59) and SS the seconds (0 to 59).

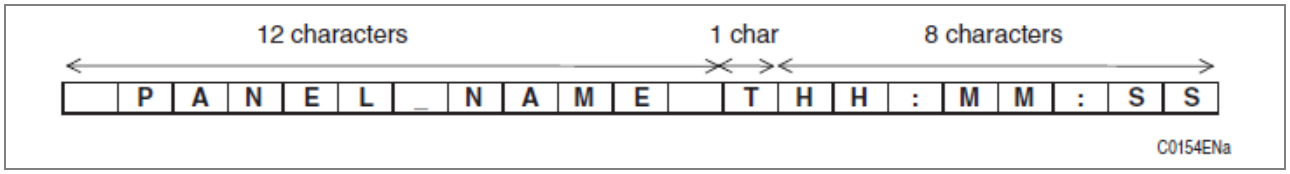


Figure 3: Time display

In the Event panel, in the Alarm panel and in the Disturbance panel, the time-stamp must be given in milliseconds. Therefore, the format for the time is **THH:MM:SS.MMM**

Date: the date is displayed only in the Event panel and in the Alarm panel. Each event and each alarm are displayed with their date and time of occurrence (time-stamp).

There are 3 configurable date formats, where DD is the day of the month (01 to 31), MM the month (01 to 12) and YY the year (00 to 99):

- DD/MM/YY
- MM/DD/YY
- YY/MM/DD

Time synchronisation state: the C26x's firmware manages the following time synchronisation states:

- not synchronised (“*”): the date/time has never been synchronised
- synchronised (“ “): date/time is synchronised

The date and time are settable in the menu tree, see chapter C26x/EN ST for setting instructions.

2.3.4 SERVICE INFORMATION PANEL

The local HMI displays information relevant to the C26x on one panel:

- C26x serial number
- software version
- version number and revision number of the first database
- version number and revision number of the second database
- state of both databases
- operating hours of the unit
- operating mode
- redundancy mode

S	E	R	V	I	C	E						*	1	2	:	3	4	:	5	6
S	E	R	I	A	L		N	B												
	0	0	0	0	3	9	6	2												
S	O	F	T	W	A	R	E		V	E	R	S	I	O	N					
					A	4	.	3	1	A										
D	B	1		V	E	R	S	I	O	N		S	T	A	T	E				
00	.	3											A	C	T	I	V	E		
D	B	2		V	E	R	S	I	O	N		S	T	A	T	E				
													N	O		B	D			
O	P	E	R	A	T	I	N	G		H	O	U	R	S						
													6	0	1					
O	P	E	R	A	T	I	N	G		M	O	D	E							
										O	P	E	R	A	T	I	O	N	A	L
R	E	D	U	N	D	A	N	C	Y		M	O	D	E						
										N	O	T		R	E	D	U	N	D	E

Figure 4: Example of Service information panel

2.3.5 LOGIN PANEL

The C264 local HMI may be configured in 2 modes:

- **Secure mode**: any action on the front panel requires authentication (Login panel is displayed).
- **Free mode**: display and navigation between view are authorized without authentication (no Login panel is displayed). Only controls and commands are authorized with authentication.

Note: The Login panel is available when no local or remote user is logged in. It is not possible to log in locally while a remote user is already connected via the DS Agile CMT.

By default, the C264 is configured in **Secure** mode with the optional disclaimer banner set to TRUE in the SCE database properties.

2.3.6 DISCLAIMER BANNER

Banner not configured

When no disclaimer banner is set in the SCE, the C264 local HMI is in **Free** mode.

When the **Free** mode is enabled, navigating between views on the local HMI is managed without verifying user permissions. In that case, no Login panel is displayed except for control actions.

Banner configured

When the disclaimer banner is configured in the SCE, the **Secure** mode is enabled by default.

Any key that is pressed on the C264 local HMI checks if the user is logged in.

If no user is logged in, the login panel displays and prompts the user to enter his/her credentials

If the CMT is connected to the C264, then a button in the CMT allows SECADM users to disable or enable the secure mode.

When the mode is changed through the CMT button, the parameter value is stored in the C264, whatever action is done on the database (download, switch ...), and even after a reboot of the C264.

Refer to the CMT chapter for further information about the LHMI authentication management.

2.3.6.1 LOGIN STATUS

The Login panel has two states: logged in to the C264 or logged out of the C264.

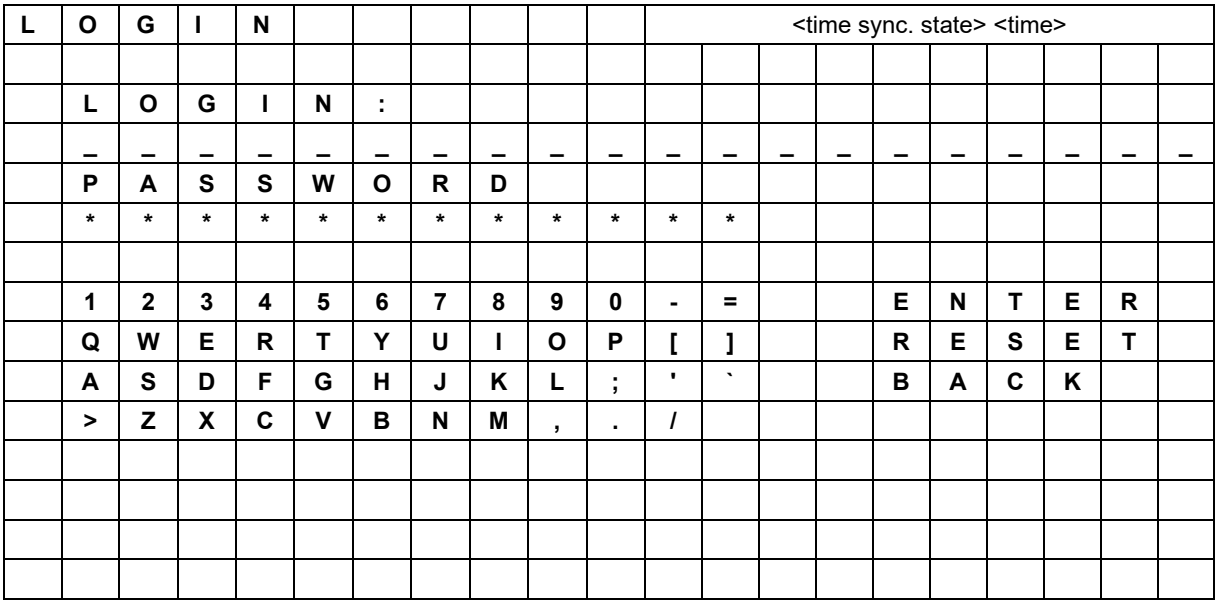


Figure 5: Example of Login panel (the user was logged out)

Logging in

When the Login panel appears, the user must fill in his/her LOGIN (log in account name) and PASSWORD.

- Press the L/R key to switch between the fields.
- To fill in the LOGIN and PASSWORD fields, use the virtual QWERTY keyboard under them.
- Select a character using the arrow keys (inverted text cursor), then press OK.
- To switch between the upper- and lower-case keyboards, press .
- Repeat the process until the field is filled in, then select ENTER and press OK.

If a wrong login/password combination is entered, the message "WRONG LOGIN PASSWORD" blinks at the bottom of the screen. The login and password sections are cleared.

The number of incorrect password entries (failed log in attempts) is defined by a security administrator using DS Agile CMT and can be limited. These failed attempts are cumulative with any failed attempts to log in to the C26x from DS Agile CMT. If the sum of the failed attempts exceeds the set permitted number, the user account is locked for a duration that is also defined by a security administrator using DS Agile CMT. This is indicated by the message "Your account is locked". The account can be unlocked early from the DS Agile CMT by a security administrator.

After logging in, if the user tries to perform an action that is not permitted by his/her account's roles, the message "INSUFFICIENT RIGHTS" is displayed at the bottom of the page and the action is denied.

After a user has logged in, the unit displays a message, usually a security warning (banner), which has been configured using DS Agile SCE:

L	**O**	**G**	**I**	**N**							<time sync. state> <time>										
	T	**H**	**I**	**S**		**I**	**S**		**T**	**H**	**E**		**B**	**A**	**N**	**N**	**E**	**R**			
	T	**E**	**X**	**T**																	
			O	**K**					**C**	**A**	**N**	**C**	**E**	**L**							

Figure 6: Example of banner

Using the  and  keys, select *OK* or *Cancel*, then press  .

- Selecting *OK* unlocks the LHMI.
- Selecting *Cancel* aborts log in and returns to the **Login** panel.

At any time during the login process, you can abort by pressing  :

- If the **Secure mode** is enabled, the default LHMI page is displayed.
- If the **Free mode** is enabled, the display reverts to the previous page (the page from which the login was called).

Inactivity Timeout

A keypad inactivity timer can be configured in the CMT to ensure that a session will not remain open after the user has left: When the timer elapses, the user is disconnected, and the default start panel is displayed.

Remote Disconnection

A security administrator may connect remotely to the unit using the DS Agile CMT even if a session is already open locally. In this case he/she will “steal” the session: The local user is disconnected, and the default start panel is displayed.

Logging out

The **Login** panel is also used to log out of the LHMI.

To reach it, repeatedly press the key  until the **Login** panel is displayed.

It shows the name of the user currently logged in:

LOGIN											<time sync. state> <time>									
	L	**O**	**G**	**I**	**N**	**:**														
	G	**E**	**R**	**R**	**Y**	**.**	**S**	**M**	**I**	**T**	**H**									
					L	**O**	**G**		**O**	**U**	**T**									

Figure 7: Example of Logout panel (the user is logged in)

Press  to log out.

The display will lock up and return to the log in screen for the duration of the configured timeout period.

2.3.7 BOARD PANEL

The Board panel is a text list indicating the states of I/O boards.

For each board, the following information is displayed:

- its configured name,
- its state, among the following ones: *OK* (board connected and operational), *Failure* (self-check fault), *Missing* (board configured but not present).

Note:
These state labels are manually set in configuration and that the exact text could slightly vary due to customer preference, but not their actual meaning (as indicated in brackets).

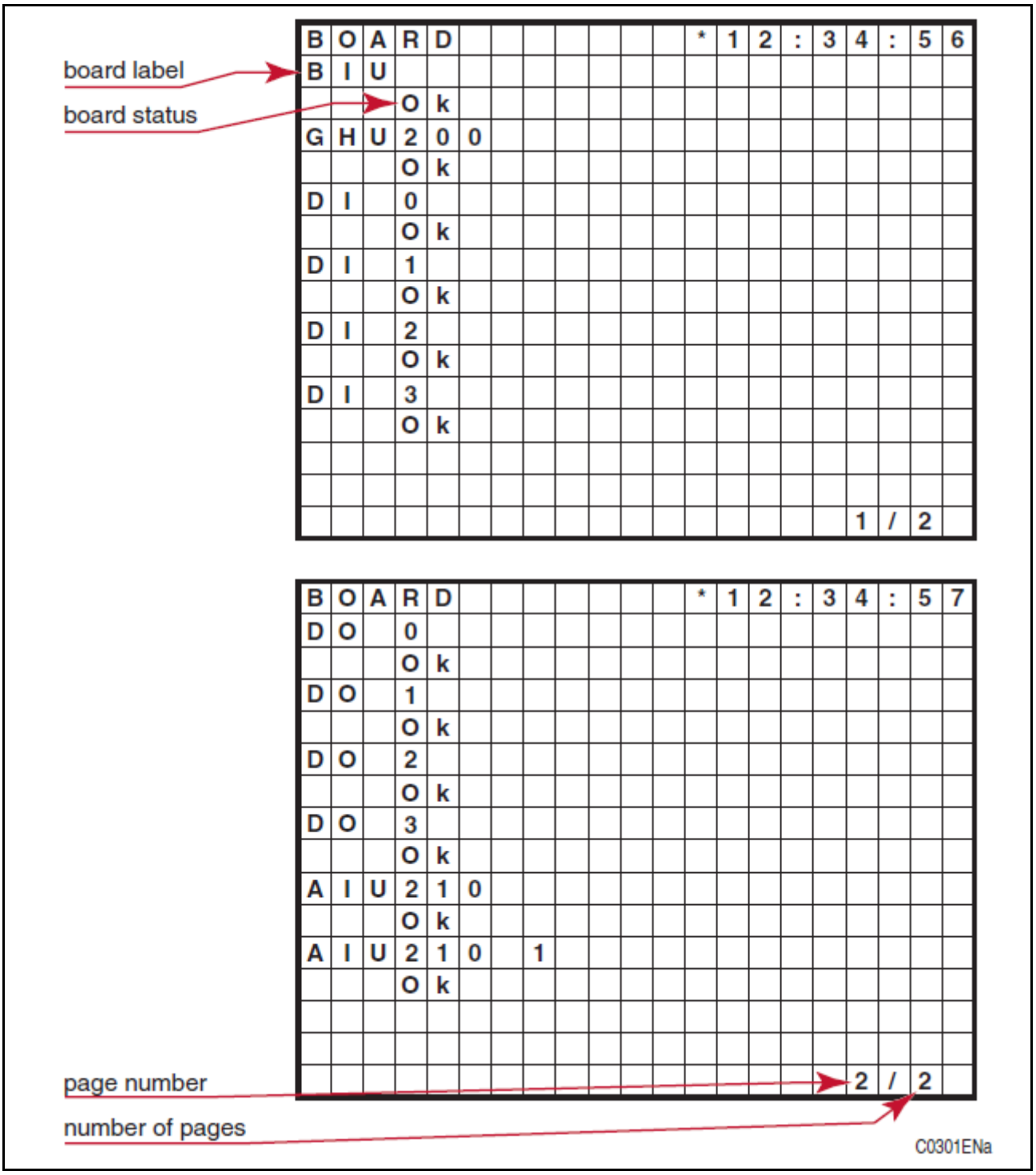


Figure 8: Example of Board panel

2.3.8 EXTERNAL DEVICE PANEL

This panel display all external devices connected to the unit by a legacy protocol and by the IP protocols (as IEC61850). This panel contains 3 sub-sets:

- IP client connection number: it defines the number of client currently connected to the unit.
- IP server connection state: it defines the list of the server connected to the unit. Each server is displayed with its name, its IP address, and the state of its connection.

server name																					
IP address												**state**									

- Legacy protocol connection state: each IED is displayed with its name, its address, and the state of its connection.

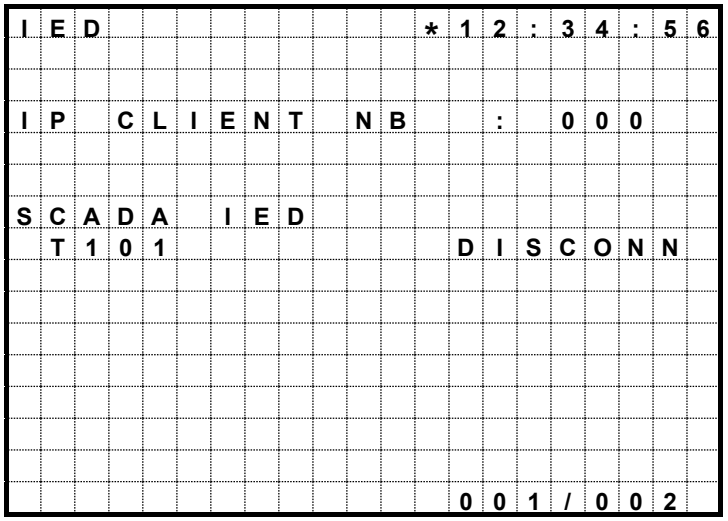
IED name																					
		address										**state**									

The panel for “IP IED” is as follows:

E	**X**	**.**	**D**	**E**	**V**	**I**	**C**	**E**	**S**		<time sync. state> <time>										
I	**P**		**C**	**L**	**I**	**E**	**N**	**T**		**N**	**B**	**:**									
I	**P**		**S**	**E**	**R**	**V**	**E**	**R**	**:**						**protocol**						
Server 1																					
Server 2																					
Server 3																					
																		page			

The panel for “Legacy IED” is as follows:

E	**X**	**.**	**D**	**E**	**V**	**I**	**C**	**E**	**S**		<time sync. state> <time>										
L	**E**	**G**	**A**	**C**	**Y**		**D**	**E**	**V**	**I**	**C**	**E**			**protocol**						
IED 1																					
IED 2																					
IED 3																					
IED 4																					
																		page			



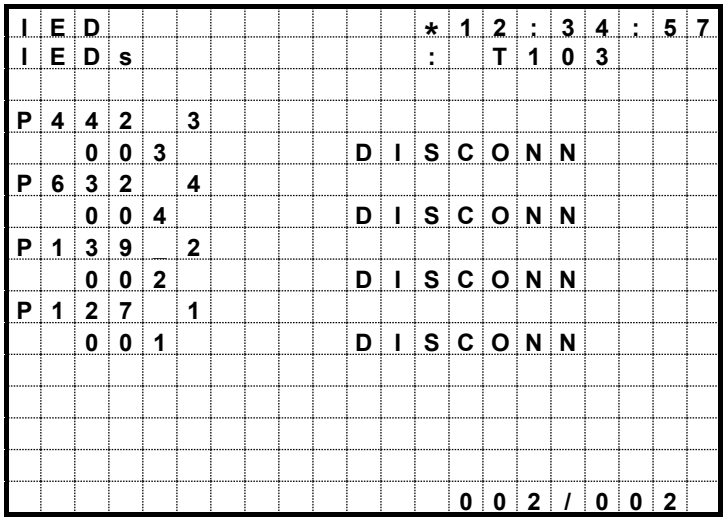


Figure 9: Example of External device panel

2.3.9 DISPLAY OF BINARY INPUT INFORMATION

For each input board defined in the configuration, the state of all the "physical" binary inputs is displayed in the **Inputs** panel.

Each panel contains:

- The board number and its type (DIU, CCU)
- A list of all the binary inputs present on the board, defined by:
  - The input number: DI xxx
  - The physical state of the input with 3 possible values (On, off , faulty)

I	N	P	U	T	S						<time sync. state> <time>									
			B	O	A	R	D		X	X				Board type						
D	I		X	X	X		value				D	I		X	X	X		value		
D	I		X	X	X		value				D	I		X	X	X		value		
D	I		X	X	X		value				D	I		X	X	X		value		
D	I		X	X	X		value				D	I		X	X	X		value		
D	I		X	X	X		value				D	I		X	X	X		value		
D	I		X	X	X		value				D	I		X	X	X		value		
D	I		X	X	X		value				D	I		X	X	X		value		
D	I		X	X	X		value				D	I		X	X	X		value		
D	I		X	X	X		value				D	I		X	X	X		value		
D	I		X	X	X		value				D	I		X	X	X		value		

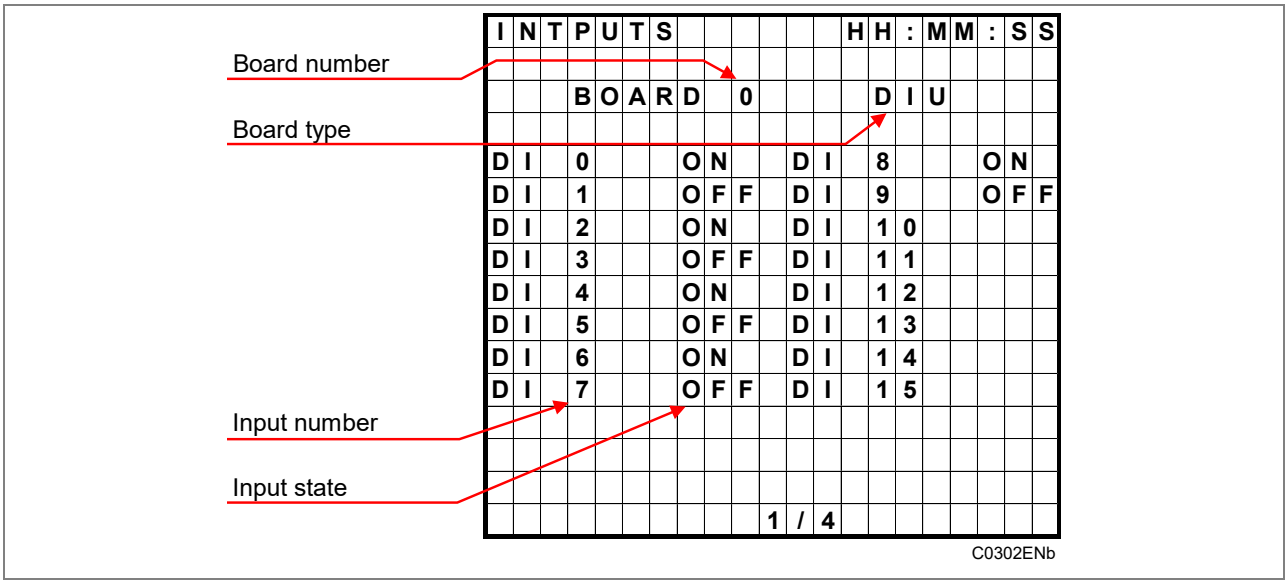


Figure 10: Example of binary input sub-panel

2.3.10 DISPLAY OF BINARY OUTPUT INFORMATION

For each output board defined in the configuration, the state of all the "physical" binary outputs is displayed in the **Outputs** panel.

Each panel contains:

- The board number and its type (DOU, HBU, CCU)
- A list of all the binary outputs present on the board, defined by:
  - The output identifier: DO xxx
  - The physical state of the output with 3 possible values (on, off, faulty)

OUTPUTS											<time sync. state> <time>									
			BOARD					X	X											
DO		X	X	X		value			DO		X	X	X		value					
DO		X	X	X		value			DO		X	X	X		value					
DO		X	X	X		value			DO		X	X	X		value					
DO		X	X	X		value			DO		X	X	X		value					
DO		X	X	X		value			DO		X	X	X		value					
DO		X	X	X		value			DO		X	X	X		value					
DO		X	X	X		value			DO		X	X	X		value					
DO		X	X	X		value			DO		X	X	X		value					
DO		X	X	X		value			DO		X	X	X		value					
DO		X	X	X		value			DO		X	X	X		value					

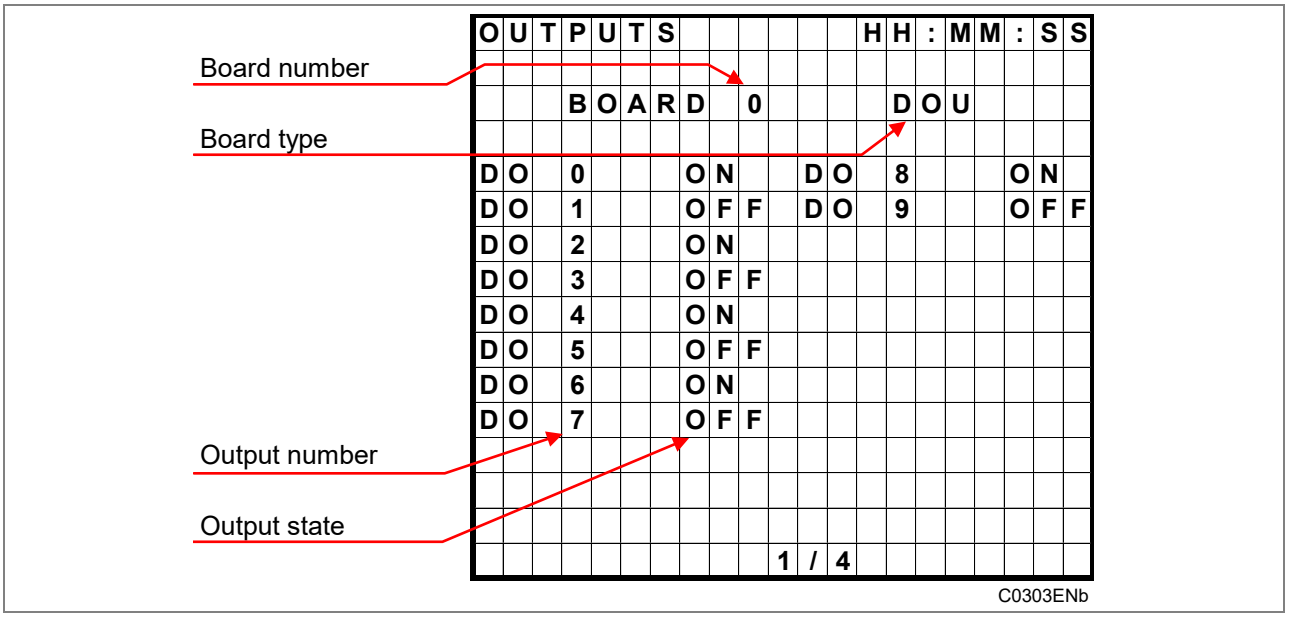


Figure 11: Example of binary output sub-panel

2.3.11 BAY PANELS

Graphical representations of bays are visible in panels. Each bay has its own panels (up to 2). Up to 12 bays can be displayed via the Front Panel of the C26x. A maximum of 9 devices can be displayed on each panel.

All the information in these panels is configurable, except for time indication.

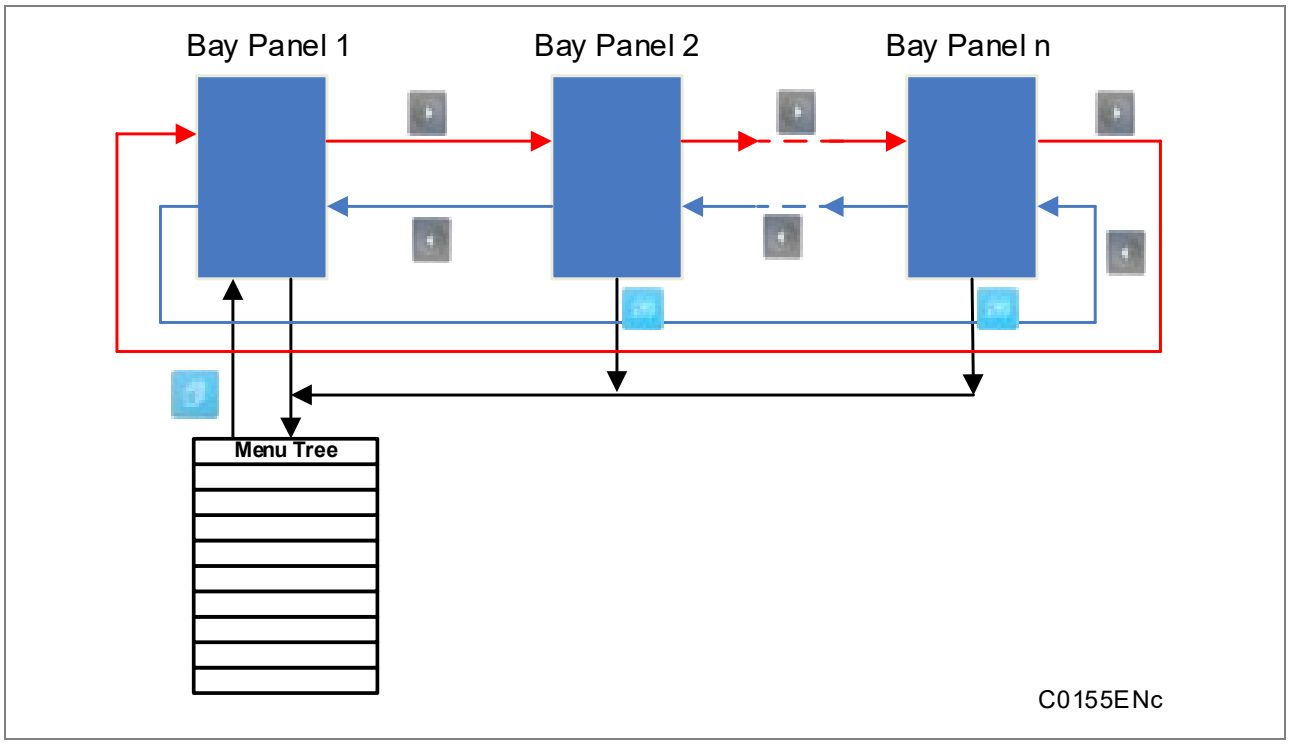


Figure 12: Bay management

When a bay is displayed over two pages, and are used to move from one page to the other.

For one bay:

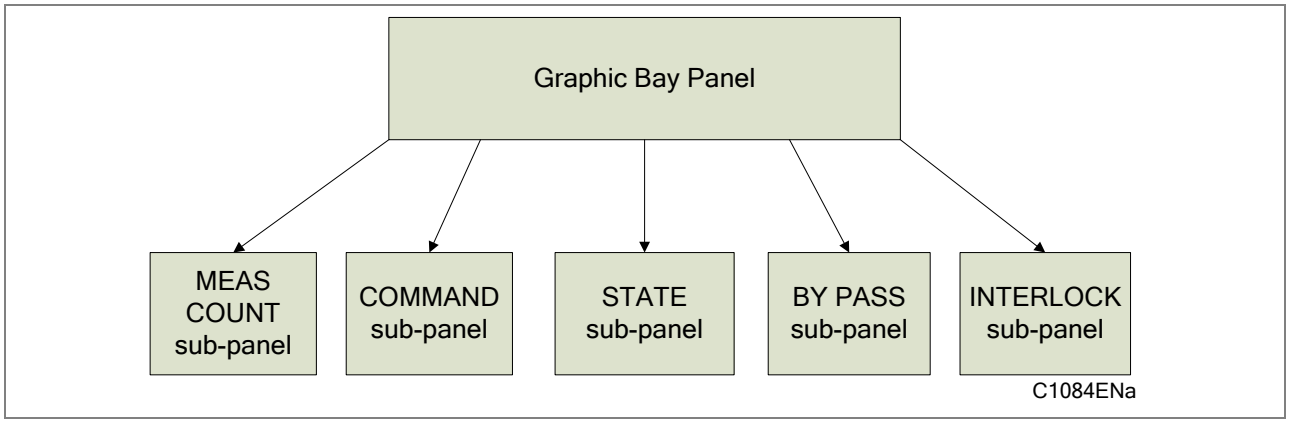


Figure 13: Bay management (cont'd)

The information displayed in the bay panel is:

- the bay's name (fixed position), 16 characters maximum
- the time (hh:mm:ss), preceded by its state (* means not synchronised)
- the bay graphical representation: the bay is displayed as a single-line diagram. Graphical pictures are made of bitmaps for modules representation, vertical and horizontal lines and labels
- the SBMC mode
- the Local / Remote bay mode
- the interlock bypass activation, if it exists
- a CT/VT measurement, displayed on a vertical graphical bargraph (Vertical Measurement Graphical Area) or on a horizontal graphical bargraph (Horizontal Measurement Graphical Area). VMGA and HMGA are exclusive. Only CT/VT measurements can be displayed on a bargraph. Up to four CT/VT measurements can be associated with a bargraph. The keys  and  are used to select the measurement to display on the bargraph. The totality of the bargraph represents either 120% or 200% of the nominal value
- the name of the measurement (fixed position)
- the value of the measurement (fixed position)
- the command report (fixed position)
- the access to datapoints panels

Example:

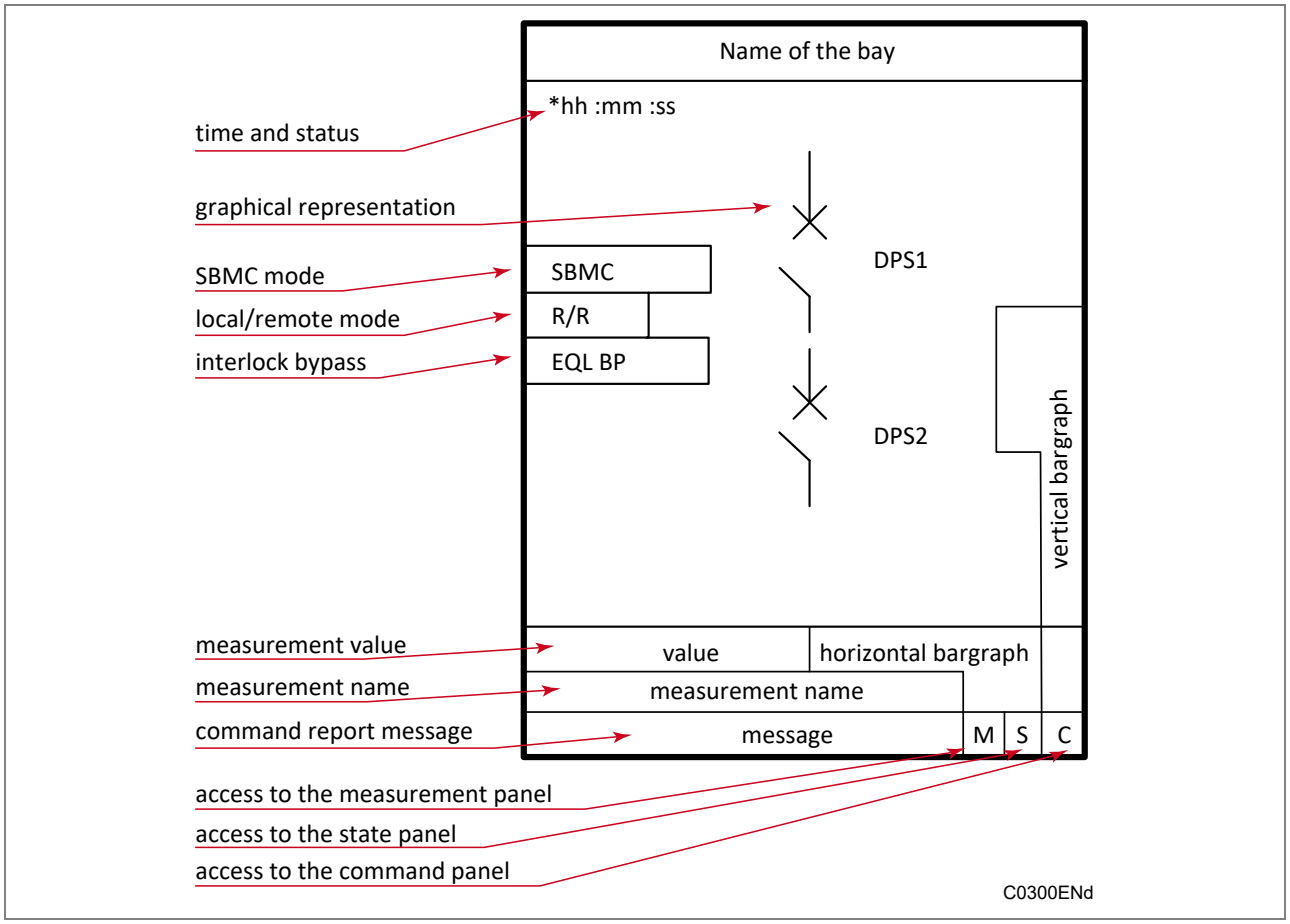


Figure 14: Example of a bay panel

2.3.11.1 STATE SUB-PANEL

This panel is used to display the state of the digital datapoints (single points, double points and multiple points).

3 lines are necessary to display any information.

S	**T**	**A**	**T**	**E**							<time sync. state> <time>									
						B	**A**	**Y**		**i**										
SPS, DPS or MPS 1 (3 lines)																				
SPS, DPS or MPS 2 (3 lines)																				
SPS, DPS or MPS 3 (3 lines)																				
SPS, DPS or MPS 4 (3 lines)																				

An SPS / DPS / MPS is defined by:

<Label of the datapoint > = 16 characters maximum																				
					Module of the BI = 16 characters maximum																
State of the BI = 21 characters maximum																				

From this panel, the operator can suppress a datapoint.

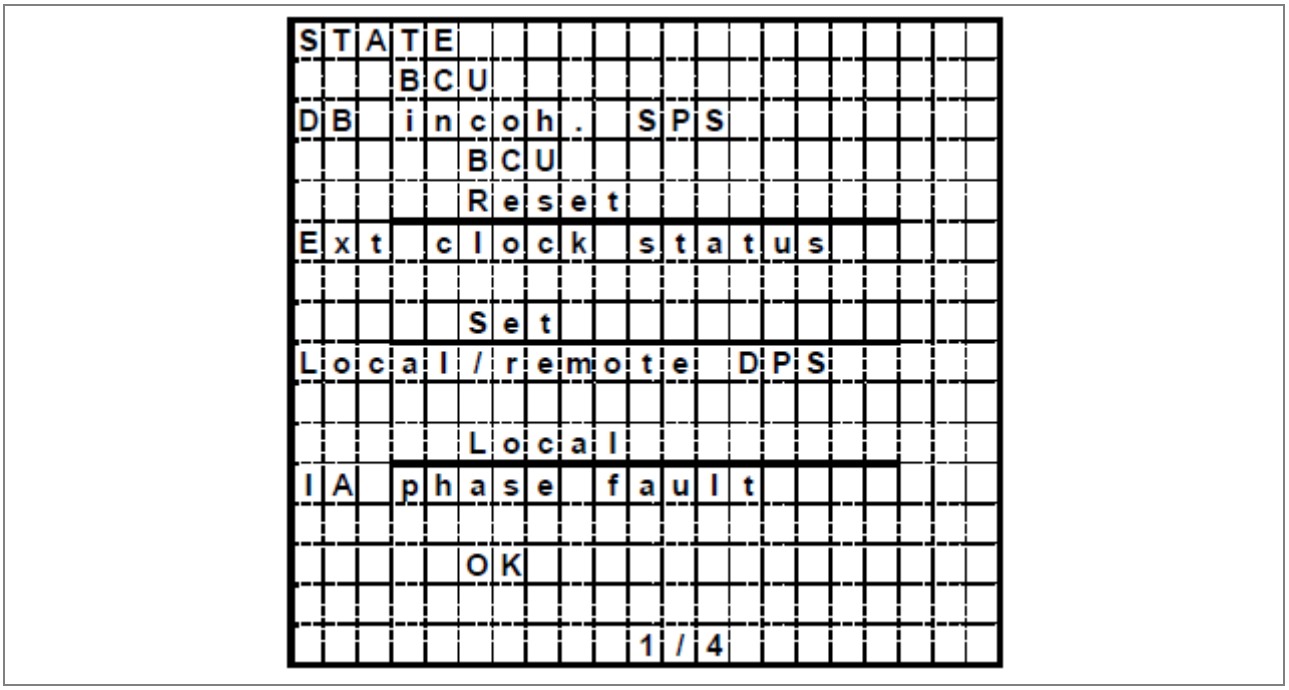


Figure 15: Example of state sub-panel

2.3.11.2 MEASUREMENT, COUNTING AND TPI SUB-PANEL

This panel allows displaying the state of the measurement, the counter and the TPI. It is defined by 3 lists of elements (Measurement, Counter and TPI), each list is distributed over several pages (3 pieces of information per page).

M	**E**	**A**	**S**		**C**	**O**	**U**	**N**	**T**		<time sync. state> <time>									
B	A	Y		i																
Measurement 1																				
Measurement 2																				
Measurement 3																				
																			...	

Display of measurements

Analogue values or digital measurements can be displayed in this panel if defined in the database. The value is displayed with 2 digits after the dot and 5 before.

<Label of the measurement > = 16 characters maximum												
					Module of the measurement = 16 characters maximum							
				Value: 7 char						Unit (5 characters)		
State of the measurement = 21 characters maximum												

Display of counters

A counter value can be displayed in this panel if defined in the database. The value is displayed with 2 digits after the dot and 5 before.

<Label of the counter > = 16 characters maximum												
					Module of the counter = 16 characters maximum							
				Value: 7 char						Unit (5 characters)		
State of the counter = 21 characters maximum												

Display of TPI

TPI can be displayed in this panel if defined in the database.

<Label of the TPI > = 16 characters maximum												
					Module of the counter = 16 characters maximum							
				Value: 3 characters								
State of the TPI = 21 characters maximum												

From this panel, you can suppress a measurement or a TPI (this option is not available for counters).

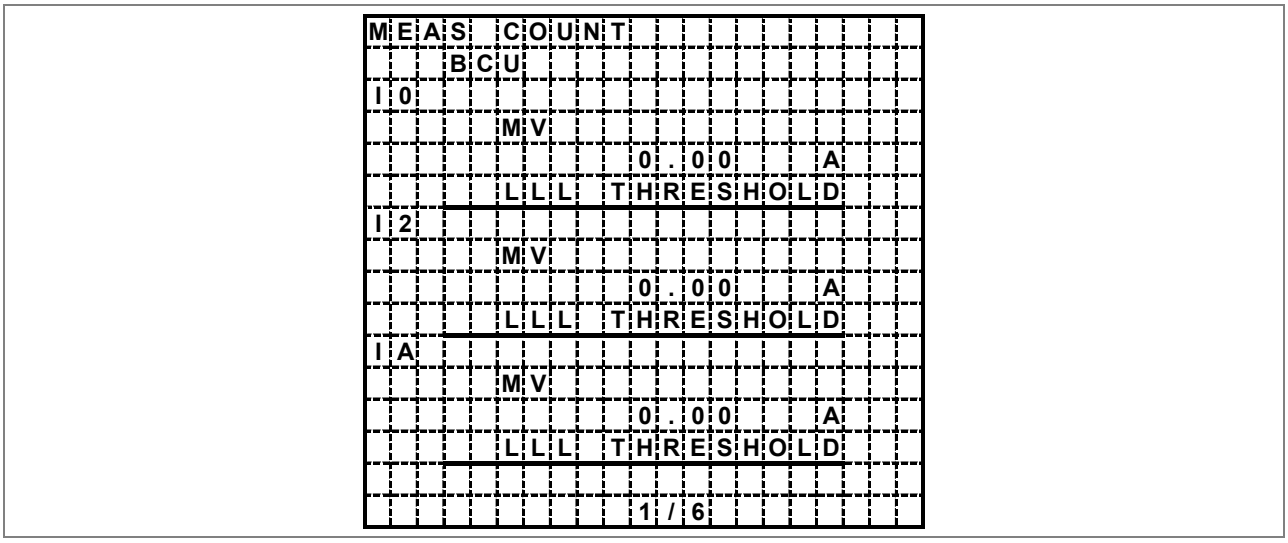


Figure 16: Example of measurement sub-panel

2.3.11.3 CONTROLS SUB-PANEL

The operator is allowed to control modules from the controls sub-panel.

The commands are displayed as following:

Name of the control			
			Name of the module
state			Label order

On this panel, the operator selects the chosen command using the key .

SBO and DE controls are possible according to the configuration

To send a DE control, operator uses the keys and for OFF and ON

To send a SBO control, operator uses the keys and to select OFF or ON. Then the execution is sent using the key .

The current state is displayed on the third line (only ON or OFF).

The key allows aborting the control.

C O M M A N D	<time sync. state> <time>
N A M E	**O F F** **T H E B A Y**
Command 1	
Command 2	
Command 3	
Command 4	
	Page

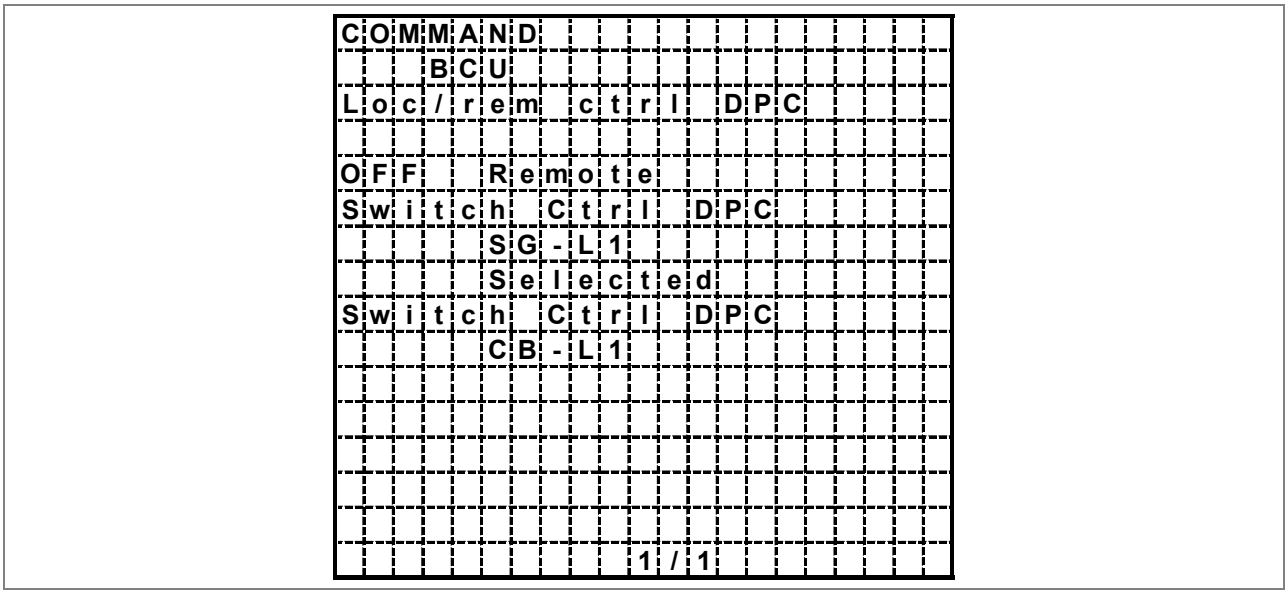


Figure 17: Example of control sub-panels

2.3.11.4 INTERLOCKING SUB-PANEL

When a module is selected in the graphic bay panel, the key allows access to the interlocking panel. Press any key to leave this panel and return to the graphic bay panel.

This panel displays the interlocking equation result (TRUE / FALSE) associated with a module control.

I	**N**	**T**	**E**	**R**	**L**	**O**	**C**	**K**			<time sync. state> <time>										
		< Label of the module > = 16 characters																			
E	**Q**	**L**		**O**	**P**	**E**	**N**		**:**				state								
E	**Q**	**L**		**C**	**L**	**O**	**S**	**E**		**:**			state								
																E	**X**	**I**	**T**		

2.3.12 ALARM PANEL (OPTIONAL)

This panel is only available if it has been selected during the configuration process.

Alarms are displayed in the form of one list in the panel. This list is a circular buffer and is displayed in a scrollable view in the same way as for the events panel.

One screen of the LCD can contain a maximum of 2 alarms:

A	**L**	**A**	**R**	**M**							<time sync. state> <time>									
<Date, time and state of time of the last alarm state change > =21 char.																				
<State of the alarm>=19 char. Max.																				Gr
<Information about the event that caused the occurrence or the state change of the alarm> 5 lines * 21 char./line maximum.																				
<Date, time and state of time of the last alarm state change > =21 char.																				
<State of the alarm>=19 char. Max.																				Gr
<Information about the event that caused the occurrence or the state change of the alarm> 5 lines * 21 char./line maximum																				

An alarm is composed of 7 lines:

- Line 1: alarm apparition time-stamp
- Line 2: alarm state and gravity
- Line 3: label of the bay
- Line 4: label of the module
- Line 5: label of the datapoint
- Line 6: state of the datapoint
- Line 7: value and unit of the datapoint (if exists)

Alarms acknowledgement and clearing is defined in the “Controls” section.

A	L	A	R	M								*	1	2	:	3	4	:	5	6
0	6	/	0	5	/	0	4	*	1	1	:M	2	2	:	3	3	.	1	2	3
I	N	C	T		A	C	T		U	N	A	C	K		A	L				1
C	2	6	4	P																
D	S	1																		
D	S	1		C	t	r	l		D	P	C									
S	E	L	E	C	T	E	D													
K	O	-	I	N	T	E	R	L	O	C	K									
0	6	/	0	5	/	0	4	*	1	1	:M	2	2	:	3	2	.	4	5	6
A	C	T		U	N	A	C	K		A	L									1
C	2	6	4	P																
C	2	6	4	P																
G	O	S	M	S	G															
					R	E	S	E	T											
														0	0	1	/	0	0	2

A	L	A	R	M								0	1	:	0	2	:	0	3
0	6	/	0	5	/	0	4	*	1	1	:M	2	2	:	3	3	.	7	8	9
A	C	T		U	N	A	C	K		A	L									1
C	A	L	C	U	1															
D	a	t	a	p	o	i	n	t	s		C	1								
S	P	S	7																	
					R	E	S	E	T											
0	6	/	0	5	/	0	4	*	1	1	:M	2	2	:	3	1	.	9	6	3
A	C	T		U	N	A	C	K		A	L									1
C	A	L	C	U	1															
D	a	t	a	p	o	i	n	t	s		C	1								
S	P	S	7																	
					R	E	S	E	T											
														0	0	1	/	0	1	6

Figure 18: Example of alarm sub-panel

2.3.13 AVR PANEL (OPTIONAL)

The AVR function is embedded in the C26x. When the AVR panel is selected during the configuration process, the local HMI interface shows the Voltage regulation function Statuses, Tap position, Voltages, Target Voltages, Various measurements, Circulating Currents and allows manual commands.

The AVR panel consists of three views (General information, details & control and analysis).

Each view shows common information:

- Line 1: **State of the time**: clock time status (* updated), **time**: system clock time
- Line 2: **Bay Name** (short name of the bay defined in configuration)
- Line 4: **Mode**: Actual AVR running mode (MANUAL, AUTOMATIC)
- Line 5: **Status**: Actual AVR status (ON, OFF)

Plus specific information in each sub panel, as detailed below.

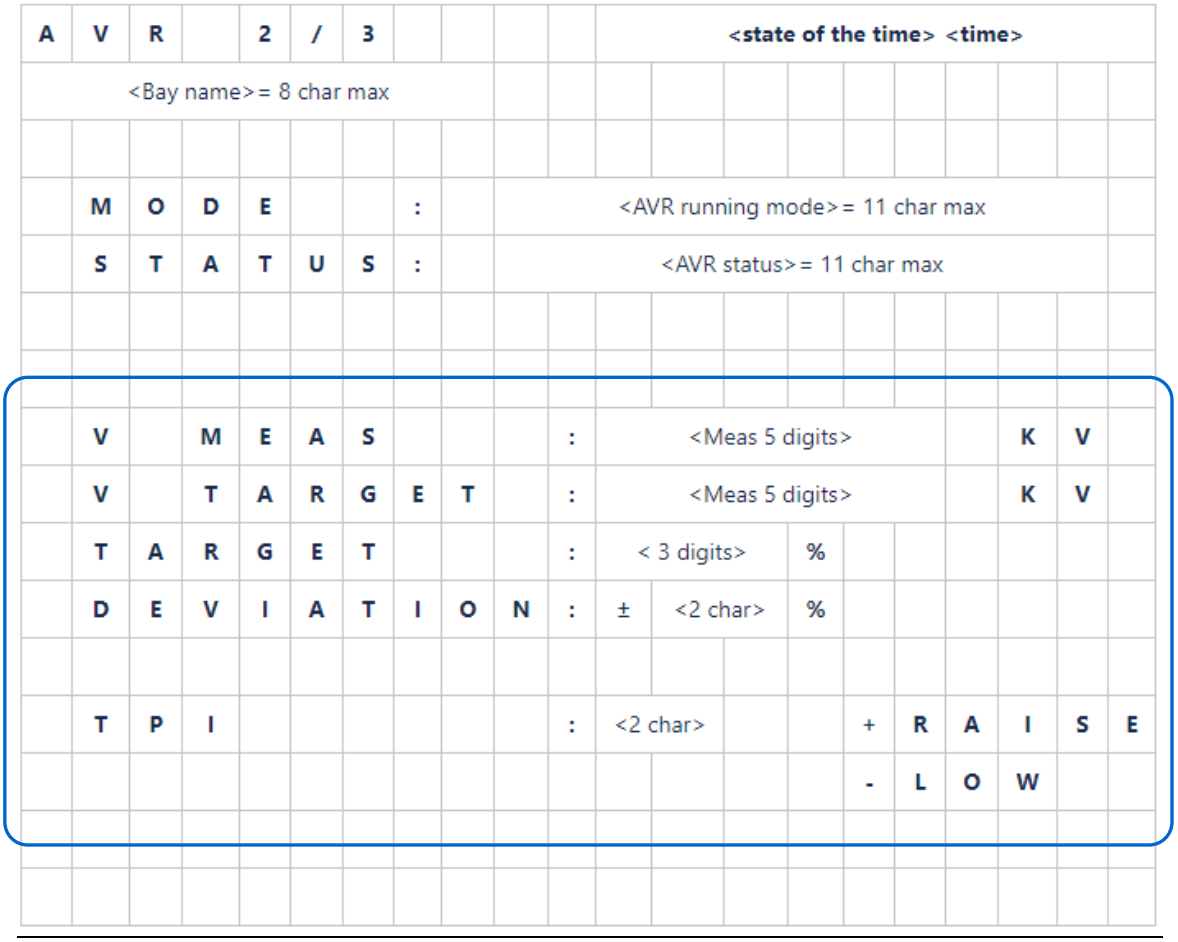
AVR panel #1: Overview



The information displayed in the ARV panel is:

- **V Meas**: Measured Voltage (regulated). Fixed format on 5 digits (xxx.xx)
- **TPI**: actual Tap Position (TPI). Fixed format on 2 digits (xx)
- **Deviation**: delta between Target voltage value and Measured Value. Fixed format on 2 digits (xx)

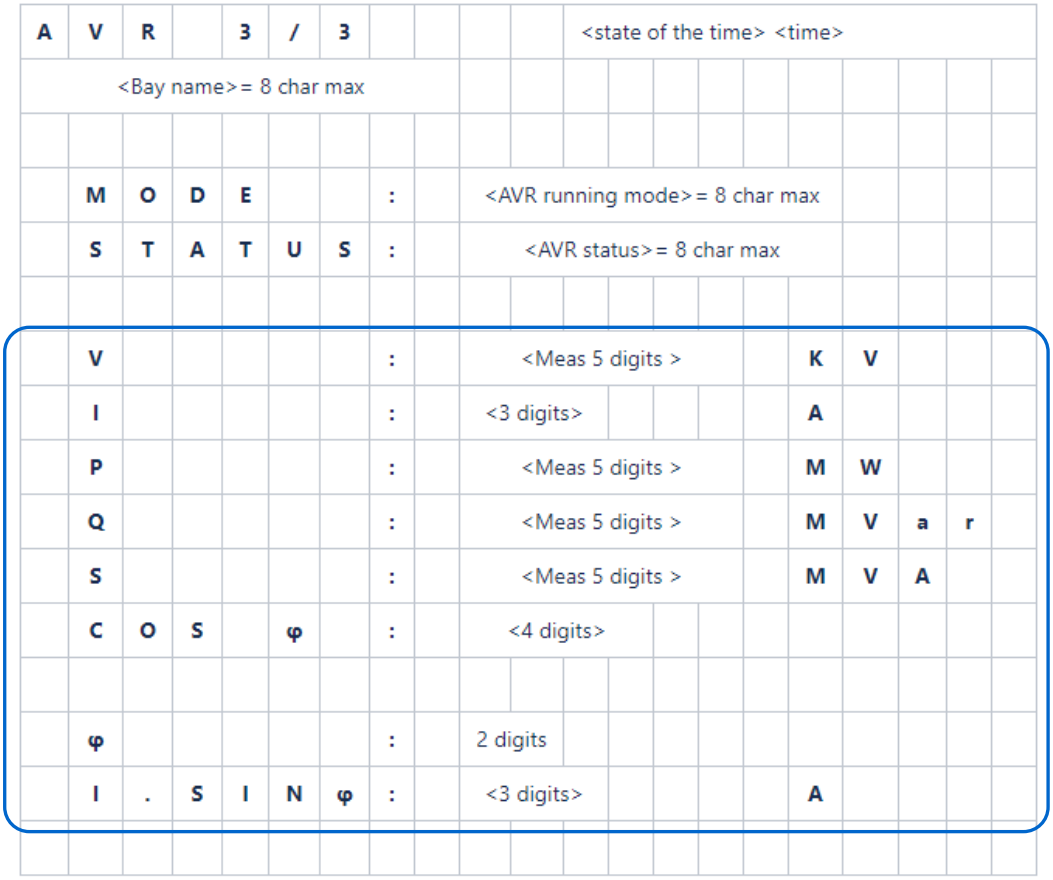
AVR panel #2: Details & Control



The information displayed in the ARV panel is:

- **V Meas**: Measured Voltage (regulated) over 5 digits (xxx.xx)
- **V Targe**t: Target Voltage for the concerned transformer (comes from a remote Setpoint or from local command, or from predefined value in database) over 5 digits (xxx.xx)
- **TARGET**: Voltage Target shown as a % of the Nominal Value (Configurable option on the Page) over 3 digits (xxx)
- **Deviation**: Delta between Target voltage value and Measured Value over 2 digits (xx).
- **TPI**: actual Tap Position over 2 digits.
- **+RAISE** / **-LOW**: selectable button for control. Control sequence for Raise/Lower.

AVR panel #3: Analysis view



- **V**: measured Voltage (regulated). Fixed format over 5 digits (xxx.xx)
- **I**: measured current. Fixed format over 3 digits (xxx)
- **P**: calculated active power. Fixed format over 5 digits (xxx.xx)
- **Q**: calculated reactive power. Fixed format over 5 digits (xxx.xx)
- **R**: calculated apparent power. Fixed format over 5 digits (xxx.xx)
- **COSPHI**: calculated power factor. Fixed format over 4 digits (xx.xx)
- **PHI**: calculated phase. Fixed format over 2 digits (x.x)
- **I.SINPHI**: calculated reactive factor. Fixed format over 4 digits (xx.xx)

2.3.14 EVENT PANEL

The event panel allows displaying the event list of the C26x in a chronological order. Display of events is done from newest to oldest: that means that the newest event declared is displayed at the top of the events panel (i.e. newest event is always rank 1).

This event list is a circular queue. List maximum size depends of C26x version series. This list is displayed in a scrollable view using arrows keys. When the circular queue is full and a new event appears, then the rank of each event is increased and the oldest event in the queue is removed.

One screen of the LCD contains at maximum 2 events.

At first time the user enters the events' panel, the 2 newest events are displayed.

E	**V**	**E**	**N**	**T**							<time sync. state> <time>									
0	**0**	**1**	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<Date, time and state of time of the event> =21 char.																				
<Information about event> **5 lines * 21 char./line maximum:**																				
0	**0**	**2**	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<Date, time and state of time of the event> =21 char.																				
<Information about event> **5 lines * 21 char./line maximum**																				

An event is composed of 7 lines:

Line 1: rank of the event in the circular queue
Line 2: event time stamp
Line 3: label of the bay
Line 4: label of the module
Line 5: label of the datapoint
Line 6: state of the datapoint
Line 7: value and unit of the datapoint (if exists)

Display mechanism for the first page:

- If the operator displays the first page, it is assumed that s/he is looking for the newest events. Therefore, the page will be updated at the apparition of any new event.

Display mechanism for an intermediate page:

- The operator displays one page between the first page and the last one, it is assumed that s/he examines more precisely these events.
- Therefore, when n events appear, the user keeps displaying the 2 same events. However, the rank of each event is incremented by n in real time in the list. When the displayed event is removed from the FIFO, the oldest event is displayed.

Display mechanism for the last page:

- Last page means displaying the two oldest event of the FIFO and the FIFO is full. When the displayed event is removed from the FIFO, the new oldest event is displayed.

E	V	E	N	T							*	1	2	:	3	4	:	5	6
0	0	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0A	6	/	0	5	/	103	2	*	1	1	:M	2	2	:	3	3	.	1	2	3
C	2	6	4	P															
C	2	6	4	P															
L	O	C	A	L	/	R	E	M	O	T	E		D	P	S				
					R	E	M	O	T	E									
0	0	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0A	6	/	0	5	/	103	2	*	1	1	:M	2	2	:	3	3	.	5	6	7
C	2	6	4	P															
C	2	6	4	P															
I	S	A	G	R	A	F		S	T	A	T	U	S						
W	A	I	T	I	N	G													
														0	0	1	/	100	0	0

Figure 19: Example of event sub-panel

2.3.15 FAULT PANEL

The first LED of the local HMI indicates 2 levels of fault.

When the LED is ON, a major fault is present. It can be:

- A database inconsistency
- A hardware fault:
  - **At C264 start-up**:
    - One or more boards are missing, compared to those defined in the database.
    - One or more boards are present but not defined in database.
    - The database is inconsistent.
  - **When the C264 is running**:
    - One or more cards no longer respond when polled
    - One or more boards respond with errors

If there is a minor fault the fault LED is blinking. It can be:

- An Isagraf issue is detected.
- An IED defined in the database is not connected to the C264.
- A SCADA defined in the database is not connected to the C264.

The Fault panel displays these faults.

2.3.16 DISTURBANCE RECORD PANEL

Display of disturbance records corresponds to the list of available disturbance records of the C26x. Two types of files are managed:

- Disturbance file from an IED
- Waveform computed inside the C26x

D	**I**	**S**	**T**	**U**	**R**	**B**					<time sync. state> <time>									
FileName											—	—	—	—	—	—	—	—	—	—
<Record beginning date, time and state of time > =21 char.																				
<Information about event that causes the recording>: 2 lines * 21 char./line maximum for controller waveform record Name of the IED for IED disturbance record																				
FileName											—	—	—	—	—	—	—	—	—	—
<Record beginning date, time and state of time > =21 char.																				

The records are displayed on the panel using 2 lists according to the origin. Displayed information depends on the origin of the file:

- waveform records are in COMTRADE format, 3 files can be displayed per page. Only the .cfg file name is displayed on the panel (the .dat files are only available to be uploaded).

Name of the file (format name . cfg)							**Type (F,S)**
Time stamp							
Bay Name / Module Name / Datapoint label (up to 2 lines)							

(F for fast waveform, S for slow waveform)

- From an IED: 3 files can be displayed per page.

Name of the file (format name . ext)									
Time stamp									
Name the IED									

2.3.17 MENU TREE

Some parameters of the C26x can be set by the operator from local HMI. The display / modification of the parameter value is done in the menu tree from the local HMI. All the parameters are group in the same path of the menu tree.

The parameters that can be modified on-line are:

- language
- counters value
- synchrocheck parameters (if applicable)
- autorecloser parameters
- pulse delay for open / close controls
- motion 00 and motion 11 delays
- persistence filtering delays
- toggling parameters
- measurements thresholds, deadband and hysteresis
- serial communication parameters

The controls that can be performed from the menu tree are:

- reset of operating hours
- change of C26x operating mode
- global alarm acknowledgement
- global alarm clearing
- database switching
- date and time setting
- modify counters value
- modify energy counters value

Note:
The key  *is used to browse the menu tree. Therefore alarm acknowledgement is not possible from the menu tree.*

The following figures show the menu tree in the three operating modes.

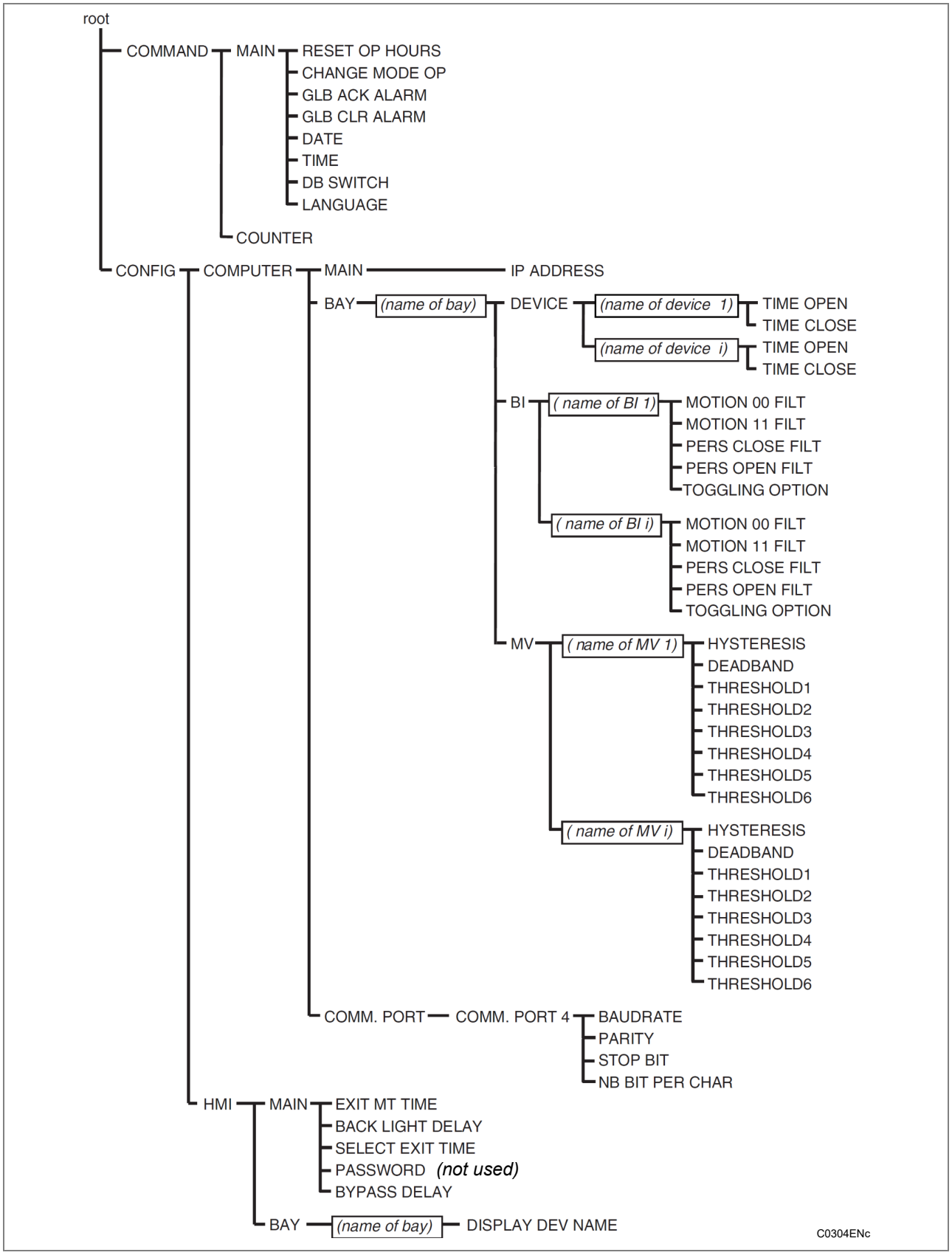


Figure 20: Menu tree in operational and test/blocked modes (example)

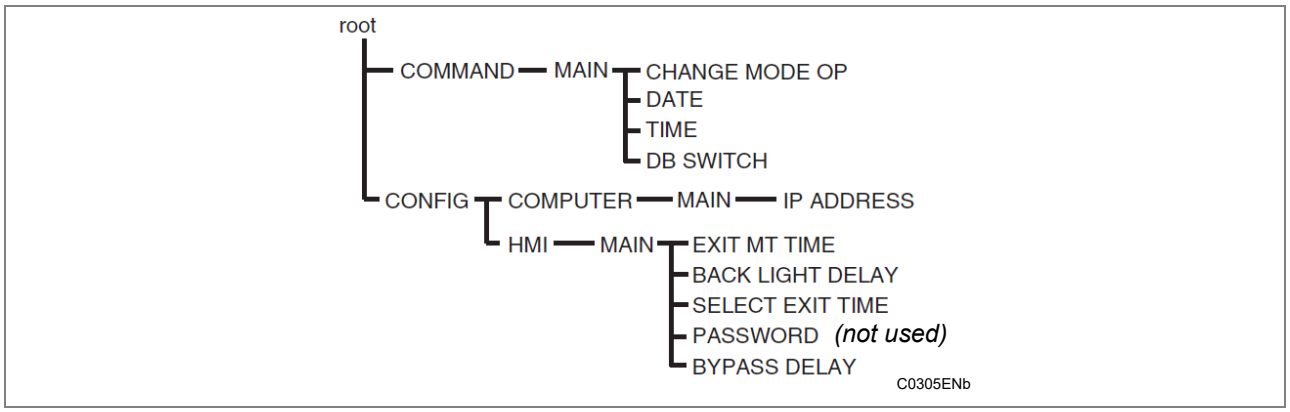


Figure 21: Menu tree in maintenance mode

2.3.18 CONTROLS

Some controls can be performed from the local HMI:

- Bay Local / Remote mode
- Control of circuit breakers or disconnecting switches
- Tap changer control
- C26x mode
- Database switch
- Reset of operating hours
- Time and date setting
- Manual reset/modification of counters and energy counters
- Alarms acknowledgement
- Alarms clearing

Some of these commands are accessible in a panel (bay panel or alarm panel), the others are accessible in the menu tree.

2.3.18.1 LOCAL / REMOTE CONTROL OF BAY

Local / Remote control of bay for LCD front panel (GHU30x)

The operator is allowed changing the bay mode:

- From local to remote
- From remote to local

If the C26x manages several bays, the state local / remote of bays is set bay by bay. Change of bay mode is enabled if a bay panel is defined. It means that, if a bay is not associated with a bay panel, its local/remote control mode cannot be controlled through the 

key of the panel.

Switch from the state remote to local can be password protected.

Switch from the state local to remote is not protected.

Local / Remote control of bay for simple panel with LEDs (GHU31x)

In case of simple panel, the operator controls all the bays of the C26x in the same time. To change mode, he has to press of the key during at least 3 seconds. A LED is necessary to display the current mode, so the 5th LED is required for that. If all the bays are NOT in the same state, the command will switch them all to local mode.

2.3.18.2 COMMANDS OF CIRCUIT BREAKERS, DISCONNECTING SWITCHES AND GENERIC MODULES

Module command is possible by 2 ways:

- From the graphical panel
- From the sub panels command

Circuit breakers, disconnecting switches or generic command are ordered from the local HMI by the operator. Commands allowed from the local HMI are:

- open
- close
- close a synchronised circuit breaker

Use the key 

to cancel the selection in the event of a command on a close_synchrocheck.

SBO command

In case of the select/execution order (SBO) for opening or closing a module, make a selection on the local HMI before an execution command.

For that, press the command key (key 

for OFF or key 

for ON) a first time for the selection command, and press key 

for the execution command.

After a positive acknowledgement of the selection command, the module is displayed in reverse video.

DE command

In event of the Direct execute order (DE) for opening or closing module, the operator sends directly the command using the command keys.

Interlocking bypass (if not inhibited in SCE)

To get access to the bypass flag modification panel once a module is selected, press the key  .

Set the interlocking bypass command BEFORE you send the execute order.

To send the bypass command, use the bypass flag on the interlocking equation (EQL).

B	**Y**	**P**	**A**	**S**	**S**						<time sync. state> <time>									
	N	**A**	**M**	**E**		**O**	**F**		**T**	**H**	**E**		**M**	**O**	**D**	**U**	**L**	**E**		
	E	**Q**	**L**		**B**	**Y**	**P**	**A**	**S**	**S**						**O**	**N**			
															E	**X**	**I**	**T**		

Note:
The flag is not displayed if the related function has been set to spare in the graphic part of SCE.

Interface with the operator on local control panel

The key is used to select graphically the module or the command of the bay. When a module is selected, its label flashes.

The operator sends this command from the bay panel with key (for OFF) or key (for ON).

The key is used to abort the choice during the selection step (in event of SBO order).

2.3.18.3 TAP CHANGER CONTROL REQUEST

The key allows selecting one by one the modules of the bay. When a transformer is selected, the operator can control it from local control panel by dealing with associated tap changer positions.

In order to command the tap changer, the bay that the transformer belongs to has to be in local mode.

The commands that can be sent through the local HMI are:

- Raise (= current tap position + 1) with the key
  - for a Double Wound transformer the Low Voltage is increased
  - for an Auto-wound transformer the Low Voltage is reduced

Note:
A "raise" control is refused if the current tap position value corresponds to the maximum position of the tap.

- Lower (= current tap position -1) with the key
  - for a Double Wound transformer the Low Voltage is reduced
  - for an Auto-wound transformer the Low Voltage is increased

Note:
A "lower" control is refused if the current tap position value corresponds to the minimum position of the tap.

- In case of "go to min", "go to max" or "go to position x" request, the C26x uses an internal automatic function (via ISaGRAF) which generates the desired controls sequences in order to reach automatically the expected position. This function may generate "Direct execute", "SBO once" or "SBO many" sequences according the configuration of the module.

2.3.18.4 C26X MODE

The operator is allowed to change the C26x mode between:

- Operational
- Maintenance
- Test/blocked

Note:
For redundant C26x units, the "test/blocked" mode's behaviour is different from that of the IEC 61850-compliant test/blocked mode used in non-redundant C26x units. See Functional Description chapter (C26x/EN FT for details).

2.3.18.5 DATA BASE SWITCH

The DS Agile C26x carries 2 databases: a current (i.e. operational) database, and a stand-by database. The operator can switch between both databases.

The operator sends this command from the menu tree.

2.3.18.6 RESET OPERATING HOURS

The operator is allowed to reset the operating hours counter.

The operator sends this command from the menu tree.

2.3.18.7 TIME AND DATE SETTING

The operator is allowed to set time and date of the C26x from the local HMI.

Time and date are set from the menu tree.

2.3.18.8 MANUAL VALUE CHANGE OF COUNTERS

Counters can be reset or assigned a new value manually by the operator at BCP.

Counters are changed from the menu tree.

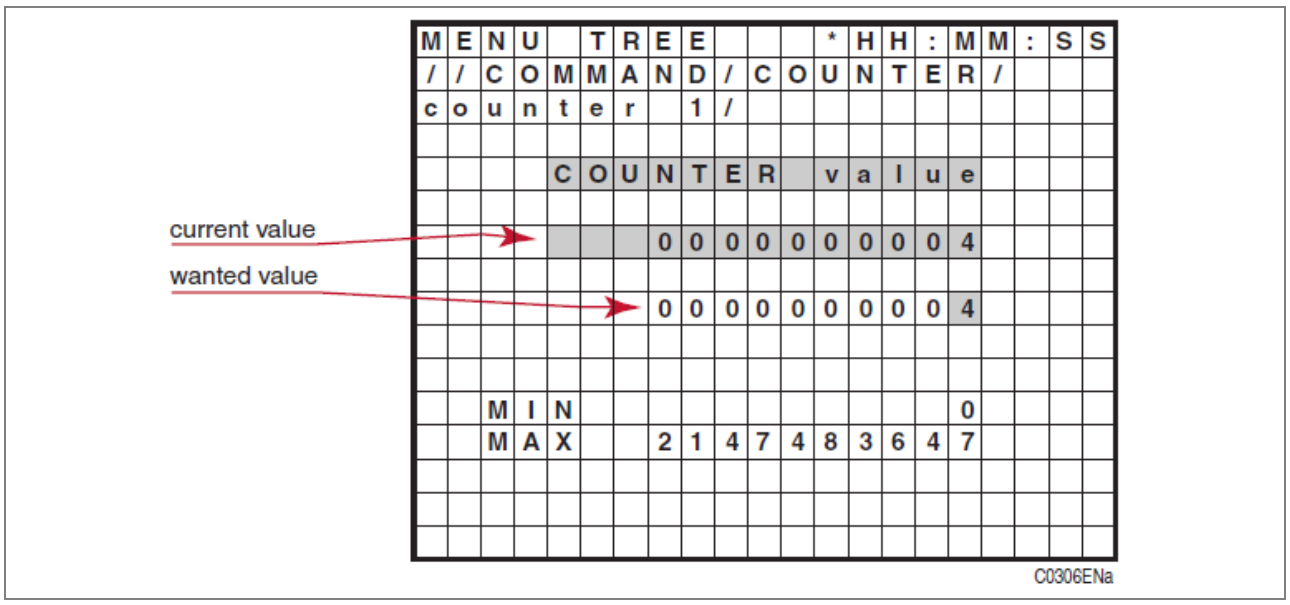


Figure 22: Example of manual value change for a counter

Figure 23: Example of manual value change for a counter

When this panel is displayed the most right digit of the wanted value is in inverse video.

Keys and are used to select the digit of the wanted value that has to be modified, and to change the value of the selected digit.

Once the correct wanted counter value is defined, it can be validated by pressing the key .

2.3.18.9 ACKNOWLEDGEMENT OF ALARMS

Acknowledgement of alarms is performed globally or on a per alarm basis:

- Global acknowledgement: the operator can acknowledge all the unacknowledged alarms of the C26x. It is performed from the menu tree.
- Alarm per alarm acknowledgement: the operator can perform the alarm acknowledgement one by one. It is done from the alarm panel.

2.3.18.9.1 Global acknowledge

The operator can acknowledge all the unacknowledged alarms of the C26x

Interface with the operator on local control panel

Acknowledgement of all alarms is done from the menu tree.

2.3.18.9.2 Alarm per alarm acknowledge

The operator can perform the alarm acknowledge one by one.

In this case, in the “alarm panel”, selects an alarm and can activate the acknowledgement.

Interface with the operator on local control panel

Acknowledgement alarm by alarm is done from the alarm panel.

The procedure of acknowledgement by the operator is the following one:

- select (in the alarm panel) one alarm with the select key  . Once the alarm is selected, the two first lines of the alarm in the alarm panel are blinking. Deselecting is performed by the key  .
- press the ‘enter’ key  .

The key  is used to abort the command.

If the key sequence is correct, the selected unacknowledged alarm is acknowledged.

The state of the alarm is then changed depending of its initial state:

- active unacknowledged ➔ active acknowledged
- inactive unacknowledged ➔ inactive acknowledged if the disappearance of the alarm has to be acknowledged

The alarm list is updated with the new state of the alarm. The alarm in the inactive acknowledged state is automatically cleared and removed from the alarm list if the automatic clearing mode is set for this alarm in the database.

2.3.18.10 ALARMS CLEARING

Clear of alarms is performed globally or on a per alarm basis:

- Global clearing: the operator can clear all the inactive acknowledged alarms of the C26x. It is performed from the menu tree.
- Alarm per alarm clearing: the operator can perform the alarm clearing one by one. It is done from the alarm panel.

2.3.18.10.1 Global clearing

The operator can clear all the inactive acknowledged alarms of the C26x

Interface with the operator on local control panel

Clear of all alarms is done from the menu tree.

2.3.18.10.2 Alarm per alarm clearing

The operator can perform the alarm clear one by one.

In this case, in the “alarm panel” he selects an alarm and can activate the clearing.

Interface with the operator on local control panel

Clearing alarm by alarm is done from the alarm panel.

The procedure of clear by the operator is as follows:

- The operator selects (in the alarm panel) one alarm with the select key  .

Only the inactive acknowledged alarm can be selected.

- Once the alarm is selected, the two first lines of the alarm in the alarm panel are blinking (deselect by pressing the key )
- Press the ‘enter’ key  .

The key  is used to abort the command.

If the key sequence is correct, the selected alarm is cleared and disappears from the list.

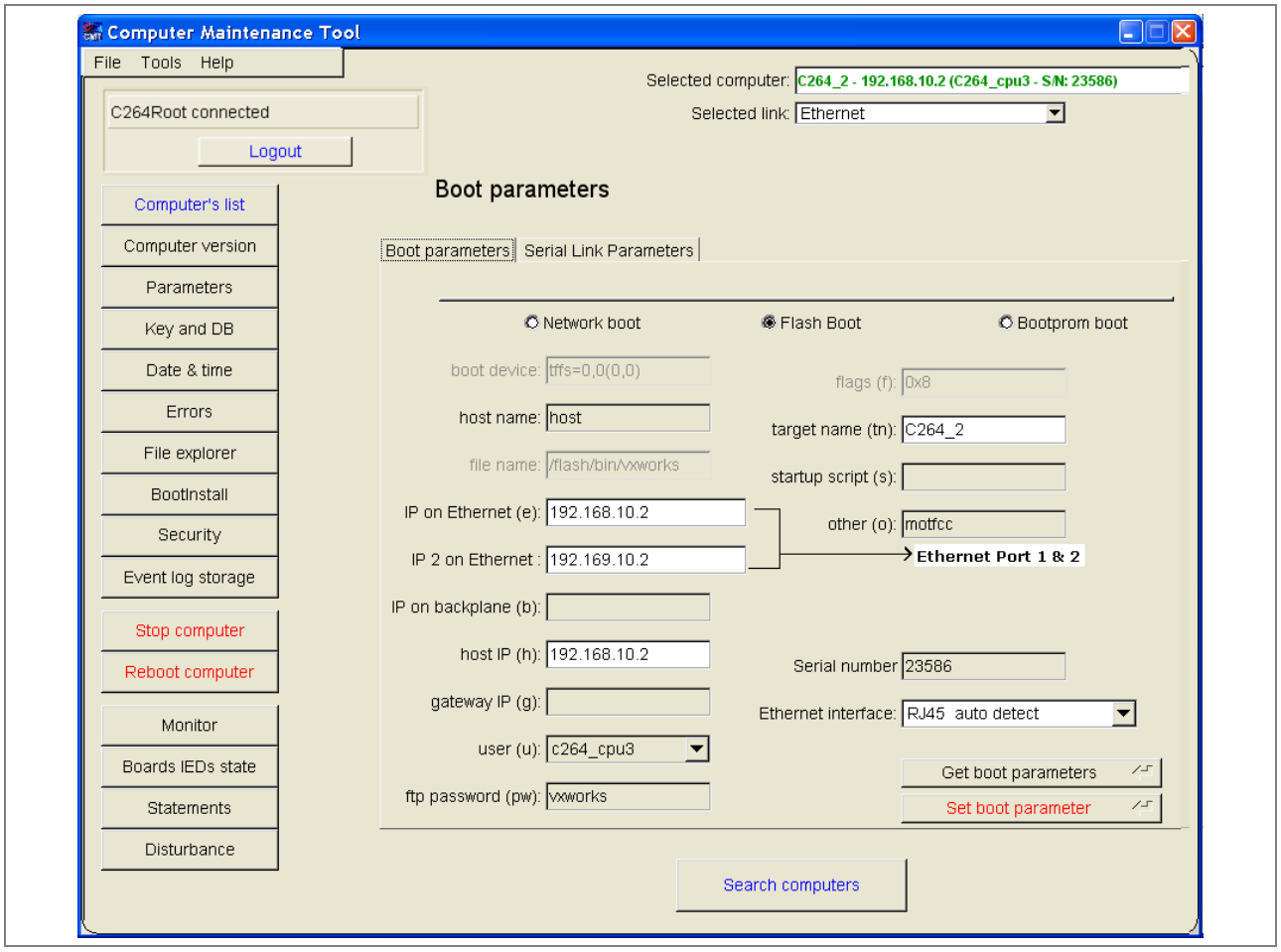
3 COMPUTER MAINTENANCE TOOL

The Computer Maintenance Tool is a graphical tool that gives access to standard commands and secures the basic maintenance interventions.

The CMT communicates with the C26x on Ethernet in direct addressing mode.

The CMT's functions are:

- Access to C26x software version and facility to download new software
- Access to C26x databases versions and descriptions and facility to download, switch new database, and upload database (for some restricted applications)
- Access to boot parameters and facility to change them
- Access to date and time and facility to change them
- Access to sequence of events



4 LOG PRINTING

Some specific events (the events to log are declared in the database) are printed and chronologically sorted on logbook printers. They are printed with their time stamping and a complete description (location and event description).

Logbook printers can be connected to the SCP (aView system HMI). The printout format, which can be defined by user during the system configuration phase, is the same across all the connected log book printers.

4.1 INPUTS

A C26x receives acquisition from various pieces of equipment (protection, sensors, etc.) and, after processing, may generate events that have to be printed. These kinds of events are defined in the database during the configuration phase.

Types of events can be:

- Binary inputs (SP, DP, MP, SI and Groups)
- Tap position indication
- Measurement
- Operator action:
- Log-in and log-off,
- Modules control
- Alarm acknowledgement / clearing

4.2 OUTPUTS

The 5 following properties can be printed. Each property is separated from the other by one blank character. The position of each property in the printed line (i.e. position 1, 2, 3, 4 or 5) is defined in configuration:

- **Chronology** – 1 character: refer to section “SOE events”
- **TimeStamp** – 24 or 26 characters: refer to section “SOE events”
- **Origin** - 67 characters: for BI, TPI, measurements, controls and alarms, the origin gives the access path to the object (refer to section “SOE events”)
- **ObjectName** - 16 characters
- **ObjectMessage** - 16 characters

The Origin, ObjectName and ObjectMessage properties contain different information depending of the associated event type.

COMMISSIONING

C26X/EN CM/E72C

Contents

1	**SCOPE OF THE DOCUMENT**	**3**
1.1	Introduction	3
1.2	Definition	3
1.3	Commissioning the product	3
1.4	Responsibility	4
1.5	Setting familiarisation	4
1.6	Requirements	4
2	**DOWNLOADING A DATABASE**	**5**
2.1	Database download with CMT	5
2.2	Database download with SMT	6
3	**COMMISSIONING TESTS WITH GHU300 OR GHU301 (WITH LCD)**	**7**
3.1	Preparation	7
3.2	Check version & number	8
3.3	Faults	9
3.4	Check the boards status	9
3.5	Checking the binary signal inputs	10
3.6	Checking the output relays	11
3.7	Testing the control functions	12
3.8	Switching from local to remote control	12
4	**COMMISSIONING TESTS WITH GHU310 OR GHU311 (WITHOUT LCD)**	**13**

1 SCOPE OF THE DOCUMENT

This document is a chapter of the DS Agile C26x manuals. It describes the database downloading and C26x commissioning and should not be confused with application commissioning. This chapter follows the chapter C26x/EN IN (Installation).

1.1 INTRODUCTION

To commission DS Agile C26x, it is necessary to verify that the hardware is functioning correctly and that the application-specific software settings have been applied to the C26x.

To verify that the DS Agile C26x is operating correctly, a database has to be loaded into the C26x. Once the database has been loaded, tests should be performed on each single C26x unit.

As the DS Agile C26x's menu language is user-selectable, it is acceptable for the Commissioning Engineer to change it to allow accurate testing as long as the menu is restored to the customer's preferred language on completion.



Caution:
Before carrying out any work on the equipment, the user should be familiar with the contents of the chapter C26x/EN SA (Safety), of the GE Grid Solutions Safety Guide: SFTY/4L M, and of all the C26x technical data.

1.2 DEFINITION

The objective of commissioning is to prove that the equipment, and any interconnections to process and other system components, is suitable for its intended purpose.

Commissioning is the activity that demonstrates that the equipment is acceptable for service. As digital devices are configured for specific application, the commissioning can be split into two main parts:

- Commissioning the product.
- Commissioning the application (when product has had its database loaded). This second part is documented and carried out through FAT (Factory Acceptance Tests), and SAT (Site Acceptance Tests) activities.

The scope of this chapter is the description of commissioning tests that prove that the C26x unit is suitable for further application tests.

1.3 COMMISSIONING THE PRODUCT

Commissioning the product starts with product reception and is continued through all off the installation procedures. Activities are divided between: -

- Visual inspection at reception.
- Inspection at Front Panel when DS Agile C26x is powered up.
- The starting point is the delivery form that describes all of the delivered hardware components that constitute the DS Agile C26x.

1.4 RESPONSIBILITY

Most commissioning activities involve a power supply that can damage the installation or cause injury to the operator. The chapter C26x/EN SA (Safety) should be read carefully before any handling.

Before starting commissioning, the contractual and human responsibilities should be clearly defined.

Only qualified and competent persons should carry out commissioning and the validation tests.

1.5 SETTING FAMILIARISATION

Commissioning the DS Agile C26x requires operation of its Human Machine Interface (the Local Control Display). The chapter C26x/EN HI contains a detailed description of the menu structure of the DS Agile C26x.

The commissioning engineer should have had training on the HMI or sufficient time should be allowed to become familiar with it (with an already commissioned device).

1.6 REQUIREMENTS

It is essential that all requirements expressed in the chapter C26x/EN IN (Installation) have been fulfilled.

The delivery form is the starting document.

2 DOWNLOADING A DATABASE

The DS Agile C26x requires a database to operate. It stores up to two databases, named “current” and “stand-by”. Only the current database is used for operation. The second database can be downloaded when the C26x is in operational or maintenance mode. A specific control allows switching between the two stored databases.

DS Agile SCE (System Configuration Editor) is used to generate the databases. SMT (System Management Tool) or CMT (Computer Maintenance Tool) are used to download and switch the databases.

The use of SMT or CMT depends on the number of controllers. For several controllers on the same Ethernet network, it is recommended to use SMT in order to ensure database consistency between units.

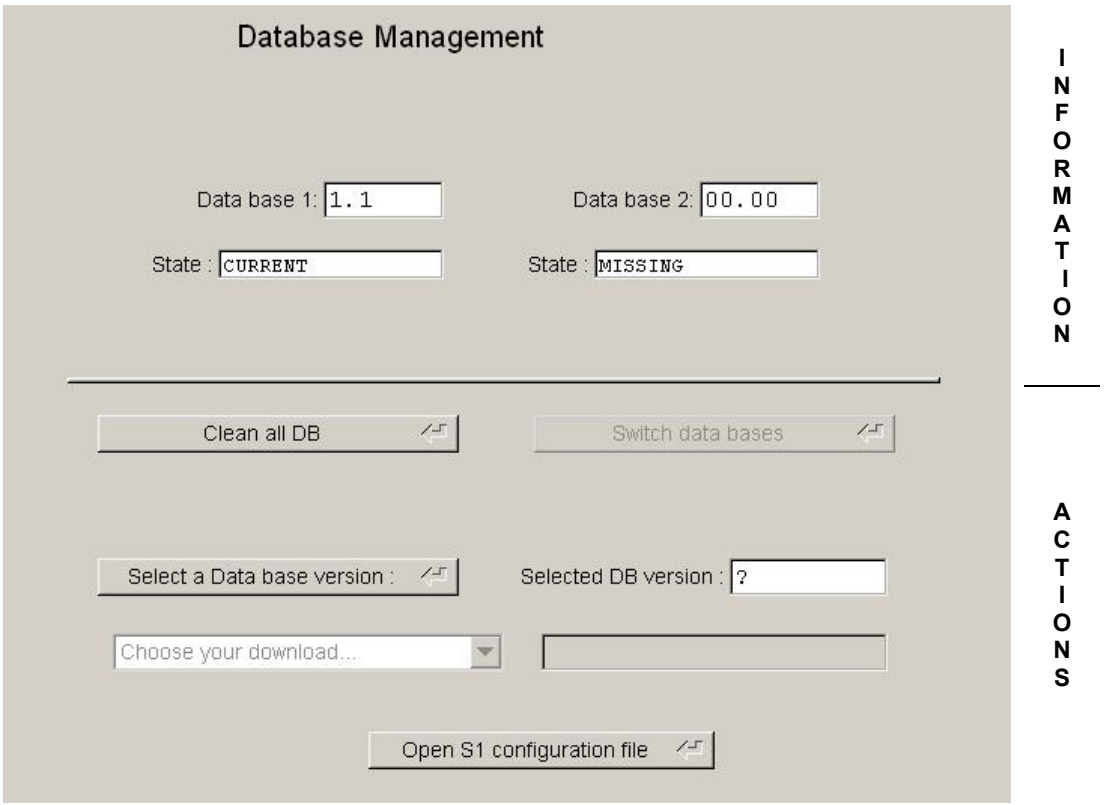
2.1 DATABASE DOWNLOAD WITH CMT

First copy the .zip database issued by SCE to the host.

Note:
Do not put the archive on the desktop nor in the My Documents folder (the path must not include any blanks).
Do not keep it in a USB drive.

In the CMT application:

- Click the **Search computers** button in the bottom part
- Select the targeted C26x in the list
- Click the **Data Base** menu button:



- Click the **Select a Data base version** button, select the bd.x.xx.zip file corresponding to the database to use and click OK; as a result, the .adb files in the archive are transferred into the folder <installation folder>/Computer/Cmt/db
- In the **Choose your download** list**,** select **Database only**; this opens a dialog box: choose the .adb file corresponding to the selected C26x and click **OK**
- Click the **Switch data bases** button; the DS Agile C26x restarts on the database you have downloaded. It starts in operational mode.

For more information, refer to the section *CMT In-depth description* in the *Installation* chapter of the C264 use manual.

2.2 DATABASE DOWNLOAD WITH SMT

2.2.1 LOADING DB UNDER SMT

First load the DB version (menu Databases > Add database…). The DB is then stored on the hard disk and appears in the database list.

Right click to “set current” the DB, then to send a “connect all”, then SMT communicates with the C26x; otherwise check wiring and settings.

2.2.2 DOWNLOAD DB ONTO C26X

Still using right buttons choose the “download all” option and wait for the acknowledgement of a successful transfer.

Note:
After a format and a bootInstall of VB6.19 version C26x and a C26x reboot using the CMT, the SMT cannot find the connected C26x; therefore it is not possible to load a DB. To retrieve the C26x, reboot it from the shell (Telnet button).

2.2.3 SWITCH TO DOWNLOADED DATA BASE

If no database has previously been installed, then the database is automatically set to be the running database. If there is a database already installed, then the downloaded database will become the standby database. In this event, the new database has to be switched to make it the running database. In both cases it is necessary to reboot the C26x to put the database into running mode.

For more information, refer to the *DS Agile system Commissioning chapter: DS Agile/EN CM*.

3 COMMISSIONING TESTS WITH GHU300 OR GHU301 (WITH LCD)

3.1 PREPARATION

After the C26x has been installed and connected as described in chapters C26x/EN IN and C26x/EN CO, the commissioning procedure can begin.

Before turning on the power supply voltage, the following items must be checked:

- Is the device connected to the protective ground at the specified location?
- Does the nominal (and measured) voltage of the battery agree with the nominal auxiliary voltage of the device?
- Are the current and voltage transformer (if used) connections, grounding, and phase sequences correct?

After the wiring work is completed, check the system to make sure it is properly isolated.

Once all checks have been made, the power supply voltage may be turned on.

After the voltage has been applied, the C26x starts up.

During start-up, various tests are carried out; the results show on the LEDs and LCD.

If a database is present in the C26x, the fourth LED will stay on.

After approximately 30 s, the C26x is ready for operation.

After the settings have been made, the following checks should be carried out before any interlocks or isolation is cancelled:

- Are the software and database versions compatible with the hardware?
- Has the setting file been uploaded into the C26x?
- Are all boards correctly assigned within the C26x?
- Are all IOs correctly configured and recognised by the C26x?
- Are all communications (S-BUS, T-BUS and L-BUS) correctly configured and recognised?
- Are the control functions fully operational?
- Is the automation running?

The following sections describe the checks to be performed to answer these questions and ensure that the C26x is fully operational in its application.

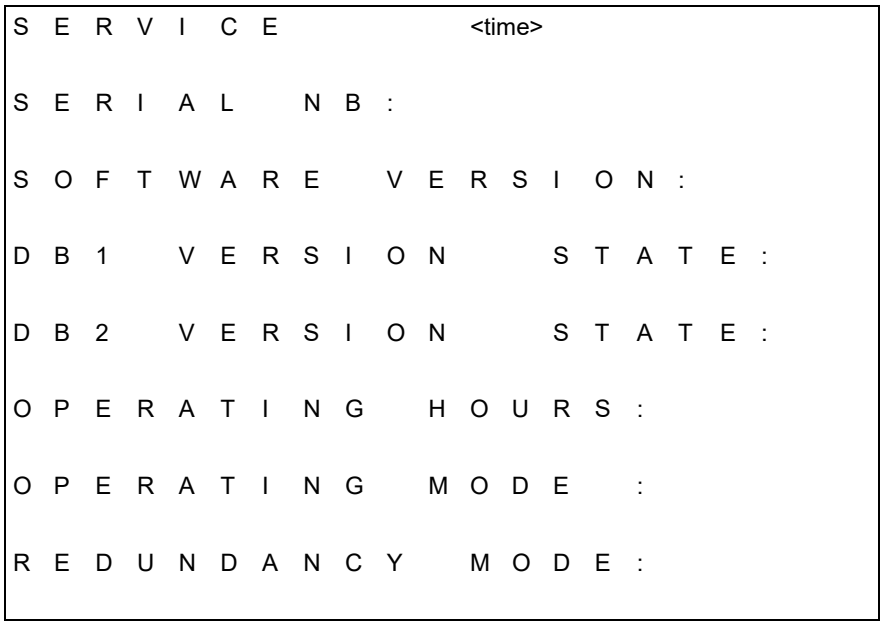
3.2 CHECK VERSION & NUMBER

In the commissioning process this panel is the first to check. The C26x serial number tells if the C26x is the ordered one, and indirectly gives the hardware version.

The software version from the VC document gives features and limits of the DS Agile C26x.

The database version is given by DS Agile SCE database version and describes all the settings on the DS Agile C26x.

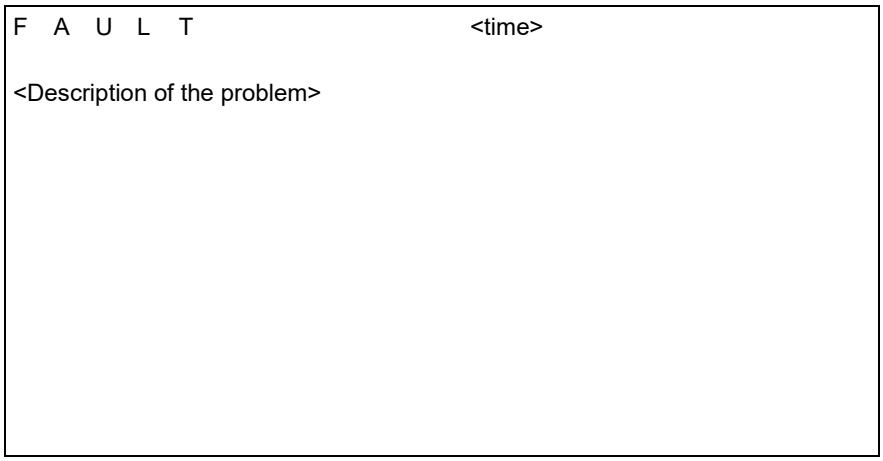
The operational mode indicates whether the device is in a maintenance or operational mode.



3.3 FAULTS

If the first LED is alight, this means that there is something wrong inside the C26x.

The FAULT panel gives information about the problem.



3.4 CHECK THE BOARDS STATUS

The C26x's front panel gives access to C26x boards status (refer to chapter C26x/EN HI).

Board labels are defined during the configuration phase. They are based on short names and are indexed automatically. The default configuration model is:

- AIU Analogue Input Unit (DC current and voltage inputs)
- AOU Analogue Output Unit (4 current analogue outputs)
- BIU Basic Interface Unit (power supply)
- CCU Circuit breaker Control Unit (SBO board)
- DIU Digital Input Unit
- DOU Digital Output Unit
- GHU Graphical Human Unit
- HBU High Break Unit
- TMU Transducerless Measurements Unit (CT/VT board)

The product checks whether the number of installed boards matches with the number of boards configured, the following messages are generated depending on the results:

- OK Board configured present and operational
- Failure Board configured present and faulty
- Missing Board configured not present
- Too many Board not configured but present (spare)

Note that these state labels are manually set in configuration and that the exact text could slightly vary due to customer preference, but not their actual meaning.

B O A R D <time>

<Board Label><Number>
<Board Status>

<Board Label><Number>
<Board Status>

<Board Label><Number>
<Board Status>

<Board Label><Number>
<Board Status>

<Board Label><Number>
<Board Status>

<Board Label><Number>
<Board Status>

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3.5 CHECKING THE BINARY SIGNAL INPUTS

The C26x front panel gives access to input status for all DI boards (DIU200, DIU210, DIU211, CCU211 or CCU200).

For DIU200, DIU210 and DIU211 boards:

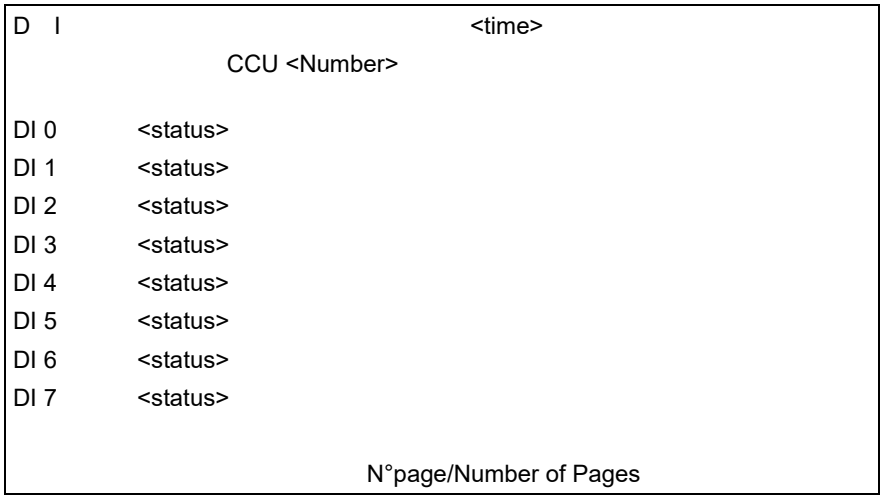
D I <time>

DIU <Number>

DI 0	<status>	DI 8	<status>
DI 1	<status>	DI 9	<status>
DI 2	<status>	DI 10	<status>
DI 3	<status>	DI 11	<status>
DI 4	<status>	DI 12	<status>
DI 5	<status>	DI 13	<status>
DI 6	<status>	DI 14	<status>
DI 7	<status>	DI 15	<status>

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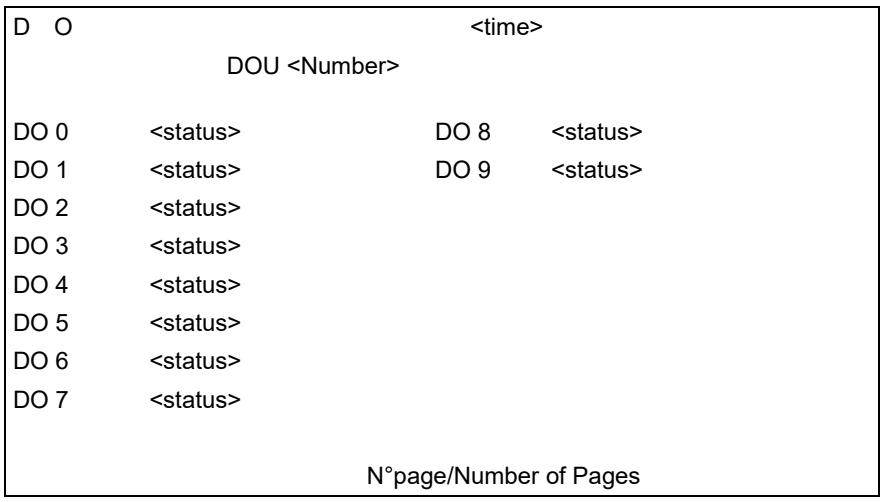
For CCU200 and CCU211boards:



3.6 CHECKING THE OUTPUT RELAYS

The C26x's front panel gives access to output relays status for all DO boards (DOU200, DOU201, HBU200, CCU211 or CCU200).

For DOU200 and DOU201 boards:



For CCU200 and CCU211 boards:

D O <time>

CCU <Number>

DO 0 <status>
DO 1 <status>
DO 2 <status>
DO 3 <status>

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3.7 TESTING THE CONTROL FUNCTIONS

The selected bay type is displayed on the Bay Panel. The activation of the Bay Panel display is described in Chapter C26x/EN HI.

If the position signals of the switchgear units are connected correctly to the C26x, then the updated switching status of the switchgear units will be displayed on the bay panel.

If the switching status is not displayed correctly, the user can check the physical state signals of the binary inputs to determine whether the status signals in the C26x are correct.

3.8 SWITCHING FROM LOCAL TO REMOTE CONTROL

Bays can be controlled locally using the keys on the local control panel or remotely through the communication interface (SCADA or system HMI).

The control point – Local or Remote – is selected either by means of the L/R key on the local control panel or via appropriately configured binary signal input. If binary signal input has been configured, then the L/R key has no effect.

Switching from Remote to Local using the L/R key on the local control panel is only possible if the L/R password has been entered. The selected control point is displayed on the Bay Panel.

3.8.1 LOCAL CONTROL

Bay to be controlled is selected by pressing the Selection key on the local control panel.

If the bay is to be controlled through binary signal inputs, then the appropriate signal input must be triggered.

3.8.2 REMOTE CONTROL

The switchgear units can be controlled via the communication interface or appropriately configured binary signal inputs.

4 COMMISSIONING TESTS WITH GHU310 OR GHU311 (WITHOUT LCD)

After the C26x has been installed and connected as described in chapters C26x/EN IN and C26x/EN CO, the commissioning procedure can begin.

Before turning on the power supply voltage, the following items must be checked:

- Is the device connected to the protective ground at the specified location?
- Does the nominal (and measured) voltage of the battery agree with the nominal auxiliary voltage of the device?
- Are the current and voltage transformer (if used) connections, grounding, and phase sequences correct?

After the wiring work is completed, make sure the system is properly isolated.

Once all checks have been made, the power supply voltage may be turned on.

After the voltage has been applied, the C26x starts up.

During start-up, various tests are carried out; the results show on the LEDs.

If a database is present in the C26x, the fourth LED will stay on.

After approximately 30 s, the C26x is ready for operation.

After the settings have been made, it is necessary to check that the software and the database versions are compatible with the hardware.

Carry put checks using the CMT (see chapter C26x/EN IN).

With the CMT, the “Computer version” button gives access to the current C26x software version, the active database and the C26x operational mode.

For a normal behaviour, the C26x mode is “ACTIVE”.

MAINTENANCE

C26X/EN MF/E72b

Contents

1	**SCOPE OF THE DOCUMENT**	**3**
2	**STANDARD MAINTENANCE OPERATION**	**4**
2.1	**Level 1 diagnosis facilities**	**4**
2.1.1	Front panel LED indications	4
2.1.2	Front panel LCD indications	5
2.1.3	Adjustment of the brightness of the front panel LCD	6
2.2	**Maintenance period**	**6**
2.3	**Method of repair**	**6**
2.3.1	Replacing the complete DS Agile C26x	7
2.3.2	Replacing a board	9
2.4	**Cleaning**	**13**
3	**MAINTENANCE OPERATIONS**	**14**
3.1	**Requirements**	**14**
3.2	**Installation and general use**	**14**
3.3	**How to determine the BOOTROM version**	**15**
3.4	**How to restore the C26x Boot Parameters**	**16**
3.5	**How to upgrade firmware from DS Agile <=v7.0.4 to >=v7.0.5**	**18**
3.5.1	Prerequisites	18
3.5.2	C264 Upgrade	18
3.6	**Updating C264 certificates**	**21**
3.6.1	Prerequisites	21
3.6.2	Updating the CMT certificate in the Local Machine certificate store	22
3.6.3	Updating the C264 certificate	24
3.6.4	Removing the old CA certificate from the Local Machine Certificate Store	26
3.6.5	Certificate verification	27
3.7	**How to Edit PTP settings locally**	**28**
3.7.1	Editing the ptp_config.xml file	28
3.7.2	Uploading PTP configuration to the C26x	29
3.8	**Reset to factory state**	**30**
3.8.1	Factory reset Flowchart	30
3.8.2	Keys to factory reset Flow Chart	31

1 SCOPE OF THE DOCUMENT

This document is a chapter of the DS Agile C26x documentation. It describes the Maintenance and Fault Finding procedures of the DS Agile C26x. Reading chapter C26x/EN SA is mandatory.

2 STANDARD MAINTENANCE OPERATION

The aim of this chapter is to describe standard methods to diagnose the DS Agile C26x status and provide common maintenance procedures for the replacement and/or addition of components.

Before any maintenance operation, please refer to the chapter C26x/EN SA (Safety) and to the GE Grid Solutions Safety Guide: SFTY/4L M/C11 (or later issue).

2.1 LEVEL 1 DIAGNOSIS FACILITIES

When maintenance action is planned, the operator should prepare, act and report.

The minimal preparation is to get the commissioning Record Sheet (see the chapter C26x/EN RS) of installed DS Agile C26x in order to see the product configuration and its history. Refer to your own experience besides this manual. It is also recommended to extract the logbook history in order to be informed of the intervention conditions.

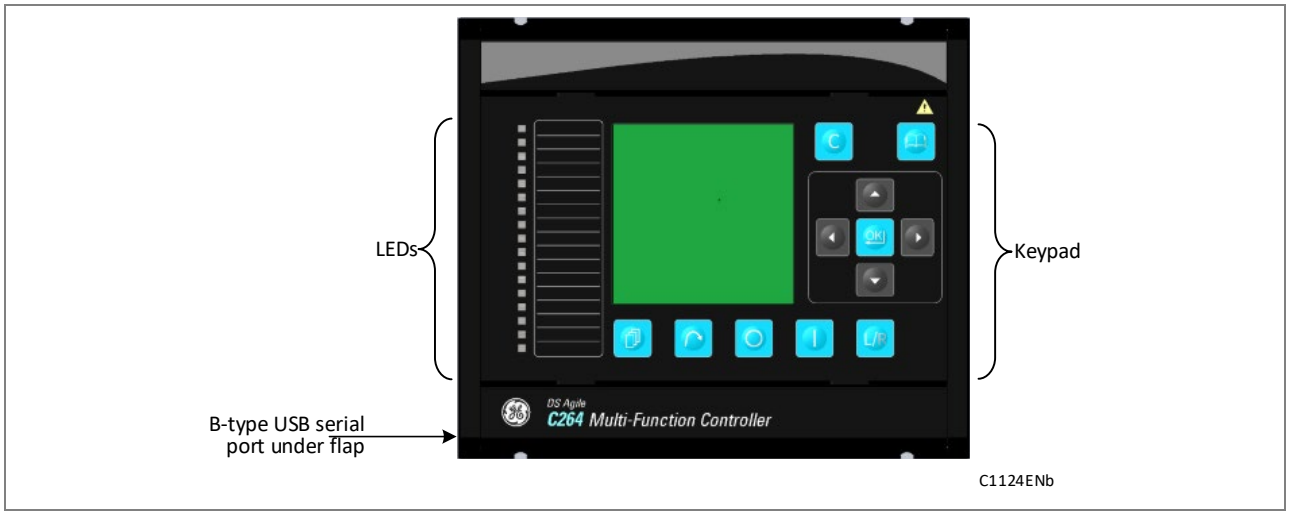
At a first level the product provides several methods to check the context of the fault. The main ones are:

- LEDs
- LCD (Liquid Crystal Display)

2.1.1 FRONT PANEL LED INDICATIONS

Refer to chapter C26x/EN HI for the precise LED's description.

On the main rack:



The first 5 LEDs indicate the DS Agile C26x status information. With reference to the chapter C26x/EN HI (Human Interface), the LEDs indicate from top to down:

LED id	Colour	LED on	LED slow blinking	LED fast blinking	LED off
1	Red	There is at least one major fault (hardware, database) (1)	There is at least one minor fault (I/O board, communication to IEDs)(2)	Not used	No fault
2	Yellow	All the alarms are acknowledged, but there is at least one alarm still active (3)	All alarms displayed in the alarm panel are inactive and acknowledged	There is at least 1 not acknowledged alarm displayed in the alarm panel	No alarm

LED id	Colour	LED on	LED slow blinking	LED fast blinking	LED off
3	Amber	C26x in operation	C26x in maintenance	C26x in test	C26x in reboot
4	Green	Power on	Not used	Not used	Power off
5 (4)	Red	All bays managed by the C26x are in LOCAL mode	Bays managed by the C26x are not in the same control mode	Not used	All bays managed by the C26x are in REMOTE

(1) Major fault: DS Agile C26x not available due to internal failure (database error, CPU board failure, …).

(2) A minor fault is a fault causing only the non availability of a part of the functionality.

(3) When the alarm disappears, the LED automatically returns to OFF.

(4) Assigned by the C26x only for front panel without LCD: GHU3x1 or for an extension C26x

A minor fault is a fault causing only the non-availability of a part of the functionality:

Symptom	LED status	Possible reason	Way to solve
Functions as commu-nication, automation, printing are well operating & the watchdog on BIU is SET	All LEDs are OFF	The cable between CPU and GHU3xx, or GHU3xx itself is not operational	Verify the connection between CPU or GHU3xx. If connection is OK and the problem is not already solved then change the GHU3xx board.
The supply is ON and the watch dog on BIU is RESET.	LED6 is ON (but LED7 thru 13 are OFF if predefined)	Problem with BIU board or CPU board	Replace BIU board or CPU board.
The C26x is not running or not fully operational	LED1 ON	Incoherent database	Download a coherent database
	At least one prede-fined LED among LED7 thru 13 is ON	Hardware fault	Go in Fault display and Board display to determine the faulty board and change it.
The C26x is not fully operational	LED1 is blinking	An IED is disconnected (LED 6 and/or 12 ON)	Go into IED display to determine the disconnected IED and verify the cable, the BIU configuration, the communication parameters inside the DS Agile configurator, the communication parameters inside the relay.
		A problem with clock synchronisation	Go into Fault display & verify that the external clock is switch ON, the external clock is connected to the antenna, the external clock is connected to the C26x.
		A problem with PLC (ISaGRAF)	Go into Fault display & connect the ISaGRAF work bench to the C26x. Verify the behaviour of the PLC.

Note:
After a reboot using the CMT, the PSL might do not work. Use the serial link instead and type 'reboot' in Hyperterminal.

2.1.2 FRONT PANEL LCD INDICATIONS

The GHU300 or GHU310 board gives access to the status of the boards, the state of digital inputs, the state of digital outputs, the connection state with external devices. The CM chapter describes this.

2.1.3 ADJUSTMENT OF THE BRIGHTNESS OF THE FRONT PANEL LCD

When the keys  and  are pressed simultaneously it is possible to decrease (resp. increase) the brightness of the front panel LCD by pressing key  (resp. ).

2.2 MAINTENANCE PERIOD

It is recommended that GE Grid Solutions products receive periodic monitoring after their installation. Deterioration may occur over time. Because of the electrical and disturbed environment, it is recommended to confirm at regular intervals that the DS Agile C26x is operating correctly.

The DS Agile C26x has been designed for a life cycle of over 15 years.

The DS Agile C26x is self-supervising and therefore requires less maintenance than previous products. Most problems will lead to an alarm so fast and appropriate action can be done. However, carry out periodic tests to ensure the DS Agile C26x is operating correctly and that the external wiring in a good condition.

If a Preventative Maintenance Policy exists within the customer's organisation then the recommended product checks should be included in the regular programme. Maintenance periods will depend on many factors, such as:

- the operating environment
- the accessibility of the site
- the amount of available manpower
- the importance of the installation in the power system
- the consequences of failure

2.3 METHOD OF REPAIR

If the DS Agile C26x should develop a fault whilst in service, depending on the nature of the fault, the watchdog contacts will change state and an alarm condition will be flagged. Due to the extensive use of surface-mount components (SMC) faulty boards should be replaced, as it is not possible to perform repairs on damaged circuits with SMC technology. Thus either the complete DS Agile C26x or just the faulty board, identified by the built-in diagnostic software, can be replaced.

The preferred method is to replace the complete DS Agile C26x as it ensures that the internal circuitry is protected against electrostatic discharge and physical damage at all times and overcomes the risk of incoherency with the new boards. In some cases, it may be difficult to remove an installed DS Agile C26x due to limited access in the back of the cubicle and rigidity of the scheme wiring then only the faulty elements will be replaced.

Replacing boards can reduce transport costs but requires clean, dry on site conditions and higher skills from the person performing the repair. If an unauthorized service centre performs the repair, the warranty will be invalidated.



Caution:
Before carrying out any work on the device, the user should be familiar with the contents of the safety and technical data chapters, as well as GE Grid Solutions' Safety Guide: Pxxx-SG-4LM-1 or later issue, and have read the ratings on the equipment's rating label.
This should avoid incorrect handling of the electronic components and damage.



Caution:
Only qualified personnel may carry out maintenance operations.
Always hold boards by their sides: Do not touch either the component side or the soldering side.
Always wear anti-static protection when handling printed circuit boards.

2.3.1 REPLACING THE COMPLETE DS AGILE C26X

The case and rear terminal blocks have been designed to facilitate removal of the complete DS Agile C26x.

Before working at the rear of the DS Agile C26x, isolate all the voltages and currents connected to the DS Agile C26x.

Note:
The DS Agile C26x units have current transformer shorting switches which close when terminal block is removed.

2.3.1.1 REPLACING THE COMPLETE DS AGILE C26X

Note:
Before any disconnection, check the labels correctly define the connectors and match with the wishing description you have. Otherwise, note the current wiring in order to prepare the new C26x installation.

1 Disconnect the power supply connector.

2 Disconnect the DS Agile C26x IRIG-B, fibre optic, Ethernet RJ45 and serial links connected on CPU board.

3 Disconnect the input/output connectors.

4 Disconnect the earth connection.

There are two types of terminal blocks used on the DS Agile C26x:

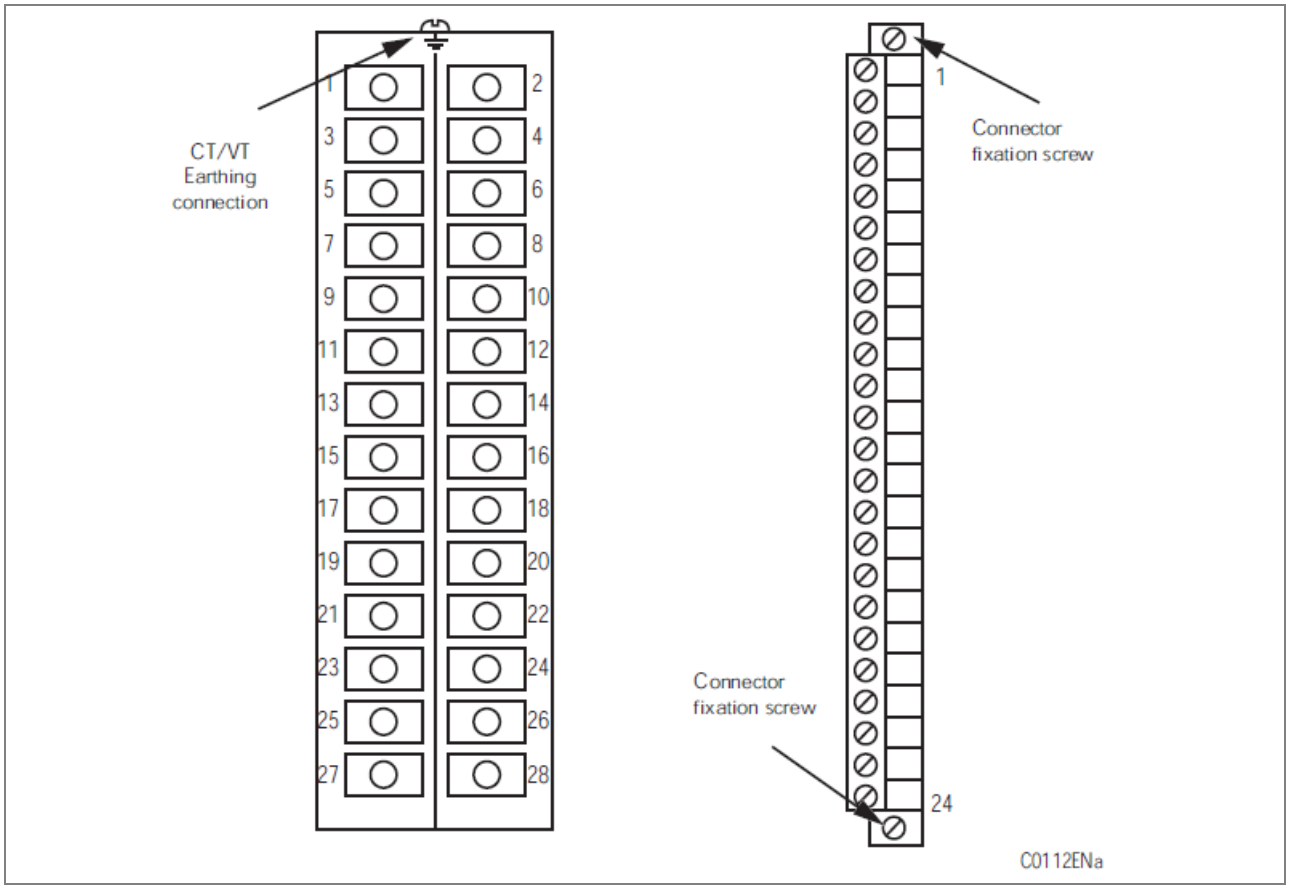


Figure 1: Location of securing screws for terminal blocks

Note:
The use of a magnetic bladed screwdriver is recommended to minimise the risk of the screws being left in the terminal block or lost. A 3 mm flat head screwdriver is recommended for fixation screws. A 6 mm flat head screwdriver is recommended for CT/VT earthing connections.

Without exerting excessive force or damaging the scheme wiring, pull the terminal blocks away from their internal connectors.

Remove the screws used to fasten the DS Agile C26x to the panel, rack, etc. These are the screws with the larger diameter cross heads that are accessible when the access covers are fitted and open.

Caution:
If the top and bottom access covers have been removed, do not remove the screws with the smaller diameter heads even if they are accessible. These screws hold the front panel on the DS Agile C26x.

Withdraw the DS Agile C26x from the panel or rack carefully and take care of its weight because there are some heavy parts due to the internal transformers.

2.3.1.2 INSTALLATION OF A NEW C26X

To reinstall the repaired or new DS Agile C26x, follow the above procedure in reverse. Ensure that each terminal block is relocated in the correct position and the case correctly earthed, IRIG-B and fibre optic connections are put back in place.

Once reinstallation is complete the DS Agile C26x should be commissioned again using the instructions in the chapter C26x/EN CM.

2.3.2 REPLACING A BOARD

To replace any of the DS Agile C26x unit's boards it is necessary to remove the front panel.

Before removing the front panel the auxiliary supply must be switched off. It is also strongly recommended that the voltage and current transformer connections and trip circuit are isolated.

Open the top and bottom access covers. With size 80TE cases the access covers have two hinge-assistance T-pieces which clear the front panel molding when the access covers are opened by more than 120°, thus allowing their removal.

If fitted, remove the transparent secondary front cover. A description of how to do this is given in Chapter C26x/EN IT (Introduction).

By applying outward pressure to the middle of the access covers, they can be bowed sufficiently so as to disengage the hinge lug allowing the access cover to be removed. The screws that fasten the front panel to the case are now accessible.

The size 40TE case has four cross head screws fastening the front panel to the case, one in each corner, in recessed holes. The size 80TE case has an additional two screws, one midway along each of the top and bottom edges of the front plate. Undo and remove the screws.



Caution:
Do not remove the screws with the larger diameter heads, accessible when the access covers are fitted and open.
These screws hold the DS Agile C26x in its mounting (panel or cubicle).

When the screws have been removed, the complete front panel can be pulled forward and separated from the metal case.



Warning:
Caution should be observed at this stage because a cable connects the front panel to the rest of the DS Agile C26x circuitry.

Additionally, from here on, the internal circuitry of the DS Agile C26x is exposed and not protected against electrostatic discharges, dust ingress, etc. Therefore ESD precautions and clean working conditions should be maintained at all times.

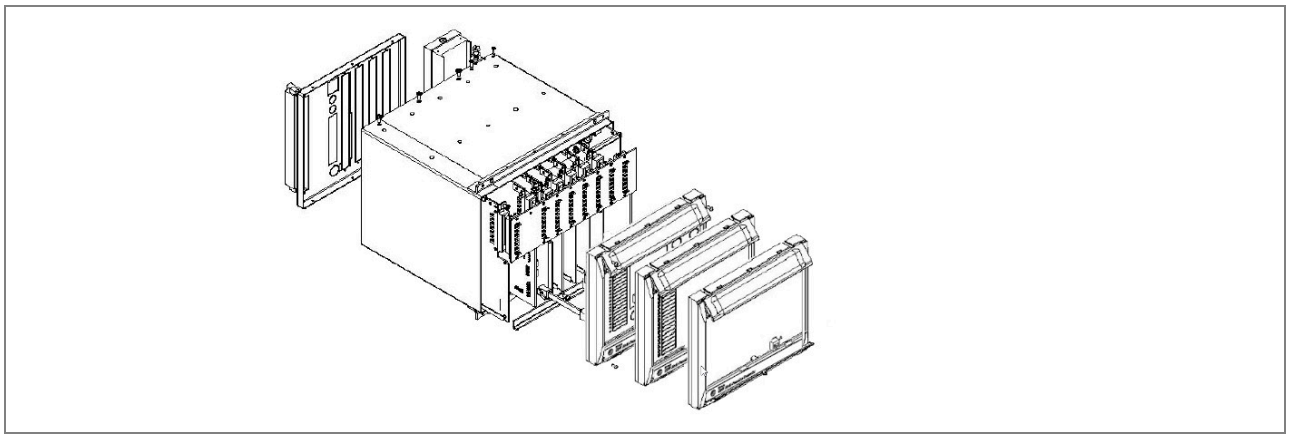


Figure 2: 40TE case with TMU2xx board

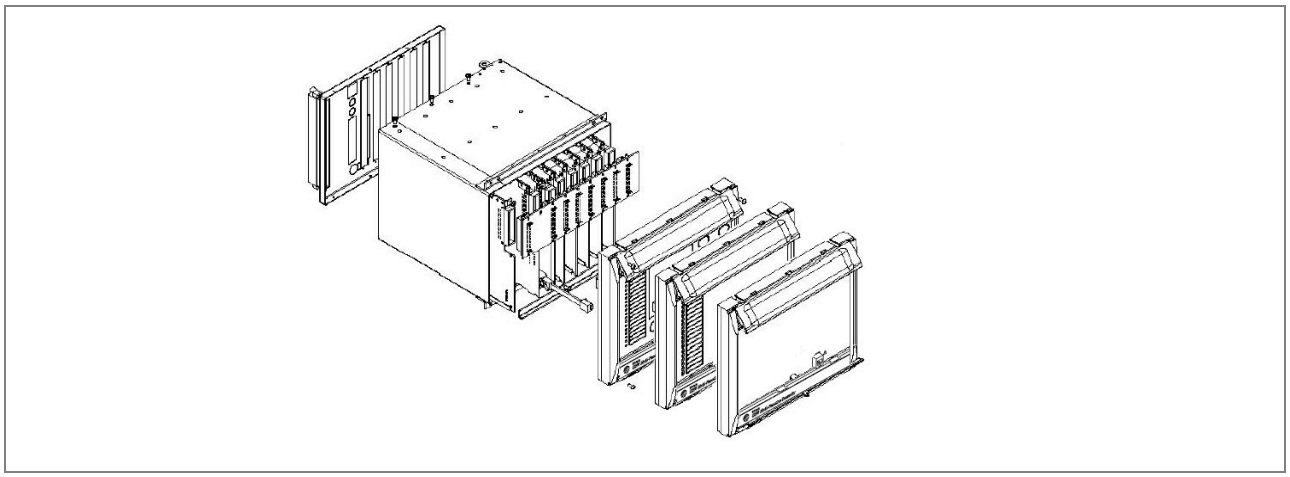


Figure 3: 40TE case without TMU2xx board

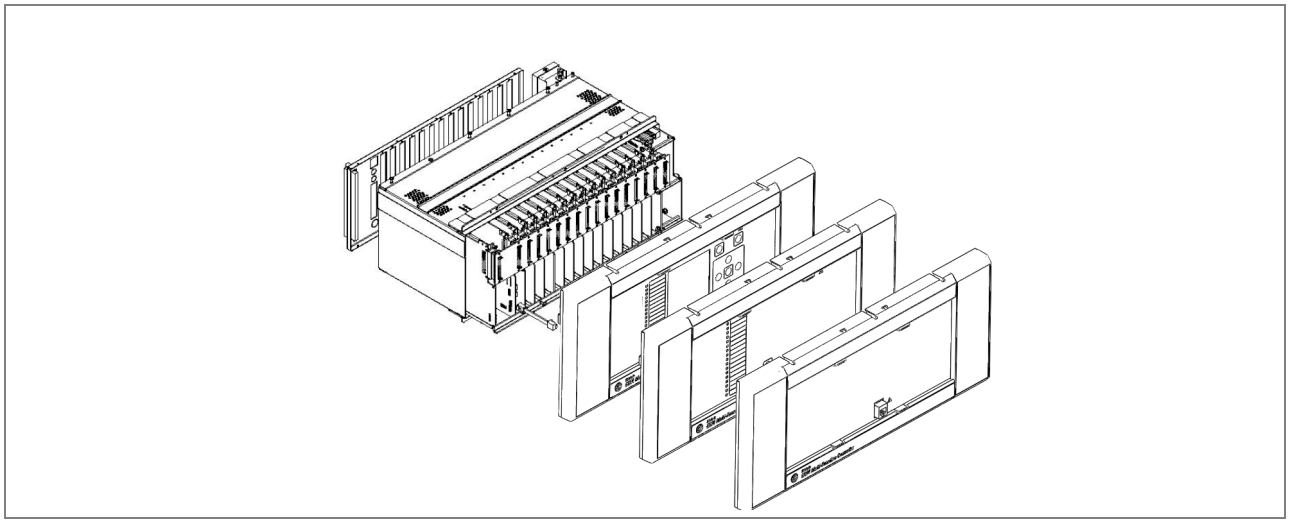


Figure 4: 80TE case with TMU2xx board

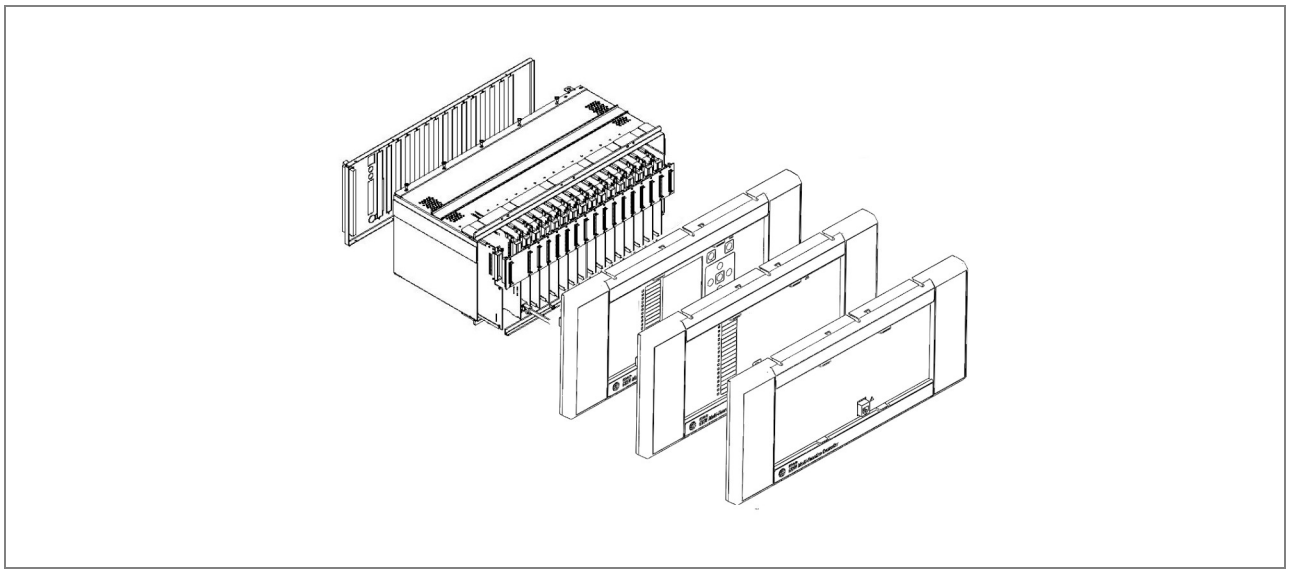


Figure 5: 80TE case without TMU2xx board

The boards within the DS Agile C26x are now accessible. Figures above show the board locations for the DS Agile C26x units in sizes 40TE and 80TE (C26x) cases.

Looking to the front of the DS Agile C26x with the front panel off, you can have access to a printed circuit that connects all the boards together: this is the backplane board.

To remove a board you need to:

- Pull the backplane board (FBP280 for 80TE case or FBP242 for 40TE case) out by holding it by the two extremities.
- Remove the screws and the maintain bar at the bottom of the case.

Note:
To ensure compatibility, always replace a faulty board with one of an identical part number and set jumpers in identical position.

All the boards are shown and described in the chapter C26x/EN HW.

2.3.2.1 REPLACEMENT OF THE BASIC INTERFACE UNIT (BIU261S OR BIU261D)

The BIU is the power supply board located on the extreme left-hand side (slot A) of DS Agile C26x.

Pull the power supply module forward, away from the rear terminal blocks and out of the case. A reasonable amount of force will be required to achieve this due to the friction between the contacts of the two medium duty terminal blocks. It is then recommended to use the special tool for extracting board (internal reference is 2070860).

Do not forget to set the jumpers on the new board in the same position as the previous one. If a BIU241 board is being replaced with a BIU261 board or module, refer to chapter Hardware for jumper positions.

Note:
For a 2-board BIU261 module, it will be necessary to remove the back-up power supply daughter board. It is held in place by 4 spacers attached to the boards using 2 x 4 pan head, 6 mm M3 screws and associated washers (standard washers on the outside of the module and tooth shakeproof washers inside). Unfasten the 4 screws on the daughter board and pull it slowly. After checking/setting the jumpers, carefully put the daughter board and washers back into place, insert the screws and fasten them.

2.3.2.2 REPLACEMENT OF THE MAIN PROCESSOR BOARD (CPU4)

After replacement of the main processor board, all the settings required for the application must be re-loaded, i.e.

1 the firmware must be updated,

2 the configuration database must be uploaded,

3 the S1 setting file must be uploaded.

The CPU board is located next to the BIU board (slot B).

Do not forget to disconnect the rear cables (RJ45 and/or optical fibers) before replacing the board and to reconnect them afterwards.

2.3.2.3 REPLACEMENT OF THE I/O BOARDS (DIU200, DIU210, DIU211, CCU200, CCU211, AOU200, DOU200, DOU201, HBU200, AIU201, AIU210, AIU211)

The I/O boards can be located in any slot from C to Q.

Do not forget to set the jumpers on the new board in the same position as the previous one.



Caution:
A skewed AOU200 board could lead a capacitor (C27) to touch an iron corner. Boards must therefore be handled carefully.

2.3.2.4 REPLACEMENT OF THE TRANSDUCERLESS MEASUREMENTS UNIT (TMU)

The measurement unit is on the extreme right-hand side of DS Agile C26x.

2.3.2.5 RE-ASSEMBLE THE DS AGILE C26X

Before re-assembling the module with a replacement board, make sure that the address for the replacement board is the same address that the board replaced by checking the jumpers on the boards.

Insert the FBP board back into the rack.

Screw the bar to the bottom of the case.

Replace the front panel. After refitting and closing the access covers, press at the location of the hinge-assistance T-pieces so that they click back into the front panel moulding.

Once the device has been reassembled after repair, it must be commissioned again (see chapter C26x/EN CM).

2.4 CLEANING

Before cleaning the DS Agile C26x ensure that all AC/DC supplies, current transformer and voltage transformer connections are isolated to prevent any risk of electric shock whilst cleaning.

Front panel cleaning: use a smooth cloth. Do not use abrasive material or detergent chemicals.

3 MAINTENANCE OPERATIONS

The CMT software is able to:

- Upgrade the C26x software
- Download and switch the databases
- Download the software key

These functions are needed for customizing the C26x.

Expert-level maintenance operations require the use of an SSH terminal. It is launched from the Security tab-pane. See *Installation chapter, C26x/EN IN*, for details.

3.1 REQUIREMENTS

A Personal Computer is needed. The PC hardware requirement is:

- COM port in RS232C (setting)
- 100 MB of free space on hard disk

The needed software is: Serial COM terminal (TeraTerm, HyperTerminal…).

- The Serial COM terminal is configured for serial communication with:
  - TTY mode
  - 115200 Baud/s
  - 8 bits no parity

Select into PC application the PORT 1 or 2 that is physically wired to the DS Agile C26x.

The serial link between PC PORT and DS Agile C26x Maintenance port is made via RS232C with straight-through cable.

3.2 INSTALLATION AND GENERAL USE

Connect the RS cable between the DS Agile C26x front panel and the PC and run the SSH software. If the parameters and wiring are correct, the connection is established.

Restart the C26x with a power reset and stop the first count down with any key. The following prompt is displayed: [VxWorks Boot]:

Each parameter is displayed one by one with each CR. If a mistake is made, press CR several times, then restart the operation again.

The stored value is displayed. If nothing is entered, pressing CR will keep the stored parameter.

The **.** key allows the replacement of the stored value with nothing.

Example of console listing (start-up):



3.3 HOW TO DETERMINE THE BOOTROM VERSION

The version is displayed after **BSP version** (B0.21C in the above screenshot).

For BOOTROM versions lower than B015: at the prompt, type: [VxWorks Boot]: v

For BOOTROM versions upper or equal to B015: just read the first lines

3.4 HOW TO RESTORE THE C26X BOOT PARAMETERS

Restoring the C26x boot parameters could be useful after a wrong maintenance action if boot parameters have been suppressed.

Checking default settings: p command

At the prompt, type: [VxWorks Boot]:p

The following information should be displayed:

- “boot device : tffs=0,0
- “processor number : 0
- “host name : <factory host PC name>
- “file name : /flash/bin/vxWorks
- “inet on ethernet : <factory C26x IP address xxx.xxx.xxx.xxx>
- “inet on backplane :
- “host inet : <factory host IP address xxx.xxx.xxx.xxx>
- “gateway inet : 0.0.0.0
- “user : <user name>
- “ftp password : <password>
- “flags : 0x0
- “target name : <factory target name>
- “startup script :
- “other : motfec

[VxWorks Boot]:

Settings to enter

The settings to enter are:

- factory host PC name: your maintenance laptop network name
- factory host IP address: your maintenance laptop IP@
- factory target name: should be the controller name defined by SCE for its database
- factory C26x IP address: should be the controller IP address defined by SCE for its database
- user name and ftp: password: FTP user name, defined for the FTP server - it is good practice to keep factory setting and to define on the PC user C264_cpu3 according to your CPU type with the password vxWorks

Do not modify other parameters.

Input new settings: c command

Configure with the **c** command the communication settings of the DS Agile C26x.

Enter the Configuration Command: [VxWorks Boot]: c

Wait till the display of [VxWorks Boot]:

Enter the Default settings Command: [VxWorks Boot]: p

The following information should be displayed:

- “boot device : tffs=0,0
- “processor number : 0
- “host name : <Enter host PC name>
- “file name : /flash/bin/vxWorks
- “inet on ethernet : <Enter C26x IP address: xxx.xxx.xxx.xxx>
- “inet on backplane :
- “host inet : <Entrer host IP address: xxx.xxx.xxx.xxx>
- “gateway inet : 0.0.0.0
- “user : <user name>
- “ftp password : <password>
- “flags : 0x0
- “target name : <target name>
- “startup script :
- “other : motfec

[VxWorks Boot]:

Now restart the controller with the new parameters, either with a power reset, or by typing:

[VxWorks Boot]: @

After the reboot the C26x is ready for receiving the application software. Refer to the chapter C26x/EN IN to go ahead.

3.5 HOW TO UPGRADE FIRMWARE FROM DS AGILE <=V7.0.4 TO >=V7.0.5

This section outlines the methods to upgrade and migrate your devices from a DS Agile v7.0.4 version or earlier to a cyber-security environment that uses certificates (DS Agile v7.0.5 or higher).

3.5.1 PREREQUISITES

Two CMT PCs are required to upgrade the C264 controllers safely.

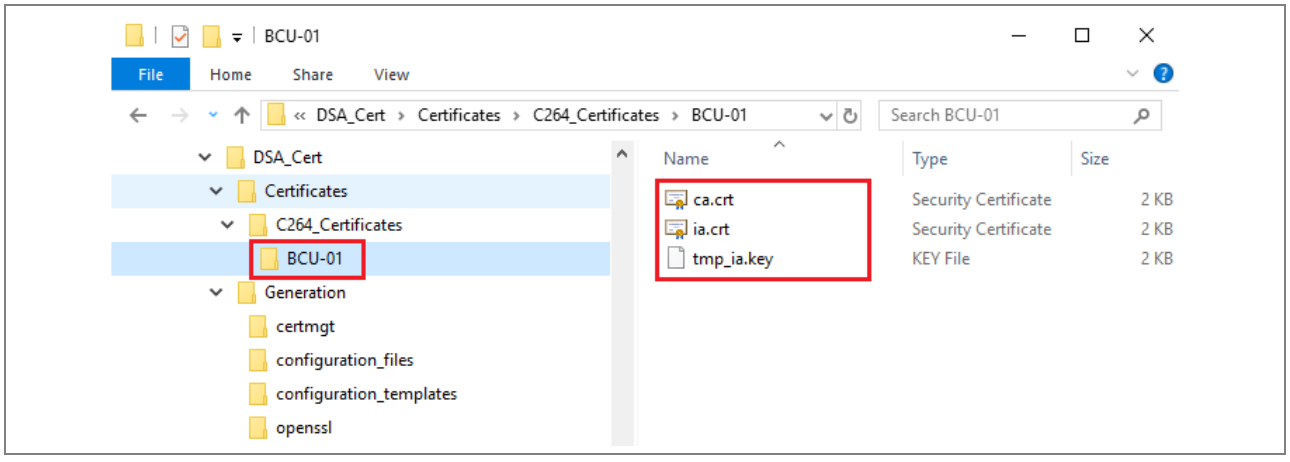
- The EWS-1 PC is to be used to manage two different versions of the **Computer Maintenance Tool**. It must be installed with:
  - One DS Agile v7.0.4 or earlier version of the CMT (called CMT-1)
  - One DS Agile v7.0.5 or higher version of the CMT (called CMT-2)
- The EWS-2 PC must be installed with one DS Agile v7.0.5 or higher version of the CMT (called CMT-2)
- The certificate for EWS-2 PC must be installed.
- Shell connection (via Tera term or Putty) on the serial link between EWS-1 PC and the C264 you wish to update

3.5.2 C264 UPGRADE

The C264 certificates to be used are generated in the C264 folder under the "**C264_certificates**" directory.

These certificates are:

- **ca.crt** (corresponding to CA_DSAgile.pem)
- **ia.crt** (corresponding to C264.pem)
- **tmp_ia.key** (corresponding to C264.key)



To upgrade your C264, follow these instructions.

Working on the **EWS-1** PC:

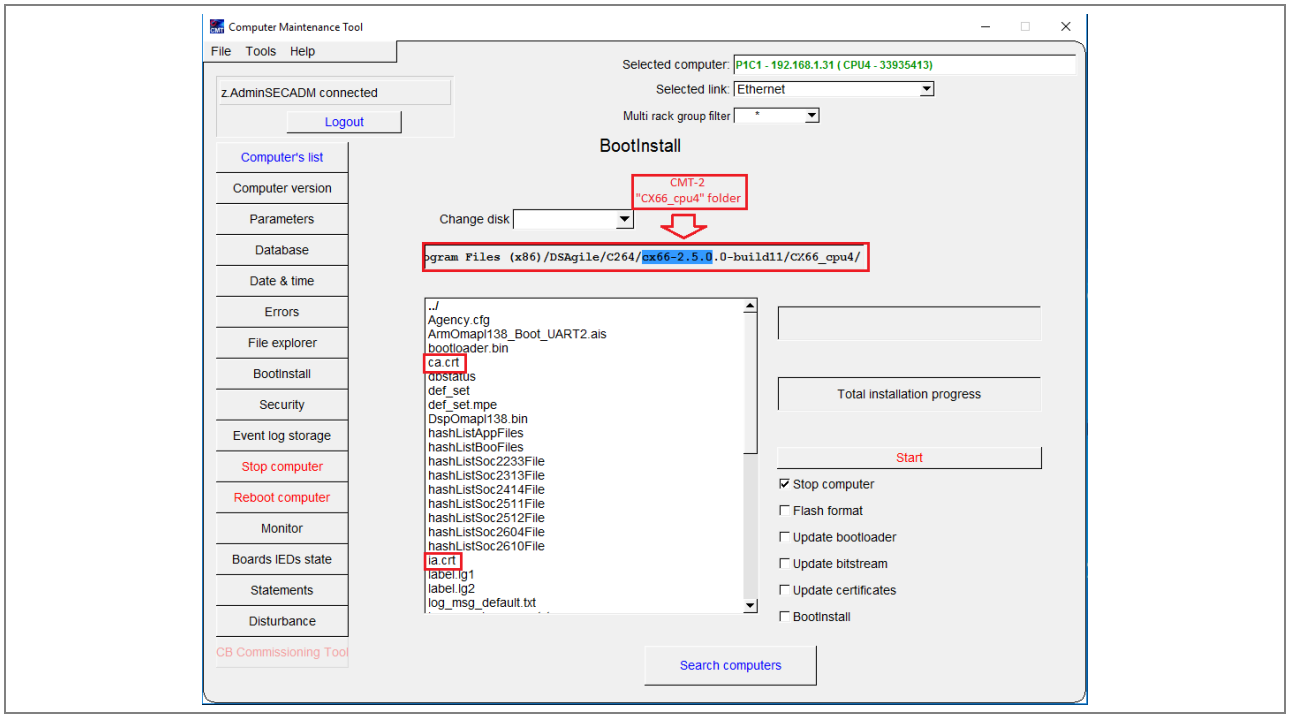
1 Copy the three C264 certificates (**ca.crt**, **ia.crt** and **tmp_ia.key**) of the C264 to be updated to the "**<Cx66 common name>**" folder of **CMT-2**:

"C:\Program Files (x86)\DSAgile\C264\cx66-2.5.x.x-buildxx\<Cx66 common name>"

2 Launch **CMT-1** and connect to the C264 to be updated

3 Still using **CMT-1**, do a full bootinstall pointing to the "**<Cx66 common name>**" folder of **CMT-2**:

- Bootloader,
- Flash format (**mandatory only for version anterior to 7.0.4**),
- Bootinstall,
- no need to change the bitstream



If the version you are migrating from is DS Agile v7.0.4.x, go to step 5.

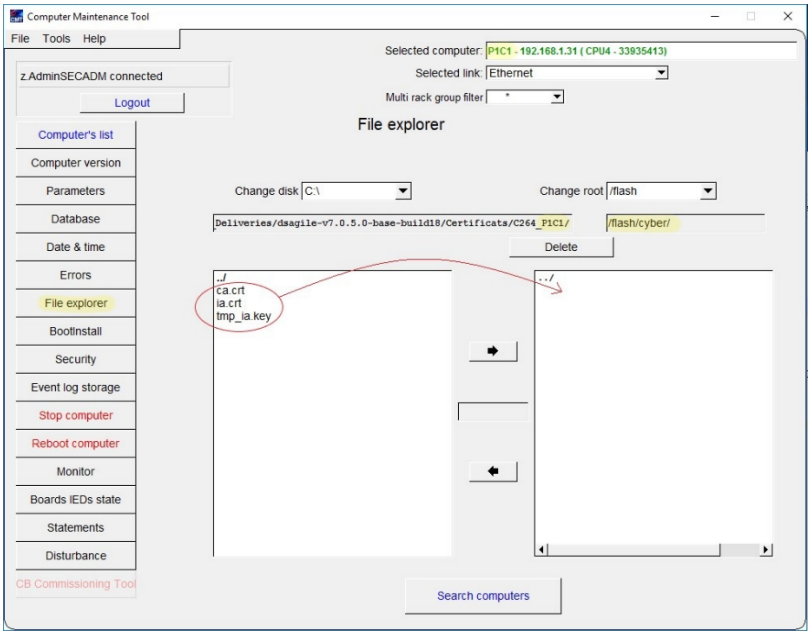
If the version you are migrating from is DS Agile v7.0.3.x or before, DO NOT REBOOT the C264

4 From the **EWS-1** PC, load manually the certificates to the C264:

- From the device's shell console (Teraterm or Putty) and after authentication, enter the command `mkdir "/flash/cyber"` to create the "cyber" folder.



- From **CMT-1**, using the file explorer, point to the **`/flash/cyber`** folder and send the certificates matching with the C264 you work on:



5 Reboot the C264.

Working on the **EWS-2** PC:

6 Launch **CMT-2** and connect to the C264 to be updated:

a For a C264 coming from a DS Agile v7.0.4 version: credentials have not been changed (unless you did a flash format, then you have default credentials)

b For C264 coming from a version earlier than DS Agile v7.0.4, use the default credentials below:

- Login: **Root**
- Password: **Root1234#**

c Do again a simple bootinstall.

After the second bootinstall, the C264 is upgraded as expected.

You can restart this process to upgrade another C264 with the corresponding certificate files.

3.6 UPDATING C264 CERTIFICATES

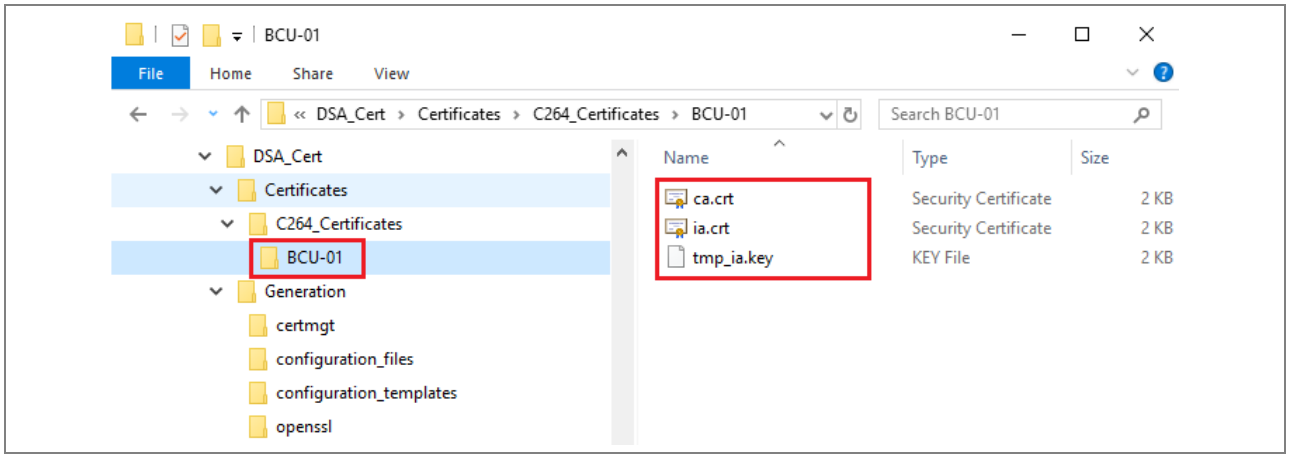
This procedure describes how to update a certificate on a C264.

Note:

*During this procedure, we assume that the **C264 network name** and **IP address have not been changed**. In the later case, the certificate must be re-generated for compatibility purposes. Refer to section **9.2 Creating certificates** for further information.*

The **DS_Agile_x.x.x_certgen.bat** file - in the "**DSA_Cert\Generation** folder – is used to generate the C264 certificates. Once generated, three certificates are stored in the C264 folder under the "**C264_certificates**" directory:

- **ca.crt** (corresponding to CA_DSAgile.pem)
- **ia.crt** (corresponding to C264.pem)
- **tmp_ia.key** (corresponding to C264.key)



3.6.1 PREREQUISITES

Before updating a C264 with a new certificate, check the following:

- CMT PC is installed with Windows-10
- Old certificates (called *CA-cert-01* and *Machine-cert-01*) are installed on the CMT PC in the "Local machine" certificate store. Use the "**certlm.msc**" command to check it.
- New .pfx certificate file (called *Machine-cert-02.pfx*) contains the new certificates (called *CA-cert-02* and *Machine-cert-02*)
- New C264 certificates (ca.crt, ia.crt, tmp_ia.key) are generated
- CMT can connect successfully to the C264 to run the update process
- If PC is already hardened, enter `sadmin bu` command in McAfee Solidifier to get in update mode as the certificates needs to be changed every time, we upgrade the C26x for Bootinstall.

3.6.2 UPDATING THE CMT CERTIFICATE IN THE LOCAL MACHINE CERTIFICATE STORE

The first step consists in updating the CA certificate of the CMT PC by:

1 Removing the “old machine certificate” (Machine-cert-01)

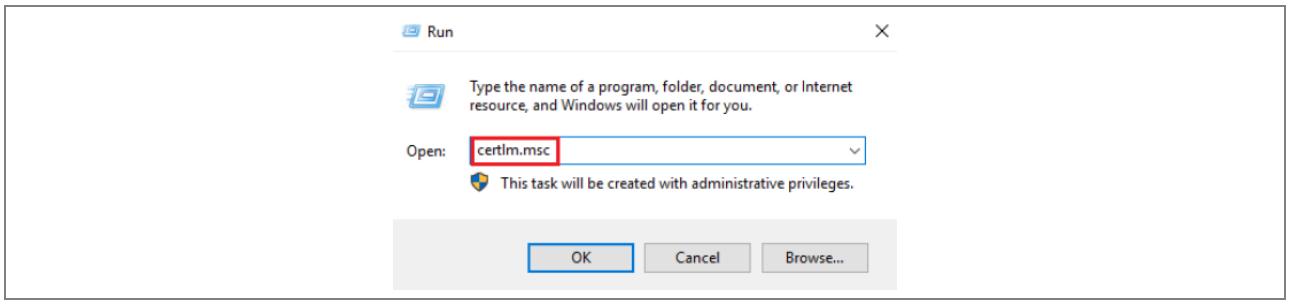
2 Importing the new certificate (CA-cert-02 and Machine-cert-02)

Both operations are described below.

3.6.2.1 REMOVING THE OLD CERTIFICATE (*MACHINE-CERT-01*) FROM THE LOCAL MACHINE CERTIFICATE STORE

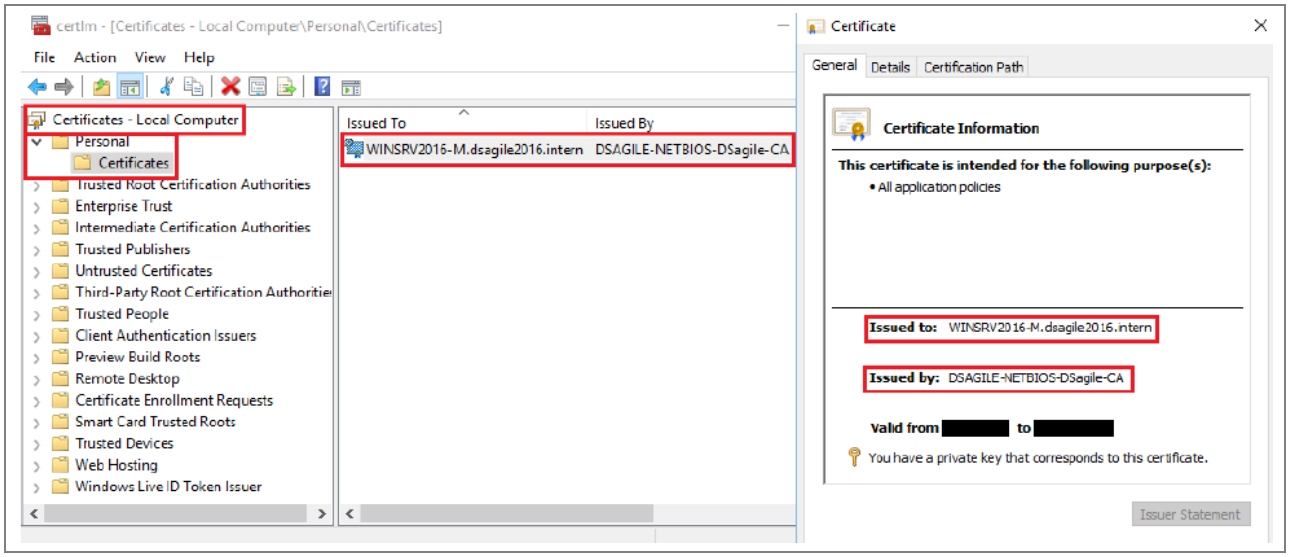
3 *Login* with *administrator privileges* on the workstation

4 Run the “**certlm.msc**” command:



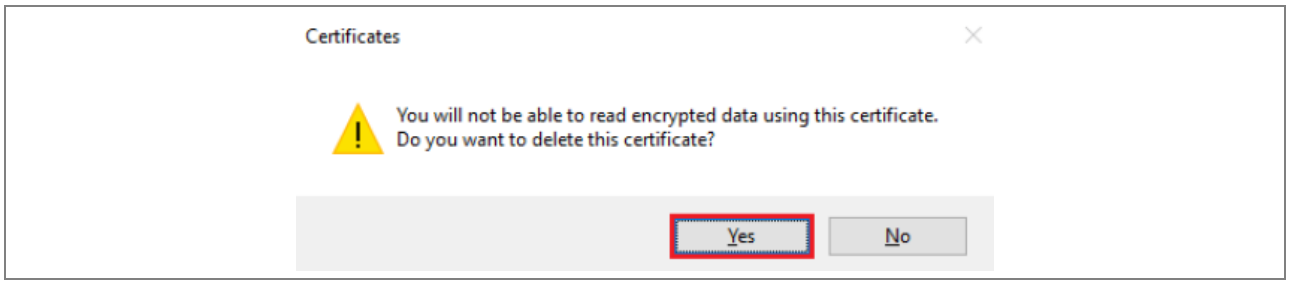
5 Open the “**Personal | Certificates**” folder

6 Select the required certificate (the certificate name depends on the server name)



7 Delete the certificate using the keyboard delete button.

8 Click on **Yes** to confirm the deletion.



Warning:

Do not remove the CA certificate stored in "Trusted Root Certification Authorities"

3.6.2.2 IMPORTING THE NEW MACHINE CERTIFICATE (MACHINE-CERT-02.PFX)

To import the certificate in the "Local Machine Certificate Store":

1 Double click on the **Machine-cert-02.pfx** file

2 Select "**Local Machine**"

3 Click on "**Yes**" or "**Next**" until the import process is complete.

For more details, refer to "9.3.1 Import new certificates to the Local Machine Certificate Store"

Once imported, you should have following certificates installed on the CMT PC, in the "Local machine" certificate store:

- in "Personal | Certificates":
  - New machine certificate (Machine-cert-02)
- In "Trusted Root Certification Authorities | Certificates"
  - Old public CA certificate (CA-cert-01)
  - New public CA certificate (CA-cert-02)

3.6.3 UPDATING THE C264 CERTIFICATE

1 On the CMT PC, copy the three certificates (ca.crt, ia.crt, tmp_ia.key) of the C264 to be updated to the "**<Cx66 common name>**" CMT folder:

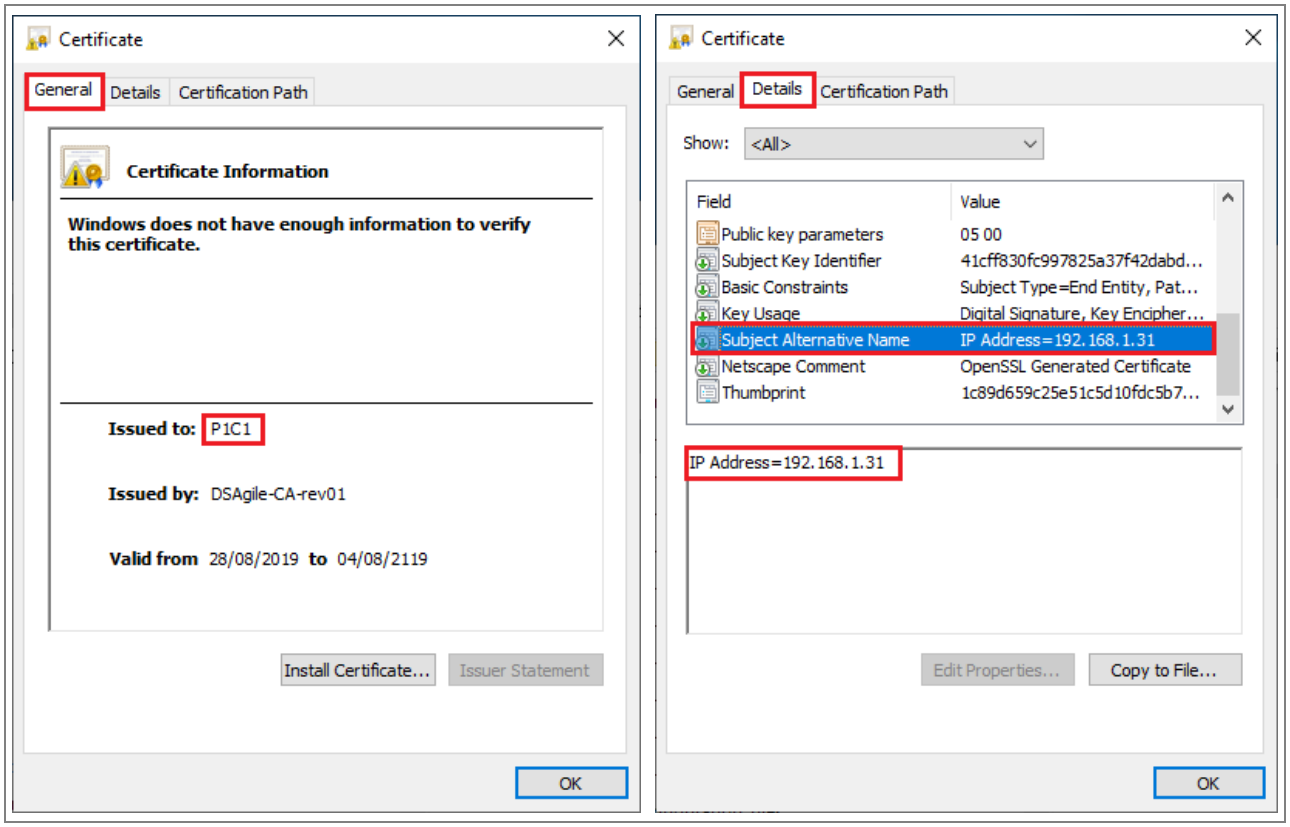
`"C:\Program Files (x86)\DSAgile\C264\cx66-2.5.x.x-buildxx\<Cx66 common name>"`

2 From the CMT, connect to the C264 to be updated

Make sure that the parameters of the certificates copied in the "<Cx66 common name>" CMT folder match the connected C264.

3 In the "**<Cx66 common name>**" CMT folder, double click on "**ia.crt**" and check that the network name and the IP address of the C264 are the same as defined in the certificate:

- In the "**General**" tab "**Issued to**:" = `C264 network name`
- In the "**Details**" tab "**Subject Alternative Name**" = `C264 IP addresses`



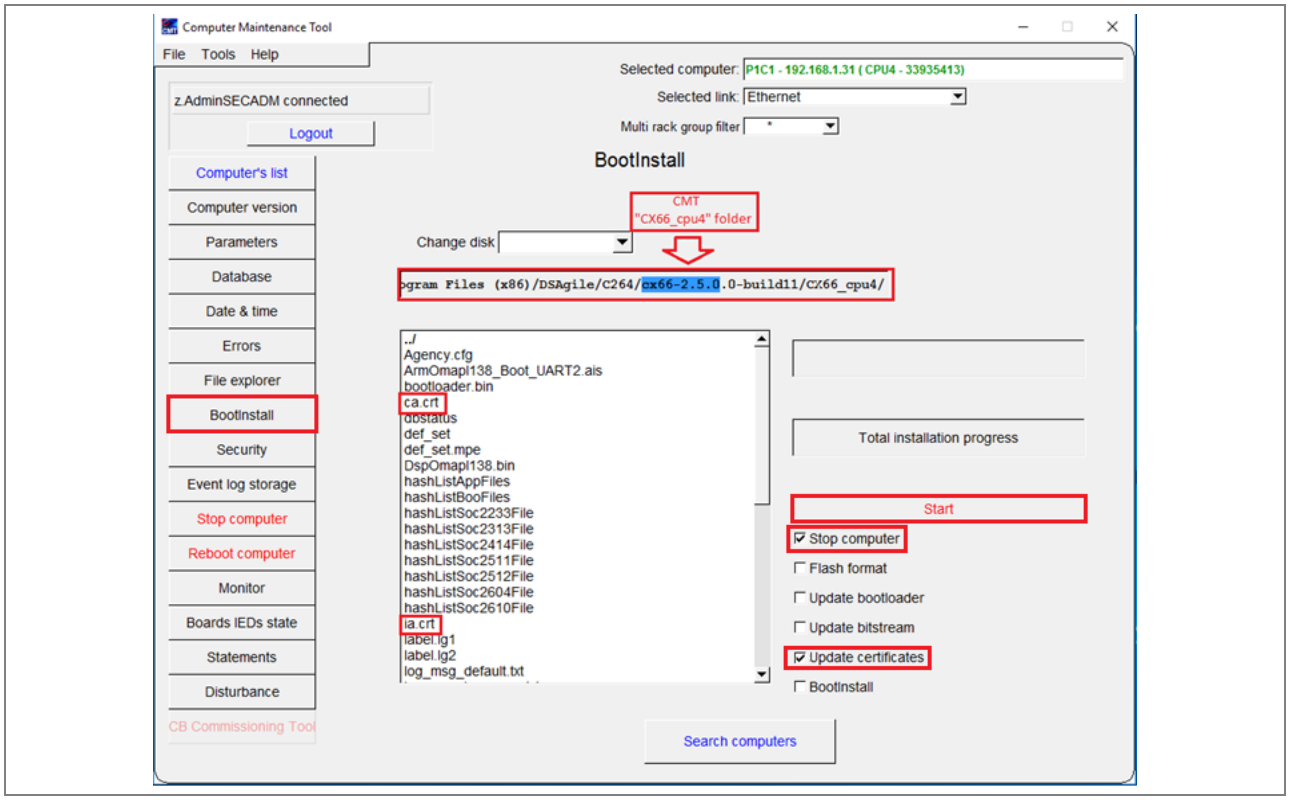
If network name or IP address have not the expected values, remove the 3 certificate files (ca.crt, ia.crt, tmp_ia.key) and replace them with the required ones.

4 On the CMT, click on **BootInstall**.

5 Point to the “cx66_cpu4” folder in which you have copied the C264 certificates (ca.crt, ia.crt, tmp_ia.key):

```
"C:\Program Files (x86)\DSAgile\C264\cx66-2.5.x.x-buildxx\CX66_cpu4"
```

6 Check the “**Update certificates**” option:



7 Click on the “**Start**” button

8 Reboot the C264 when the “**Update certificates**” process is complete.

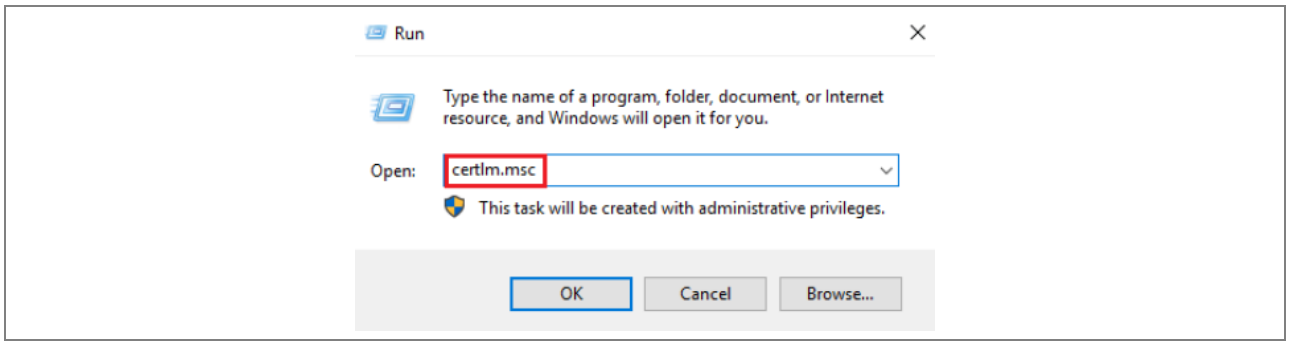
To upgrade another C264, repeat this procedure with the corresponding certificate files.

When all C264 are updated, remove the old CA certificate as described in next chapter.

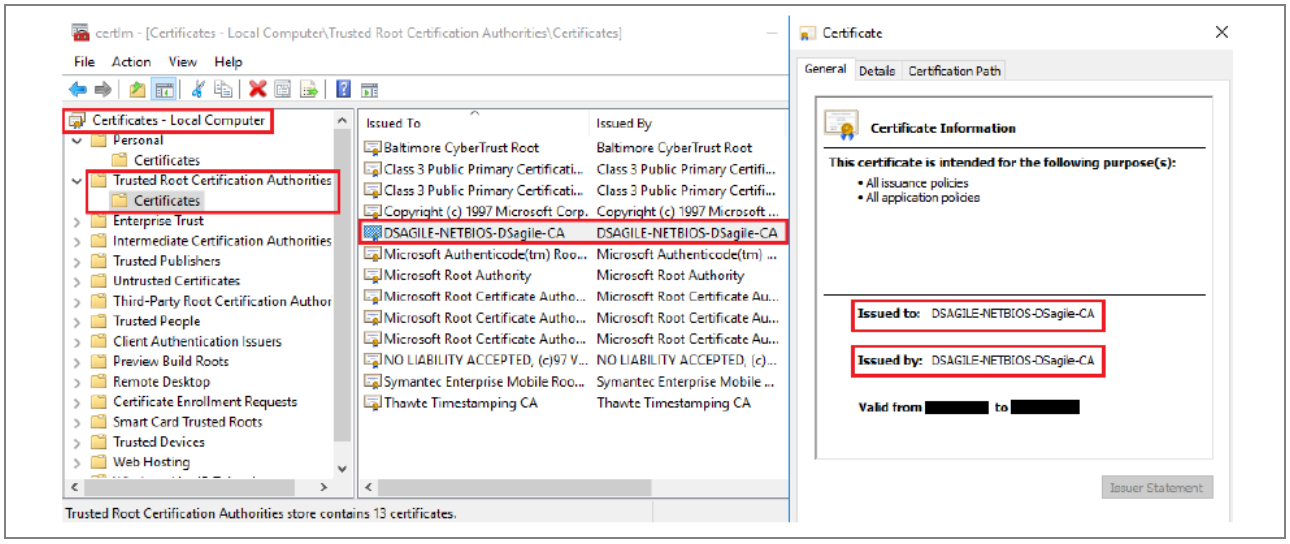
3.6.4 REMOVING THE OLD CA CERTIFICATE FROM THE LOCAL MACHINE CERTIFICATE STORE

1 Logon as a user with administrator permissions on the CMT PC

2 Run the "**certlm.msc**" command

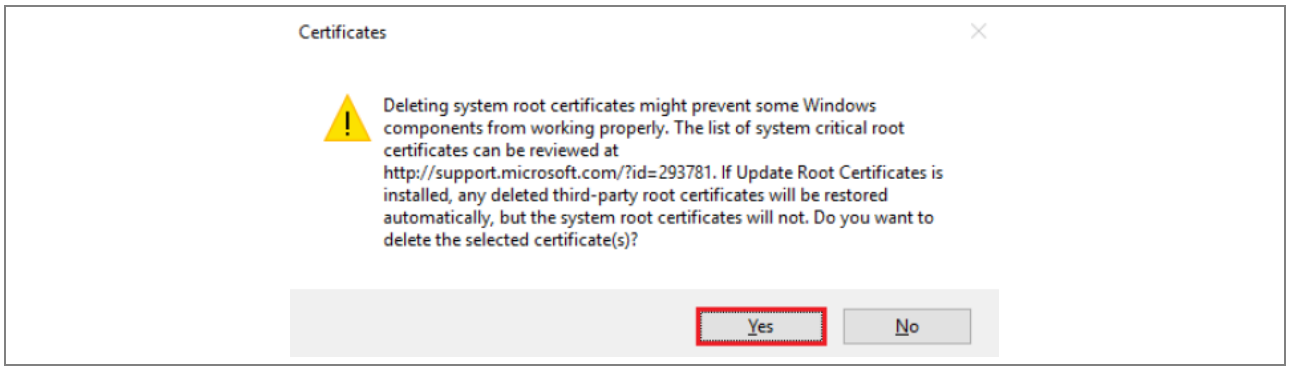


3 Open the "**Trusted Root Certification Authorities**" folder and find the old CA name (*CA-cert-01*):



4 Delete it using the keyboard delete button.

5 Click on "**YES**" to confirm the deletion.



9 To fully remove the certificates, run the following cipher command:
`Cipher /w:C:\ProgramData\DSAgile\C264\cx66-2.5.0.0-buildxx\certificates\<Cx66 common name>`

3.6.5 CERTIFICATE VERIFICATION

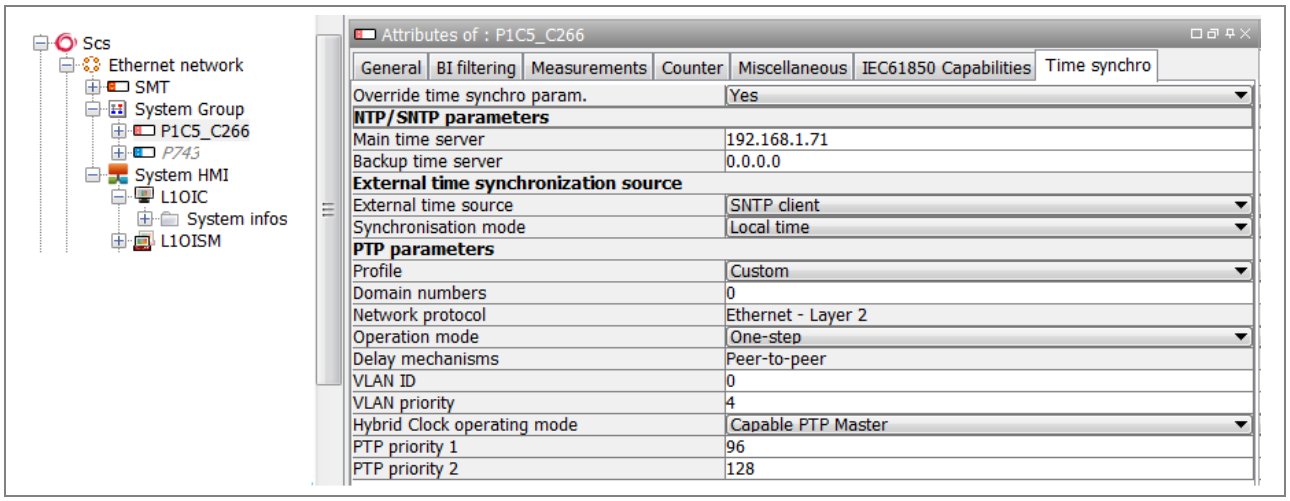
- Check that CMT PC certificate and C26x certificate are issued from the same DS Agile CA certificate
  - If not already installed, install the CMT PC certificate in Local Machine certificate store.

    The public DS Agile CA certificate will be automatically installed in “Trusted Root Certification Authorities” folder in Local Machine certificate store.
- Ensure that you have loaded the expected certificate on the C26x
  - if a C26x has a certificate with no IP corresponding to its configured IP address:
    - Connect from the front face serial link with “Root” account
    - From the command line, change the IP address of the C26x to one IP defined in the certificate
    - Reboot the C26x
    - Load the expected certificate from the CMT
    - Connect from the front face serial link with “Root” account
    - From the command line, change the IP address of the C26x to the IP defined in the certificate updated from CMT
    - Reboot the C26x
    - Connect from CMT to confirm that the certificate issue is fixed.
- Check that the C26x network cable is connected to the expected port (s):
    - Network port(s) to use depends on the configured bitstream
    - When you are in **Factory configuration**, use **network port 3**

3.7 HOW TO EDIT PTP SETTINGS LOCALLY

The C26x computers can be configured to communicate with one PTP-enabled External synchronization source. They can be defined either as a Preferred PTP Master clock or as a PTP Slave-Only clock.

Time synchronization parameters are set individually for each C26x computers in the SCE (**Time synchro** tab):



Time synchronization settings are then downloaded/updated to the **ptp_config.xml** file provided with the binaries file of the C26x, when switching database.

3.7.1 EDITING THE PTP_CONFIG.XML FILE

In some cases, you may want to edit these settings for a specific C264 without regenerating the complete database from the SCE.

To edit the **ptp_config.xml** file, follow these instructions:

1 Start the CMT. The CMT is usually found in `C:\Program Files (x86)\DSAgile\DCS\C264\cx66-X.X.X.X-buildXX\Cmt`, or by clicking **Start | DSAgile | CMT**.

2 In the **Available Computers** list, click **Search** computers and select the relevant CPU4.

3 Log into the CPU4 (*User name: cpu4*; *Password: cpu4*)

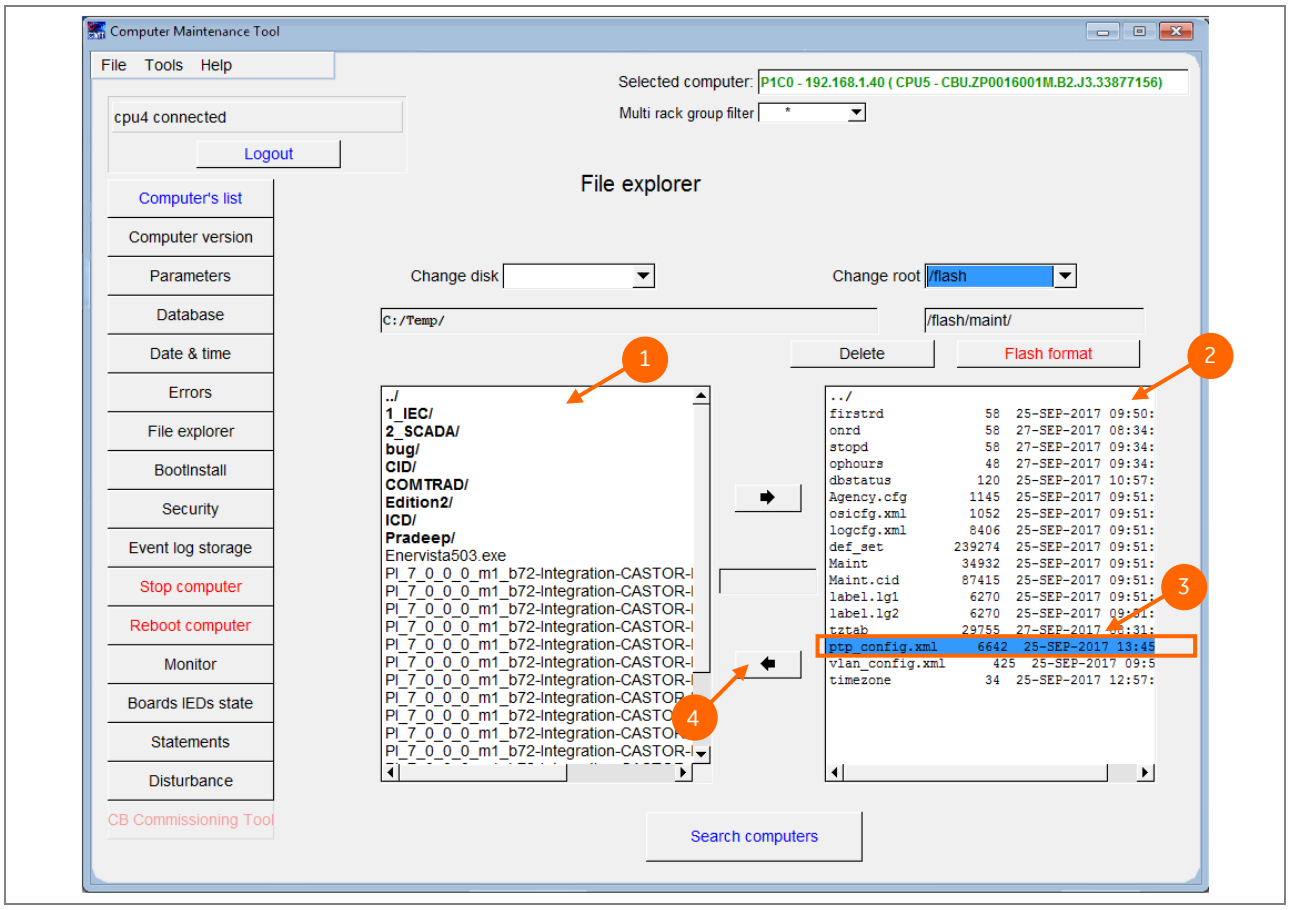
4 Click on the **File explorer** button;

5 Use the **Change root** drop-down list to point to the C26x **/flash/maint/** folder.

6 The left part is an image of the local PC file system (1), the right one is an image of the C26x files system (2).

7 Browse the C26x structure and select the **ptp_config.xml** file (3).

8 Then, click on  to transfer the file from the C26x to your PC (4). The file selected on the C26x is uploaded on the PC, in the current directory.



9 On your PC, open the **ptp_config.xml** file using any xml editor

10 Edit the desired attributes.

11 Save the file.

3.7.2 UPLOADING PTP CONFIGURATION TO THE C26X

Once you have completed changes to the **ptp_config.xml** file, you must upload it to the C264:

1 Go to the CMT

2 On the PC-side, the default current directory is the latest selected directory (value saved in the Registry).

3 Browse your PC structure and select the **ptp_config.xml** file you have just modified (just click on it once)

4 Then click on  to upload the file selected on the PC browser to the directory selected on the C26x. Note that the file is automatically overwritten if it already exists on the C26x.

5 Reboot the C26x to take these changes into account.

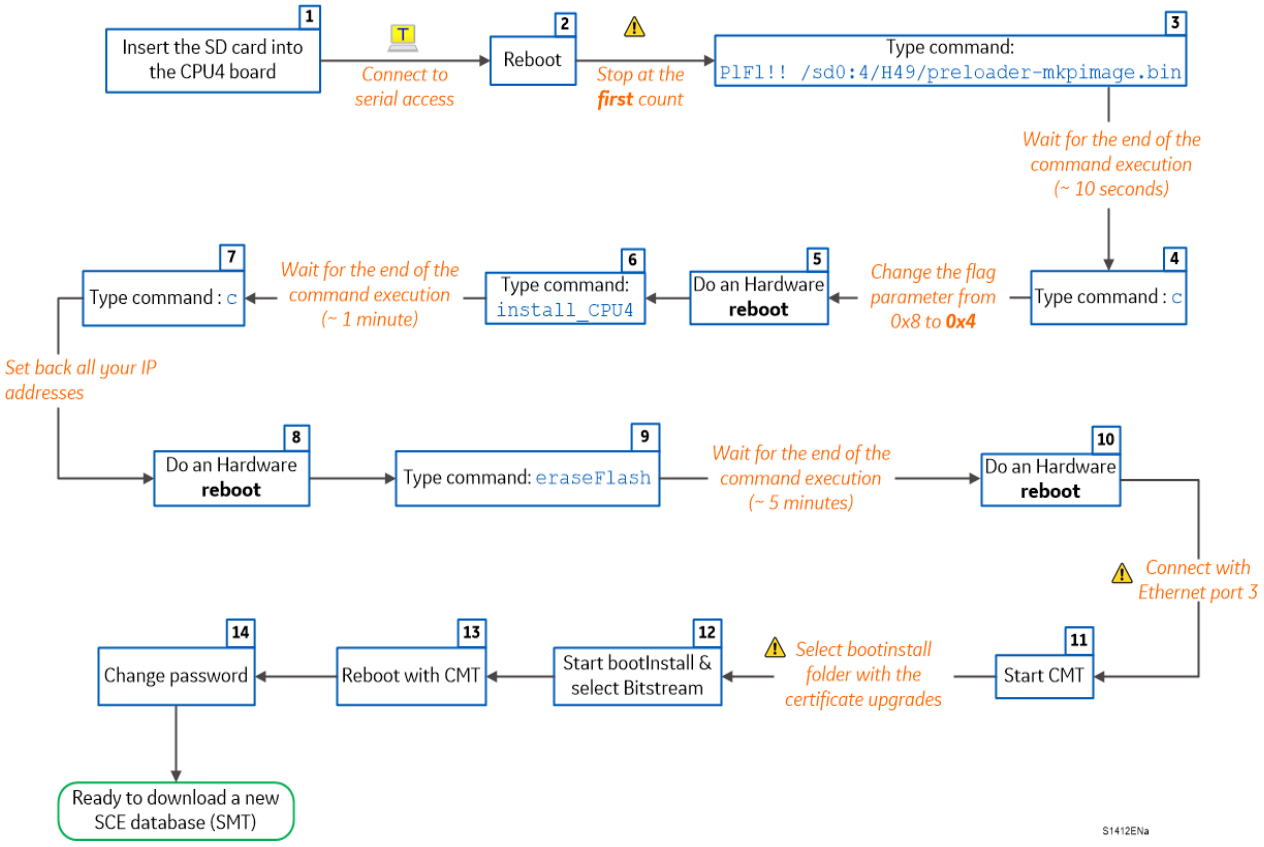
3.8 RESET TO FACTORY STATE

This section provides a detailed procedure to get back a C264 that cannot communicate anymore with the CMT application due to certificate issues.

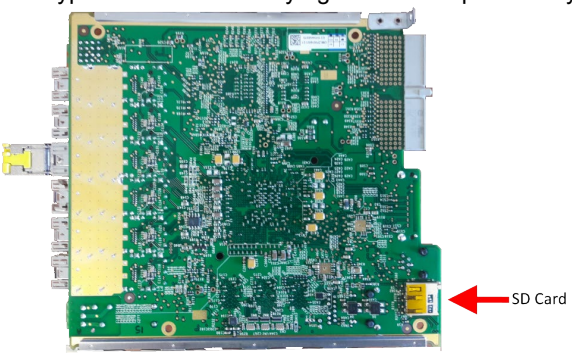
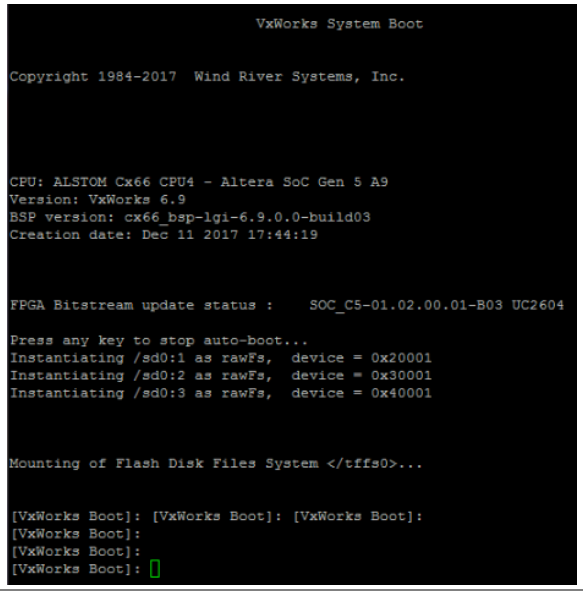
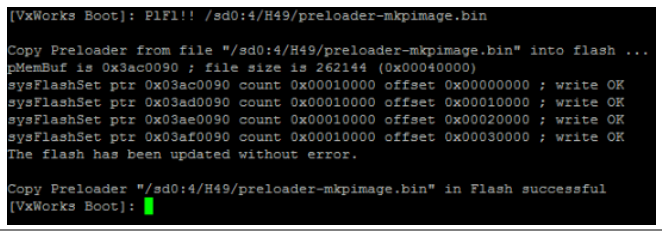
When the communication between the C264 and any CMT application is lost due to certificate issues (SSL connection error message), the solution consists in resetting the C264 as explained below.

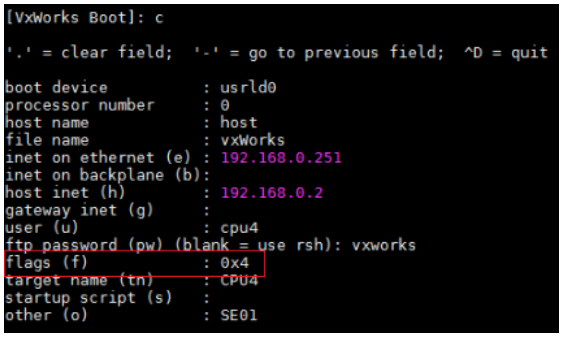
3.8.1 FACTORY RESET FLOWCHART

As a last resort, it may be necessary to reset the C26x to factory state and start firmware upgrade and configuration over.



3.8.2 KEYS TO FACTORY RESET FLOW CHART

Step to Execute	Description
1	This step is necessary for prototype CPU4 boards only. Ignore this step for newly installed C264 as they are already equipped 
2	Restart the CPU4 and stop it at first count. If the SD card is recognized, instantiating shell line shall be displayed (See image above) 
3	Pay attention to the command syntax: `PlFl!! /sd0:4/H49/preloader-mkpimage.bin` It is "*PLFL"* command (where "L" letters are in lowercases). The preloader is loaded: 

Step to Execute	Description
4	In the Shell, enter the command: `c` and change the flag parameter from 0x8 to 0x4. Check that the boot device parameter is `usrld0` Here is what you should get after modification: 
5	Restart the CPU4 board doing a hard reboot. The board shall start from the SD card
6	In the shell, enter the command: `install_CPU4` LogIndus installation begins.
7	When the installation is completed, use the `c` command in the shell to set back all your IP addresses.
8	Do a hard reboot on the CPU4. Once rebooted, the logIndus version shall be installed.
9	In the shell, enter the command: `eraseFlash` It will start the flash format process.
10	Do a hard reboot on the CPU4 Your CPU4 board is now as new.
11	Now the CPU4 is empty from any configuration. Except serial, remember to connect to this CPU4 using a SAN connection (bitstream has been set to 2313 by default). If you do not use a SAN connection, the following error message may be issued from the CMT, in spite the CPU is pinging. 
12 & 13	Before reinstalling the CPU4 software from the CMT (classical installation) copy the associated certificates files into the "*CX66_cpu4*" folder. Then, launch the BootInstall by following the procedure described in the Installation chapter of the C264 user manual (section BOOTINSTALL UPDATE). The BootInstall process may take about 15 minutes per CPU4. Once BootInstall is done, reboot the CMT
14	Warning: remember the password you will need to set at the first connection (mandatory step). Default credentials: Login: `Root` Password: `Root1234#`

RECORD SHEET

C26X/EN RS/E72

Contents

1 SCOPE OF THE DOCUMENT 3

2 COMMISSIONING RECORD 4

3 MAINTENANCE RECORD SHEET 5

1 SCOPE OF THE DOCUMENT

This document is a chapter of the DS Agile C26x documentation. It describes the Commissioning record sheet and the Maintenance Record of this unit.

The purpose of this chapter is to follow the history of the DS Agile C26x hardware replacement.

2 COMMISSIONING RECORD

Commissioning Date:

Engineer:

Station Name:

Circuit Name:

Front Plate Information

Under the top access cover, there is the following type of label:

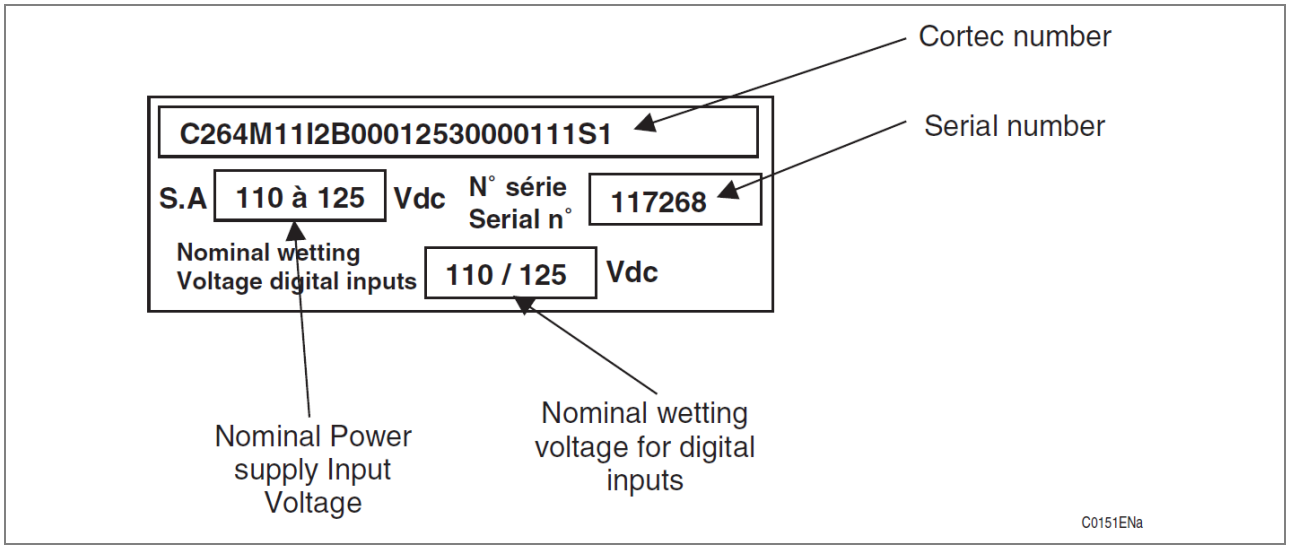


Figure 1: Front plate information

Fill in the following array according to the label under the top access cover:

Serial number	
Cortec number	
Auxiliary voltage for power supply	
Nominal wetting voltage for digital inputs	

	*Delete as appropriate
Have all relevant safety instructions been followed?	Yes/No*

Product checks

Visual inspection with the unit de-energized

Relay damaged?	Yes/No*
Rating information correct for installation?	Yes/No*
Case earth installed?	Yes/No*

3 MAINTENANCE RECORD SHEET

Product Serial number	

DATE	Engineer	Board type	Slot letter in the rack (between A and Q)	Previous board Serial number	New board Serial number
/ /					
/ /					
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TECHNICAL DATA

C26X/EN TD/E72b

Contents

1	**SCOPE OF THE DOCUMENT**	**3**
2	**GENERAL DATA**	**4**
2.1	**Design**	**4**
2.2	**Installation Position**	**4**
2.3	**Degree of Protection**	**4**
2.4	**Weight**	**4**
2.5	**Dimensions and Connections**	**4**
2.6	**Environmental conditions**	**5**
2.7	**DS Agile C26x: Configuration**	**5**
2.7.1	C26x – Comparison of Board Installations Between Models	6
2.7.2	C26x-80TE – Board Installation	7
2.7.3	C26x-40TE – Board Installation	8
2.7.4	C26x-80TE – Signals	9
2.7.5	C26x-40TE – Signals	10
2.7.6	C26x: Element limits	11
2.8	**Terminals**	**14**
2.9	**Creepage Distances and Clearances**	**14**
3	**RATINGS**	**15**
3.1	**Auxiliary Voltage**	**15**
3.1.1	Universal, Single- or Dual-input power supply (BIU261S/BIU261D)	15
3.1.2	BIU261S/BIU261D Digital Outputs	16
3.1.3	BIU261S/BIU261D Digital Intputs	16
3.2	**Circuit breaker Control Unit (CCU) Digital Inputs**	**16**
3.2.1	CCU200 Digital Inputs	16
3.2.2	CCU211 Digital Inputs	17
3.3	**Circuit breaker Control Unit (CCU) Digital Outputs**	**17**
3.3.1	CCU200 Digital Outputs	17
3.3.2	CCU211 Digital Outputs	18
3.4	**Digital Input Unit (DIU) Digital Inputs**	**19**
3.4.1	DIU200 Digital Inputs	19
3.4.2	DIU211 Digital Inputs	19
3.4.3	DIU221 Digital Inputs	20
3.5	**Digital Output Unit (DOU) Digital Outputs**	**20**
3.5.1	DOU201 Digital Outputs	20
3.6	**High Break Unit (HBU) High Break/High Speed Digital Outputs**	**21**
3.7	**Analogue Input Unit (AIU) Analogue Inputs**	**22**
3.7.1	AIU201 Analogue Inputs	22
3.7.2	AIU211 Analogue Inputs	23
3.7.3	Saturation values	23
3.8	**Transducerless Measurement Unit (TMU) CT/VT Analogue Inputs**	**24**
3.8.1	General	24
3.8.2	TMU220 – Current Transformers (CT)	24
3.8.3	TMU220 – Voltage Transformers (VT)	24
3.8.4	TMU210 – Protective Current Transformers (CT)	25
3.8.5	TMU210 – Protective Voltage Transformers (VT)	26

3.8.6 TMU2xx - A/D Converter 26
3.9 Analogue Output Unit (AOU) 27
3.9.1 AOU200 Analogue Outputs 27
3.10 Table of dielectric strengths & Independent Circuits 30

4 BURDENS 33

4.1 Power Supply Board/module 33
4.1.1 Maximum measured burden for BIU261 power supply 33
4.1.2 Burden for binary input 33
4.2 Circuit breaker Control Units (CCU) Input Burdens 33
4.2.1 Burden for binary input 33
4.3 Digital Input Unit (DIU) Input Burden 34
4.3.1 DIU200 Input Burden 34
4.3.2 DIU211 Binary Input Burden 34
4.3.3 DIU221 Binary Input Burden 34
4.4 Transducerless Measurement Unit (TMU) CT/VT Input Burden 34

5 ACCURACY 36

5.1 Reference Conditions 36
5.2 Measurement Accuracy 36
5.2.1 TMU220 - Measurement Accuracy 36
5.2.2 TMU210 - Measurement Accuracy 36
5.3 Protection Accuracy 37
5.3.1 TMU210 – Protection Accuracy 37
5.4 Compounded power values Accuracy 37
5.4.1 TMU210 – Compounded Power Values Accuracy 37
5.5 Acquisition / Conversion 37
5.5.1 TMU210 – Compounded Power Values Accuracy 37
5.6 How to Measure the Isolation Resistance 38

6 TYPE TESTS 39

6.1 Dielectric Strength Tests 39
6.2 Mechanical Test 39
6.3 Atmospheric Test 39
6.4 DC Auxiliary Supply Test 40
6.5 AC Auxiliary Supply Test 40
6.6 Compatibility (EMC) Tests 40

7 ACHILLES CERTIFICATION 42

8 APPENDIX: PROTOCOLS AND PORTS USED BY THE C264 43

1 SCOPE OF THE DOCUMENT

This document is a chapter of the DS Agile C26x documentation, listing its technical characteristics.

2 GENERAL DATA

2.1 DESIGN

In conformance with European Commission Directives:

- Electromagnetic Compatibility (EMC) 2014/30/EU
- Low voltage (LVD) 2014/35/EU

Surface-mounted case suitable for wall mounting or flush-mounted case for 19” cubicles and for control panels.

2.2 INSTALLATION POSITION

Vertical ±15°

2.3 DEGREE OF PROTECTION

In conformance with DIN VDE 0470 and standards IEC60255-27:2013 and IEC60255-26:2013:

- Protection of equipment against ingress of solid foreign objects and water (Environmental)
  - Front panel with RJ11 connector ("blind"): No claim
  - Front panel without RJ11 connector (with LCD and/or LEDs): IP2X
  - Sides for standard 40TE case: IP2X
  - Sides for ventilated 40TE and 80TE cases: No claim
  - Rear: No claim
- Protection of persons against access to hazardous parts (Safety)
  - Front panel with RJ11 connector ("blind"): IP1X
  - Front panel without RJ11 connector (with LCD and/or LEDs): IP2X
  - Sides for standard 40TE and ventilated 40TE/80TE cases: IP2X
  - Rear for standard 40TE and ventilated 40TE/80TE cases: IP1X

2.4 WEIGHT

- Standard 40TE and ventilated 40TE cases: approximately 4 kg
- Ventilated 80TE case: approximately 8 kg

2.5 DIMENSIONS AND CONNECTIONS

Please refer to the dimensional drawings (C26x/EN HW, hardware description chapter) and to the terminal connection diagrams (C26x/EN CO).

2.6 ENVIRONMENTAL CONDITIONS

In power plant and substation environments, C26x is intended to be used in the normal service conditions listed below:

Item	Operating conditions	Storage conditions
Ambient Air Temperature[5]	-25°C/+55°C	-40°C/+70°C[1]
Solar radiation	Negligible	
Altitude	≤ 2 000 m	
Relative humidity (24 h average)	From 5 % to 95 % RH[2]	
Atmospheric pressure	86kPa to 106kPa	
Air pollution by dust, salt, smoke, corrosive/flammable gas, vapours	No significant air pollution[4]	
Vibration, earth tremors	Class 1[3]	

Note 1: The GE C26x should be stored in its supplied packaging.

Note 2: No condensation or ice is considered.

Note 3: According to IEC 60255-21 series

Note 4: These conditions correspond to maximum values given for classes 3C1 and 3S1 in IEC 60721-3-3.

Note 5: The ambient air temperature is the maximum or minimum temperature around the enclosure of C26x

2.7 DS AGILE C26X: CONFIGURATION

The DS Agile C26x includes:

- A case
- A rack with slots for the boards
- A combination of the C26x's boards fitted in dedicated slots

There are many types of DS Agile C26x units. Each has a specific purpose and includes some combination of boards to achieve that purpose:

- C26x in 80TE case (ventilated)
- C26x in compact 40TE case (ventilated)

2.7.1 C26X – COMPARISON OF BOARD INSTALLATIONS BETWEEN MODELS

Board	Purpose	C26x 80TE	C26x 40TE
BIU261	Power supply board	X	X
CPU4	Ethernet communication channels	X	X
CCU200	Circuit breaker control unit	X	X
CCU211	Circuit breaker control unit	X	X
DIU200	Digital and counter acquisition Digital measurement acquisition Datapoints: SPS DPS SCT DCT DM	X	X
DIU211	Digital and counter acquisition Digital measurement acquisition Datapoints: SPS DPS SCT DCT DM	X	X
DIU221	Digital and counter acquisition Digital measurement acquisition Datapoints: SPS DPS SCT DCT DM	X	X
DOU201	Execution of single or dual, transient or permanent conditions Set datapoints	X	X
HBU200	Execution of single or dual, transient or permanent conditions	X	X
AIU201	Analogue measurement acquisition	X	X
AIU211	Analogue measurement acquisition	X	X
TMU210	CT and VT sampling acquisition MV calculations with acquired samples	X	X
TMU220	CT and VT sampling acquisition MV calculations with acquired samples	X	X
AOU200	Analogue output board	X	X
SRP28x	Networking	X	X
SRP29x	Networking	X	X
GHU3AB, see note 1	Graphic panel board with LED channels	GHU 2A1	GHU 2A0
Note 1: For GHU3 A B: B for the size B=B includes all possibilities: B=0 or 1 B=0 Small B=1 Large A for the LCD A=A includes all possibilities: A=0, 1, or 2 A=0 Has LCD A=1 Has no LCD A=2 Has remote LCD			

2.7.2 C26X-80TE – BOARD INSTALLATION

Board	Slots - Viewed from the rear of the case																Maximum Nr of Installed Boards	
	Q	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A	With TMU	Without TMU
BIU261																	X	1	1
CPU4																X		1	1
CCU200, see note 1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			≤ 14	≤ 15
CCU211, see note 1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			≤ 14	≤ 15
DIU200	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			≤ 14	≤ 15
DIU211	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			≤ 14	≤ 15
DIU221	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			≤ 14	≤ 15
DOU201	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			≤ 14, see note 3	≤ 15, see note 3
HBU200	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			≤ 2	≤ 2
AIU201	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			≤ 6	≤ 6
AIU211	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			≤ 6	≤ 6
TMU210, see note 1	X																	1	0
TMU220, see note 1	X																	1	0
AOU200	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			≤ 4	≤ 4
SRP28x														X	X			≤ 1	≤ 1
SRP29x														X	X			≤ 1	≤ 1
GHU3A1, see note 2																		1	1

Note 1: If you install a TMU, do not install the CCU in slot P and do not install the CCU in the slot adjacent to the TMU.

Note 2: For an explanation of the GHU3AB codes, please refer to C26x – Comparison of Board Installations Between Models

Note 3: If the application causes all of the DOs to be activated at the same time: ≤ 6

2.7.3 C26X-40TE – BOARD INSTALLATION

Board	Slots - Viewed from the rear of the case								Maximum Number of Installed Boards	
	H	G	F	E	D	C	B	A	With TMU	Without TMU
BIU2xx								X	1	1
CPU4							X		1	1
CCU200, see note 1	X	X	X	X	X	X			≤ 3	≤ 6
CCU211, see note 1	X	X	X	X	X	X			≤ 3	≤ 6
DIU200	X	X	X	X	X	X			≤ 3	≤ 6
DIU211	X	X	X	X	X	X			≤ 4	≤ 6
DIU221	X	X	X	X	X	X			≤ 4	≤ 6
DOU201	X	X	X	X	X	X			≤ 4	≤ 6
HBU200	X	X	X	X	X	X			≤ 2	≤ 2
AIU201	X	X	X	X	X	X			≤ 4	≤ 6
AIU211	X	X	X	X	X	X			≤ 4	≤ 6
TMU210, see note 1	X = 1								1	0
TMU220, see note 1	X = 1								1	0
AOU200	X	X	X	X	X	X			≤ 4	≤ 4
SRP28x					X	X			≤ 2	≤ 2
SRP29x					X	X			≤ 2	≤ 2
GHU3A0, see note 2									1	1

Note 1: If you install a TMU, do not install the CCU in slot F and do not install the CCU in the slot adjacent to the TMU.

Note 2: For an explanation of the GHU3xx codes, please refer to *C26x – Comparison of Board Installations Between Models*

2.7.4 C26X-80TE – SIGNALS

Board	Signals						Maximum Number of Boards: Maximum number of configurable signals	
	AI	AO	DI	DO	CI	VI	With TMU	Without TMU
BIU261			2	2				
CPU4								
CCU200, see note 1			8	4			13: 104 DI + 52 DO	15: 120 DI + 60 DO
CCU211, see note 1			8	4			13: 104 DI + 52 DO	15: 120 DI + 60 DO
DIU200			16				14: 224 DI	15: 240 DI
DIU211			16				14: 224 DI	15: 240 DI
DIU221			16				14: 224 DI	15: 240 DI
DOU201				10			14: 140 DO	15: 150 DO
HBU200				10			2: 20 DO	2: 20 DO
AIU201	4						6: 24 AI	6: 24 AI
AIU211	8						6: 48 AI	6: 48 AI
TMU210, see note 1	8				4	4	1: 4 CI, 4 VI	
TMU220, see note 1	9				4	5	1: 4 CI, 5 VI	
AOU200		4					6: 24 AO	6: 24 AO
SRP28x								
SRP29x								
GHU3A1, see note 2								

Note 1: Do not install the CCU in the slot adjacent to the TMU.

Note 2: For an explanation of the GHU3xx codes, please refer to *C26x – Comparison of Board Installations between Models*

2.7.5 C26X-40TE – SIGNALS

Board	Signals						Maximum Number of Boards: Maximum number of configurable signals	
	AI	AO	DI	DO	CI	VI	With TMU	Without TMU
BIU261			2	2				
CPU4								
CCU200, see note 1			8	4			3: 24 DI + 12 DO	6: 48 DI + 24 DO
CCU211, see note 1			8	4			3: 24 DI + 12 DO	6: 48 DI + 24 DO
DIU200			16				4: 64 DI	6: 96 DI
DIU211			16				4: 64 DI	6: 96 DI
DIU221			16				4: 64 DI	6: 96 DI
DOU200				10			4: 40 DO	6: 60 DO
DOU201				10			4: 40 DO	6: 60 DO
HBU200				10			2: 20 DO	2: 20 DO
AIU201	4						4: 16 AI	6: 24 AI
AIU211	8						4: 32 AI	6: 48 AI
TMU210, see note 1	8				4	4	1: 4 CI, 4 VI	
TMU220, see note 1	9				4	5	1: 4 CI, 5 VI	
AOU200		4					4: 16 AO	6: 24 AO
SRP28x								
SRP29x								
GHU3A0, see note 2								

Note 1: Do not install the CCU in the slot adjacent to the TMU.

Note 2: For an explanation of the GHU3xx codes, please refer to *C26x – Comparison of Board Installations between Models*

2.7.6 C26X: ELEMENT LIMITS



Caution:
The global performance of C26x is less than the sum of the performances of its components. For a detailed performance check, please contact us.



Caution:
The size of a C26x database, i.e. the relevant .adb file included in the .zip databag generated using DS Agile SCE must not exceed 16 MB.

Elements	Limits
BCU level capacity	Limit value
Max. electrical bays (with CTVT acquisition) using TMU210	2
Max. electrical bays (with CTVT acquisition) using TMU220	2
Max. electrical bays (with CTVT acquisition) using one TMU210 and one TMU220 in the same bay	1
Max. electrical bays (with CTVT acquisition) using IEC61850-9.2LE Sample Values (SV)	2
Nb of SV in a SampleValueGroup (eq. to electrical bay with CTVT acq.)	10
Max. SampleValueGroup(s) dedicated to one electrical bay managed by BCU	2
BCU storage features	
Event records for front panel (LHMI)	200
Event records (for CMT tool)	2048
Disturbance files generated by Fast Waveform Recorder (depending of recording time)	480 cycles max. on 1, 2, 3, 4 or 5 files
Disturbance files generated by Slow Waveform Recorder (depending of recording time)	5000 records max. on 1, 2, 5, 10, 20, 50 files
Maximum Number of analogical channels present in a disturbance file generated by Slow Waveform Recorder (3)	up to 5 current channels, up to 5 voltages channels
Maximum Number of analogical channels present in a disturbance file generated by Fast Waveform Recorder (4)	up to 5 current channels, up to 5 voltages channels
Maximum number of logical channels in a disturbance file	128
BCU Internal Ethernet switch capacity	
Max. SAN ports (without redundant ports used for PRP or HSR)	6
Max. SAN ports (with 2 redundant ports used for PRP or HSR)	4
BCU IEC61131-3 automation capacity	
Fast automation (FBD)	
Max. PSL Interlocking equations (interlock FBD) per BCU	200
Max. fast automations with at least 1 setting	29
Max. settings per fast automations	100 for 'Boolean' type, and 100 for 'timer' type
PSL operators / functions (max number of PSL lines in the BCU file, after SCE optimisation and generation)	256

Slow automation (ISAGRAF)	
Max. slow automations per BCU	256
Max. slow automations with at least 1 setting	29
Max. settings per slow automations	200
SCADA protocols	**Limit value**
SCADA communication ports	4
Admissible different SCADA protocols (ex: T104 AND T101,...)	2
Max. SCADA serial protocols (on BIU2xx serial ports)	2
T104 slave (server) protocols (with up to 4 Clients, only one server active at same time)	4
T104 slave event buffer size	5000
Station Bus level (SBUS)	**Limit value**
Station Bus communication (mandatory for conventional and digital DCS architecture)	1
Max. Station Bus servers (BCU and IEDs, for a BCU client)	150 to 250
Max. Station Bus clients (for a BCU server)	20
Maximum incoming GOOSES	96
Agency goose incoming/outgoing time (SBUS GOOSE)	< 3ms
Process Bus level (PBUS)	**Limit value**
Max. number of GOOSE Control Blocks subscribed	16
Max. number of GOOSE Control Blocks published	16
Max. independent SCUs connected to the same Bay Controller Unit	16
Max. redundant SCUs connected to the same Bay Controller Unit	8
Max. redundant Sample Value Group(s) usable by electrical bay (managed by BCU)	2 per dynamic arrangement
Max. MU connected to the same Process Bus (100Mb PBUS)	8
Max. MU connected to the same Process Bus (1Gb PBUS)	80
Max. SVCB simultaneously used on the same Sample Value Group	6
Max. subscribers acquired in same time by BCU (IEC61850-9.2LE Sample Values frames)	6
GOOSE size (IEC61850 only)	128 binary inputs / 64 measurements
Max number of subscribers acquired in same time by BCU (IEC61850-9.2LE Sample Values frames)	6
Trip goose incoming/outgoing time (PBUS GOOSE)	< 500µs
Legacy Bus level (LBUS)	**Limit value**
Master Legacy protocols (for IED communication)	4
Admissible different Legacy protocols (ex: T101 AND Mobdus...)	2
Max. Master Legacy serial protocols (on BIU2xx serial ports)	2
Max. IED per Legacy Bus basis	16
BCU Logical module(s) steady-state capacity	**Limit value**
Max. number of bays managed per Bay Controller Unit	128
Max. number of bays displayed at bay level (LHMI)	12
Max. number of circuit breakers (CB) managed per Bay Controller Unit	128
Disconnectors and earth switches (DS, ES, EF)	512
Max. number of Transformers managed per Bay Controller Unit	10
Max. number of Busbars managed per Bay Controller Unit	10
Max. number of BI managed per Bay Controller Unit (previously called "digital input points")	10000
Max. number of MPS managed per Bay Controller Unit	2000

Max. number of digital output Control Points wired on BCU and IED (SPC, DPC)	1200
Max. number of digital inputs acquired by the Bay Controller Unit boards (DI)	240
Max. number of digital outputs acquired by the Bay Controller UniTt boards (DO)	150
Max. number of analog inputs (measurements) acquired by Bay Controller Unit boards (AI)	48
Max number of analog outputs generated by the Bay Controller Unit boards (AO)	16
Max. number of analog Measurements client & Server (MV)	2400
Max. number of thresholds managed per analog measurement	6
Max. number of segments per analog measurement linearization	20
Max. number of Tap Position Indication wired on BCU and IED (TPI)	128
Max. number of SPI managed per Bay	4
Max. number of Counters wired on BCU and IED (SCT, DCT)	128
Max. number of counters wired on BCU	8*
Max. number of Setpoints wired on BCU or IED (digital or analogue)	256
Logical combination of binary inputs (BI GROUP)	512
Max. number of groups of analog measurements (xPS triggers)	16
Max. number of analog measurements in a group	16
Max. number of different units for MV / Setpoint / Counter	40
BCU Logical module(s) real time capacity	**Limit value**
Receiving flow of MV[1]	200 values /sec
Receiving flow of SPS/DPS[1]	100 state changes /sec
Total receiving flow (MV and SPS and DPS)	300 values and state changes /sec

1: the MV and SPS/DPS must not be sent to the Local HMI for the maximum performance.

2: MU = digital merging unit

3: depending of the analog measurement device (SV, TMU220, TMU210)

4: depending of the analog measurement device (SV, TMU220, TMU210), including the use case with one TMU210 and one TMU220 allocated in the same electrical bay

(*) Please refer to BCU- Pulse Counter Processing

2.8 TERMINALS

PC Maintenance Interface

- DIN 41652 connector, type female D-Sub, 9-pin, installed on the front panel
- A direct wired cable is required.

Conventional communication links

- M3 threaded terminal ends, self-centring with wire protection for conductor cross sections from 0.2 to 2.5 mm² for BIU261 board
- CPU4: Optical fibre connectors are LC-type small form-factor pluggable (SFP) transceivers that can use both single and multi-mode fibre. Centre wavelength: 1300 nm.

Input /Output or power supply modules

M3 threaded terminal ends, self-centring with wire protection for conductor cross sections from 0.2 to 2.5 mm² for these boards:

- AIU201, AIU211
- AOU200
- BIU261
- CCU200, CCU211
- DIU200, DIU211, DIU221
- DOU201
- HBU200

The I/O and BIU261 boards include a 24-pin, 5.08 mm pitch male-connector.

Current-measuring and Voltage-measuring inputs

- M5 threaded terminal ends, self-centring with wire protection for conductor cross sections between 2.5 and 4 mm² for the TMU board.
- The TMU board includes this connector: MIDOS 28 terminal block.

2.9 CREEPAGE DISTANCES AND CLEARANCES

In accordance with IEC 60255-27:2013.

Pollution degree 2, working voltage 250 V.

Overvoltage category III, impulse test voltage 5 kV.

3 RATINGS

3.1 AUXILIARY VOLTAGE

3.1.1 UNIVERSAL, SINGLE- OR DUAL-INPUT POWER SUPPLY (BIU261S/BIU261D)

The power supply input(s) of the BIU261S board and of the BIU261D dual-input power supply module are available with the following auxiliary voltage ranges:

BIU261S

Nominal ranges	Operative DC range	Operative AC range
48 to 250 V_{DC}	40.8 (48-15%) to 300 (250+20%) V_{DC}	-
110 to 250 V_{AC}	-	88 (110-20%) to 300 (250+20%) V_{AC}

BIU261D: Main power supply input

Nominal ranges	Operative DC range	Operative AC range
110 to 250 V_{DC}	88 (110-20%) to 300 (250+20%) V_{DC}	-
110 to 250 V_{AC}	-	88 (110-20%) to 300 (250+20%) V_{AC}

BIU261D: Backup power supply input (DC range only)

Nominal ranges	Operative DC range
110 to 250 V_{DC}	88 (110-20%) to 300 (250+20%) V_{DC}

Note:
The main and backup power supply inputs can use identical or different operating ranges (rating and/or AC/DC type).

The nominal frequency (f_n) for the AC auxiliary voltage is dual rated at 50/60 Hz, the operating range is 44 Hz to 66 Hz.

The BIU261 board has the following characteristics:

- Inrush current:

Power input voltage (V_{DC})	Measured peak current (A)	Power up duration (ms)
110	19.4	110
220	43.8	92

- Maximum power supply: 60 W
- Nominal output voltage: + 5 V and +12 V
- Full load permitted power outage of both power supply inputs: 20 ms
- Protection against polarity reversal
- Insulation resistance: >100 MΩ (common mode) at 500 V_{DC}
- Dielectric strength: 2 kV (common mode) – 50 Hz for 1 minute

Power supply input selection

A power supply source is considered available if its level is above 80% of the minimum value of the operative range, i.e. 80% x 48 V = 38.4 V or 80% x 110 V = 88 V. A 5% hysteresis is added in order to avoid any toggling in the availability status, i.e. the availability status will pick up at 80% $V_{AUX\ MIN}$ and drop off at 75% $V_{AUX\ MIN}$.

If the primary power supply input is lost while it is being used, the BIU261 switches to the secondary power supply input. It will switch back to the primary power supply when the latter becomes available again and has been stable for a few seconds.

If the secondary power supply is lost while it is being used, the BIU261 instantly switches to the primary power supply. It will continue to use the primary power supply source as long as it is available, even when the secondary power supply becomes available again.

3.1.2 BIU261S/BIU261D DIGITAL OUTPUTS

On the BIU261S board, as well as on the BIU261D's mother board, the characteristics of the Watchdog Relay Contacts are the same as the characteristics for the NO+NC contacts fitted on the DOU201 board.

On the BIU261S board, as well as on the BIU261D's mother board, the characteristics of the two output relays used for C26x redundancy are the same as for the single-pole output-relay fitted on the DOU201 board.

3.1.3 BIU261S/BIU261D DIGITAL INTPUTS

BIU261S/BIU264D provide two isolated logic inputs intended to be driven from the volt-free contacts on Output1 and Output2. The inputs are designed to operate from 48V DC to 250VDC (+/- 20%) allowing them to be powered by the local supply voltage.

Characteristic of the isolated inputs:

- Guaranteed Logic 0 level = 10V
- Guaranteed Logic 1 level = 38V
- Threshold Level 0 to 1 = 29V
- Threshold Level 1 to 0 = 19V
- Maximum input voltage = 300VDC

3.2 CIRCUIT BREAKER CONTROL UNIT (CCU) DIGITAL INPUTS

3.2.1 CCU200 DIGITAL INPUTS

For the CCU200 board, for the variants A01 to A04, the eight inputs have the same attributes as the inputs for the DIU200 board.

The CCU200 board is available in five nominal voltage variants, as follows:

Board variant	Nominal voltage (+/-20%)	Triggering threshold (V_{DC})	Same for DIU200
A01	24V_{DC}	if V >10.1V_{DC} Input status is set if V < 5V_{DC} Input status is reset	Yes
A02	48 to 60V_{DC}	if V >17.4V_{DC} Input status is set if V < 13.5V_{DC} Input status is reset	Yes
A03	110 to 125V_{DC}	if V > 50V_{DC} Input status is set if V< 34.4V_{DC} Input status is reset	Yes

Board variant	Nominal voltage (+/-20%)	Triggering threshold (V_{DC})	Same for DIU200
A04	220V_{DC}	if V > 108V_{DC} Input status is set if V< 63V_{DC} Input status is reset	Yes
A07	110 to 125V_{DC}	if V > 86V_{DC} input status is set if V < 67V_{DC} input status is reset	No

3.2.2 CCU211 DIGITAL INPUTS

There are six variants of the CCU211 board, as follows:

Board variant	Nominal voltage (+/-20%)	Triggering threshold (V_{DC})
A01	24 V_{DC}	if V >10 V_{DC} Input status is set if V < 8 V_{DC} Input status is reset
A02	48 to 60 V_{DC}	if V >17.4 V_{DC} Input status is set if V < 12.5 V_{DC} Input status is reset
A03	110 to 125 V_{DC}	if V > 50 V_{DC} Input status is set if V< 29.9 V_{DC} Input status is reset
A04 or A07	220 V_{DC} or 110 to 125 V_{DC} (with 80% Threshold)	if V > 86 V_{DC} Input status is set if V< 67 V_{DC} Input status is reset
A08	220 V_{DC} (with 80% Threshold)	if V > 176 V_{DC} Input status is set if V < 132 V_{DC} Input status is reset

3.3 CIRCUIT BREAKER CONTROL UNIT (CCU) DIGITAL OUTPUTS

3.3.1 CCU200 DIGITAL OUTPUTS

Each relay of the CCU board has double pole contacts. To get the attributes described below, you must wire the two output contacts of each relay in series.

In the table that follows, the Break attribute shows in two cases:

- You use each of the output contacts separately
- You wire the two output contacts of each relay in serial. In this event, you make the best use of the Break function for each relay

On the CCU200 board, the details of the 4 Output Relay Contacts show in this table:

Description	Values
Nominal operating voltage range	24 to 250 VDC / 230 VAC
Carry (steady state current)	5 A
Making capacity (rated inrush current)	5 A continuously 30 A for 500 ms or 250 A for 30 ms
Breaking capacity (Output contacts used separately)	DC: 50 W resistive, 30 W inductive (L/R = 40 ms) AC: 1250 VA resistive, 1250 VA inductive (power factor = 0.7) In these conditions, the contact resistance is still lower than 250 mΩ for 10 000 operations
Breaking capacity (Output contacts wired in serial)	DC: 80 W resistive for currents lower than 1 A, 100 W resistive for currents higher than 1 A, 30 W inductive (L/R = 40 ms) AC: 1250 VA resistive, 1250 VA inductive (power factor = 0.7) In these conditions, the contact resistance is still lower than 250 mΩ for 10 000 operations
Breaking time	< 7 ms

Description	Values
Double pole contacts	Normally open
Number of operations	Unloaded contact: > 100 000 Loaded contact: >10 000

Dielectric strength of the coil and the contacts: 5000 V_{RMS}

Dielectric strength of adjacent contacts: 2500 V_{RMS}

Isolation: 2 kV (CM) at 50 Hz for 1 minute

The board is designed and monitored to prevent any unwanted event.

3.3.2 CCU211 DIGITAL OUTPUTS

For the CCU211 board, the Digital Output (DO) attributes include:

- 4 double-pole switch-relays with normally open (NO) contacts
- 1 common +ve and 1 common -ve contact for 2 relays
- A self-monitoring device for the output control chain: address check, state monitoring
- The +5V voltage is monitored to prevent issuing an unwanted signal
- You can configure the digital outputs only in the double remote signalling configuration
- Dielectric strength of the coil and the contacts: 5000 V_{RMS}
- Dielectric strength of adjacent contacts: 2500 V_{RMS}
- The board is designed and monitored to prevent issuing an unwanted signal

In the table that follows, the Break attribute shows in two cases:

- You use each of the output contacts separately
- You wire the two output contacts of each relay in serial. In this event, you make the best use of the Break function for each relay
- For more details, please refer to the table that follows.

Description	Values
Nominal operating voltage range	24 to 250 V_{DC} / 230 V_{AC}
Carry (steady state current)	5 A
Making capacity (rated inrush current)	5 A continuously 30 A for 500 ms or 250 A for 30 ms
Breaking capacity (output contact used separately)	DC: 50 W resistive, 30 W inductive (L/R = 40 ms) AC: 1250 VA resistive, 1250 VA inductive (power factor = 0.7) In these conditions, the contact resistance is still lower than 250 mΩ for 10000 operations
Breaking capacity (Output contacts wired in serial)	DC: 80 W resistive for currents lower than 1 A, 100 W resistive for currents higher than 1 A, 30 W inductive (L/R = 40 ms) AC: 1250 VA resistive, 1250 VA inductive (power factor = 0.7) In these conditions, the contact resistance is still lower than 250 mΩ for 10 000 operations
Breaking time	< 7 ms
Double pole contacts	Normally open

Description	Values
Number of operations	Unloaded contact: > 100 000 Loaded contact: >10 000

3.4 DIGITAL INPUT UNIT (DIU) DIGITAL INPUTS

3.4.1 DIU200 DIGITAL INPUTS

The DIU200 board has 16 digital inputs and is available in four nominal voltage variants:

Board variant	Field voltage	Triggering threshold		Trigger current	Current at rated voltage	Max. power
		Pick-up	Drop-off			
A01	24 V_{DC}	10.1 V_{DC}	5 V_{DC}	>0.17 mA	3 mA	0.12 W
A02	48-60 V_{DC}	17.9 V_{DC}	13.5 V_{DC}	>0.17 mA	5.22 mA (48 V_{DC})/ 7 mA (60 V_{DC})	0.66 W
A03	110-125 V_{DC}	52.3 V_{DC}	34.4 V_{DC}	>0.33 mA	2.6 mA (110 V_{DC})/ 3.5 mA (125 V_{DC})	0.62 W
A04	220 V_{DC}	108 V_{DC}	63 V_{DC}	>0.46 mA	2 mA	0.66 W

3.4.2 DIU211 DIGITAL INPUTS

In the C26x case, the DIU211 board can replace a DIU200 board. The external connections are the same as for these boards.

The DIU211 board includes 16 opto-isolated digital-inputs, with one common for two inputs.



Warning:
Where digital inputs are energized at 300 V the C26x ambient operating temperature is limited to 40°C and the maximum number of simultaneously energized digital inputs must not exceed 50% per DIU211 module.

The inputs are suitable for use on systems with nominal battery voltages from 24 V_{DC} to 220 V_{DC} (+/- 20%). The inputs respond to negative input voltages. The inputs are not self-checked. The threshold voltage depends on the voltage range which is set by positioning a jumper on the board (see *Hardware* chapter):

Variant	Input voltage	Triggering threshold		Trigger current	Current at rated voltage	Rated power
		Pick-up	Drop-off			
A01	24 V_{DC}	10 V_{DC}	8 V_{DC}	30 mA for 2 ms	3.2 mA	0.077 W
A02	48 V_{DC} – 60 V_{DC}	17.4 V_{DC}	12.5 V_{DC}	30 mA for 2 ms	2.9 mA at 48 V	0.14 W
A03	110 V_{DC} – 125 V_{DC}	50 V_{DC}	29.9 V_{DC}	30 mA for 2 ms	2.4 mA at 110 V	0.26 W
A04	220 V_{DC}	86 V_{DC}	67 V_{DC}	30 mA for 2 ms	1.9 mA	0.42 W
A07	110 V_{DC} – 125 V_{DC} with 80% threshold	86 V_{DC}	67 V_{DC}	30 mA for 2 ms	2.4 mA at 110 V	0.26 W
A08	220 V_{DC} with 80% threshold	176 V_{DC}	132 V_{DC}	30 mA for 2 ms	1.9 mA	0.42 W

For an input voltage from the threshold value to 18 V, the input current is 30 mA. The voltage applied to the input terminals, with an amplitude between 19 V_{DC} and 264 V_{DC} powers the pulse generation circuit. The circuit drives a current pulse with an amplitude of 30 mA. The pulse duration is between 1 ms and 2 ms.

To reduce thermal dissipation, especially at high input voltages, the inputs draw a current of less than 1.6 mA.

A high current circulation inside binary contacts for a short period cleans them and thus allows the boards to be used in contaminated environments.

3.4.3 DIU221 DIGITAL INPUTS

In the C26x case, the DIU221 board can replace a DIU200 board or a DIU211 board. The external connections are the same as for these boards.

The DIU221 board includes 16 galvanically isolated (40 kΩ) digital inputs, with one common for two inputs.

The inputs are suitable for use on systems with nominal battery voltages of 158-170 V_{DC} (A09 variant) or 250 V_{DC} ±20% (A10 variant). The inputs do not respond to negative input voltages. The inputs are not self-checked.

Variant	Input voltage	Triggering threshold	
		Pick-up	Drop-off
A09	170 V_{DC}	170 V_{DC}	154 V_{DC}
A10	250 V_{DC}	200 V_{DC}	150 V_{DC}

The voltage applied to the input terminals powers the pulse generation circuit. The circuit drives a high-current "rejection" pulse with an amplitude of up to 140 mA. The pulse duration is approximately 3 ms. It carries an electric charge of at least 200 µC. It allows the boards to be used in contaminated environments by burning off possible deposits on the contacts.

In order to reduce thermal dissipation, the 40 kΩ resistance is switched off when the input voltage level crosses the pick-up threshold.

The rejection pulse is allowed to fire only once every 4 seconds in order to prevent the risk of component damage. It is fired before the input channel turns on. By the time it has finished, the voltage has continued to rise enough to cross the input pick-up threshold and the 40 kΩ resistance is switched off.

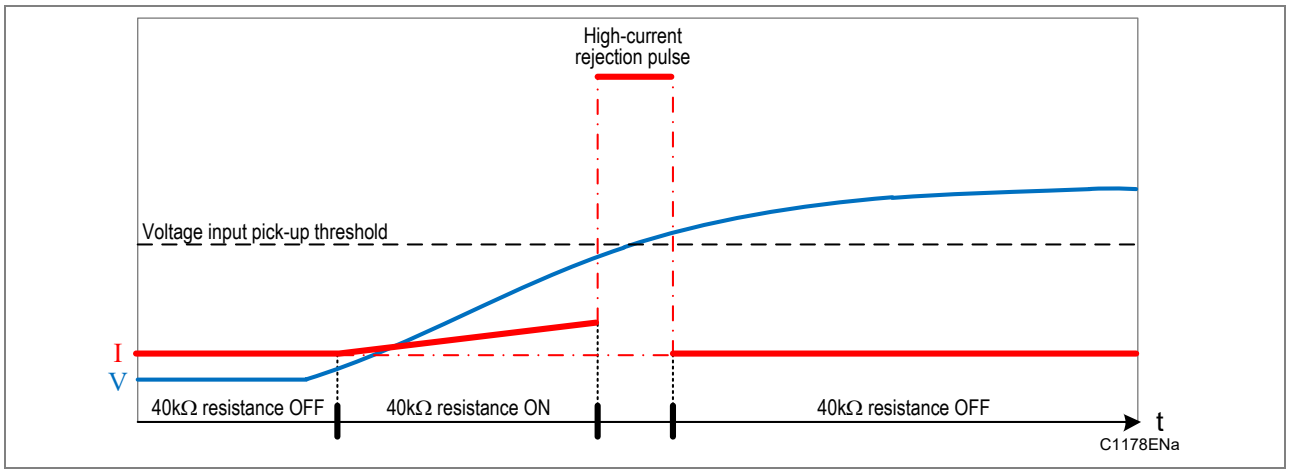


Figure 1: Input channel response curve

3.5 DIGITAL OUTPUT UNIT (DOU) DIGITAL OUTPUTS

3.5.1 DOU201 DIGITAL OUTPUTS

The DOU201 board provides:

- 10 insulated digital outputs (with relays)
- 8 single pole relays with one normally open (NO) contact
- 2 double pole relays with 1 common for 2 output contacts (NO/NC changeover)

External connections remain the same as for earlier versions of the board.

The characteristics of the output relay contacts of a DOU201 board are given in this table:

Description	Values
Nominal operating voltage range	24 to 250 V_{DC} / 230 V_{AC}
Carry (steady state current)	5 A
Making capacity (rated inrush current)	5 A continuously 30 A for 500 ms (open for 40 s afterwards) or 250 A for 30 ms
Making time	< 7 ms
Breaking capacity	Breaking capacity for 100 000 operations: DC: 150 W resistive, 15 W inductive (L/R = 20 ms) AC: 1500 VA resistive, Breaking capacity reduced to 90 000 operations: AC: 1500 VA inductive (power factor = 0.7) Breaking capacity confirmed after 10 000 operations (contact resistance still lower than 250 mΩ): DC: 30 W inductive (L/R = 40 ms)
8 single-pole relays	Normally open contacts
2 double-pole relays	1 common for 2 output contacts (NO/NC changeover)
Number of operations	Unloaded contact: > 100 000 Loaded contact: >10 000

The location of the DOU201 in the C26x rack defines the address of the board. If you use the DOU201 as a spare of a previous board, you can use the jumper to define the address of the board. Use the SCE to define this location (refer to C26x/EN AP).

- Dielectric strength of the coil and the contacts: 5000 V_{AC}.
- Isolation: 2 kV (CM) at 50 Hz for 1 minute
- The board is designed and monitored to prevent issuing an unwanted signal.

3.6 HIGH BREAK UNIT (HBU) HIGH BREAK/HIGH SPEED DIGITAL OUTPUTS

The HBU200 board is used for applications requiring high rupture capacity. It provides 10 single pole output relays with normally open (NO) contacts.

The characteristics of the output relay contacts of an HBU200 board are given in this table:

Description	Values
Nominal operating voltage range	up to 250 V_{DC} / 250 V_{AC} + 20%
Transient impulse clamping level	450 V minimum
Carry (steady state current)	Single pole: 10 x 10 A at 55°C Double pole: 5 x 16 A at 40°C
Making capacity (rated inrush current)	33 A for 3 s
Maximum inrush current	100 A for 30 ms
Making time	< 0.5 ms
I^2t rating	300 A^2/s

Description	Values
Contact resistance	Make: 33 mΩ Carry: 10 mΩ
Breaking capacity	Breaking capacity for 10 000 operations: DC: 7500 W resistive, 2500 W inductive (L/R = 40 ms) AC: 7500 W resistive, 2500 W inductive
Number of operations	Unloaded contact: > 100 000 Loaded contact: >10 000

The location of the HBU200 board in the C26x rack defines the address of the board. . If you use the HBU200 as a spare of a previous board, you can use the jumper to define the address of the board. Use the SCE to define this location (refer to C26x/EN AP).

- Isolation: 2 kV (CM) at 50 Hz for 1 minute, 4 kV impulse
- The board is designed and monitored to prevent issuing an unwanted signal.

3.7 ANALOGUE INPUT UNIT (AIU) ANALOGUE INPUTS

3.7.1 AIU201 ANALOGUE INPUTS

The AIU201 board provides 4 independent analogue inputs (AI). You can set each AI input current range or input voltage range as shown in the table that follows:

Type	Ranges
Current input range	[–1 mA .. +1 mA] [–5 mA .. +5 mA] [–10 mA .. +10 mA] [–20 mA .. +20 mA] (see C26x/EN AP for settable sensor ranges)
Voltage input range	[–1.25 V .. +1.25 V] [–2.5 V .. +2.5 V] [–5 V .. +5 V] [–10 V .. +10 V]
Sampling period	100 ms
Accuracy	0.1% full scale at 25°C
AD conversion	16 bits (15 bits + sign bit)
Common mode rejection ratio (CMMR)	> 100 dB
Serial mode rejection ratio (SMMR)	> 40 dB
Range of Gain: user-selectable	1, 2, 4, 16
Input impedance for voltage inputs	11 kΩ
Input impedance for current inputs	75 Ω

You can set the ranges during the configuration phase.

To select the current or voltage, choose the input number of the connector.

AD conversion

The zero offset value is computed by the conversion of a 0 V voltage reference.

The gain is adjusted automatically by software by connecting a known voltage reference to the amplifier.

The zero offset values and the gain are adjusted regularly in order to compensate for the deviations caused by variations of temperature (drift: as much as 30 ppm/°C) and ageing.

3.7.2 AIU211 ANALOGUE INPUTS

Transducers deliver the DC current signals to the AIU211 board. The AIU211 board provides 8 insulated analogue input values on 8 independent galvanic-isolated channels. This means that there is no common point of contact between two analogue inputs.

You can configure each analogue input in the current range as shown in the table that follows:

Type	Ranges
Current input range	[–1 mA .. +1 mA] [–5 mA .. +5 mA] [–10 mA .. +10 mA] [–20 mA .. +20 mA] (see AP chapter for settable sensor ranges)
Sampling period	100 ms
Accuracy	0.1% full scale for each range at 25°C
AD conversion	16 bits (15 bits + sign bit)
Common mode rejection ratio (CMMR) 50Hz, 60Hz	> 100 dB
Serial mode rejection ratio (SMMR)	> 40 dB
Input impedance for current inputs	75 Ω

Temperature drift: as much as 30 ppm/°C between 0°C and 70°C

You can set the ranges during the configuration phase.

To select the current range, choose the input number of the connector.

The AIU211 board replaces the AIU210 Board: the interface on the internal Bus is compatible with the AIU210.

3.7.3 SATURATION VALUES

Range	Saturation values
[–10 V .. +10 V]	-12.6 V / +12.6 V
[–5 V .. +5 V]	-6.3 V / +6.3 V
[–2.5 V .. +2.5 V]	-3.2 V / +3.2 V
[–1.25 V .. +1.25 V]	-1.26 V / +1.26 V
[–1 mA .. +1 mA]	-1.26 mA / +1.26 mA
[–5 mA .. +5 mA]	-6.3 mA / +6.3 mA
[–10 mA .. +10 mA]	-12.6 mA / +12.6 mA
[–20 mA .. +20 mA]	-25.2 mA / +25.2 mA

3.8 TRANSDUCERLESS MEASUREMENT UNIT (TMU) CT/VT ANALOGUE INPUTS

3.8.1 GENERAL

For C26x BCUs, you can install TMU210, and TMU220 boards.

The TMU220 provides 4 Current Transformer (CT) inputs & 5 Voltage Transformer (VT) inputs.

The TMU210 provides 4 Current Transformer (CT) inputs & 4 Voltage Transformer (VT) inputs.

3.8.2 TMU220 – CURRENT TRANSFORMERS (CT)

On the terminal block, there are two available nominal currents, each with different attributes.

The current measurement inputs to each of the 4 Current Transformers (CT) include the following attributes:

Description	Operating range	
	1 A	5 A
Nominal AC current (In)	1 A_{RMS}	5 A_{RMS}
Minimum measurable current with same accuracy	0.2 A_{RMS}	0.2 A_{RMS}
Maximum measurable continuous current	4 A_{RMS} (4*In)	20 A_{RMS} (4*In)
Frequency	50 or 60 Hz ± 10%	50 or 60 Hz ± 10%

TMU220 CT overload withstand:

Duration	Strength	
	1 A	5 A
3 seconds: not measurable, with no destruction	6 A_{RMS} (6*In)	30 A_{RMS} (6*In)
1 second: not measurable, with no destruction	20 A_{RMS} (20*In)	100 A_{RMS} (20*In)

3.8.3 TMU220 – VOLTAGE TRANSFORMERS (VT)

The voltage measurement inputs to each of the 5 Voltage Transformers (VT) include the following attributes:

Description	Operating range
Nominal AC voltage (Vn) range	57.73 V_{RMS} to 270 V_{RMS}
Minimum measurable voltage	7 V_{RMS}
Maximum continuous, measurable voltage	300 V_{RMS}
Frequency operating range	50 or 60 Hz ± 10%

VT overload withstand:

Duration	Strength
10 seconds with no destruction	880 V_{RMS}

3.8.4 TMU210 – PROTECTIVE CURRENT TRANSFORMERS (CT)

On the terminal block, there are two available nominal currents: 1A and 5A. Each has different attributes. Use jumpers to set the 1A or 5A nominal current (refer to the block diagram, in the connection chapter).

The current measurement inputs to each of the 4 Current Transformers (CT) include the following characteristics:

I PHASE		
Standard values for rated secondary current (In)	**1A**	**5A**
Minimal current validity threshold	0.018A_{eff} (*1)	0.09A_{eff} (*2)
Minimal operating current*	0,1A_{eff}	0,5Aeff
Rated continuous thermal value*	4A_{eff} (400%)	20A_{eff} (400%)
Maximal operating currents*	30A_{eff} / 10s 40A_{eff} / 5s	150A_{eff} / 10s 200A_{eff} / 5s
Rated short-time thermal value**	100A_{eff} / 1s	500A_{eff} / 1s
Rated frequency range	50 or 60Hz ±10% (45 to 66 Hz)	
Consumption	<0.007VA at In	<0.144VA at In

(*1): With lower threshold hysteresis of 8mA

(*2): With lower threshold hysteresis of 40mA

I SENSIBLE		
Standard values for rated secondary current (Ien)	**1A**	**5A**
Minimal current validity threshold	0.012A_{eff} (*3)	0.06A_{eff} (*4)
Minimal operating current*	0,01A_{eff}	0,05A_{eff}
Rated continuous thermal value*	0.8A_{eff} (80%)	4A_{eff} (80%)
Maximal operating current*	8A_{eff} / 10s	40A_{eff} / 10s
Rated short-time thermal values**	30A_{eff} / 10s 100A_{eff} / 1s	150Aeff / 10s 500A_{eff} / 1s
Rated frequency range	50 or 60Hz ±10% (45 to 66 Hz)	
Consumption	< 500µVA at 0.1In	< 500µVA at 0.1In

(*3): With lower threshold hysteresis of 2mA

(*4): With lower threshold hysteresis of 10mA

I VERY SENSIBLE		
Standard values for rated secondary current (Ien)	**1A**	**5A**
Minimal current validity threshold	0,003A_{eff} (*5)	0,012A_{eff} (*6)
Minimal operating current*	0,002A_{eff}	0,01A_{eff}
Rated continuous thermal value*	0.01A_{eff} (1%)	0.05A_{eff} (1%)
Maximal operating current*	1A_{eff} / 10s	5A_{eff} / 10s
Rated short-time thermal values**	30A_{eff} / 10s 100A_{eff} / 1s	150A_{eff} / 10s 500A_{eff} / 1s
Rated frequency range	50 or 60Hz ±10% (45 to 66 Hz)	
Consumption	< 500µVA at 0.1In	< 500µVA at 0.1In

*(*5): With lower threshold hysteresis of 1mA*

*(*6): With lower threshold hysteresis of 2mA*

** At ambient temperature and rated frequently (Fn)*

*** not measurable without destruction*

3.8.5 TMU210 – PROTECTIVE VOLTAGE TRANSFORMERS (VT)

The 3 or 4 phase voltage measurement inputs to each of the 4 Voltage Transformers (VT) include the following characteristics:

Voltage Transformer (VT)	
Standard values for rated secondary voltage (Vn)	100V/√3, 100V/3, 100V, 110V/√3, 110V/3, 110V, up to 130 V_{eff}
Minimal voltage validity threshold (with upper threshold hysteresis of 1.0V)	1,0 V_{eff}
Minimal operating voltage*	5,7 V_{eff}
Rated continuous thermal value*	110V_{eff} (190%)
Maximum operating voltage	260 V_{eff} / 10s
Rated short-time thermal values**	338 V_{eff} / 10s
Consumption	<0,08VA at 57.7V <0,4VA at 130V <1.5VA at 260V
Rated frequency range	50 or 60Hz ±10% (45 to 66 Hz)

** at full scale value, rated frequency (Fn) and into operating temperature range*

*** not measurable without destruction*

Connection option by setting:

For 3 phase voltage input: 3Vpn / 2 Vpn + Vr / 2Vpp + Vr

For 4 phase voltage input: 3Vpn / 3 Vpn + Vr / 2 Vpn + Vr / 3 Vpp + Vr / 2 Vpp + Vr

All voltage and power phase protection are done on Vpp voltage directly measured or derived, and Vr is directly measured or derived.

3.8.6 TMU2XX - A/D CONVERTER

On the TMU2xx boards, the A/D converter includes the following attributes:

Description	Values
Width	16 bits
Conversion period	< 30 µs
Scanning period	80 samples/cycle
Linearity error	± 2 LSB
SINAD ratio as much as 1kHz	>80 db
Low passed filter at 1kHz	-40 db/decade

3.9 ANALOGUE OUTPUT UNIT (AOU)

3.9.1 AOU200 ANALOGUE OUTPUTS

The AOU200 board provides 4 analogue current outputs. Each output is related to a Read Inhibit relay. An external power supply supplies power to the outputs.

The analogue outputs, the relays and the power supply are one isolated group.

The external power supply must supply a regulated voltage of +48V±5% and a power of 10 W for each AOU200 board

For the AOU200 board, the output attributes are as follows:

Value	Maximal Impedance
± 5 mA (± 20% ⇨ ± 6 mA)	4 kΩ
± 10 mA (± 20% ⇨ ± 12 mA)	2 kΩ
± 20 mA (± 20% ⇨ ± 24 mA)	1 kΩ
+ 4 mA to +20 mA	

After calibration, and at 25°C, precision = 0.1% X (the full scale + 20%)
Between -10°C and +70°C, maximum deviation <100ppm/°C

100 ms after the command, the current output is stable. The management of the AOU200 board with an RI relay shows in the figure below. When the RI relay is in the closed position, you can read the value.

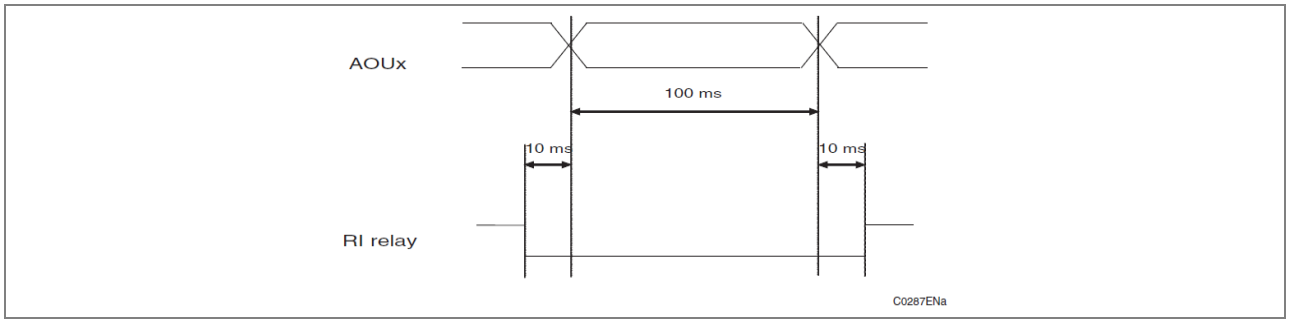


Figure 2: AOU board management with an RI relay

Watchdog relay and RI relays characteristics:

Contact type	NO
Max operating voltage	250 V_{DC} / 230 V_{AC}
Make and Carry	2.5 A continuously 30 A for 500 ms 100 A for 30 ms
Break	DC: 50 W resistive, 15 W inductive (L/R = 40 ms) AC: 1250 VA resistive 1250 VA inductive (power factor cosφ = 0.7 – relay duration is lower)
Operating time	< 7ms
Maximum frequency of switching	360 operations each hour, on nominal load

Contact type	NO
Life Period	100 000 operations, on resistive load at 250 V_{AC}, 8 A

The watchdog feature is used to send an alarm signal in case of an AOU200 board failure: This signal is sent (alarm) if:

- the automatic cyclical refresh (“I’m alive” periodic signal from the CPU, part of the communication protocol) of the WD function is interrupted, or
- communications with the CPU board are no longer possible, or
- the field voltage used by the analogue outputs is lost.

The associated green LED is lit when there is no alarm present.

3.10 TABLE OF DIELECTRIC STRENGTHS & INDEPENDENT CIRCUITS

How to read the table.

Column 2 (Type of Terminals), each line defines an independent circuit or independent circuit group.

Type of Board	Type of Terminals (Numbers of Terminals)	Dielectric Withstand (CM, 60s)
BIU261 (ZP0027001)	Digital Outputs (1 to 3) Watchdog (4 to 6) Digital Inputs (7 to 9) RS232/RS485 (12 to 21) Main Power Supply (23, 24)	2000V_{AC} 2800V_{DC} 2000V_{AC} 2800V_{DC} 2000V_{AC} 2800V_{DC} 2000V_{AC} 2800V_{DC} 2000V_{AC} 2800V_{DC}
BIU261 Daughter Board (ZP0028001)	Backup Power Supply (1, 2)	2000V_{AC} 2800V_{DC}
CPU4 (ZP0063001→ZP0016001)	Alarm (1 to 3)	2000V_{AC} 2800V_{DC}
AIU201 (2070913)	Analog Inputs (1 to 5) Analog Inputs (7 to 11) Analog Inputs (13 to 17) Analog Inputs (19 to 23)	2800V_{DC} 2800V_{DC} 2800V_{DC} 2800V_{DC}
AIU211 (2071652)	Analog Inputs (1 to 2) Analog Inputs (3 to 4) Analog Inputs (7 to 8) Analog Inputs (9 to 10) Analog Inputs (13 to 14) Analog Inputs (14 to 16) Analog Inputs (19 to 20) Analog Inputs (21 to 22)	2000V_{AC} 2800V_{DC} 2000V_{AC} 2800V_{DC} 2000V_{AC} 2800V_{DC} 2000V_{AC} 2800V_{DC} 2000V_{AC} 2800V_{DC} 2000V_{AC} 2800V_{DC} 2000V_{AC} 2800V_{DC} 2000V_{AC} 2800V_{DC}
AOU200 (2071441)	Ext. Power (1,3) Analog Outputs (17 to 24) Watchdog (5, 6) Read Inhibit AO no. 1 to 4 (8 to 15)	2800V_{DC} 2000V_{AC} 2000V_{AC}
DIU200 (45196503A1-A4) DIU211 (ZP0011001) DIU221 (ZP0062001)	2x Digital Inputs (1 to 3) 2x Digital Inputs (4 to 6) 2x Digital Inputs (7 to 9) 2x Digital Inputs (10 to 12) 2x Digital Inputs (13 to 15) 2x Digital Inputs (16 to 18) 2x Digital Inputs (19 to 21) 2x Digital Inputs (22 to 24)	2000V_{AC} 2800V_{DC} 2000V_{AC} 2800V_{DC} 2000V_{AC} 2800V_{DC} 2000V_{AC} 2800V_{DC} 2000V_{AC} 2800V_{DC} 2000V_{AC} 2800V_{DC} 2000V_{AC} 2800V_{DC} 2000V_{AC} 2800V_{DC}

Type of Board	Type of Terminals (Numbers of Terminals)	Dielectric Withstand (CM, 60s)
DOU201 (2071730A01)	Digital Output (1 to 2)	2000V_{AC} 2800V_{DC}
	Digital Output (3 to 4)	2000V_{AC} 2800V_{DC}
	Digital Output (5 to 6)	2000V_{AC} 2800V_{DC}
	Digital Output (7 to 8)	2000V_{AC} 2800V_{DC}
	Digital Output (9 to 10)	2000V_{AC} 2800V_{DC}
	Digital Output (11 to 12)	2000V_{AC} 2800V_{DC}
	Digital Output (13 to 14)	2000V_{AC} 2800V_{DC}
	Digital Output (15 to 16)	2000V_{AC} 2800V_{DC}
	Digital Outputs (19 to 21)	2000V_{AC} 2800V_{DC}
	Digital Outputs (22 to 24)	2000V_{AC} 2800V_{DC}
CCU200 (45196501A1-A7) CCU211 (2071732)	2x Digital Inputs (1 to 3)	2000V_{AC} 2800V_{DC}
	2x Digital Inputs (4 to 6)	2000V_{AC} 2800V_{DC}
	2x Digital Inputs (7 to 9)	2000V_{AC} 2800V_{DC}
	2x Digital Inputs (10 to 12)	2000V_{AC} 2800V_{DC}
	2 x Digital Outputs (13 to 18)	2000V_{AC} 2800V_{DC}
	2 x Digital Outputs (19 to 24)	2000V_{AC} 2800V_{DC}
HBU200 (ZP0026001)	High Break Output (1 to 2)	2000V_{AC} 2800V_{DC}
	High Break Output (3 to 4)	2000V_{AC} 2800V_{DC}
	High Break Output (6 to 7)	2000V_{AC} 2800V_{DC}
	High Break Output (8 to 9)	2000V_{AC} 2800V_{DC}
	High Break Output (11 to 12)	2000V_{AC} 2800V_{DC}
	High Break Output (13 to 14)	2000V_{AC} 2800V_{DC}
	High Break Output (16 to 17)	2000V_{AC} 2800V_{DC}
	High Break Output (18 to 19)	2000V_{AC} 2800V_{DC}
	High Break Output (21 to 22)	2000V_{AC} 2800V_{DC}
	High Break Output (23 to 24)	2000V_{AC} 2800V_{DC}
SWR212 SWR214 (ZP0021001-2)	4 x Ethernet Port (ports pins 1 to 8)	1500V_{DC}
	Alarm (1 to 3)	2000V_{AC} 2800V_{DC}
SWU20x (2070745A01-A05)	4 x Ethernet Port (ports pins 1 to 8)	1500V_{DC}
	Alarm (1 to 3)	2000V_{AC} 2800V_{DC}
SWT214 (ZP0032001)	4 x Ethernet Port (ports pins 1 to 8)	1500V_{DC}
	Alarm (1 to 3)	2000V_{AC} 2800V_{DC}
SRP282 SRP284 (ZP0020001→ZP0015001) SRP292 SRP294 (ZP0059001→ZP0015003)	3 x Ethernet Port (ports pins 1 to 8)	1000V_{AC} 1500V_{DC}
	Alarm (1 to 3)	2000V_{AC} 2800V_{DC}
	IRIG-B (1,2)	2000V_{AC} 2800V_{DC}
DPU282 DPU284 (ZP0020002→ZP0015001)	3 x Ethernet Port (ports pins 1 to 8)	1000V_{AC} 1500V_{DC}
	Alarm (1 to 3)	2000V_{AC} 2800V_{DC}
SVU282 SVU284 (ZP0020004→ZP0015001)	3 x Ethernet Port (ports pins 1 to 8)	1000V_{AC} 1500V_{DC}
	Alarm (1 to 3)	2000V_{AC} 2800V_{DC}
	IRIG-B (1,2)	2000V_{AC} 2800V_{DC}

Type of Board	Type of Terminals (Numbers of Terminals)	Dielectric Withstand (CM, 60s)
TMU210 (2071469A01-A03) TMU220 (2071613A01)	Current Input (1 to 4)	$2000V_{AC}$ $2800V_{DC}$
	Current Input (5 to 8)	$2000V_{AC}$ $2800V_{DC}$
	Current Input (9 to 12)	$2000V_{AC}$ $2800V_{DC}$
	Current Input (13 to 16)	$2000V_{AC}$ $2800V_{DC}$
	Voltage Input (19 to 20) – TMU220 *Only*	$2000V_{AC}$ $2800V_{DC}$
	Voltage Input (21 to 22)	$2000V_{AC}$ $2800V_{DC}$
	Voltage Input (23 to 24)	$2000V_{AC}$ $2800V_{DC}$
	Voltage Input (25 to 26)	$2000V_{AC}$ $2800V_{DC}$
	Voltage Input (27 to 28)	$2000V_{AC}$ $2800V_{DC}$

4 BURDENS

4.1 POWER SUPPLY BOARD/MODULE

4.1.1 MAXIMUM MEASURED BURDEN FOR BIU261 POWER SUPPLY

Item	Power Supply Voltage	VA (VA)
Maximum burden AC powered on main power supply	110 Vac	73.2
Maximum burden AC powered on main power supply	220 Vac	84.3
Maximum burden DC powered on main power supply	110 Vdc	38.3
Maximum burden DC powered on secondary power supply	110 Vdc	36.8
Maximum burden DC powered on main power supply	220 Vdc	39.2
Maximum burden DC powered on secondary power supply	220 Vdc	38.3

4.1.2 BURDEN FOR BINARY INPUT

Power Input Voltage (V_{DC})	Measured max Value (W)
110	0.16
220	0.69

4.2 CIRCUIT BREAKER CONTROL UNITS (CCU) INPUT BURDENS

4.2.1 BURDEN FOR BINARY INPUT

On the CCU211 board, the binary input burdens are as follows:

Power input voltage (V_{DC})	Measured maximum value (W)
48	0.27
60	0.33

4.3 DIGITAL INPUT UNIT (DIU) INPUT BURDEN

4.3.1 DIU200 INPUT BURDEN

On the DIU200 board, the input burdens are as follows:

Voltage level	Maximum Power For 1 input	Maximum Power For 16 inputs	Maximum Power For 4/5/6 boards	Maximum Power For 15 boards
24 V_{DC}	0.03 W	0.23 W	0.93 W / 1.15 W / 1.38 W	3.5 W
48 V_{DC}	0.04 W	0.6 W	2.3 W / 2.9 W / 3.5 W	8.7 W
60 V_{DC}	0.17 W	1.3 W	5.3 W / 6.6 W / 7.9 W	19.8 W
110 V_{DC}	0.33 W	2.7 W	10.6 W / 13.2 W / --	39.6 W
225 V_{DC}	0.4 W	3.2 W	12.7 W / -- / --	47.6 W

4.3.2 DIU211 BINARY INPUT BURDEN

To reduce thermal dissipation, especially at high input voltage levels, the inputs use less than 1.6 mA.

The DIU211 board includes the following input burdens:

Voltage level	Maximum Power For 1 input	Maximum Power For 8 inputs	Maximum Power For 4/5/6 boards	Maximum Power For 15 boards
19.2 V_{DC}	0.03 W	0.23 W	0.93 W / 1.15 W / 1.38 W	3.5 W
48 V_{DC}	0.07 W	0.6 W	2.3 W / 2.9 W / 3.5 W	8.7 W
110 V_{DC}	0.17 W	1.3 W	5.3 W / 6.6 W / 7.9 W	19.8 W
220 V_{DC}	0.33 W	2.7 W	10.6 W / 13.2 W / --	39.6 W
264 V_{DC}	0.4 W	3.2 W	12.7 W / -- / --	47.6 W

5

4.3.3 DIU221 BINARY INPUT BURDEN

The DIU221 board includes the following binary input burdens:

Voltage level	Maximum Power For 1 input	Maximum Power For 8 inputs	Maximum Power For 4/5/6 boards	Maximum Power For 15 boards
19.2 V_{DC}	0.03 W	0.23 W	0.93 W / 1.15 W / 1.38 W	3.5 W
48 V_{DC}	0.07 W	0.6 W	2.3 W / 2.9 W / 3.5 W	8.7 W
110 V_{DC}	0.17 W	1.3 W	5.3 W / 6.6 W / 7.9 W	19.8 W
220 V_{DC}	0.33 W	2.7 W	10.6 W / 13.2 W / --	39.6 W
264 V_{DC}	0.4 W	3.2 W	12.7 W / -- / --	47.6 W

4.4 TRANSDUCERLESS MEASUREMENT UNIT (TMU) CT/VT INPUT BURDEN

For the TMU210 / TMU220 boards, the input burdens on the internal transformers are as follows:

CT burden (at nominal current – In)	Nominal consumption (VA)	
	TMU210	TMU220
1 A	< 0.02	< 0.02
5 A	< 0.2	< 0.2

VT burden (at nominal voltage – Vn)	Nominal consumption (VA)	
	TMU210	TMU220
Vn = 130 VRMS	< 0.1	< 0.01

TMU210 board:

The input burden on the internal 5 V rail is 0.3 W.

TMU220 board:

The input burden on the internal 5 V rail is 0.3 W.

5 ACCURACY

To secure the proper accuracy for calculations, the sampling frequency must be exactly adapted to the signal frequency that fluctuates around the basic frequency (50 / 60 Hz).

For all specified accuracy, the repeatability is ± 2.5% unless otherwise specified.

If no range is specified for the validity of the accuracy, then the specified accuracy is valid over the full setting range.

5.1 REFERENCE CONDITIONS

Quantity	Reference conditions	Test tolerance
General		
Ambient temperature	20 °C	±2 °C
Atmospheric pressure	86kPa to 106kPa	-
Relative humidity	45 to 75 %	-
Input energising quantity		
Current	In	±5%
Voltage	Vn	±5%
Frequency	50 or 60Hz	±0.5%
Auxiliary supply	48-250V_{DC} 110-250V_{AC}	±5%

5.2 MEASUREMENT ACCURACY

5.2.1 TMU220 - MEASUREMENT ACCURACY

Measurement	Accuracy
Current (with measurement CT)	0.2% full scale
Voltage (with voltage droppers)	0.2% full scale
Power (with measurement CT)	0.5% at best
Frequency	± 0.014 Hz
Amplitude	< 1%
Phase	± 1°
Overall temperature coefficient	± 10 ppm/°C
Harmonics	H15

5.2.2 TMU210 - MEASUREMENT ACCURACY

Measurement	Accuracy
Typical current accuracy in the operating range*	±2% from 0.1In to 40In ±0.5% at In
Typical current accuracy below the operating range (only applicable for I Phase)*	± 5mA below 0.1In
standard accuracy classes for protective current transformers	5VA cl. 1 (acc. IEC61869-2:2012)
Voltage accuracy*	± 0.5% typical
standard accuracy classes for protective voltage transformers	5VA cl. 1 (acc. IEC 61869-3:2011)
Absolute phase accuracy*	1° (60')

Measurement	Accuracy
Operating temperature range	-25°C - +55°C

** At ambient temperature and rated frequently (Fn)*

5.3 PROTECTION ACCURACY

5.3.1 TMU210 – PROTECTION ACCURACY

Measurement	Value
Current threshold accuracy	± 1%*
standard accuracy classes for protective current transformers	5VA cl. 5P (acc. IEC 61869-2:2012)
Absolute phase current accuracy	± 1° (60')*
Voltage threshold accuracy	± 3%*
standard accuracy classes for protective voltage transformers	5VA 3P (acc. IEC 61869-3:2011)
Absolute phase voltage accuracy	± 2° (120')*

** at full scale value, rated frequency (Fn) and into operating temperature range*

5.4 COMPOUNDED POWER VALUES ACCURACY

5.4.1 TMU210 – COMPOUNDED POWER VALUES ACCURACY

Compounded value for Synchrocheck	Value
Compounded values accuracy	< 2 %*
Phase difference (computed Δφ value)	± 2° *

Active Power		Reactive Power	
Cos	Deviation	Sin	Deviation
0.866	< 1.5%*	0.866	< 3%*
0.5	< 3%*	0.5	< 1.5%*

** at full scale value, rated frequency (Fn) and into operating temperature range*

5.5 ACQUISITION / CONVERSION

5.5.1 TMU210 – COMPOUNDED POWER VALUES ACCURACY

Compounded value for Synchrocheck	Value
Compounded values accuracy	< 2 %*
Phase difference (computed Δφ value)	± 2° *

5.6 HOW TO MEASURE THE ISOLATION RESISTANCE

To measure the isolation resistance, execute the following steps:

1 Apply a continuous voltage of 500 V to both points.

2 Wait a minimum of 5 seconds to stabilize the reading.

3 Make a record of the isolation resistance.

4 The isolation resistance must be higher than 100 M ohms, in agreement with procedure LQD/P52/1

6 TYPE TESTS

The C26x unit has been designed, manufactured and certified fully compliant with the generally applicable environmental standards, such as:

- IEC 60255-27:2013
- IEC 61850-3:2013

6.1 DIELECTRIC STRENGTH TESTS

C26x Unit – Dielectric Strength Test

Type Test Name	Type Test Standard	Conditions
Insulation Resistance	IEC 61850-3:2013 subclause 6.9.2.2	> 500 MΩ at 500 V_{DC} (CM and DM)
Dielectric Voltage	IEC 61850-3:2013 subclause 6.9.2.3	50 Hz for 1 minute, 2 kV_{AC} (CM and DM), 0.5 kV (CM and DM)
High Voltage Impulse Test	IEC 61850-3:2013 subclause 6.6.3	5 kV

6.2 MECHANICAL TEST

Type Test Name	Type Test Standard	Conditions
Vibration Response	IEC 61850-3:2013 subclause 6.10.1	Class 2: Acceleration: 1g from 10 to 150 Hz
Vibration Endurance	IEC 61850-3:2013 subclause 6.10.1	Class 2: Acceleration: 1g from 10 to 150 Hz
Shock response	IEC 61850-3:2013 subclause 6.10.2	Class 1: 15g, 11 ms
Shock response	IEC 61850-3:2013 subclause 6.10.2	Class 2: 10g, 11 ms
Bump Test	IEC 61850-3:2013 subclause 6.10.2	Class 1: 10g, 16 ms
Single axis sine sweep seismic test	IEC 61850-3:2013 subclause 6.10.3	Class 2: Acceleration: 2g Displacement: 7.5 mm upon axis x Acceleration: 1g Displacement: 3.5 mm upon axis y

6.3 ATMOSPHERIC TEST

The product operating has been tested from -40°C to +65°C (certified from -25°C to +55°C).

Type Test Name	Type Test Standard	Conditions
Damp Heat – Steady state	IEC 61850-3:2013 subclause 6.9.3.6	Test Ab: +40°C / 56 days / 93% RH
Cold Test - Operating	IEC 61850-3:2013 subclause 6.9.3.2	Test Ad: - 25°C / 96 h -40°C / 96 h
Cold Test - Storage	IEC 61850-3:2013 subclause 6.9.3.4	Test Ab: -40°C / 96 h

Type Test Name	Type Test Standard	Conditions
Dry Heat Test – Operating	IEC 61850-3:2013 subclause 6.9.3.1	+55°C / 96 h +65°C / 96 h
Dry Heat Test – Storage	IEC 61850-3:2013 subclause 6.9.3.3	Test Bb: +70°C / 96 h +85°C / 96 h
Change of temperature	IEC 61850-3:2013 subclause 6.9.3.5	Test Nb Start +22°C Min -25°C, Max +55°C Min -40°C, Max +65°C
Damp heat cyclic (12h+12h)	IEC 61850-3:2013 subclause 6.9.3.7	Test Db Start +25°C RH=60% 96h (25°C, RH 97% and 55°C, RH 93%)

6.4 DC AUXILIARY SUPPLY TEST

Type Test Name	Type Test Standard	Conditions
Inrush current	IEC 61850-3:2013 subclauses 6.8.1.2 and 6.8.2.2	110 V_{DC}, I < 19.4 A, T < 110 ms 220 V_{DC}, I < 43.8 A, T < 92 ms
DC voltage interruptions and dips	IEC 61850-3:2013 subclause 6.7.3	ΔU 100% for 50ms ΔU 30% for 100ms, ΔU 60% for 100ms
Reverse polarity	IEC 60255-27:2013 subclause 10.6.6	Polarity – for the lower potential of the supply Polarity + for the lower potential of the supply
Voltage ripple	IEC 61850-3:2013 subclause 6.7.3	AC 100 Hz ripple superimposed on DC max. and min. auxiliary supply at 10% of rated DC value

6.5 AC AUXILIARY SUPPLY TEST

Type Test Name	Type Test Standard	Conditions
AC Voltage dips & short interruptions	IEC 61850-3:2013 subclause 6.7.3	ΔU 100% for 50ms ΔU 30% for 100ms ΔU 60% for 100ms

6.6 COMPATIBILITY (EMC) TESTS

Type Test Name	Type Test Standard	Conditions
Electrostatic discharge	IEC 61850-3:2013 subclause 6.7.3	Level 3: 6 kV contact / 8 kV air
Electrical Fast Transient	IEC 61850-3:2013 subclause 6.7.3	Level 4: 4 kV peak voltage (CDN) 2 kV peak voltage (Clamp) 5-kHz and 100-kHz repetition freq.
Surge immunity	IEC 61850-3:2013 subclause 6.73	Level 4: 4 kV (line-to-earth) – 2 kV (line-to-line)
Conduced disturbances, induced by radiofrequency fields	IEC 61850-3:2013 subclause 6.7.3	Level 3: 10 V, 0.15 – 80 MHz
Power Frequency Magnetic Field Immunity	IEC 61850-3:2013 subclause 6.7.3	Level 5: 100A/m continuous 1000A/m for 1 s

Type Test Name	Type Test Standard	Conditions
Pulse magnetic field	IEC 61000-4-9:2001	Level 5: 1000 A/m peak 6.4/16 µs magnetic field
Damped oscillatory magnetic field immunity	IEC 61000-4-10:2001 subclause 11	Level 5: 100 A/m peak Applied in all planes at: 100 kHz, repetition rate ≥ 40 Hz, during 60s 1 MHz, repetition rate ≥ 400 Hz, during 60 s
Power Frequency	IEC 61000-4-16 (1998)	CM 500 V / DM 250 V via 0.1 µF
Conducted emission	IEC 61850-3:2013 subclause 6.7.4	CISPR11 Gr 1 Class A and CISPR22 Class A: from 0.15 to 30 MHz
Radiated emission	IEC 61850-3:2013 subclause 6.7.4	CISPR22 Class A: from 30 to 1000 MHz
Radiated, radio-frequency electromagnetic fields	IEC 61850-3:2013 subclause 6.7.3	Level 3: 10 V/m Frequency sweep: 80-3000 MHz Spot frequencies: 80 MHz ± 0.5 % 160 MHz ± 0.5 % 380 MHz ± 0.5 % 450 MHz ± 0.5 % 900 ± 5 MHz 1 850 ± 5 MHz 2 150 ± 5 MHz
Mains Frequency Voltage	IEC 61850-3:2013 subclause 6.7.3	Level 4: 30 Vrms for 60 s 300 Vrms for 3 s
Slow damped oscillatory wave	IEC 61850-3:2013 subclause 6.7.3	Level 3: 2.5 kV (CM) and 1 kV (DM) 100 kHz and 1 MHz

7 ACHILLES CERTIFICATION

DS Agile C26x unit has been certified fully compliant with the requirements set forth by:

- **Achilles Level 1 Certification – Embedded devices**

  Achilles Level 1 certification examines a specified control protocol (Ethernet, ARP, LLDP, IP, ICMP, IGMP, TCP and UDP) to assess the safety, reliability and network robustness of industrial devices and certifies that they meet a comprehensive set of requirements and conformance criteria.

  DS Agile C26x unit was tested with the Achilles Test Platform's Level 1 test suite:

  - Date of Certification: **18th June 2018**
  - Firmware version: **cx66 – 2.0.0.0 – build59**
  - Certificate N°: **403-062818**

8 APPENDIX: PROTOCOLS AND PORTS USED BY THE C264

Application	Protocol / communication	Port
C264	SSH	22
	RPC standard service (UDP/TCP) IEC 61850 Agency CMT (UDP/TCP) MiCOM S1	111 102 5100, 5101 5001
	IEC 60870-5-104	2404

SECURE DEPLOYMENT GUIDE

C26X/EN SD/E72

Contents

1	**INTRODUCTION**	**2**
2	**DEFENSE-IN-DEPTH STRATEGY**	**3**
3	**ENVIRONMENT**	**4**
4	**SECURE INSTALLATION**	**5**
4.1	**Verifying software integrity**	**5**
4.2	**Upgrading firmware to the latest version**	**5**
4.3	**Hardening**	**5**
4.4	**Configuring Secure Protocols**	**5**
4.5	**User Access control**	**6**
4.5.1	Default user accounts	6
4.5.2	Local user account	6
4.5.3	Role base access control	6
4.5.4	Local security policies	7
4.5.5	Front panel authentication bypass	7
4.5.6	Central authentication with RADIUS	7
4.6	**Configuring security event logging**	**7**
4.6.1	Local security event logs	7
4.6.2	Central logging	8
4.7	**Network interface configuration**	**8**
4.7.1	Dedicated Ethernet port for configuration	8
4.7.2	VLAN and MAC address filtering	8
4.7.3	SRP28 board	8
5	**MAINTAINING SECURITY**	**10**
5.1	**Periodic security audits**	**10**
5.2	**Backup and restore procedures**	**10**
5.3	**Vulnerability monitoring and firmware updates**	**10**
5.4	**Reporting a vulnerability**	**10**
6	**DECOMMISSIONING**	**12**
6.1	**Secure decommissioning recommendations**	**12**
7	**SECURE OPERATION GUIDELINES**	**13**
8	**APPENDICES**	**14**
8.1	**Achilles ACC Level 1 certification**	**14**
8.2	**List of supported protocols**	**14**
8.3	**Deterministic output**	**15**
8.4	**Resource management**	**15**
8.5	**IEC62443-4-1 mapping**	**15**

1 INTRODUCTION

This document assumes that the reader is familiar with DS Agile C26x. It lists best practices to securely install and operate DS Agile C26x.

It applies to DS Agile 7.6 and later.

This document is the response to IEC62443-4-1 “Practice 8 - Security Guidelines” requirements.

2 DEFENSE-IN-DEPTH STRATEGY

The product implements the following security features:

- Secure design process to ensure that cyber security is part of the design process and not an afterthought.
- Security and penetration testing to detect as much as possible vulnerabilities at the design stage.
- Digital signature of firmware/software package to allow integrity and authenticity verification before installation.
- Monitoring of software components vulnerabilities and security bulletins to inform users of the newly discovered vulnerabilities and threats.
- User authentication and personal account.
- Role based access control and least privileges to enforce area of responsibilities.
- Password and user account policies to prevent use of weak passwords and password brute force attack.
- Centralized user management (using LDAP) to allow prompt removal of user accounts.
- Security event logging for post-incident analysis.
- Centralized security event logging using SYSLOG protocol to send event to a SOC and allow close to real time security monitoring.
- Secure configuration protocols using TLS to protect credentials and sensitive information while in transit.
- Hardening to reduce the attack surface.

To complement the defense in depth strategy, the product shall be installed in a secure environment. See paragraph 3 Environment.

3 ENVIRONMENT

DS Agile C26x is designed to be installed and operated in an industrial environment, connected to a private network.

While the rest of this guide describes security at the product level, requirements to achieve security go beyond just the product.

GE recommends that security applies to the whole system in which the DS Agile C26x is installed, following a defence-in-depth approach. Security includes (but is not restricted to):

- User security awareness training,
- Security policies,
- Access control,
- Network security measures, such as segmentation, use or firewalls, use of secure protocols…
- Security monitoring, such as network intrusion detection systems, security event logging…
- Physical security, such as building access control, locked cabinets.

In addition, remote configuration/monitoring of the device (i.e. not from the front panel) shall be done from a secure engineering workstation through a trusted network link.

Refer to Secure Deployment Guide user manual (SDG_enM_XXX) for more information on DS Agile automation and control system cyber security.

4 SECURE INSTALLATION

4.1 VERIFYING SOFTWARE INTEGRITY

Before installing any software, the installation package integrity shall be verified.

GE software are digitally signed.

Digital signature verification of a piece of software is done by right-clicking on the filename and selecting the Digital Signature tab in the Properties menu. The signature Details shall read “This digital signature is OK”.

The software shall not be installed when the signature verification fails. In such a case, please contact your support organization.

DS Agile C264 does not implement a secure boot process and does not verify firmware integrity after installation. Recommendations in paragraph 2 and 3 shall be implemented to mitigate this limitation.

4.2 UPGRADING FIRMWARE TO THE LATEST VERSION

DS Agile C26x firmware must be upgraded to the latest version available for the major version used, to take advantage of all fixed known vulnerabilities.

The DS Agile C26x firmware upgrade procedure can be found in chapter INSTALLATION of C26x user manual (C26x_enM_XXX).

4.3 HARDENING

Hardening consists in disabling unused features in DS Agile C26x.

Most features won’t be enabled unless explicitly configured.

The features listed below are enabled by default (mostly to simplify installation) and shall be reviewed:

- SSH command line interface. Refer to Installation chapter of C26x user manual (c26x_enM_XXX)
- SNMP (as of DS Agile 7.6, SNMP cannot be disabled)
- Ethernet ports (as of DS Agile 7.6, Ethernet ports cannot be disabled)

See 7.2 List of supported protocols for a list of all protocols and services that can be enabled by configuration.

4.4 CONFIGURING SECURE PROTOCOLS

DS Agile C26x uses the TLS protocol in the following cases:

- Communication with the CMT configuration tool
- Security event logging to a syslog server over TLS
- EAP-TTLS with RADIUS

TLS needs a private key and public key certificate (PKC) to be deployed on the C26x, and a PKC to be deployed on the engineering workstation.

Refer to Installation chapter of C26x user manual (C26x_enM_XXX).

As DS Agile C26x does not support Certificate Revocation Lists nor certificate auto provisioning, GE recommends self-signed certificates with a long expiring date.

DS Agile does not support IEC61850 protocols encryption, giving possibility to a breach of integrity or authenticity. Recommendations in paragraph 2 and 3 shall be implemented to mitigate this limitation.

4.5 USER ACCESS CONTROL

4.5.1 DEFAULT USER ACCOUNTS

DS Agile C26x is delivered with one factory user account:

User name	Default password	Roles
Root	Root1234#	Viewer Operator Engineer System Administrator Security Administrator

The Root username cannot be changed, cannot be deleted and cannot be disabled.

Password change is mandatory at first connection using the CMT.

Root user's password shall be changed at the end of commissioning (e.g. SAT) activity.

4.5.2 LOCAL USER ACCOUNT

DS Agile C26x supports the creation of personal user accounts.

When centralized authentication with RADIUS is not used, personal user accounts shall be created and granted the minimum number of roles needed to accomplish for his/her work.

When centralized authentication with RADIUS is used (see section Central Authentication with Radius Below), at least one user for each of the 4 supported roles shall be created, to be used when the RADIUS authentication server is unreachable.

The passwords for these shared accounts shall be kept secret until needed and changed after use.

Note: passwords are stored locally and protected by PBKDF2 with SHA-256 and a unique 64 bits salts.

Refer to Installation chapter of C26x user manual (C26x_enM_XXX).

4.5.3 ROLE BASE ACCESS CONTROL

DS Agile C26x supports the following default roles:

- Viewer
- Operator
- Engineer
- System Administrator
- Security Administrator

To be compliant with the IEC 62351-8 standard on cybersecurity, the C264 can also manage the IEC 62351-8 roles list by activating the EC 62351-8 roles option in the CMT.

For details of permissions associated with each role, refer to Functional Description chapter and to the Installation chapter of C26x user manual (C26x_enM_XXX).

4.5.4 LOCAL SECURITY POLICIES

Local security policies shall be configured:

- Session's inactivity timeout (in minutes). Recommended value: 15
- Password minimum length. Recommended value: 9 or more
- Password complexity. Recommended value: enabled
- Maximum number of failed logins attempts before account locking. Recommended value: 5
- Duration of lockout (in seconds). Recommended value: 30
- Password expiration time (in months). Recommended value: none.
- Proper usage banner: can be customized using the SCE tool.

Refer to Installation chapter of C26x user manual (C26x_enM_XXX)

4.5.5 FRONT PANEL AUTHENTICATION BYPASS

Front panel authentication can be disabled to accommodate situations when the delay introduced by entering a password is not considered acceptable in operating conditions.

GE recommends that compensating measures be put in place, such as front panel access control with physical means.

Refer to Installation chapter of C26x user manual (C26x_enM_XXX).

4.5.6 CENTRAL AUTHENTICATION WITH RADIUS

When a central authentication server is available, DS Agile C26x shall be configured to authenticate users against it. This facilitate user management and account revocation, which is mandated by many standards and regulations.

The DS Agile C26x RADIUS supplicant supports 3 authentication protocols:

- PAP: insecure, available for backward compatibility reasons. Shall not be used.
- PEAPv0/EAP-MSCHAPv2
- EAP-TTLS

Authentication with RADIUS is configured using the SCE tool.

Refer to Installation chapter of C26x user manual (C26x_enM_XXX).

Refer to Secure Deployment Guide user manual (SDG_enM_XXX).

4.6 CONFIGURING SECURITY EVENT LOGGING

4.6.1 LOCAL SECURITY EVENT LOGS

DS Agile C26x firmware logs security events in a text file, that can be viewed using the CMT tool.

The log file cannot be modified. The file stores up to 2048 events and is circular: when full, the oldest event is deleted and the newest added.

Local security logging cannot be disabled and there is no need to configure it.

4.6.2 CENTRAL LOGGING

DS Agile C26x support logging security events to a central syslog server.

GE recommends forwarding all security logs to a central syslog server to provide a unique view of all system events as well as enforce log long term storage and integrity.

GE recommends configuring syslog over TLS when supported by the syslog server.

Logging to a syslog server is configured using the SCE tool.

Refer to Application chapter of C26x user manual (C26x_enM_XXXX).

4.7 NETWORK INTERFACE CONFIGURATION

4.7.1 DEDICATED ETHERNET PORT FOR CONFIGURATION

Ethernet port number 3 on the CPU board is dedicated to configuration.

While it is possible to do configuration and maintenance using any Ethernet port, GE recommends configuring the dedicated for such activity, leaving only operational protocols (such as IEC61850 and time synchronization) on the other ports.

Refer to Installation chapter, Boot parameters section of the C26x user manual (C26x_enM_XXX).

4.7.2 VLAN AND MAC ADDRESS FILTERING

In order to enforce network segregation and reduce the network attack surface, GE recommends that VLAN filtering and MAC address filtering to be configured on all Ethernet ports.

Particularly because IEC61850 extensively uses layer 2 broadcast, whitelisting multicast MAC addresses and VLANs (GOOSE, SV, PTP) on DS Agile C26x Ethernet interfaces will reduce the burden on the CPU board.

Refer to Installation chapter of C26x user manual (C26x_enM_XXX).

4.7.3 SRP28 BOARD

4.7.3.1 UPGRADING FIRMWARE TO THE LATEST VERSION

SRP28 firmware shall be upgraded to the latest version available, to take advantage of all fixed known vulnerabilities.

Refer to Installation chapter of C26x user manual (C26x_enM_XXX).

4.7.3.2 ACCESS CONTROL

SRP28 board is delivered with 2 factory user account:

User name	Default password	Roles
Root	changeit	Root
User	changeit	Root

The Root username cannot be changed, cannot be deleted and cannot be disabled.

Passwords shall be changed at installation and again at the end of commissioning (e.g. SAT) activity.

4.7.3.3 SECURITY POLICIES

SRP28 security policies shall be configured:

- Session’s inactivity timeout (in seconds). Recommended value: 600
- Password minimum length. Recommended value: 9 or more
- Password complexity. Recommended value: enabled
- Maximum number of failed logins attempts before account locking. Recommended value: 5
- Duration of lockout (in hours). Recommended value: 1
- Proper usage banner

Refer to Network Monitoring chapter of C26x user manual (C26x_enM_XXX).

5 MAINTAINING SECURITY

Once security has been properly configured, it is important to create procedures to maintain security over time.

5.1 PERIODIC SECURITY AUDITS

The configuration applied in Secure installation paragraph shall be recorded.

Periodically, particularly after maintenance activity, the security configuration shall be audited and deviations tracked and fixed.

5.2 BACKUP AND RESTORE PROCEDURES

Firmware installation packages and configuration files shall be backed up following any configuration/maintenance activity.

A restore procedure shall be prepared for quick service restoration following an incident.

5.3 VULNERABILITY MONITORING AND FIRMWARE UPDATES

GE responsibility discloses vulnerabilities found on its products.

User's shall periodically check for newly published vulnerabilities and available firmware updates and define a security update policy.

All GE software packages are digitally signed. Digital signature shall be verified before installation.

5.4 REPORTING A VULNERABILITY

Providing a legitimate pathway for vulnerability disclosure provides an essential link between GE and the cybersecurity community.

To submit a vulnerability in a Grid Solutions product to the GE PSIRT team, please fill up the form at https://www.ge.com/security. Please do not include identifiable sensitive data (e.g. personal data, specific system configuration) within the body of the communication or any attachments (e.g. screenshots, images or log files).

We actively encourage reports to be sent to us for remediation prior to a public disclosure, so that we can properly address any vulnerabilities.

We request the following when reporting a vulnerability:

- Please provide your report in English.
- Include specific information about affected products, including model or serial numbers, geographic location, software version, and the means of obtaining the product.
- If you have developed a proof-of-concept for exploiting the vulnerability, please include the code and explanation for the exploit.
- If you are aware of any incidents of this vulnerability being exploited on equipment in the field (e.g. a Grid Solutions' customer was directly impacted by this vulnerability).
- Information on how you discovered the vulnerability, your thoughts on impact or CVSS scoring, and potential remediations will help us to triage the vulnerability more quickly.
- Please include relevant information about yourself or the company/organization you are representing, or if you prefer to remain anonymous.
- Please let us know if you have a preferred method of contact during our internal triage process.

- Please include your intentions for disclosing the vulnerability to us, or if you intend to disclose the vulnerability to the public.

In response, you can expect the following from us:

- We will acknowledge receipt of your message within 48 hours.
- In the following phase of initial triage and assessments, an appropriate member of the GE PSIRT may reach out to you to:
  - Request additional information, or
  - Communicate an expected process and timeline, or
  - Notify you that the report is either out of scope or will not be triaged for other reasons.
- Once we have conducted our own assessment of the vulnerability, we will communicate our process and findings as a result of the investigation.
- We will provide public recognition for the security researcher (if requested) and if the report results in a public disclosure.

By submitting a request, you acknowledge that Grid Solutions may use in an unrestricted manner (and allow others to do the same) any data or information that you provide to Grid Solutions. Your submission does not grant you any rights under Grid Solutions intellectual property or create any obligations for Grid Solutions.

6 DECOMMISSIONING

6.1 SECURE DECOMMISSIONING RECOMMENDATIONS

GE recommends preventing unauthorized disclosure of information from the device using an appropriate decommissioning method.

Decommissioning is a complex matter: physical destruction may be forbidden by recycling/waste management laws, filesystem format is ineffective, advanced technical may be conducted offsite introducing supply chain and audit complications.

Hence GE cannot recommend a decommissioning method.

For organizations to have appropriate controls on the information they are responsible for safeguarding, they must first identify and classify information.

Regarding DS Agile C26x:

- Information is stored in soldiered flash memory and a removable SD card on the CPU board.
- Passwords are stored locally protected by PBKDF2 with SHA-256 and a unique 64 bits salts to make clear text recovery extremely difficult per today's standards.

Regarding the SRP28 board:

- Information is stored in soldiered flash memory on the board

Passwords are stored locally protected by DES-crypt()

7 SECURE OPERATION GUIDELINES

For a secure operation of the product, GE recommends that:

- Users be assigned a specific role and not rely on the almighty Administrator account for tasks that do no necessitate full administrative power.
- Users don’t share their passwords.
- Users change their passwords when they believe there might a possibility of unwanted disclosure.
- Default account passwords be changed before putting the device in operation.
- Users log out of their session when finished (although an inactivity timeout can be set to automatically terminate user sessions).
- GE delivered certificates be replaced with certificate provided by the end user.
- The product never be connected to a public network, nor the Internet.
- Only the required services are configured and enabled.
- Transient asset that must be connected to the product be carefully controlled and checked for malware.

8 APPENDICES

8.1 ACHILLES ACC LEVEL 1 CERTIFICATION

DS Agile C26x has obtained Achilles ACC Level 1 certification.

Particularly, the certification acknowledge that DS Agile C26x operation go back to normal when the communication stress test stops.

8.2 LIST OF SUPPORTED PROTOCOLS

DS Agile C26x supports the following protocols (as server):

Protocol	Port	Comment
SSH	22	(Secure) C26x Shell
IEC 61850 Agency	102	This port is used for the IEC61850 communication (server side)
IEC61850 component for the "tunneling"	100x	Used for Tunneling feature provided by 61850 agency
RPC standard service (UDP/TCP)	111	Used for Tunneling feature provided by 61850 agency. Used by the IEC61850 component to directly call procedures between client and server.
CMT over TLS	5100	(Secure)
CMT IP search (UDP)	5101	(Secure) Device search cx66 with IP@ : UDP - port 5101
MiCOM S1 over TLS	5001	(Secure)
IEC 60870-5-104	2404	
Radius (UDP)	1812 1813	(Secure)for authentication (Secure)for accounting
SNTP (UDP)	123	
SNMP (UDP)	161	
PTP (UDP)	319	
PTP (UDP)	320	
Isagraf (TCP)	1131	
Isagraf (TCP)	1113	
Syslog (TCP over TLS)	6514	(Secure)
Syslog (UDP)	514	(Secure)

8.3 DETERMINISTIC OUTPUT

In the event of an anomaly, DS Agile C26x triggers the physical watchdog relay.

Additionally, depending on the type of anomaly, DS Agile C26x will enter:

- Downgraded mode: affected data will be marked “invalid”
- Fault mode: a restarting loop during which no data is available
- Halt mode: all output relays are de-energized, no data is available, operation is stopped.
-

8.4 RESOURCE MANAGEMENT

By using the following features, DS Agile C26x makes sure that security function does not interfere with operations:

- Circular local log file (protect against filesystem over usage)
- Dedicated Ethernet management interface
- Capability to disable front panel authentication
- Redundancy support, to upgrade one IED’s firmware while the backup IED is in charge of operations.
-

8.5 IEC62443-4-1 MAPPING

SG-1 Product defense in depth	2 Defense-in-Depth strategy
SG-2 Defense in depth measures expected in the environment	3 Environment
SG-3 Security hardening guidelines	4 Secure Installation 5 Maintaining security
SG-4 Secure disposal guidelines	6 Decommissioning
SG-5 Secure operation guidelines	7 Secure operation guidelines
SG-6 Account management guidelines	4 Secure Installation
SG-7 Documentation review	Covered by NPI process and quality processes.

GLOSSARY

C26X/EN LX/E72

Term/Acronym	Description
100Base Fx	Fiber optic ports are full/half duplex at 100 Mbps only.
10Base Tx and 100Base TX	The copper ports are full/half duplex and auto-sense the transmission speed. They will auto-negotiate with the connected device to determinate the optimal speed. When the connected device is only capable of transmitting at 10 Mbps, the Ethernet switch unit or board follows 10 Mbps.
A/D	Analog/Digital
ACSI	Abstract Communication Service Interface Mapping from standard IEC 61850 abstract specification of a communication service to a concrete communication infrastructure based on the CORBA standard.
ADC	Analog to Digital Converter
AE qualifier	Application Entity qualifier (Used internally by IEC 61850 to identify a server Application)
AI	Analogue Input (Measurement Value including state attribute) Usually voltage or current DC signals delivered by transducers, and representing an external value (refer to CT/VT for AC).
AIU	Analogue Input Unit C264 controller's board for DC analogue inputs
Alarm	An alarm is any event set as alarmed during the configuration process
AO	Analogue Output Value corresponding to a desired output current applied to a DAC
AOU	Analogue Output Unit (C264 controller's board for analogue outputs)
ASCII	American Standard Code for Information Interchange
ASDU	Application Specific Data Unit Name given in the OSI protocol for applicative data (T101, T104)
AVR	Automatic Voltage Regulation built-in automation used to regulate secondary voltage using an automatic tap change control. A set of features can be added, refer to C264/EN FT
Bay	Set of LV, MV or HV apparatus (switching devices and transformers) and IEDs (Protection, Measurement…) usually built around a Circuit Breaker and controlled by a Bay Controller Unit.
BCD	Binary Coded Decimal C264-supported coding on a set of Digital Inputs that determines a Digital Measurement, then a Measurement value (with a specific invalid code when coding is not valid). Each decimal digit is coded over 4 binary digits.
BCP	Bay Control Point Name given to the device or part used to control a bay. It can be a Mosaic Panel, a C264 unit's LCD,… Usually associated with Remote/Local control.
BCU	Bay Control Unit Name given to the C264 that manages a bay.
BI	Binary Input (or Information) Name given in the C264 controller to information that has already been filtered, before it becomes an SPS, DPS… with time tag and quality attributes.
BIU	Basic Interface Unit C264 controller's board for auxiliary power supply, watchdog relay, redundancy I/O.
BRCB	Buffered Report Control Block
CB	Circuit Breaker Specific dipole switch with capability to make line current and break fault current. Some have isolation capability (nominal earth on each side)
CCU	Circuit breaker Control Unit C264 controller's board dedicated to switch control with 8 DIs, and 4 DOs
CDM	Conceptual Data Modeling Modeling of system/device data using a hierarchy of structured data (called object of class) with their attributes, method or properties and the relations between them. It maps common data to devices or components of devices, with a guaranty of interoperability.

Term/Acronym	Description
Class	Defined in IEC 61850 as the description of a set of objects that share the same attributes, services, relationships, and semantics.
Client	Defined in IEC 61850 as an entity that requests a service from a server and that receives unsolicited messages from a server.
CMT	Controller Management Tool
CO	Command, logic information Output (Functional Component) / Contact Open
COMTRADE	COMmon format for TRAnsient Data Exchange (IEC 60255-24 international standard)
CPU4	Central Processing Unit C264 controller's main board
CT	Current Transformer Basically the device connected to the electrical process used to extract a current measurement. By extension part of a device (C264) that receives AC values and converts it to a numerical measurement value.
CT/VT conventional	Current and Voltage transformers By extension, it is the C264 controller's TMU board.
DAC	Data Acquisition component of the GPT
DAC	Digital to Analogue Converter Used to generate analogue signals (usually DC) from a digital value.
DANP	Double Attached Node implementing PRP (defined by IEC 62439-3) Such an IED sends the messages over two separate networks.
DB	DataBase Tool or set of data that define all the configuration of a system or specific device such as a substation computer or bay controller. Contrary to setting parameters, a DB has a structure that cannot be modified on-line. DBs are always versioned.
DCF77	External master clock and protocol transmission LF transmitter located at Mainflingen, Germany, about 25 km south-east of Frankfurt , broadcasting legal time on a 77.5 kHz standard frequency.
DCO	Double Control Output
DCS	Digital Control System Generic name of system based on numeric communication and devices, to be opposed to traditional electrically wired control.
DCT	Double CounTer Counter based on 2 DIs with complementary states (counting switchgear operations for example).
DE	Direct Execute
DFT	Discrete Fourier Transform
DI	Digital Input Binary information related to the presence or to the absence of an external signal, delivered by a voltage source.
DIU	DC Input Unit C264 controller's board hosting digital inputs
DM	Digital Measurement Measurement value acquired from DIs with a specific encoding: BCD, Gray, 1 among N…
DO	Digital Output Used to apply a voltage to an external device via a relay, in order to execute single or dual, transient or permanent commands.
DOF	Degree Of Freedom Used for a template attribute, that can be modified or not when used. An attribute has a degree of freedom if a user can modify the values of its instances.
DOU	Digital Output Unit C264 controller's board hosting digital outputs.
DP	Data Point, low-level object in the structure, wired or not, with or without links

Term/Acronym	Description
DPC	Double (Point) Control Two digit and/or relays outputs with complementary states (OPEN, CLOSE) used for device control.
DPS	Double Point Status, information derived from 2 digital inputs Usually used for Position indication of switching devices (OPEN, CLOSE).
EPATR	"Ensemble de Protection Ampèremétrique de Terre Résistante" (French legacy very resistive earth current module).
EQL	Equation Logic, especially for interlocking.
Event	An event is a time-stamped change of state/value acquired or transmitted by a digital control system.
FAT	Factory Acceptance Test Validation procedures executed with the customer at the factory.(i.e. SAT)
FBD	Functional Block Diagram One of the IEC 61131-3 programming languages (language used to define configurable automations).
FIFO	First In First Out
FP	Front Panel
FSS	Force Suppress Substitute
FTP	Foil Twisted Pair
Gateway	Level 6 session of OSI, the gateway can be any device transferring data between different networks and/or protocols. The RTU function of the C264 behaves like a gateway at the SCADA or RCP level. The DS Agile Gateway is a separate PC-based application dedicated to this function.
GHU	Graphic Human interface Unit C264 controller's front panel interface (LCD, buttons, front RS port)
GIS	Gas Insulated Substation
GMT	Greenwich Mean Time, former absolute time reference. Replaced by UTC.
GOOSE	Generic Object Oriented Substation Event
GPS	Global Positioning System Based on triangulation from satellite signal, that transmit also absolute GMT time used to synchronise a master clock.
GPT	Generic Protocol Translator software, supplied by ASE
Group	Logical combination of BIs (i.e. SP, DP, SI or other groups)
Half-duplex	A system that allows packets to transmitted and received, but not at the same time. Contrasts with full-duplex.
HBU	High Break Unit: BCU board used in applications requiring high rupture capacity.
HMGA	Horizontal Measurement Graphical Area
HMI	Human Machine Interface Can be DS Agile aView (system HMI) or C264 LCD (Local HMI) or LEDs, Mosaic...
HSBP	High Speed BackPlane (internal Ethernet link between a CPU4 and a SRP28x boards through the HSBP bus)
HSR	High availability Seamless Redundancy protocol. HSR is typically used in a ring topology, however redundant connections to other networks are possible, in particular to PRP networks.
HV	High Voltage (for example 30 kV to 150 kV)
I/O	Input/Output
IEC	International Electro-technical Commission
IED	Intelligent Electronic Device Global term covering a whole range of microprocessor-based products capable of data collection and information processing.
IRIG-B	Inter-Range Instrumentation Group standard format B. This is an international standard for time-synchronisation based on an analogue signal.

Term/Acronym	Description
JAMMED	Invalid state of a Double Point: Occurs when the 2 associated digital inputs are still in state 0 after a user- settable time-delay, i.e. when the transient state “motion” is considered as ended.
L/R	Local / Remote
L-BUS	Legacy Bus Generic name of Legacy or field networks and protocols used to communicate between C264 (Legacy Gateway function) and IED on field bus. Networks are based on (RS232,) 422, 485. Protocols are IEC 60850-5-103 (T103 is not supported in this version or VDEW), Modbus.
LC	Fibre optic snap-on connector, IEC 61754-20-compliant, for high density connection.
LCD	Liquid Crystal Display on the C264 front panel HMI
LD	Ladder Diagram, one of the IEC 1131-3 programming languages (language used to define configurable automations).
LD	Logical Device, defined in IEC 61850 as: An entity that represents a set of typical substation functions.
LDBI	Database identity brick
LHMI	Front panel Local HMI of the C264 controller
LN	Logical Node Defined in IEC 61850 as an entity that represents a typical substation function.
LOC	Local Operator Console, dedicated to maintenance operations
LPHD	Logical node PHysical Device
LSB	Least Significant Bit
LSP	Load Shedding Pre-selection
LV	Low Voltage
MAC address	The Media Access Control address is a unique 48-bit hardware address assigned to every network interface card. Usually written in the form 01:23:45:67:89:ab
MCB	Miniature Circuit Breaker. In the SCE configuration, its position is associated with the tap changer.
MEAS	Values acquired through digital or analogue inputs (with value, state, and time stamp)
Metering (non-tariff)	Values computed depending on the values of digital or analogue inputs during variable periods of time (time integration).
Metering (tariff)	Values computed depending on the values of digital or analogue inputs during variable periods and dedicated to energy tariff metering. These values are provided by dedicated “tariff computers” which are external to the control system.
MMS	Manufacturing Message Specification (ISO 9506)
Modbus	Communication protocol used on secondary networks with IEDs or with a SCADA RCP. There are 2 versions: standard MODICON.
Module	Term used in DS Agile SCE to encompass all electrical HV devices: switchgear, transformers, motors, generators, capacitors, …
MOTION	Transient state of a Double Point Occurs when the two associated digital inputs are momentarily in state 0 (e.g. position indication when a switching device is operating). The acceptable duration of the transient state is user-settable.
MU	Merging Unit Interface device which takes signals from the instrument transformer sensors and performs digital signal processing to generate and distribute output sampled value streams according to IEC 61850-9-2LE standardised definitions for communication with substation IEDs and controllers.
MV	Medium Voltage or Measurement Value
NC	Normally Closed (for a relay/contact)

Term/Acronym	Description
NCIT	Non-Conventional Instrument Transformers New generation of captor-based, for example using light diffraction under an electric field, CT/VTs, without spires, that provide direct voltage and current numerical values to the communicating IEDs.
NO	Normally Open (for a relay/contact)
OSI	Open System Interconnection ISO standard that splits and defines communication in 7 layers : physical, link, network, transport, session, presentation, application.
OWS	Operator WorkStation (DS Agile aView)
PHY	OSI Physical Layer: The physical layer provides for transmission of cells over a physical medium.
PLC	Programmable Logic Control: Includes PSL and ISaGRAF Within the PLC-programs are defined the configurable control sequences or automations used by DS Agile IEDs and Gateway (ISaGRAF only).
PRP	Parallel Redundancy Protocol (defined in IEC 62439-3:2010)
PSL	Programmable Scheme Logic
PTP	Precision Time Protocol: Protocol used to synchronize clocks throughout a computer network. Defined in the standard IEEE 1588.
RCC	Remote Control Centre: computer or system that is not part of the substation control system. RCC communicates with and supervises the DS Agile system using a protocol.
RCP	Remote Control Point Name given to the device or part used to remotely control several bays or substations. Usually associated with Remote/Local substation control. It is a SCADA interface managed through the Telecontrol BUS. Several RCPs can be managed with different protocols.
RedBox	PRP or HSR Redundancy Box
RI	Read Inhibit, output that indicates the availability of an analogue output (e.g. during DAC processing time).
RMON	Short for remote monitoring, a network management protocol that allows network information to be gathered at a single workstation. Whereas SNMP gathers network data from a single type of Management Information Base (MIB), RMON 1 defines nine additional MIBs that provide a much richer set of data about network usage. For RMON to work, network devices, such as hubs and switches, must be designed to support it. The newest version of RMON, RMON 2, provides data about traffic at the network layer in addition to the physical layer. This allows administrators to analyze traffic by protocol.
RMS	Root Mean Square Average value of a sinusoid that is used for calculations.
RTU	Remote Terminal Unit Standalone controller that acquires data and transmits it to RCP or SCADA. The RTU is attached to the T-BUS.
SAN	Single Attached Node (defined by IEC 62439-3). Unlike DANP, such an IED requires a REDundancy Box to send the messages over two separate networks or over an HSR network.
SAT	Site Acceptance Test Validation procedures performed on site with the customer.
SBMC	Site-Based Maintenance Control mode A bay in SBMC mode does not take into account the commands issued from the RCP; moreover, some of its digital points and measurements (defined during the configuration process) are no longer sent to the RCP (they are “automatically” suppressed).
SBO	Select Before Operate Control made of two steps, selection and execution. The selection step returns a feedback. It can be used to select a circuit before execution of the command. Commands are included in a protocol frame between the system HMI and the BCU and sent over wired outputs to the switching device (e.g. DO select with DI Select, then DO execute).
S-BUS	Station Bus, federal network between DS Agile devices.
SCADA	Supervisory Control And Data Acquisition, equivalent to RCC.

Term/Acronym	Description
SCE	System Configuration Editor
SCL	System Configuration Language (IEC 61850-6) for substation automation
SCP	Substation Control Point Name given to the device or part used to control locally several bays or substations. Usually associated with Remote/Local substation control. It normally refers to DS Agile's system HMI, aView.
SCS	Substation Control System
SCT	Single Counter
SCU	Switchgear Control Unit used in Process Bus applications.
Server	Defined in IEC 61850 as an entity that provides services to clients or issues unsolicited messages.
Setpoints (analogue)	Analogue setpoints are analogue outputs delivered as current loops. Used to send instruction values to the process or auxiliary device.
Setpoints (digital)	Digital values sent on multiple parallel wired outputs. Each wired output represent one bit of the value. Digital setpoints are used to send instruction values to the electrical process or to auxiliary devices.
SFC	Sequential Function Chart IEC 61131-3 programming language (used to define configurable automation)
SFP	Small Form-factor Pluggable transceiver Hot-pluggable transceiver used for both telecommunication and data communications applications.
SI	Single Input or System Indication: Binary information that does not come from an external interface, but is related to an internal state of the controller (time status, hardware faults…) or the result of an inner function (AR, …) PSL or ISaGRAF.
SIG	Status Input Group (idem MPS)
SINAD	Signal-plus-Noise-plus-Distorsion to Noise-plus-Distorsion ratio, in dB
SIT	Status Input Double Bit (idem DPS)
SNMP	Simple Network Management Protocol: protocol governing network management and monitoring of network devices and their functions.
SNTP	Simple Network Time Protocol
SOE	Sequence Of Events, i.e. the event list
SP SPS SPC	Single Point Single Point Status Single Point Control
SPI	Step Point Indication (same as TPI)
SRP	Switch Redundancy Protocol, PRP Ethernet switch board fitted in H38x Ethernet switch and in C264 BCU.
ST	Structured Text An IEC 61131-3 programming language to define configurable automation.
STP	Shielded Twisted Pair.
Suppression (Automatic)	A binary information belonging to a bay in SBMC mode is automatically suppressed for the remote controller. However changes of state are indicated locally, at SCP level.
Suppression (Manual)	A binary information can be suppressed by a command issued by an operator. No subsequent change of state on a "suppressed information" can trigger any action such as display, alarm or transmission.
T-BUS	Telecontrol Bus, generic name of networks and protocols used for communications between DS Agile Gateway or the C264 Telecontrol Interface function and the RCP. Networks use RS232, RS485, or Ethernet (T104). Protocols are IEC 60850-5-101 (T101) or MODICON Modbus.

Term/Acronym	Description
TC	True Contact A double counter is acquired on two contacts. One is called the true contact (TC), the other is the complemented contact (CC). Normally these contacts have complementary states.
TCIP	Tap Changer In Progress
TDD	Total Demand Distortion, similar to the THD but applied to currents and with a rated current (In) used as reference.
THD	Total Harmonic Distortion, sum of all voltage harmonics.
TMU	Transducerless Measurement Unit
TPI	Tap Position Indication (for transformers). Frequently acquired via a Digital Measurement.
TS	Tele-Signalling Logic position transmitted by a remote signal
UCA	Utility Communications Architecture Communications standard mainly used in the US
URCB	Unbuffered Report Control Block
UTC	Universal Time Co-ordinates (or Universal Time Code) UTC replaces GMT and it is identical.
VdBS	Versioned data Base System, SCE-generated databag ready for download.
VDEW	German subset of the IEC 60870-5-103 protocol.
VMGA	Vertical Measurement Graphical Area
Voltage level	Set of bays in which plants and devices operate at the same voltage (e.g. 275 kV).
VT	Voltage Transformer Basically the device connected to the electrical process used to extract a voltage measurement. By extension part of a device (C264) that receives this AC value & converts it to a numerical measurement value. VTs are wired in parallel.

WARNING

This guide gives instructions for installation, commissioning and operation of the **DS Agile C26x**.
However, the guide cannot cover all conceivable circumstances or include detailed information on all topics. In the event of questions or specific problems, do not take any action without proper authorization. Please contact the appropriate GE Grid Solutions technical sales office and request the necessary information.

Refer to the System Release Notes for new features.

Any agreements, commitments, and legal relationships and any obligations on the part of GE Grid Solutions, including settlement of warranties, result solely from the applicable purchase contract, which is not affected by the contents of the guide.

PC OPERATING SYSTEM COMPATIBILITY

GE Grid Solutions has conducted compatibility and performance tests with the version of Microsoft's Windows operating system indicated at the beginning of the Introduction chapter of this manual.

Depending on when the system is installed or upgraded, some of the hardware components described in this manual may be no longer available. Please check currently approved hardware in the latest release.

Although the software may run with other versions of Windows, GE Grid Solutions does not take any responsibility in possible malfunctions and may not be able to provide support for problems occurring when running our software on an unapproved operating system.



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C26x/EN M/E72