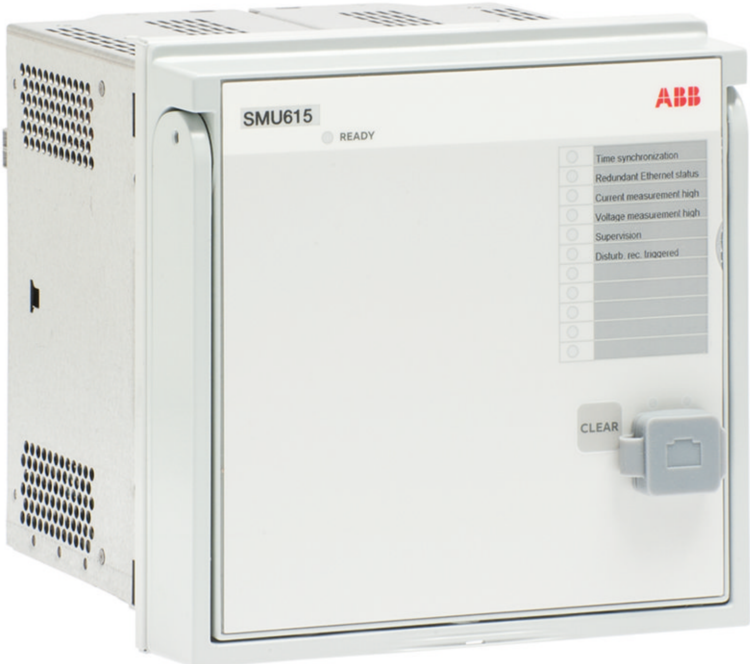
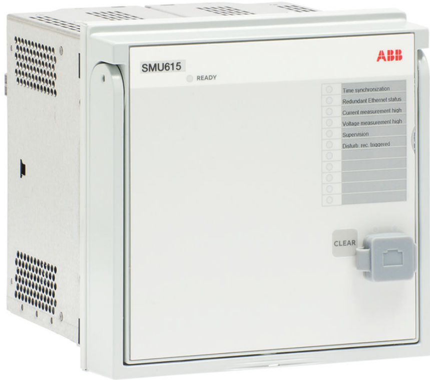
RELION®

Substation Merging Unit SMU615

Technical Manual





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Warranty

Please inquire about the terms of warranty from your nearest ABB representative.

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This product complies with following directive and regulations.

Directives of the European parliament and of the council:

- Electromagnetic compatibility (EMC) Directive 2014/30/EU
- Low-voltage Directive 2014/35/EU
- RoHS Directive 2011/65/EU

UK legislations:

- Electromagnetic Compatibility Regulations 2016
- Electrical Equipment (Safety) Regulations 2016
- The Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment Regulations 2012

These conformities are the result of tests conducted by the third-party testing in accordance with the product standard EN / BS EN 60255-26 for the EMC directive / regulation, and with the product standards EN / BS EN 60255-1 and EN / BS EN 60255-27 for the low voltage directive / safety regulation.

The product is designed in accordance with the international standards of the IEC 60255 series.

Contents

1 Introduction

1.1 This manual

The technical manual contains application and functionality descriptions and lists function blocks, logic diagrams, input and output signals, setting parameters and technical data sorted per function. The manual can be used as a technical reference during the engineering phase, installation and commissioning phase, and during normal service.

1.2 Intended audience

This manual addresses system engineers and installation and commissioning personnel, who use technical data during engineering, installation and commissioning, and in normal service.

The system engineer must have a thorough knowledge of protection systems, protection equipment, protection functions and the configured functional logic in the merging units. The installation and commissioning personnel must have a basic knowledge in handling electronic equipment.

1.3 Product documentation

1.3.1 Product documentation set

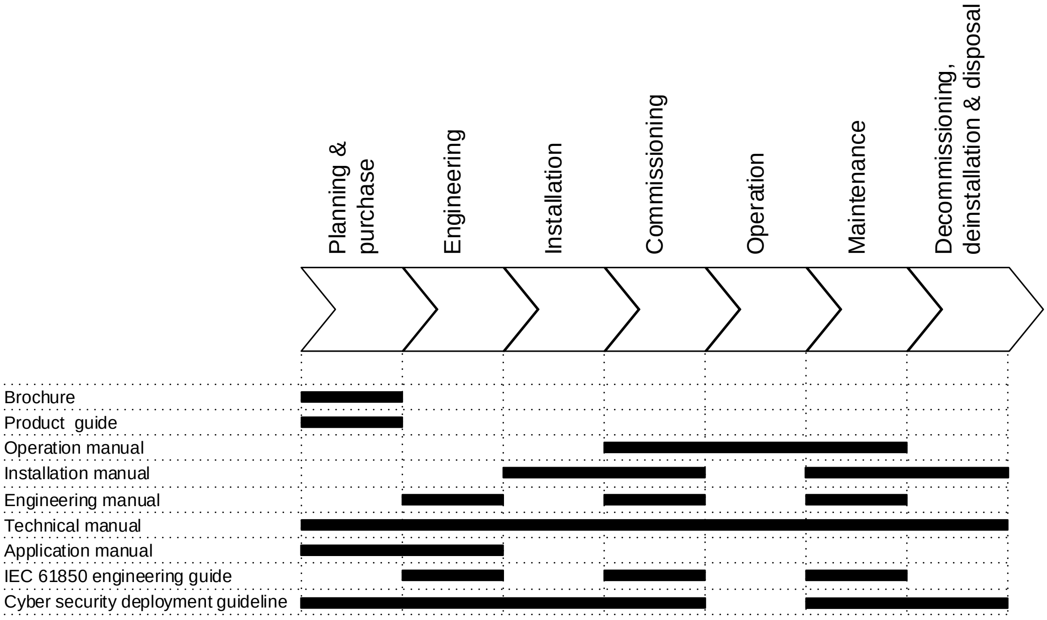


Figure 1: The intended use of documents during the product life cycle

1.3.2 Document revision history

Document revision/date	Product version	History
A/2017-09-28	1.0	First release
B/2019-05-17	1.0	Content updated
C/2022-08-23	1.0	Content updated
D/2023-03-06	1.0	Content updated

1.3.3 Related documentation

Contact ABB for information on SMU615 related documentation.

1.4 Symbols and conventions

1.4.1 Symbols

The electrical warning icon indicates the presence of a hazard which could result in electrical shock.

The warning icon indicates the presence of a hazard which could result in personal injury.

The caution icon indicates important information or warning related to the concept discussed in the text. It might indicate the presence of a hazard which could result in corruption of software or damage to equipment or property.

The information icon alerts the reader of important facts and conditions.

The tip icon indicates advice on, for example, how to design your project or how to use a certain function.

Although warning hazards are related to personal injury, it is necessary to understand that under certain operational conditions, operation of damaged equipment may result in degraded process performance leading to personal injury or death. Therefore, comply fully with all warning and caution notices.

1.4.2 Document conventions

A particular convention may not be used in this manual.

- Abbreviations and acronyms are spelled out in the glossary. The glossary also contains definitions of important terms.
- Menu paths are presented in bold.

  Select **Main menu** > **Settings**.
- Parameter names are shown in italics.

  The function can be enabled and disabled with the *Operation setting*.
- Parameter values are indicated with quotation marks.

  The corresponding parameter values are "On" and "Off".
- Input/output messages and monitored data names are shown in Courier font.
- This document assumes that the parameter setting visibility is "Advanced".

1.4.3 Functions, codes and symbols

Table 1: Functions included in the merging unit

Function	IEC 61850	IEC 60617	IEC-ANSI
Measurement			
Disturbance recorder	RDRE1	DR (1)	DFR (1)
Three-phase current measurement	CMMXU1	3I (1)	3I (1)
Sequence current measurement	CSMSQI1	I1, I2, I0 (1)	I1, I2, I0 (1)
Residual current measurement	RESCMMXU1	Io (1)	In (1)
Three-phase voltage measurement	VMMXU1	3U (1)	3V (1)
Sequence voltage measurement	VSMSQI1	U1, U2, U0 (1)	V1, V2, V0 (1)
Three-phase power and energy measurement	PEMMXU1	P, E (1)	P, E (1)
Frequency measurement	FMMXU1	f (1)	f (1)
IEC 61850-9-2 LE sampled value sending	SMVSENDER	SMVSENDER	SMVSENDER
Condition monitoring and supervision			
Circuit-breaker condition monitoring	SSCBR1	CBCM (1)	CBCM (1)
Trip circuit supervision	TCSSCBR1	TCS (1)	TCM (1)
	TCSSCBR2	TCS (2)	TCM (2)
Current circuit supervision	CCSPVC1	MCS 3I (1)	MCS 3I (1)
Fuse failure supervision	SEQSPVC1	FUSEF (1)	60 (1)
Arc detection	ARCDSARC1	ARCD (1)	AFD (1)
	ARCDSARC2	ARCD (2)	AFD (2)
	ARCDSARC3	ARCD (3)	AFD (3)
Control			
Circuit-breaker control	CBXCBR1	I <-> O CB (1)	I <-> O CB (1)
Disconnector control	DCXSWI1	I <-> O DCC (1)	I <-> O DCC (1)
	DCXSWI2	I <-> O DCC (2)	I <-> O DCC (2)
Earthing switch control	ESXSWI1	I <-> O ESC (1)	I <-> O ESC (1)
Disconnector position indication	DCSXSWI1	I <-> O DC (1)	I <-> O DC (1)
	DCSXSWI2	I <-> O DC (2)	I <-> O DC (2)

Table continues on the next page

Function	IEC 61850	IEC 60617	IEC-ANSI
Earthing switch indication	ESSXSWI1	I <-> O ES (1)	I <-> O ES (1)
Other			
Minimum pulse timer (2 pcs)	TPGAPC1	TP (1)	TP (1)
	TPGAPC2	TP (2)	TP (2)
	TPGAPC3	TP (3)	TP (3)
	TPGAPC4	TP (4)	TP (4)
Minimum pulse timer (2 pcs, second resolution)	TPSGAPC1	TPS (1)	TPS (1)
Minimum pulse timer (2 pcs, minute resolution)	TPMGAPC1	TPM (1)	TPM (1)
Pulse timer (8 pcs)	PTGAPC1	PT (1)	PT (1)
	PTGAPC2	PT (2)	PT (2)
Time delay off (8 pcs)	TOFGAPC1	TOF (1)	TOF (1)
	TOFGAPC2	TOF (2)	TOF (2)
	TOFGAPC3	TOF (3)	TOF (3)
	TOFGAPC4	TOF (4)	TOF (4)
Time delay on (8 pcs)	TONGAPC1	TON (1)	TON (1)
	TONGAPC2	TON (2)	TON (2)
	TONGAPC3	TON (3)	TON (3)
	TONGAPC4	TON (4)	TON (4)
Set-reset (8 pcs)	SRGAPC1	SR (1)	SR (1)
	SRGAPC2	SR (2)	SR (2)
	SRGAPC3	SR (3)	SR (3)
	SRGAPC4	SR (4)	SR (4)
Move (8 pcs)	MVGAPC1	MV (1)	MV (1)
	MVGAPC2	MV (2)	MV (2)
Generic control point (16 pcs)	SPCGAPC1	SPC (1)	SPC (1)
	SPCGAPC2	SPC (2)	SPC (2)
Master trip	TRPPTRC1	Master Trip (1)	94/86 (1)
	TRPPTRC2	Master Trip (2)	94/86 (2)

Table continues on the next page

Function	IEC 61850	IEC 60617	IEC-ANSI
	TRPPTRC3	Master Trip (3)	94/86 (3)
	TRPPTRC4	Master Trip (4)	94/86 (4)
	TRPPTRC5	Master Trip (5)	94/86 (5)

2 SMU615 overview

2.1 Overview

SMU615 is a dedicated substation merging unit intended for measuring current and voltage signals from the instrument transformers and merging them into the standard digital output format that other devices can further use for various power system protection application purposes. SMU615 itself includes no protection functionality but it offers the physical interface into the switchgear primary equipment, that is, circuit breaker, disconnector and earthing switch. SMU615 is a member of ABB's Relion® product family and is characterized by the compactness, simplicity and withdrawable-unit design.

SMU615 has been designed to unleash the full potential of the IEC 61850 standard for communication and interoperability in the digital substations. SMU615 supports process bus according to IEC 61850-9-2 LE with IEEE 1588 v2 time synchronization and both conventional CT/VT inputs and sensor inputs.

2.1.1 Product version history

Product version	Product history
1.0	Product released

2.1.2 PCM600 and merging unit's connectivity package version

- Protection and Control IED Manager PCM600 2.7 or later
- SMU615 Connectivity Package Ver.1.0 or later

Contact ABB for information on the latest connectivity package.

2.2 Local HMI

The LHMI is used for monitoring the merging unit. The LHMI comprises the push button, LED indicators and communication port.

Figure 2: Example of the LHMI

2.2.1 LEDs

The LHMI includes a dedicated Ready LED indicator and 11 matrix programmable LEDs on front of the LHMI.

The LEDs can be configured with PCM600 and the operation mode can be selected via WHMI or PCM600.

2.2.2 Keypad

The LHMI keypad contains a push button which is used to acknowledge alarms.

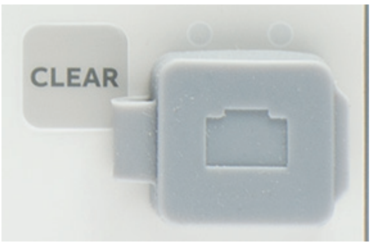


Figure 3: LHMI command push button and RJ-45 communication port

2.3 Web HMI

The WHMI allows secure access to the merging unit via a Web browser. When the *Secure Communication* parameter in the merging unit is activated, the Web server is forced to take a secured (HTTPS) connection to WHMI using TLS encryption. The WHMI is verified with Internet Explorer 8.0, 9.0, 10.0 and 11.0.

WHMI offers several functions.

- Programmable LEDs and event lists
- System supervision
- Parameter settings
- Measurement display
- Disturbance records
- Phasor diagram
- Importing/Exporting parameters
- Report summary

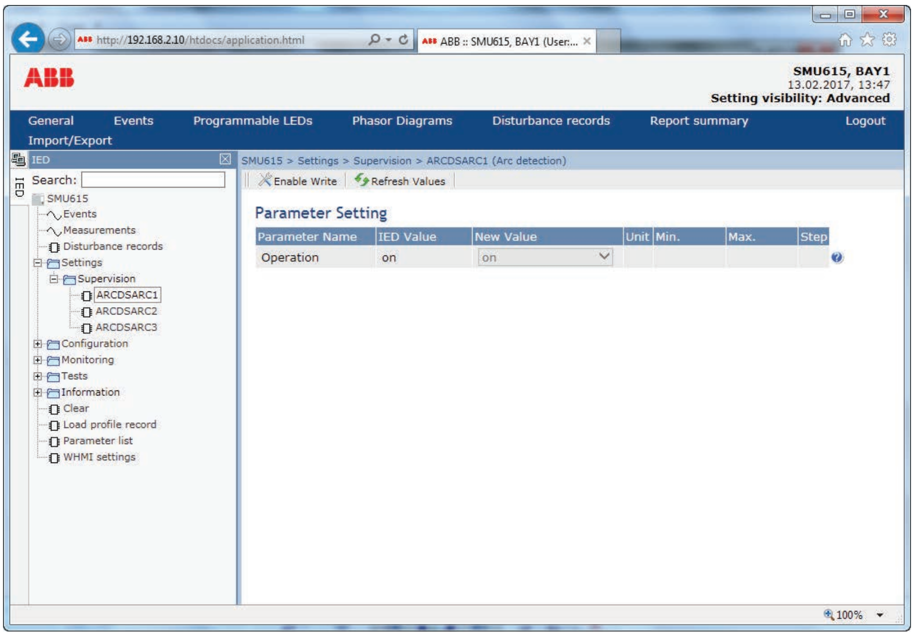


Figure 4: Example view of the WHMI

The WHMI can be accessed locally and remotely.

- Locally by connecting the laptop to the merging unit via the front communication port.
- Remotely over LAN/WAN.

WHMI is enabled by default on the rear port and always enabled (cannot be disabled) on the front port.

If the WHMI is accessed locally via the front communication port, the following features are available.

- Setting the merging unit to test mode and testing of outputs
- Trip circuit lockout reset
- Restoring factory settings

2.4 Authorization

Four user categories have been predefined for the WHMI, each with different rights and default passwords.

The default passwords in the merging unit delivered from the factory can be changed with Administrator user rights.

Table 2: Predefined user categories

Username	User rights
VIEWER	Read only access
OPERATOR	• Clearing indications
ENGINEER	• Changing settings • Clearing event list • Clearing disturbance records • Changing system settings such as IP address, serial baud rate or disturbance recorder settings • Setting the merging unit to test mode • Selecting language
ADMINISTRATOR	• All listed above • Changing password • Factory default activation

For user authorization for PCM600, see PCM600 documentation.

2.4.1 Audit trail

The merging unit offers a large set of event-logging functions. Critical system and merging unit security-related events are logged to a separate nonvolatile audit trail for the administrator.

Audit trail is a chronological record of system activities that allows the reconstruction and examination of the sequence of system and security-related events and changes in the merging unit. Both audit trail events and process related events can be examined and analyzed in a consistent method with the help of Event List in WHMI and Event Viewer in PCM600.

The merging unit stores 2048 audit trail events to the nonvolatile audit trail. Additionally, 1024 process events are stored in a nonvolatile event list. Both the audit trail and event list work according to the FIFO principle. Nonvolatile memory is based on a memory type which does not need battery backup nor regular component change to maintain the memory storage.

Audit trail events related to user authorization (login, logout, violation remote and violation local) are defined according to the selected set of requirements from IEEE 1686. The logging is based on predefined user names or user categories. The user audit trail events are accessible with IEC 61850-8-1, PCM600 and WHMI.

Table 3: Audit trail events

Audit trail event	Description
Configuration change	Configuration files changed
Firmware change	Firmware changed
Firmware change fail	Firmware change failed
Attached to retrofit test case	Unit has been attached to retrofit case
Removed from retrofit test case	Removed from retrofit test case
Control remote	DPC object control remote
Test on	Test mode on
Test off	Test mode off
Reset trips	Reset latched trips (TRPPTRC*)
Time change	Time changed directly by the user. Note that this is not used when the merging unit is synchronised properly by the appropriate protocol (IEEE 1588 v2).
View audit log	Administrator accessed audit trail
Login	Successful login from IEC 61850-8-1 (MMS), WHMI or FTP.
Logout	Successful logout from IEC 61850-8-1 (MMS), WHMI or FTP.
Password change	Password changed
Firmware reset	Reset issued by user or tool
Audit overflow	Too many audit events in the time period
Violation remote	Unsuccessful login attempt from IEC 61850-8-1 (MMS), WHMI or FTP.
Violation local	Unsuccessful login attempt from IEC 61850-8-1 (MMS), WHMI or FTP.

PCM600 Event Viewer can be used to view the audit trail events and process related events. Audit trail events are visible through dedicated Security events view. Since only the administrator has the right to read audit trail, authorization must be used in PCM600. The audit trail cannot be reset, but PCM600 Event Viewer can filter data. Audit trail events can be configured to be visible also in WHMI Event list together with process related events.

To expose the audit trail events through Event list, define the *Authority logging* level parameter via **Configuration** > **Authorization** > **Security**. This exposes audit trail events to all users.

Table 4: Comparison of authority logging levels

Audit trail event	Authority logging level			
	None	Configuration change	Settings edit	All
Configuration change		•	•	•
Firmware change		•	•	•
Firmware change fail		•	•	•
Attached to retrofit test case		•	•	•
Removed from retrofit test case		•	•	•
Control remote			•	•
Test on			•	•
Test off			•	•
Reset trips			•	•
Time change				•
View audit log				•
Login				•
Logout				•
Password change				•
Firmware reset				•
Violation local				•
Violation remote				•

2.5 Communication

The merging unit supports a range of communication protocols including IEC 61850 and IEC 61850-9-2 LE. Operational information and controls are available through these protocols. However, some communication functionality, for example, horizontal communication between the merging units, is only enabled by the IEC 61850 communication protocol.

The IEC 61850 communication implementation supports all monitoring and control functions. Additionally, parameter settings and disturbance recordings can be accessed using the IEC 61850 protocol. Disturbance recordings are available to any Ethernet-based application in the IEC 60255-24 standard COMTRADE file format. The merging unit can send and receive binary signals from other devices (so-called horizontal communication) using the IEC 61850-8-1 GOOSE profile, where the highest performance class with a total transmission time of 3 ms is supported. Furthermore, the merging unit supports sending of analog values using GOOSE messaging. The merging unit meets the GOOSE performance requirements for tripping applications in distribution substations, as defined by the IEC 61850 standard.

The merging unit can support five simultaneous clients. If PCM600 reserves one client connection, only four connections are left for other clients.

All communication connectors, except for the front port connector, are placed on integrated optional communication modules. The merging unit can be connected to Ethernet-based communication systems via the RJ-45 connector (100Base-TX) or the fiber-optic LC connector (100Base-FX).

2.5.1 Ethernet redundancy

IEC 61850 specifies a network redundancy scheme that improves the system availability for substation communication. It is based on two complementary protocols defined in the IEC 62439-3:2012 standard: parallel redundancy protocol PRP-1 and high-availability seamless redundancy HSR protocol. Both protocols rely on the duplication of all transmitted information via two Ethernet ports for one logical network connection. Therefore, both are able to overcome the failure of a link or switch with a zero-switchover time, thus fulfilling the stringent real-time requirements for the substation automation horizontal communication and time synchronization.

PRP specifies that each device is connected in parallel to two local area networks. HSR applies the PRP principle to rings and to the rings of rings to achieve cost-effective redundancy. Thus, each device incorporates a switch element that forwards frames from port to port.

IEC 62439-3:2012 cancels and replaces the first edition published in 2010. These standard versions are also referred to as IEC 62439-3 Edition 1 and IEC 62439-3 Edition 2. The merging unit supports IEC 62439-3:2012 and it is not compatible with IEC 62439-3:2010.

PRP

Each PRP node, called a doubly attached node with PRP (DAN), is attached to two independent LANs operated in parallel. These parallel networks in PRP are called LAN A and LAN B. The networks are completely separated to ensure failure independence, and they can have different topologies. Both networks operate in parallel, thus providing zero-time recovery and continuous checking of redundancy to avoid communication failures. Non-PRP nodes, called single attached nodes (SANs), are either attached to one network only (and can therefore communicate only with DANs and SANs attached to the same network), or are attached through a redundancy box, a device that behaves like a DAN.

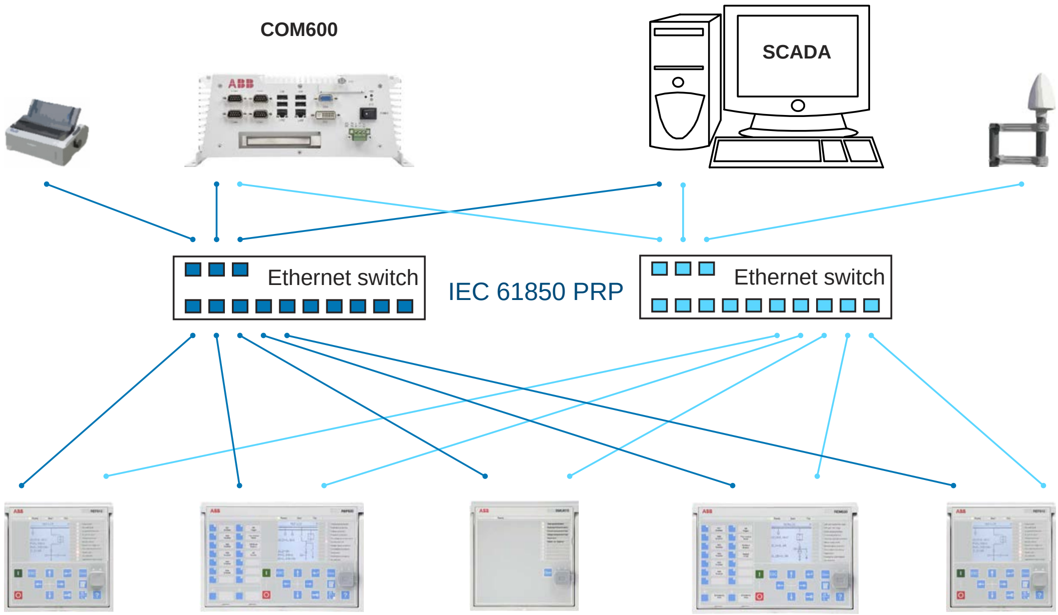


Figure 5: PRP solution

In case a laptop or a PC workstation is connected as a non-PRP node to one of the PRP networks, LAN A or LAN B, it is recommended to use a redundancy box device or an Ethernet switch with similar functionality between the PRP network and SAN to remove additional PRP information from the Ethernet frames. In some cases, default PC workstation adapters are not able to handle the maximum-length Ethernet frames with the PRP trailer.

There are different alternative ways to connect a laptop or a workstation as SAN to a PRP network.

- Via an external redundancy box (RedBox) or a switch capable of connecting to PRP and normal networks
- By connecting the node directly to LAN A or LAN B as SAN
- By connecting the node to the merging unit's interlink port

HSR

HSR applies the PRP principle of parallel operation to a single ring, treating the two directions as two virtual LANs. For each frame sent, a node, DAN, sends two frames, one over each port. Both frames circulate in opposite directions over the ring and each node forwards the frames it receives, from one port to the other. When the originating node receives a frame sent to itself, it discards that to avoid loops; therefore, no ring protocol is needed. Individually attached nodes, SANs, such as laptops and printers, must be attached through a “redundancy box” that acts as a ring element. For example, a merging unit with HSR support can be used as a redundancy box.

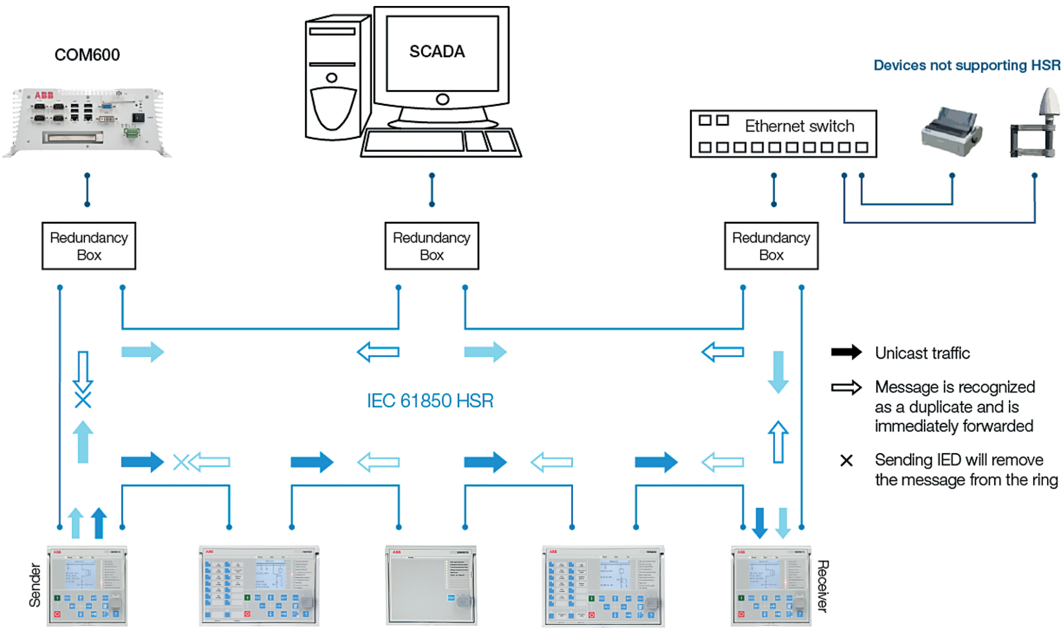


Figure 6: HSR solution

2.5.2 Process bus

Process bus IEC 61850-9-2 defines the transmission of Sampled Measured Values within the substation automation system. International Users Group created a guideline IEC 61850-9-2 LE that defines an application profile of IEC 61850-9-2 to facilitate implementation and enable interoperability. Process bus is used for distributing process data from the primary circuit to all process bus compatible devices in the local network in a real-time manner. The data can then be processed by any protection relay to perform different protection, automation and control functions.

With process bus the galvanic wiring for sharing busbar voltage value can be replaced with Ethernet communication. Transmitting measurement samples over process bus brings also higher error detection because the signal transmission is automatically supervised. Additional contribution to the higher availability is the possibility to use redundant Ethernet network for transmitting SMV signals.

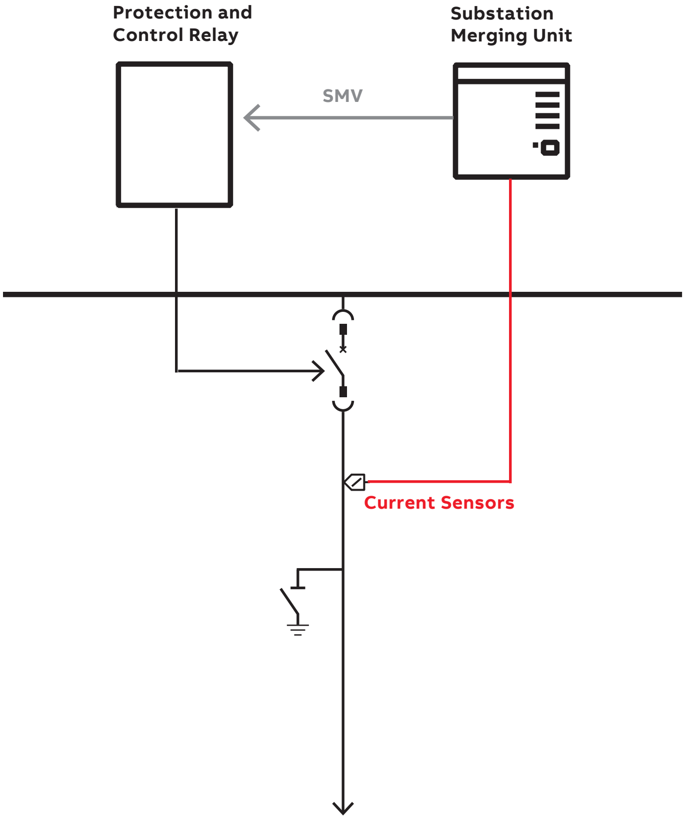


Figure 7: SMU615 sending current measurements as sampled measured values to a protection relay

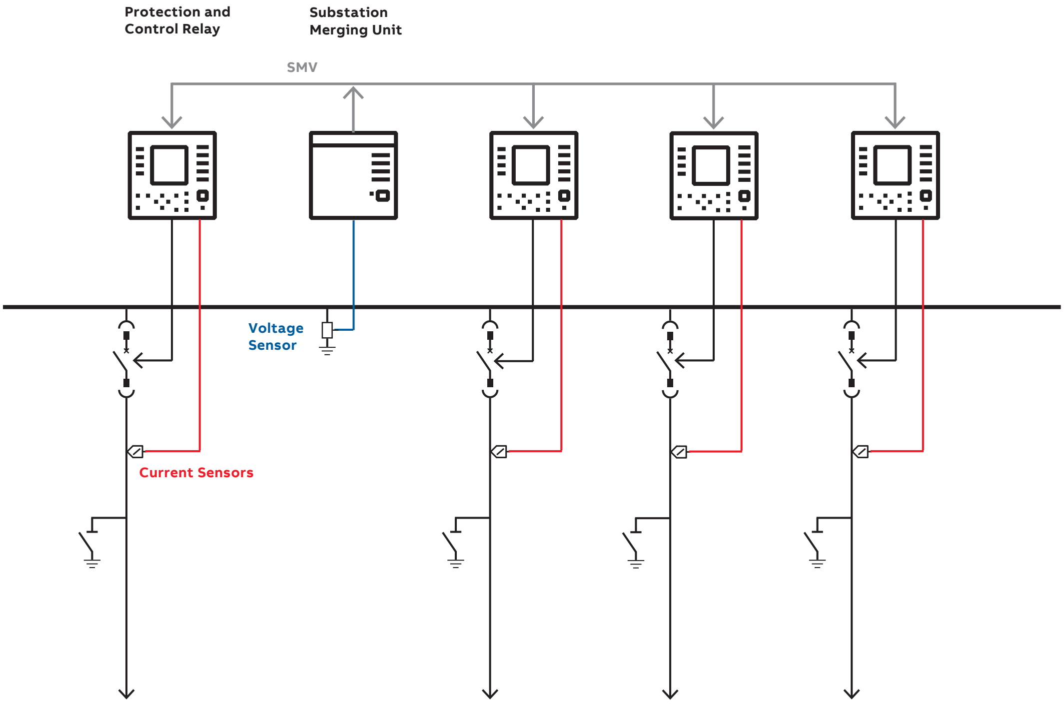


Figure 8: SMU615 sending voltage measurements as sampled measured values to protection relays

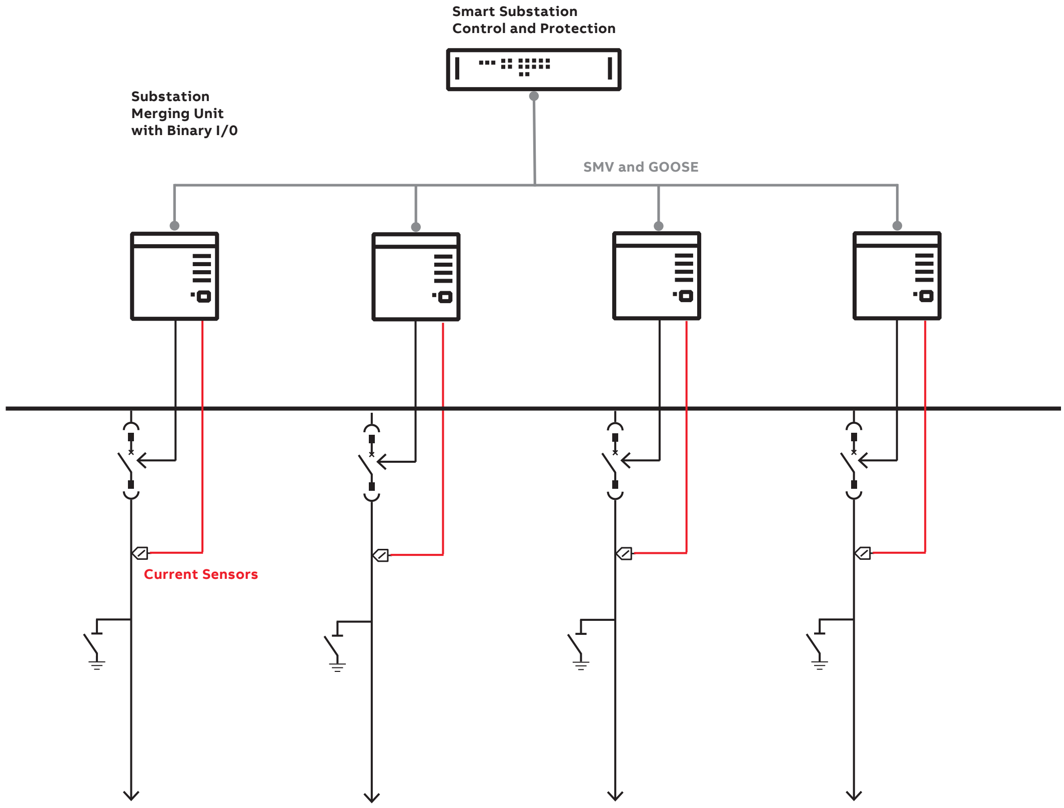


Figure 9: Smart substation control and protection SSC600 with SMU615

The merging unit supports IEC 61850 process bus with sampled values of analog currents and voltages. The measured values are transferred as sampled values using the IEC 61850-9-2 LE protocol which uses the same physical Ethernet network as the IEC 61850-8-1 station bus. The intended application for sampled values is sharing the measured voltages and currents from the merging unit to other devices with 9-2 support.

The merging units with process bus based applications use IEEE 1588 v2 Precision Time Protocol (PTP) according to IEEE C37.238-2011 Power Profile for high accuracy time synchronization. With IEEE 1588 v2, the cabling infrastructure requirement is reduced by allowing time synchronization information to be transported over the same Ethernet network as the data communications.

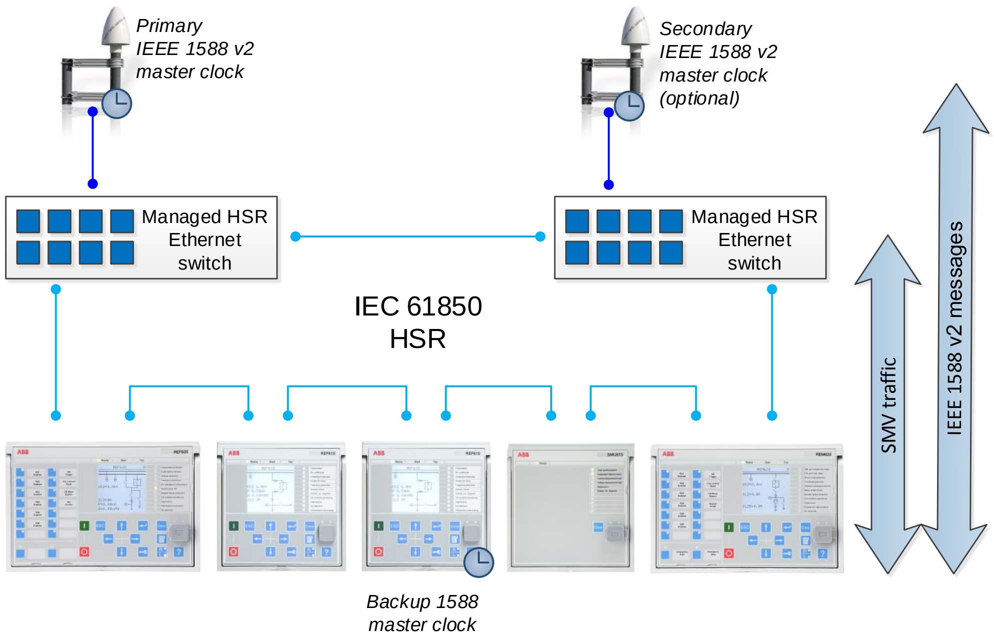


Figure 10: Example network topology with process bus, redundancy and IEEE 1588 v2 time synchronization

The process bus is available for all merging units. See the IEC 61850 engineering guide for detailed system requirements and configuration details.

2.5.3 Secure communication

The merging unit supports secure communication for WHMI and file transfer protocol. If the *Secure Communication* parameter is activated, protocols require TLS based encryption method support from the clients. In this case WHMI must be connected from a Web browser using the HTTPS protocol and in case of file transfer the client must use FTPS.

3 Basic functions

3.1 General parameters

3.1.1 Analog input settings, phase currents

Table 5: Analog input settings, phase currents

Parameter	Values (Range)	Unit	Step	Default	Description
Primary current	1.0...6000.0	A	0.1	100.0	Rated primary current
Secondary current	2=1A 3=5A			2=1A	Rated secondary current
Amplitude Corr A	0.9000...1.1000		0.0001	1.0000	Phase A amplitude correction factor
Amplitude Corr B	0.9000...1.1000		0.0001	1.0000	Phase B amplitude correction factor
Amplitude Corr C	0.9000...1.1000		0.0001	1.0000	Phase C amplitude correction factor
Nominal current	39...4000	A	1	1300	Network Nominal Current (In)
Rated secondary Val	1.000...150.000	mV/Hz	0.001	3 000	Rated Secondary Value (RSV) ratio
Reverse polarity	0=False 1=True			0=False	Reverse the polarity of the phase CTs

3.1.2 Analog input settings, residual current

Table 6: Analog input settings, residual current

Parameter	Values (Range)	Unit	Step	Default	Description
Primary current	1.0...6000.0	A	0.1	100.0	Primary current
Secondary current	1=0.2A 2=1A			2=1A	Secondary current
Amplitude Corr	0.9000...1.1000		0.0001	1.0000	Amplitude correction
Reverse polarity	0=False 1=True			0=False	Reverse the polarity of the residual CT

3.1.3 Analog input settings, phase voltages

Table 7: Analog input settings, phase voltages

Parameter	Values (Range)	Unit	Step	Default	Description
Primary voltage	0.100 ... 440.000	kV	0.001	20.000	Primary rated voltage
Secondary voltage	60...210	V	1	100	Secondary rated voltage
VT connection	1=Wye 2=Delta			2=Delta	Voltage transducer measurement connection
Amplitude Corr A	0.9000 ... 1.1000		0.0001	1.0000	Phase A Voltage phasor magnitude correction of an external voltage transformer
Amplitude Corr B	0.9000 ... 1.1000		0.0001	1.0000	Phase B Voltage phasor magnitude correction of an external voltage transformer
Amplitude Corr C	0.9000 ... 1.1000		0.0001	1.0000	Phase C Voltage phasor magnitude correction of an external voltage transformer
Division ratio	1000 ... 20000		1	10000	Voltage sensor division ratio
Voltage input type	1=Voltage trafo 3=CVD sensor			1=Voltage trafo	Type of the voltage input
Angle Corr A	-8.000 … 8.000 deg	deg	0.0001	0.0000	Phase A Voltage phasor angle correction of an external voltage transformer
Angle Corr B	-8.000 … 8.000 deg	deg	0.0001	0.0000	Phase B Voltage phasor angle correction of an external voltage transformer
Angle Corr C	-8.000 … 8.000 deg	deg	0.0001	0.0000	Phase C Voltage phasor angle correction of an external voltage transformer

3.1.4 Authorization settings

Table 8: Authorization settings

Parameter	Values (Range)	Unit	Step	Default	Description
Remote Update	0=Disable 1=Enable			0=Disable	Remote update
Secure Communication	0=False 1=True			1=True	Secure Communication
Authority logging	1=None 2=Configuration change 5=Settings edit 6=All			1=None	Authority logging level

Table continues on the next page

Parameter	Values (Range)	Unit	Step	Default	Description
Remote override	0=False [1] 1=True [2]			1=True	Disable authority
Remote viewer				0	Set password
Remote operator				0	Set password
Remote engineer				0	Set password
Remote administrator				0	Set password
Local viewer				0	Set password
Local operator				0	Set password
Local engineer				0	Set password
Local administrator				0	Set password

3.1.5 Binary input settings

Table 9: Binary input settings

Parameter	Values (Range)	Unit	Step	Default	Description
Threshold voltage	16...176	Vdc	2	16	Binary input threshold voltage
Input osc. level	2...50	events/s	1	30	Binary input oscillation suppression threshold
Input osc. hyst	2...50	events/s	1	10	Binary input oscillation suppression hysteresis

Adjust the binary input threshold voltage correctly. The threshold voltage should be comparable to the nominal value instead of the default minimum value. The factory default is 16 V to ensure the binary inputs' operation regardless of the auxiliary voltage used (24, 48, 60, 110, 125, 220 or 250 V DC). However, the default value is not optimal for the higher auxiliary voltages. The binary input threshold voltage should be set as high as possible to prevent any inadvertent activation of the binary inputs due to possible external disturbances. At the same time, the threshold should be set so that the correct operation is not jeopardized in case of undervoltage of the auxiliary voltage.

3.1.6 Binary signals in card location Xnnn

Table 10: Binary input signals in card location Xnnn

Name	Type	Description
Xnnn-Input m [1]	BOOLEAN	See the application manual for standard configuration specific terminal connections

1 Authorization override is disabled, communication tools ask password to enter the merging unit.
2 Authorization override is enabled, communication tools do not need password to enter the merging unit, except for WHMI which always requires it.
1 Xnnn = Slot ID, for example, X100, X110, as applicable

Table 11: Binary output signals in card location Xnnn

Name	Type	Default	Description
Xnnn-Pmm [1] [2]	BOOLEAN	0=False	See the application manual for standard configuration specific terminal connections

3.1.7 Binary input settings in card location Xnnn

Table 12: Binary input settings in card location Xnnn

Name [1]	Value	Unit	Step	Default
Input m [3] filter time	5...1000	ms		5
Input m inversion	0= False 1= True			0=False

3.1.8 Ethernet front port settings

Table 13: Ethernet front port settings

Parameter	Values (Range)	Unit	Step	Default	Description
IP address				192.168.0.254	IP address for front port (fixed)
Mac address				XX-XX-XX-XX-XX-XX	Mac address for front port

3.1.9 Ethernet rear port settings

Table 14: Ethernet rear port settings

Parameter	Values (Range)	Unit	Step	Default	Description
IP address				192.168.2.10	IP address for rear port(s)
Subnet mask				255.255.255.0	Subnet mask for rear port(s)
Default gateway				192.168.2.1	Default gateway for rear port(s)
Mac address				XX-XX-XX-XX-XX-XX	Mac address for rear port(s)

3.1.10 General system settings

Table 15: General system settings

Parameter	Values (Range)	Unit	Step	Default	Description
Rated frequency	1=50Hz			1=50Hz	Rated frequency of the network

Table continues on the next page

[2] Pmm = For example, PO1, PO2, SO1, SO2, as applicable

[3] m = For example, 1, 2, depending on the serial number of the binary input in a particular BIO or AIM card

Parameter	Values (Range)	Unit	Step	Default	Description
	2=60Hz				
Phase rotation	1=ABC 2=ACB			1=ABC	Phase rotation order
Bay name				SMU615	Bay name in system

3.1.11 HMI settings

Table 16: HMI settings

Parameter	Values (Range)	Unit	Step	Default	Description
FB naming convention	1=IEC61850 2=IEC60617 3=IEC-ANSI			1=IEC61850	FB naming convention used in IED
Web HMI timeout	1...60	min	1	3	Web HMI login timeout
SLD symbol format	1=IEC 2=ANSI			1=IEC	Single Line Diagram symbol format
Setting visibility	1=Basic 2=Advanced			1=Basic	Setting visibility for HMI

3.1.12 IEC 61850-8-1 MMS settings

Table 17: IEC 61850-8-1 MMS settings

Parameter	Values (Range)	Unit	Step	Default	Description
Unit mode	1=Primary [1] 0=Nominal [2] 2=Primary-Nominal [3]			0=Nominal	IEC 61850-8-1 unit mode

3.2 Self-supervision

The merging unit's extensive self-supervision system continuously supervises the relay’s software, hardware and certain external circuits. It handles the run-time fault situation and informs the user about a fault through the communication channels. The target of the self-supervision is to safeguard the relay’s reliability by increasing both dependability and security. The dependability can be described as the relay’s ability to operate when required. The security can be described

1 MMS client expects primary values from event reporting and data attribute reads
2 MMS client expects nominal values from event reporting and data attribute reads; this is the default for PCM600
3 For PCM600 use only. When Unit mode is set to "Primary", the PCM600 client can force its session to "Nominal" by selecting "Primary-Nominal" and thus parameterizing in native form. The selection is not stored and is therefore effective only for one session. This value has no effect if selected via the front port WHMI.

as the relay scheme's ability to refrain from operating when not required. The dependability is increased by letting the system operators know about the problem, giving them a chance to take the necessary actions as soon as possible. The security is increased by preventing the relay from making false decisions, such as issuing false control commands.

There are two types of fault indications.

- Internal faults
- Warnings

3.2.1 Internal faults

When an internal relay fault is detected, the relay protection operation is disabled, the green Ready LED begins to flash and the self-supervision output relay is de-energized, i.e. the change-over contact is released.

An event about the fault is stored as a message on the WHMI. The text `Internal Fault` with an additional text message, a code, date and time, is stored to indicate the fault type.

Different actions are taken depending on the severity of the internal fault. In case of a temporary fault, the merging unit tries to recover from the situation by restarting. Restarting varies per fault type. The restart procedure includes two stages; when the merging unit detects a fault, it restarts itself in a few seconds after the fault occurrence. If the merging unit did not recover after the first fast self-recovery attempts (typically 1-2 restarts), or the fault reoccurs during the next 60 minutes, the next self-recovery attempts (typically 3 restarts) are delayed for 10 minutes. In case of a permanent fault, the merging unit stays in the internal fault mode. All output relays are de-energized and contacts are released for the internal fault. The merging unit continues to perform internal tests during the fault situation. If the internal fault disappears, the green Ready LED stop flashing and the merging unit returns to the normal service state.

One possible cause for an internal fault situation is a so-called soft error. The soft error is a probabilistic phenomenon which is rare in a single device, statistically not happening more often than once in a relay's lifetime. No hardware failures are expected and a full recovery from the soft error is possible by a self-supervision controlled restart of the merging unit.

The self-supervision signal output operates on the closed-circuit principle. Under normal conditions, the merging unit is energized and the contact gaps 3-5 in slot X100 is closed. If the auxiliary power supply fails or an internal fault is detected, the contact gaps 3-5 are opened.

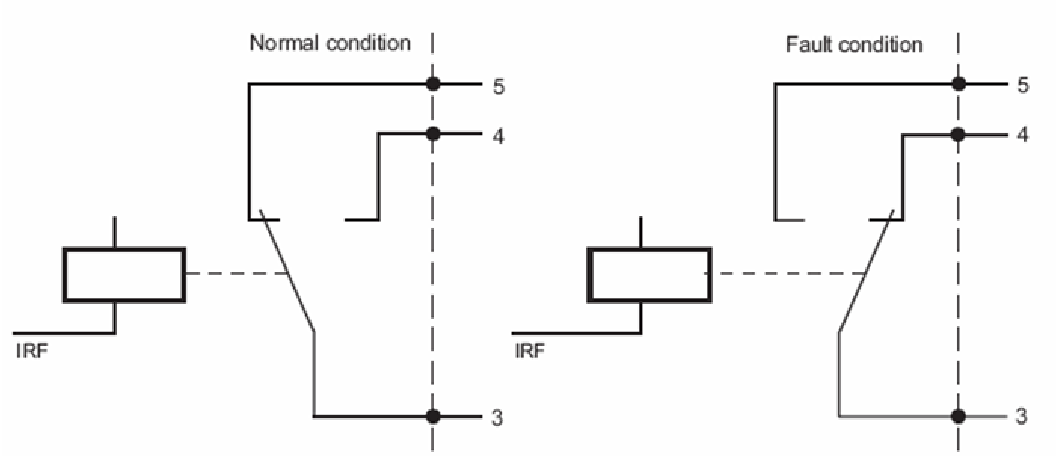


Figure 11: Output contact

The internal fault code indicates the type of internal relay fault. When a fault appears, the code must be recorded so that it can be reported to ABB customer service.

Table 18: Internal fault indications and codes

Fault indication	Fault code	Additional information	Fast self-recovery attempt (# of attempts)	Slow 10 min self-recovery (# of attempts)	Immediate permanent IRF-mode	Action in permanent fault state
Internal Fault System error	2	Start up error: HW/SW mismatch	No	No	Yes	If relay SW has just been updated, redo it. If not recovered, contact your nearest ABB representative to check the next possible corrective action.
Internal Fault System error	2	Start up or runtime error: Data bus error, CPU module	Yes (2)	Yes (3)	No	Restart the relay. If recovered by restarting, continue relay normal operation. If not recover by restarting, replace the relay, most probably hardware failure in CPU module.
Internal Fault System error	2	Start up error: SCL file missing	No	No	Yes	Do factory restore or rewrite configuration using PCM600.
Internal Fault System error	2	Start up error: Missing order number	No	No	Yes	Do factory restore. If not recovered, contact your nearest ABB representative to check the next possible corrective action.
Internal Fault System error	2	Start up error: FPGA HW error, CPU module	Yes (2)	Yes (3)	No	Restart the relay. If recovered by restarting, continue relay normal operation. If not recover by restarting, replace the relay, most probably hardware failure in CPU module.
Internal Fault System error	2	Start up error: FPGA image corrupted, CPU module	Yes (2)	Yes (3)	No	Restart the relay or if relay SW has just been updated, redo it. If recovered by restarting, continue relay normal operation. If not recovered by restarting or redoing SW update, replace the relay, most probably hardware failure in CPU module.
Internal Fault System error	2	Runtime error: CPU internal fault	Yes (2)	Yes (3)	No	Restart the relay. If recovered by restarting, continue relay normal operation. If not recover by restarting, replace the relay, most probably hardware failure in CPU module.

Table continues on the next page

Fault indication	Fault code	Additional information	Fast self-recovery attempt (# of attempts)	Slow 10 min self-recovery (# of attempts)	Immediate permanen t IRF-mode	Action in permanent fault state
Internal Fault File system error	7	Start up error or runtime error: file system error	Yes (2)	Yes (3)	No	Restart the relay. If recovered by re-starting, continue relay normal op-eration. If not recover by restart-ing, replace the relay, most probably hardware failure in CPU module.
Internal Fault Test	8	Internal fault test activated manual-ly by the user.	No	No	-	Just check the "Internal fault test" -setting parameter position, if relay is in test mode
Internal Fault SW watchdog error	10	Start up error: Watchdog reset has occurred too many times with-in an hour. Note! This is different indication than Warning code 10: Watchdog reset	No	No	Yes	Restart the relay. If recovered by re-starting, continue relay normal op-eration. If not recover by restarting, replace the relay.
Internal Fault SO-relay(s),X100	43	Runtime error: Faulty Signal Out-put relay(s) in card located in slot X100.	Yes (2)	Yes (3)	No	Check wirings. Restart the relay. If recovered by restarting, continue relay normal operation. If not recov-er by restarting, exchange the hard-ware module in slot X100.
Internal Fault SO-relay(s),X110	44	Runtime error: Faulty Signal Out-put relay(s) in card located in slot X110.Runtime error:	Yes (2)	Yes (3)	No	Check wirings. Restart the relay. If recovered by restarting, continue relay normal operation. If not recov-er by restarting, exchange the hard-ware module in slot X110.
Internal Fault SO-relay(s),X120	45	Runtime error: Faulty Signal Out-put relay(s) in card located in slot X120.	Yes (2)	Yes (3)	No	Check wirings. Restart the relay. If recovered by restarting, continue relay normal operation. If not recov-er by restarting, exchange the hard-ware module in slot X120.
Internal Fault SO-relay(s),X130	46	Runtime error: Faulty Signal Out-put relay(s) in card located in slot X130.	Yes (2)	Yes (3)	No	Check wirings. Restart the relay. If recovered by restarting, continue relay normal operation. If not recov-er by restarting, exchange the hard-ware module in slot X130.
Internal Fault PO-relay(s),X100	53	Runtime error: Faulty Power Out-put relay(s) in card located in slot X100.	Yes (2)	Yes (3)	No	Check wirings. Restart the relay. If recovered by restarting, continue relay normal operation. If not recov-er by restarting, exchange the hard-ware module in slot X100.
Internal Fault PO-relay(s),X110	54	Runtime error: Faulty Power Out-put relay(s) in card located in slot X110.	Yes (2)	Yes (3)	No	Check wirings. Restart the relay. If recovered by restarting, continue relay normal operation. If not recov-er by restarting, exchange the hard-ware module in slot X110.
Internal Fault PO-relay(s),X120	55	Runtime error: Faulty Power Out-put relay(s) in card located in slot X120.	Yes (2)	Yes (3)	No	Check wirings. Restart the relay. If recovered by restarting, continue relay normal operation. If not recov-er by restarting, exchange the hard-ware module in slot X120.
Internal Fault PO-relay(s),X130	56	Runtime error: Faulty Power Out-put relay(s) in card located in slot X130.	Yes (2)	Yes (3)	No	Check wirings. Restart the relay. If recovered by restarting, continue relay normal operation. If not recov-er by restarting, exchange the hard-ware module in slot X130.
Internal Fault Light sensor error	59	Runtime error: Faulty ARC light sensor input(s).	Yes (2)	Yes (3)	No	Check wirings. Restart the relay. If recovered by restarting, continue

Table continues on the next page

Fault indication	Fault code	Additional information	Fast self-recovery attempt (# of attempts)	Slow 10 min self-recovery (# of attempts)	Immediate permanent IRF-mode	Action in permanent fault state
						relay normal operation. If not recover by restarting, exchange the communication module including ARC inputs in slot X000.
Internal Fault Conf. error,X000	62	Start up error: Card in slot X000 is wrong type, is missing, does not belong to original configuration or card firmware is faulty.	No	No	Yes	"Check that the communication card in slot X000 is proper type and properly installed. Check that the plug-in unit is properly installed and plug-in unit handle is properly fixed to closed position. Then restart the relay. If does not recover by restarting, it is hardware module failure most likely. Exchange the communication module in slot X000. In some rare cases also communication storm may cause this. Detach the ethernet communication cable(s) from the communication module and reboot the relay. If not recover,exchange the communication module in slot X000. "
Internal Fault Conf. error,X100	63	Start up error: Card in slot X100 is wrong type, is missing, does not belong to original configuration or card firmware is faulty.	No	No	Yes	"Check that the card in slot X100 is proper type and properly installed. Check that the plug-in unit is properly installed and plug-in unit handle is properly fixed to closed position. Then restart the relay. If does not recover by restarting, it is hardware module failure most likely. Exchange the hardware module in slot X100."
Internal Fault Conf. error,X110	64	Start up error: Card in slot X110 is wrong type, is missing, does not belong to original configuration or card firmware is faulty.	No	No	Yes	"Check that the card in slot X110 is proper type and properly installed. Check that the plug-in unit is properly installed and plug-in unit handle is properly fixed to closed position. Then restart the relay. If does not recover by restarting, it is hardware module failure most likely. Exchange the hardware module in slot X110."
Internal Fault Conf. error,X120	65	Start up error: Card in slot X120 is wrong type, is missing, does not belong to original configuration or card firmware is faulty.	No	No	Yes	"Check that the card in slot X120 is proper type and properly installed. Check that the plug-in unit is properly installed and plug-in unit handle is properly fixed to closed position. Then restart the relay. If does not recover by restarting, it is hardware module failure most likely. Exchange the hardware module in slot X120."
Internal Fault Conf. error,X130	66	Start up error: Card in slot X130 is wrong type, is missing, does not belong to original configuration or card firmware is faulty.	No	No	Yes	"Check that the card in slot X130 is proper type and properly installed. Check that the plug-in unit is properly installed and plug-in unit handle is properly fixed to closed position. Then restart the relay. If does not recover by restarting, it is hardware module failure most likely. Exchange the hardware module in slot X130."
Internal Fault Card error,X000	72	Card in slot X000 is faulty.	Yes (2)	Yes (3)	No	"Check the plug-in unit connector pins in the card by detaching the plug-in unit. If pins are OK, exchange the communication module in slot X000. In some rare cases also communication storm may cause

Table continues on the next page

Fault indication	Fault code	Additional information	Fast self-recovery attempt (# of attempts)	Slow 10 min self-recovery (# of attempts)	Immediate permanent IRF-mode	Action in permanent fault state
						this. Detach the ethernet communication cable(s) from the communication module and reboot the relay. If not recover,exchange the communication module in slot X000. "
Internal Fault Card error,X100	73	Card in slot X100 is faulty.	Yes (2)	Yes (3)	No	Exchange the hardware module in slot X100.
Internal Fault Card error,X110	74	Card in slot X110 is faulty.	Yes (2)	Yes (3)	No	Exchange the hardware module in slot X110.
Internal Fault Card error,X120	75	Card in slot X120 is faulty.	Yes (2)	Yes (3)	No	Exchange the hardware module in slot X120.
Internal Fault Card error,X130	76	Card in slot X130 is faulty.	Yes (2)	Yes (3)	No	Check the plug-in unit connector pins in the card by detaching the plug-in unit. If pins are OK, exchange the hardware module in slot X130.
Internal Fault LHMI module	79	Runtime error: LHMI LCD error. The fault indication may not be seen on the LHMI during the fault.	Yes (2)	Yes (3)	No	Restart the relay. If recovered by restarting, continue relay normal operation. If not recover by restarting, check LHMI connection cable and connection to be proberly fixed. If then not recovered by restarting, exchange the LHMI module.
Internal Fault RAM error	80	Runtime error: Error in the RAM memory on the CPU module.	Yes (2)	Yes (10)	No	If recovered by restarting, continue relay normal operation. If not recover by restarting, replace the relay, most probably hardware failure in CPU module.
Internal Fault ROM error	81	Runtime error: Error in the ROM memory on the CPU module.	Yes (2)	Yes (3)	No	Restart the relay. If recovered by restarting, continue relay normal operation. If not recover by restarting, replace the relay, most probably hardware failure in CPU module.
Internal Fault EEPROM error	82	Start up error: Error in the EEPROM memory on the CPU module.	No	No	Yes	Restart the relay. If recovered by restarting, continue relay normal operation. If not recover by restarting, replace the relay, most probably hardware failure in CPU module.
Internal Fault EEPROM error	82	Start up error: CRC check failure in the EEPROM memory on bootup on the CPU module.	Yes (2)	Yes (3)	No	Restart the relay. If recovered by restarting, continue relay normal operation. If not recover by restarting, replace the relay, most probably hardware failure in CPU module.
Internal Fault FPGA error	83	Runtime error: Error in the FPGA on the CPU module.	Yes	Yes (3)	No	Restart the relay. If recovered by restarting, continue relay normal operation. If not recover by restarting, replace the relay, most probably hardware failure in CPU module.
Internal Fault RTC error	84	Start up error: Error in the RTC on the CPU module.	Yes	Yes (3)	No	Restart the relay. If recovered by restarting, continue relay normal operation. If not recover by restarting, replace the relay, most probably hardware failure in CPU module.
Internal Fault RTD card error,X130	96	Runtime error: RTD card located in slot X130 may have permanent fault. Temporary	Yes	Yes (3)	No	Restart the relay. If recovered by restarting, continue relay normal operation. If not recover by restarting, exchange the hardware module in slot X130.

Table continues on the next page

Fault indication	Fault code	Additional information	Fast self-recovery attempt (# of attempts)	Slow 10 min self-recovery (# of attempts)	Immediate permanent IRF-mode	Action in permanent fault state
		error has occurred too many times within a short time.				
Internal Fault COM card error	116	Runtime error: Error in the COM card.	Yes	Yes (3)	No	Restart the relay. If recovered by restarting, continue relay normal operation. If not recover by restarting, exchange the communication module in slot X000.

For further information on internal fault indications, see the operation manual.

3.2.2 Warnings

In case of a warning, the merging unit continues to operate except for those functions possibly affected by the fault, and the green Ready LED remains lit as during normal operation.

An event about the warnings are stored with the text `Warning` additionally provided with the name of the warning, a numeric code and the date and time on the WHMI.

If a warning appears, record the name and code so that it can be provided to ABB customer service.

Table 19: Warning indications and codes

Warning indication	Warning code	Additional information
Warning Watchdog reset	10	A watchdog reset has occurred.
Warning Power down det.	11	The auxiliary supply voltage has dropped too low.
Warning IEC61850 error	20	Error when building the IEC 61850 data model.
Warning Dataset error	24	Error in the Data set(s).
Warning Report cont. error	25	Error in the Report control block(s).
Warning GOOSE contr. error	26	Error in the GOOSE control block(s).
Warning SCL config error	27	Error in the SCL configuration file or the file is missing.

Table continues on the next page

Warning indication	Warning code	Additional information
Warning Logic error	28	Too many connections in the configuration.
Warning SMT logic error	29	Error in the SMT connections.
Warning GOOSE input error	30	Error in the GOOSE connections.
ACT error	31	Error in the ACT connections.
Warning GOOSE Rx. error	32	Error in the GOOSE message receiving.
Warning AFL error	33	Analog channel configuration error.
Warning SMV config error	34	Error in the SMV configuration.
Warning Comm. channel down	35	Redundant Ethernet (HSR/PRP) communication interrupted.
Warning Unack card comp.	40	A new composition has not been acknowledged/accepted.

For further information on warning indications, see the operation manual.

3.3 Programmable LEDs

3.3.1 Function block

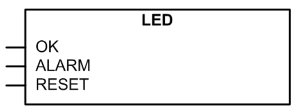


Figure 12: Function block

3.3.2 Functionality

The programmable LEDs reside on the right side of the LHMI.

Figure 13: Programmable LEDs on the right side of the LHMI

All the programmable LEDs in the HMI of the merging unit have two colors, green and red. For each LED, the different colors are individually controllable.

Each LED has two control inputs, `ALARM` and `OK`. The color setting is common for all the LEDs. It is controlled with the *Alarm colour* setting, the default value being "Red". The `OK` input corresponds to the color that is available, with the default value being "Green".

Changing the *Alarm colour* setting to "Green" changes the color behavior of the `OK` inputs to red.

The `ALARM` input has a higher priority than the `OK` input.

Each LED is seen in the Application Configuration tool as an individual function block. Each LED has user-editable description text for event description. The state ("None", "OK", "Alarm") of each LED can also be read under a common monitored data view for programmable LEDs.

The LED status also provides a means for resetting the individual LED via communication. The LED can also be reset from configuration with the `RESET` input.

The resetting and clearing function for all LEDs is under the **Clear** menu.

The menu structure for the programmable LEDs is presented in *Figure 14*. The common color selection setting *Alarm colour* for all `ALARM` inputs is in the **General** menu, while the LED-specific settings are under the LED-specific menu nodes.

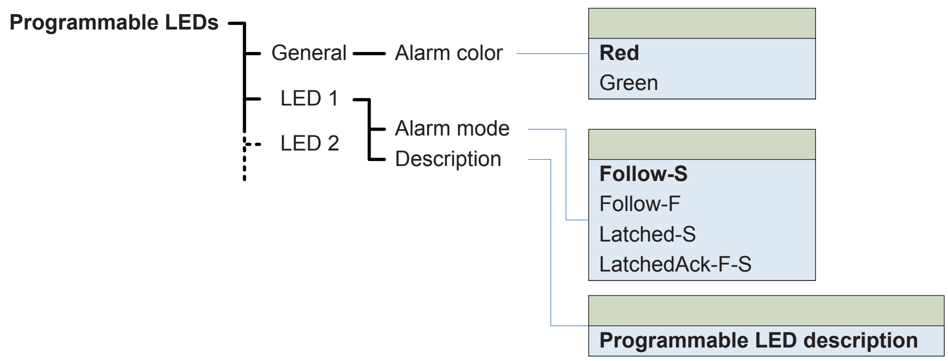


Figure 14: Menu structure

Alarm mode alternatives

The `ALARM` input behavior can be selected with the alarm mode settings from the alternatives "Follow-S", "Follow-F", "Latched-S" and "LatchedAck-F-S". The `OK` input behavior is always according to "Follow-S". The alarm input latched modes can be cleared with the reset input in the application logic.

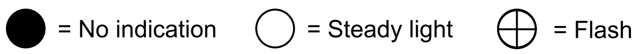


Figure 15: Symbols used in the sequence diagrams

"Follow-S": Follow Signal, ON

In this mode `ALARM` follows the input signal value, Non-latched.

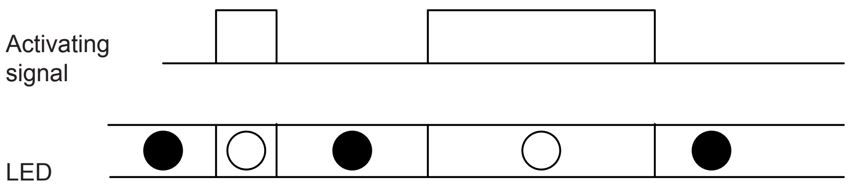


Figure 16: Operating sequence "Follow-S"

"Follow-F": Follow Signal, Flashing

Similar to "Follow-S", but instead the LED is flashing when the input is active, Non-latched.

"Latched-S": Latched, ON

This mode is a latched function. At the activation of the input signal, the alarm shows a steady light. After acknowledgement by the local operator pressing any key on the keypad, the alarm disappears.

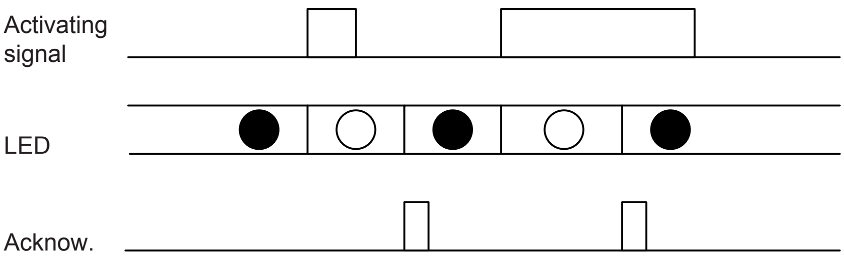


Figure 17: Operating sequence "Latched-S"

"LatchedAck-F-S": Latched, Flashing-ON

This mode is a latched function. At the activation of the input signal, the alarm starts flashing. After acknowledgement, the alarm disappears if the signal is not present and gives a steady light if the signal is present.

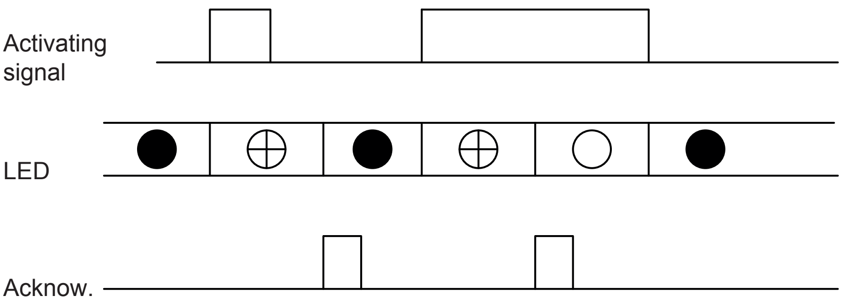


Figure 18: Operating sequence "LatchedAck-F-S"

3.3.3 Signals

3.3.3.1 Input signals

Table 20: Input signals

Name	Type	Default	Description
OK	BOOLEAN	0=False	Ok input for LED 1
ALARM	BOOLEAN	0=False	Alarm input for LED 1
RESET	BOOLEAN	0=False	Reset input for LED 1
OK	BOOLEAN	0=False	Ok input for LED 2
ALARM	BOOLEAN	0=False	Alarm input for LED 2
RESET	BOOLEAN	0=False	Reset input for LED 2
OK	BOOLEAN	0=False	Ok input for LED 3
ALARM	BOOLEAN	0=False	Alarm input for LED 3
RESET	BOOLEAN	0=False	Reset input for LED 3

Table continues on the next page

Name	Type	Default	Description
OK	BOOLEAN	0=False	Ok input for LED 4
ALARM	BOOLEAN	0=False	Alarm input for LED 4
RESET	BOOLEAN	0=False	Reset input for LED 4
OK	BOOLEAN	0=False	Ok input for LED 5
ALARM	BOOLEAN	0=False	Alarm input for LED 5
RESET	BOOLEAN	0=False	Reset input for LED 5
OK	BOOLEAN	0=False	Ok input for LED 6
ALARM	BOOLEAN	0=False	Alarm input for LED 6
RESET	BOOLEAN	0=False	Reset input for LED 6
OK	BOOLEAN	0=False	Ok input for LED 7
ALARM	BOOLEAN	0=False	Alarm input for LED 7
RESET	BOOLEAN	0=False	Reset input for LED 7
OK	BOOLEAN	0=False	Ok input for LED 8
ALARM	BOOLEAN	0=False	Alarm input for LED 8
RESET	BOOLEAN	0=False	Reset input for LED 8
OK	BOOLEAN	0=False	Ok input for LED 9
ALARM	BOOLEAN	0=False	Alarm input for LED 9
RESET	BOOLEAN	0=False	Reset input for LED 9
OK	BOOLEAN	0=False	Ok input for LED 10
ALARM	BOOLEAN	0=False	Alarm input for LED 10
RESET	BOOLEAN	0=False	Reset input for LED 10
OK	BOOLEAN	0=False	Ok input for LED 11
ALARM	BOOLEAN	0=False	Alarm input for LED 11
RESET	BOOLEAN	0=False	Reset input for LED 11

3.3.4 Settings

3.3.4.1 Non group settings

Table 21: Non group settings

Parameter	Values (Range)	Unit	Step	Default	Description
Alarm colour	1=Green 2=Red			2=Red	Colour for the alarm state of the LED
Alarm mode	0=Follow-S 1=Follow-F 2=Latched-S 3=LatchedAck-F-S			0=Follow-S	Alarm mode for programmable LED 1

Table continues on the next page

Parameter	Values (Range)	Unit	Step	Default	Description
Description				Programmable LEDs LED 1	Programmable LED description
Alarm mode	0=Follow-S 1=Follow-F 2=Latched-S 3=LatchedAck-F-S			0=Follow-S	Alarm mode for programmable LED 2
Description				Programmable LEDs LED 2	Programmable LED description
Alarm mode	0=Follow-S 1=Follow-F 2=Latched-S 3=LatchedAck-F-S			0=Follow-S	Alarm mode for programmable LED 3
Description				Programmable LEDs LED 3	Programmable LED description
Alarm mode	0=Follow-S 1=Follow-F 2=Latched-S 3=LatchedAck-F-S			0=Follow-S	Alarm mode for programmable LED 4
Description				Programmable LEDs LED 4	Programmable LED description
Alarm mode	0=Follow-S 1=Follow-F 2=Latched-S 3=LatchedAck-F-S			0=Follow-S	Alarm mode for programmable LED 5
Description				Programmable LEDs LED 5	Programmable LED description
Alarm mode	0=Follow-S 1=Follow-F 2=Latched-S 3=LatchedAck-F-S			0=Follow-S	Alarm mode for programmable LED 6
Description				Programmable LEDs LED 6	Programmable LED description
Alarm mode	0=Follow-S 1=Follow-F 2=Latched-S 3=LatchedAck-F-S			0=Follow-S	Alarm mode for programmable LED 7
Description				Programmable LEDs LED 7	Programmable LED description
Alarm mode	0=Follow-S 1=Follow-F 2=Latched-S 3=LatchedAck-F-S			0=Follow-S	Alarm mode for programmable LED 8
Description				Programmable LEDs LED 8	Programmable LED description
Alarm mode	0=Follow-S 1=Follow-F 2=Latched-S 3=LatchedAck-F-S			0=Follow-S	Alarm mode for programmable LED 9

Table continues on the next page

Parameter	Values (Range)	Unit	Step	Default	Description
Description				Programmable LEDs LED 9	Programmable LED description
Alarm mode	0=Follow-S 1=Follow-F 2=Latched-S 3=LatchedAck-F-S			0=Follow-S	Alarm mode for programmable LED 10
Description				Programmable LEDs LED 10	Programmable LED description
Alarm mode	0=Follow-S 1=Follow-F 2=Latched-S 3=LatchedAck-F-S			0=Follow-S	Alarm mode for programmable LED 11
Description				Programmable LEDs LED 11	Programmable LED description

3.3.5 Monitored data

3.3.5.1 Monitored data

Table 22: Monitored data

Name	Type	Values (Range)	Unit	Description
Programmable LED 1	Enum	0=None 1=Ok 3=Alarm		Status of programmable LED 1
Programmable LED 2	Enum	0=None 1=Ok 3=Alarm		Status of programmable LED 2
Programmable LED 3	Enum	0=None 1=Ok 3=Alarm		Status of programmable LED 3
Programmable LED 4	Enum	0=None 1=Ok 3=Alarm		Status of programmable LED 4
Programmable LED 5	Enum	0=None 1=Ok 3=Alarm		Status of programmable LED 5
Programmable LED 6	Enum	0=None 1=Ok 3=Alarm		Status of programmable LED 6
Programmable LED 7	Enum	0=None 1=Ok 3=Alarm		Status of programmable LED 7

Table continues on the next page

Name	Type	Values (Range)	Unit	Description
Programmable LED 8	Enum	0=None 1=Ok 3=Alarm		Status of programmable LED 8
Programmable LED 9	Enum	0=None 1=Ok 3=Alarm		Status of programmable LED 9
Programmable LED 10	Enum	0=None 1=Ok 3=Alarm		Status of programmable LED 10
Programmable LED 11	Enum	0=None 1=Ok 3=Alarm		Status of programmable LED 11

3.4 Time synchronization

3.4.1 Time master supervision GNRLLTMS

3.4.1.1 Function block

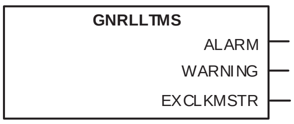


Figure 19: Function block

3.4.1.2 Functionality

The merging unit has an internal real-time clock which can be either free-running or synchronized from an external source. The real-time clock is used for time stamping events, recorded data and disturbance recordings.

The merging unit is provided with a 48 hour capacitor backup that enables the real-time clock to keep time in case of an auxiliary power failure.

The setting *Synch source* determines the method to synchronize the real-time clock. If it is set to “None”, the clock is free-running and the settings *Date* and *Time* can be used to set the time manually. Other setting values activate a communication protocol that provides the time synchronization. Only one synchronization method can be active at a time. IEEE 1588 v2 provides time master redundancy.

The merging unit supports IEEE 1588 v2 to update the real-time clock. IEEE 1588 v2 with GPS grandmaster clock provides the best accuracy ±1 µs.

The merging unit's 1588 time synchronization complies with the IEEE C37.238-2011 Power Profile, interoperable with IEEE 1588 v2. According to the power profile, the frame format used is IEEE 802.3 Ethernet frames with 88F7 Ethertype as communication service and the delay mechanism is P2P. *PTP announce mode* determines the format of PTP announce frames sent by the merging unit when acting as 1588 master, with options “Basic IEEE1588” and “Power Profile”. In the “Power Profile” mode, the TLVs required by the IEEE C37.238-2011 Power Profile are included in announce frames.

Time master supervision functionality is provided when the merging unit itself is synchronized from an external source (master). The EXCLKMSTR output is activate whenever the merging unit is configured with an external *Synch source* and synchronized by any external master. During the operation the ALARM and WARNING outputs can be used to supervise the external masters. The WARNING output is activated, if connection to the primary external master is lost. After losing the connection to the primary master at first, the ALARM output is activated in case no other acceptable master is found. The ALARM output can also be active, if the master clock accuracy is not within the limits. The ALARM and WARNING outputs are automatically deactivated, if the connection to the master is recovered. For 1588 systems, the time master supervision functionality also includes an automatic learning feature based on the system devices' PTP priority. For example, if the primary master device is replaced by a new device with a higher configured priority compared to the original primary master device, the new device becomes the new primary master. This also automatically deactivates the WARNING and ALARM outputs. The *Clear clock list* parameter is available via the HMI or PCM600 path **Configuration** > **Time** > **Synchronization** in case the old stored masters should be manually cleared.

3.4.1.3 Signals

GNRLLTMS output signals

Table 23: GNRLLTMS output signals

Name	Type	Description
ALARM	BOOLEAN	Time synchronization alarm
WARNING	BOOLEAN	Time synchronization warning
EXCLKMSTR	BOOLEAN	External Clock Master

3.4.1.4 Settings

Table 24: Time format

Parameter	Values (Range)	Unit	Step	Default	Description
Time format	1=24H:MM:SS:MS 2=12H:MM:SS:MS			1=24H:MM:SS:MS	Time format
Date format	1=DD.MM.YYYY 2=DD/MM/YYYY 3=DD-MM-YYYY 4=MM.DD.YYYY			1=DD.MM.YYYY	Date format

Parameter	Values (Range)	Unit	Step	Default	Description
	5=MM/DD/YYYY 6=YYYY-MM-DD 7=YYYY-DD-MM 8=YYYY/DD/MM				

Table 25: Time settings

Parameter	Values (Range)	Unit	Step	Default	Description
Synch source	0=None 3=IEEE 1588			3=IEEE 1588	Time synchronization source
PTP domain ID	0...255		1	0	The domain is identified by an integer, the domainNumber, in the range of 0 to 255.
PTP priority 1 [1]	0...255		1	128	PTP priority 1, in the range of 0 to 255.
PTP priority 2	0...255		1	128	PTP priority 2, in the range of 0 to 255.
PTP announce mode	1=Basic IEEE1588 2=Power Profile			1=Basic IEEE1588	PTP announce frame mode

Table 26: Time settings

Parameter	Values (Range)	Unit	Step	Default	Description
Date				0	Date
Time				0	Time
Local time offset	-840...840	min	1	0	Local time offset in minutes

Table 27: Time settings

Parameter	Values (Range)	Unit	Step	Default	Description
DST in use	0=False 1=True			1=True	DST in use setting
DST on time (hours)	0...23	h		2	Daylight saving time on, time (hh)
DST on time (minutes)	0...59	min		0	Daylight saving time on, time (mm)
DST on date (day)	1...31			1	Daylight saving time on, date (dd:mm)
DST on date (month)	1=January 2=February 3=March 4=April 5=May 6=June 7=July 8=August			5=May	Daylight saving time on, date (dd:mm)

Table continues on the next page

[1] Smaller value has higher priority

Parameter	Values (Range)	Unit	Step	Default	Description
	9=September 10=October 11=November 12=December				
DST on day (week-day)	0=reserved 1=Monday 2=Tuesday 3=Wednesday 4=Thursday 5=Friday 6=Saturday 7=Sunday			0=reserved	Daylight saving time on, day of week
DST off time (hours)	0...23	h		2	Daylight saving time off, time (hh)
DST off time (mi-nutes)	0...59	min		0	Daylight saving time off, time (mm)
DST off date (day)	1...31			25	Daylight saving time off, date (dd:mm)
DST off date (month)	1=January 2=February 3=March 4=April 5=May 6=June 7=July 8=August 9=September 10=October 11=November 12=December			9=September	Daylight saving time off, date (dd:mm)
DST off day (week-day)	0=reserved 1=Monday 2=Tuesday 3=Wednesday 4=Thursday 5=Friday 6=Saturday 7=Sunday			0=reserved	Daylight saving time off, day of week
DST offset	-720...720	min	1	60	Daylight saving time offset

3.5 Test mode

3.5.1 Function blocks

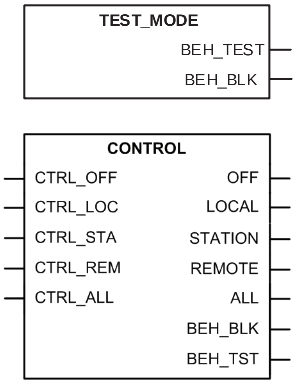


Figure 20: Function blocks

3.5.2 Functionality

The mode of all the logical nodes in the merging unit's IEC 61850 data model can be set with *Test mode*. *Test mode* is selected through one common parameter via the HMI path **Tests** > **IED test**. By default, *Test mode* can only be set through WHMI via front port RJ-45. *Test mode* is also available via IEC 61850 communication (LD0.LLN0.Mod).

Table 28: Test mode

Test mode	Description	TEST_MODE BEH_BLK
Normal mode	Normal operation	FALSE
IED blocked	Function working as in “Normal mode” but ACT configuration can be used to block physical outputs to process. Control function commands blocked.	TRUE
IED test	Function working as in “Normal mode” but in parallel with test parameters.	FALSE
IED test and blocked	Function working as in “Normal mode” but in parallel with test parameters. ACT configuration can be used to block physical outputs to process. Control function commands blocked.	TRUE

Behavior data objects in all logical nodes follow LD0.LLN0.Mod value. If "Normal mode" is selected, behaviour data objects follow mode (.Mod) data object of the corresponding logical device.

Vertical and horizontal communication is not blocked by the “IED blocked” or “IED test and blocked” modes.

3.5.3 Application configuration and Test mode

The physical outputs from control commands to process are blocked with ”IED blocked” and “IED test and blocked” modes. If physical outputs need to be blocked from the other functions, the application configuration must be used to block these signals. Blocking scheme needs to use `BEH_BLK` output of TEST_MODE function block.

3.5.4 Control mode

The mode of all logical nodes located under CTRL logical device can be set with *Control mode*. The *Control mode* parameter is available via the HMI or PCM600 path **Configuration** > **Control** > **General**. By default, *Control mode* can only be set through WHMI via front port RJ-45. *Control mode* inherits its value from *Test mode* but *Control mode* ”On”, “Blocked” and “Off” can also be set independently. *Control mode* is also available via IEC 61850 communication (CTRL.LLN0.Mod).

Table 29: Control mode

Control mode	Description	Control BEH_BLK
On	Normal operation	FALSE
Blocked	Control function commands blocked	TRUE
Off	Control functions disabled	FALSE

Behavior data objects under CTRL logical device follow CTRL.LLN0.Mod value. If "On" is selected, behavior data objects follow the mode of the corresponding logical device.

3.5.5 Application configuration and Control mode

The physical outputs from commands to process are blocked with “Blocked“ mode. If physical outputs need to be blocked totally, meaning also commands from the binary inputs, the application configuration must be used to block these signals. Blocking scheme uses `BEH_BLK` output of CONTROL function block.

3.5.6 Authorization

By default, *Test mode* and *Control mode* can only be set via WHMI using the RJ-45 front port. It is possible to write test mode by remote client, if it is needed in configuration. This is also done via WHMI using the RJ-45 front port only by setting the *Remote test mode* parameter via **Tests** > **IED test** > **Test mode**. Remote operation is possible only when the control position of the merging unit is in remote position. Local and remote control can be selected via Control function block in application configuration.

When using the Signal Monitoring tool to force online values, the following conditions need to be met.

- *Remote force* is set to “All levels”
- *Test mode* is enabled
- Control position of the merging unit is in remote position

Table 30: Remote test mode

Remote test mode	61850-8-1-MMS	WHMI/PCM600
Off	No access	No access
Maintenance	Command originator category maintenance	No access
All levels	All originator categories	Yes

3.5.7 LHMI indications

The green Ready LED flashes to indicate that the “IED test and blocked” mode or "IED test" mode is activated.

3.5.8 Signals

3.5.8.1 CONTROL input signals

Table 31: CONTROL input signals

Name	Type	Default	Description
CTRL_OFF	BOOLEAN	0	Control OFF
CTRL_LOC	BOOLEAN	0	Control local
CTRL_STA	BOOLEAN	0	Control station
CTRL_REM	BOOLEAN	0	Control remote
CTRL_ALL	BOOLEAN	0	Control all

3.5.8.2 TEST_MODE output signals

Table 32: TEST_MODE output signals

Name	Type	Description
BEH_BLK	BOOLEAN	Logical device LD0 block status
BEH_TST	BOOLEAN	Logical device LD0 test status

3.5.8.3 CONTROL output signals

Table 33: CONTROL output signals

Name	Type	Description
OFF	BOOLEAN	Control OFF
LOCAL	BOOLEAN	Control local
STATION	BOOLEAN	Control station

Table continues on the next page

Name	Type	Description
REMOTE	BOOLEAN	Control remote
ALL	BOOLEAN	Control all
BEH_BLK	BOOLEAN	Logical device LD0 block status
BEH_TST	BOOLEAN	Logical device LD0 test status

3.6 Nonvolatile memory

In addition to the setting values, the merging unit can store some data in the nonvolatile memory.

- Up to 1024 events are stored. The stored events are visible in WHMI and Event viewer tool in PCM600.
- Circuit breaker condition monitoring
- Latched alarm LEDs' statuses
- Trip circuit lockout
- Counter values

3.7 Sensor inputs for currents and voltages

This chapter gives short examples on how to define the correct parameters for sensor measurement interfaces.

Sensors can have correction factors, measured and verified by the sensor manufacturer, to increase the measurement accuracy. Correction factors are recommended to be set to the relay. Two types of correction factors are available for voltage and current (Rogowski) sensors. The Amplitude correction factor is named *Amplitude corr. A(B/C)* and Angle correction factor is named *Angle corr A(B/C)*. These correction factors can be found on the Sensor's rating plate and/or sensor routine test protocol. If the correction factors are not available, contact the sensor manufacturer for more information.

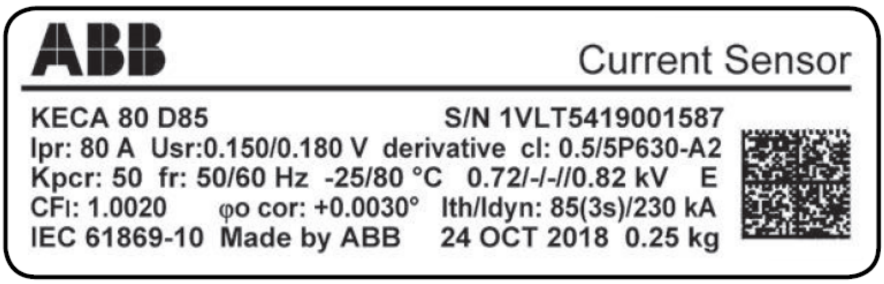


Figure 21: Example of ABB Rogowski current sensor KECA 80 D85 rating plate

Current (Rogowski) sensor setting example

In this example, an 80 A/0.150 V at 50 Hz (0.180 V at 60 Hz) sensor, such as the example shown in *Figure 21*, is used in a 50 Hz electrical network. The application has a 150 A nominal current (In) corresponding to the protected object's nominal current. The application nominal current is set to Rogowski sensor setting *Primary current*. Taken from the sensor's technical data, this example sensor can be used with up to 4000 A application nominal current. As the Rogowski sensor is linear and does not saturate, the 80 A/0.150 V at 50 Hz sensor also works as a 150 A/0.28125 V at 50 Hz sensor. When defining another primary value for the sensor, also the nominal voltage has to be redefined to maintain the same transformation ratio. However, the setting in the protection relay (*Rated Secondary Value*) is not in V but in mV/Hz, which makes the same setting *Rated Secondary Value* valid for both 50 and 60 Hz nominal frequency.

$$RSV = \frac{\frac{I_n}{I_{pr}} \times K_r}{f_n}$$

(Equation 1)

RSV	*Rated Secondary Value* in mV/Hz
I_n	Application nominal current
I_{pr}	Sensor-rated primary current
f_n	Network nominal frequency
K_r	Sensor-rated voltage at the rated current in mV

In this example, the value is as calculated using the equation.

$$\frac{\frac{150A}{80A} \times 150mV}{50Hz} = 5.625\frac{mV}{Hz}$$

(Equation 2)

With this information, the protection relay's current (Rogowski) sensor settings can be set.

Table 34: Example setting values for current (Rogowski) sensor

Setting	Value
Primary current	150 A
Rated secondary value	5.625 mV/Hz

When considering setting values for current sensor interfaces and for protection functions utilizing these measurements, it should be noted that the sensor measurement inputs in the relay have limits for linear behavior. When this limit is exceeded, the input starts to saturate. The saturation is reflected to the protection functions connected to the sensor inputs. To ensure that the related protection functions operate correctly, the start value setting for protection functions utilizing either instantaneous or definite minimum time characteristics must not exceed the linear measurement range. Furthermore, the effect on protection functions utilizing inverse time characteristics should be considered. The upper limit of the linear measurement range depends on the selected application nominal current and the type of the current sensor used. *Table 34* shows the limits for an 80A/150mV 50Hz sensor.

Table 35: Application nominal current relation to the upper limit of linear measurement range

Application nominal current (In)	Rated secondary value with 80A / 0.150 V at 50 Hz (0.180 V at 60 Hz)	Upper limit of linear measurement range
40...800 A	1.500...30.000 mV/Hz	60 × I_n
800...1250 A	30.000...46.875 mV/Hz	60...40 × I_n
1250...2500 A	46.875...93.750 mV/Hz	40...20 × I_n
2500...4000 A	93.750...150.000 mV/Hz	20...12.5 × I_n

Table 35 shows the upper limits of the linear measurement range based on a certain range in application nominal current. The linear measurement limit for a given application nominal current can be derived from the values stated in the table with a simple proportion equation. For example, the upper limit for linear measurement for 3000 A application nominal current would be 17.5 xIn.

It can also be calculated from *Table 35* that with the stated sensor the relay input can linearly measure up to 50 kA (RMS) short circuit currents.

Rogowski sensor and overcurrent protection setting evaluation example

A 20 kV utility substation with a single busbar switchgear rated up to 40 kA shortcircuit currents has one incomer and 20 outgoing feeder relays using 80 A/0.150 V at 50 Hz Rogowski current sensors with rating plate values similar to *Figure 21*. For the incomer panel, electrical system designer has evaluated the application nominal current to be 1250 A. Customer specification for these protection relays defines normal instantaneous and time-delayed overcurrent and earth-fault protection functions. Overcurrent protection requires functions to be settable up to 20 xIn.

The sensor setting *Primary current* is set to be the same as the evaluated application nominal current 1250 A. According to the sensor's technical data, the application nominal current matches the sensor's capability which is up to 4000 A.

The setting *Rated secondary value* is calculated by using *Equation 2*.

$$\frac{\frac{1250A}{80A}\cdot 150mV}{50Hz} = 46.875\frac{mV}{Hz}$$

(Equation 3)

From *Table 35* it is seen that with the 1250 A application nominal current value, the maximum setting for overcurrent protection is 40 xIn. This covers the customer specification requirements for overcurrent settings of up to 20 xIn.

Voltage sensor setting example

The voltage sensor is based on the resistive divider or capacitive divider principle. Therefore, the voltage is linear throughout the whole measuring range. The output signal is a voltage, directly proportional to the primary voltage. For the voltage sensor, all parameters are readable directly from its rating plate and/or sensor routine test protocol, and conversions are not needed.

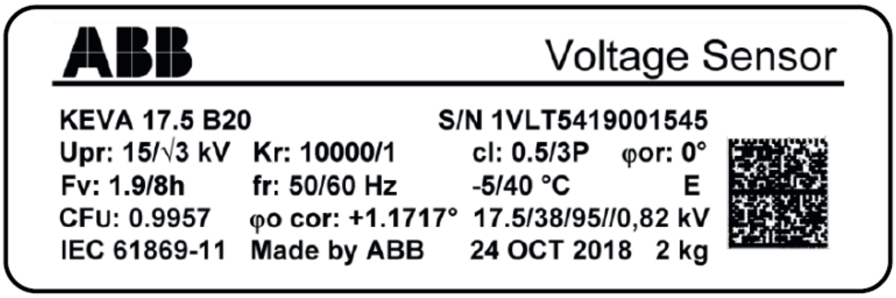


Figure 22: Example of ABB voltage sensor KEVA 17.5 B21 rating plate

In this example the system phase-to-phase voltage rating is 10 kV. Thus, the *Primary voltage* parameter is set to 10 kV. For protection relays with sensor measurement support, the *Voltage input type* is set to "Voltage sensor". The VT connection parameter is set to the "WYE" type. The division ratio for ABB voltage sensors is most often 10000:1. Thus, the *Division ratio* parameter is usually set to "10000". The primary voltage is proportionally divided by this division ratio.

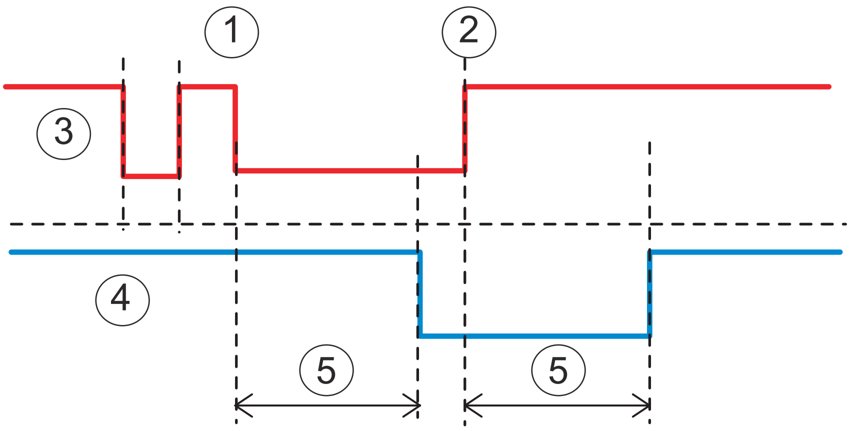
Table 36: Example setting values for voltage sensor

Setting	Value
Primary voltage	10 kV
VT connection	Wye
Voltage input type	3=Voltage sensor
Division ratio	10000

3.8 Binary input

3.8.1 Binary input filter time

The filter time eliminates debounces and short disturbances on a binary input. The filter time is set for each binary input of the merging unit.



1 t_0
2 t_1
3 Input signal
4 Filtered input signal
5 Filter time

Figure 23: Binary input filtering

At the beginning, the input signal is at the high state, the short low state is filtered and no input state change is detected. The low state starting from the time t_0 exceeds the filter time, which means that the change in the input state is detected and the time tag attached to the input change is t_0. The high state starting from t_1 is detected and the time tag t_1 is attached.

Each binary input has a filter time parameter "Input # filter", where # is the number of the binary input of the module in question (for example "Input 1 filter").

Table 37: Input filter parameter values

Parameter	Values	Default
Input # filter time	5...1000 ms	5 ms

3.8.2 Binary input inversion

The parameter *Input # invert* is used to invert a binary input.

Table 38: Binary input states

Control voltage	Input # invert	State of binary input
No	0	FALSE (0)
Yes	0	TRUE (1)
No	1	TRUE (1)
Yes	1	FALSE (0)

When a binary input is inverted, the state of the input is TRUE (1) when no control voltage is applied to its terminals. Accordingly, the input state is FALSE (0) when a control voltage is applied to the terminals of the binary input.

3.8.3 Oscillation suppression

Oscillation suppression is used to reduce the load from the system when a binary input starts oscillating. A binary input is regarded as oscillating if the number of valid state changes (= number of events after filtering) during one second is equal to or greater than the set oscillation level value. During oscillation, the binary input is blocked (the status is invalid) and an event is generated. The state of the input will not change when it is blocked, that is, its state depends on the condition before blocking.

The binary input is regarded as non-oscillating if the number of valid state changes during one second is less than the set oscillation level value minus the set oscillation hysteresis value. Note that the oscillation hysteresis must be set lower than the oscillation level to enable the input to be restored from oscillation. When the input returns to a non-oscillating state, the binary input is deblocked (the status is valid) and an event is generated.

Table 39: Oscillation parameter values

Parameter	Values	Default
Input osc. level	2...50 events/s	30 events/s
Input osc. hyst	2...50 events/s	10 events/s

3.9 Binary outputs

The merging unit provides a number of binary outputs used for tripping, executing local or remote control actions of a breaker or a disconnector, and for connecting the merging unit to external annunciation equipment for indicating, signalling and recording.

Power output contacts are used when the current rating requirements of the contacts are high, for example, for controlling a breaker, such as energizing the breaker trip and closing coils.

The contacts used for external signalling, recording and indicating, the signal outputs, need to adjust to smaller currents, but they can require a minimum current (burden) to ensure a guaranteed operation.

The merging unit provides both power output and signal output contacts. To guarantee proper operation, the type of the contacts used are chosen based on the operating and reset time, continuous current rating, make and carry for short time, breaking rate and minimum connected burden. A combination of series or parallel contacts can also be used for special applications. When appropriate, a signal output can also be used to energize an external trip relay, which in turn can be confiugred to energize the breaker trip or close coils.

Using an external trip relay can require an external trip circuit supervision relay.

All contacts are freely programmable, except the internal fault output IRF.

3.9.1 Power output contacts

Power output contacts are normally used for energizing the breaker closing coil and trip coil, external high burden lockout or trip relays.

3.9.1.1 Dual single-pole power outputs PO1 and PO2

Dual (series-connected) single-pole (normally open/form A) power output contacts PO1 and PO2 are rated for continuous current of 8 A. The contacts are normally used for closing circuit breakers and energizing high burden trip relays. They can be arranged to trip the circuit breakers when the trip circuit supervision is not available or when external trip circuit supervision relay is provided.

The power outputs are included in slot X100 of the power supply module.

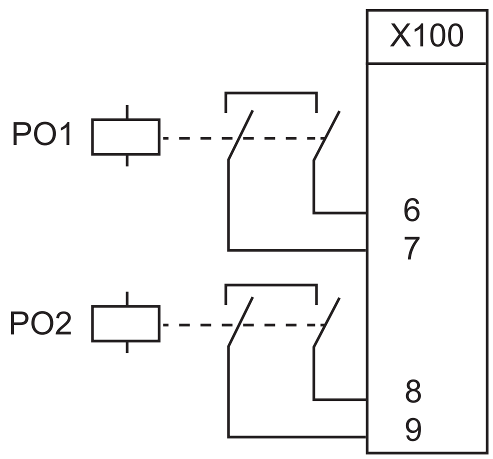


Figure 24: Dual single-pole power output contacts PO1 and PO2

3.9.1.2 Double-pole power outputs PO3 and PO4 with trip circuit supervision

The power outputs PO3 and PO4 are double-pole normally open/form A power outputs with trip circuit supervision.

When the two poles of the contacts are connected in series, they have the same technical specification as PO1 for breaking duty. The trip circuit supervision hardware and associated functionality which can supervise the breaker coil both during closing and opening condition are also provided. Contacts PO3 and PO4 are almost always used for energizing the breaker trip coils.

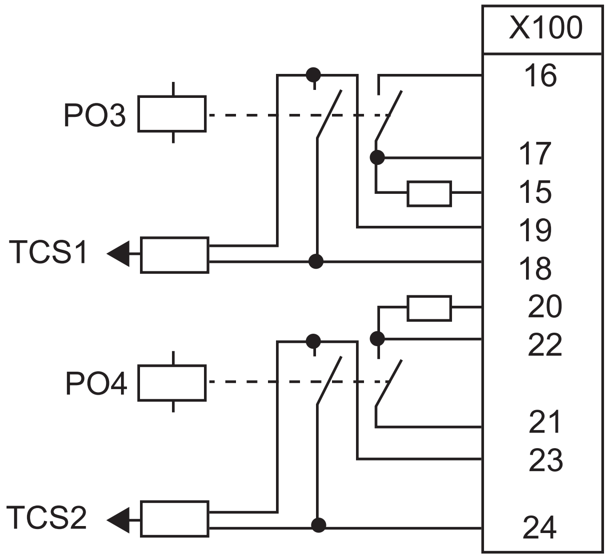


Figure 25: Double-pole power outputs PO3 and PO4 with trip circuit supervision

Power outputs PO3 and PO4 are included in the power supply module located in slot X100 of the merging unit.

3.9.1.3 Dual single-pole high-speed power outputs HSO1, HSO2 and HSO3

HSO1, HSO2 and HSO3 are dual parallel connected, single-pole, normally open/form A high-speed power outputs. The high-speed power output is a hybrid discrete and electromechanical output that is rated as a power output.

The outputs are normally used in applications that require fast relay output contact activation time to achieve fast opening of a breaker, such as, arc-protection or breaker failure protection, where fast operation is required either to minimize fault effects to the equipment or to avoid a fault to expand to a larger area. With the high-speed outputs, the total time from the application to the relay output contact activation is 5...6 ms shorter than when using output contacts with conventional mechanical output relays. The high-speed power outputs have a continuous rating of 6 A.

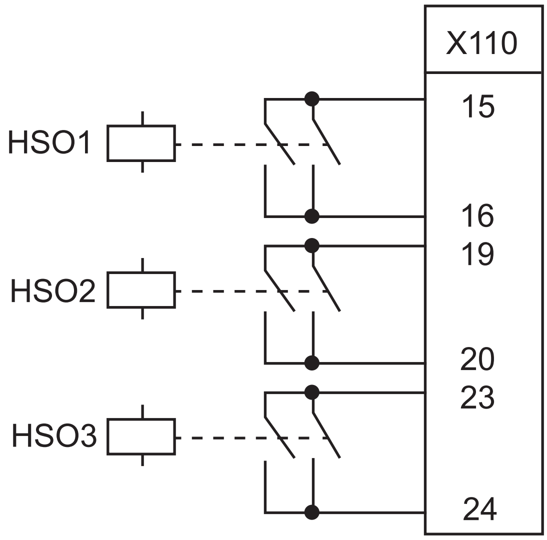


Figure 26: High-speed power outputs HSO1, HSO2 and HSO3

The reset time of the high-speed output contacts is longer than that of the conventional output contacts.

High-speed power contacts are part of the card BIO0007 with eight binary inputs and three HSOs.

3.9.2 Signal output contacts

Signal output contacts are single-pole, single (normally open/form A or change-over/form C) signal output contacts (SO1, SO2,...) or parallel connected dual contacts.

The signal output contacts are used for energizing, for example, external low burden trip relays, auxiliary relays, annunciators and LEDs.

A single signal contact is rated for a continuous current of 5 A. It has a make and carry for 0.5 seconds at 15 A.

When two contacts are connected in parallel, the relay is of a different design. It has the make and carry rating of 30 A for 0.5 seconds. This can be applied for energizing breaker close coil and tripping coil. Due to the limited breaking capacity, a breaker auxiliary contact can be required to break the circuit.

3.9.2.1 Internal fault signal output IRF

The internal fault signal output (change-over/form C) IRF is a single contact included in the power supply module of the merging unit.

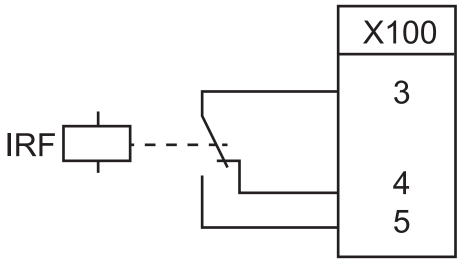


Figure 27: Internal fault signal output IRF

3.9.2.2 Signal outputs SO1 and SO2 in power supply module

Signal outputs (normally open/form A or change-over/form C) SO1 (dual parallel form C) and SO2 (single contact/form A) are part of the power supply module of the merging unit.

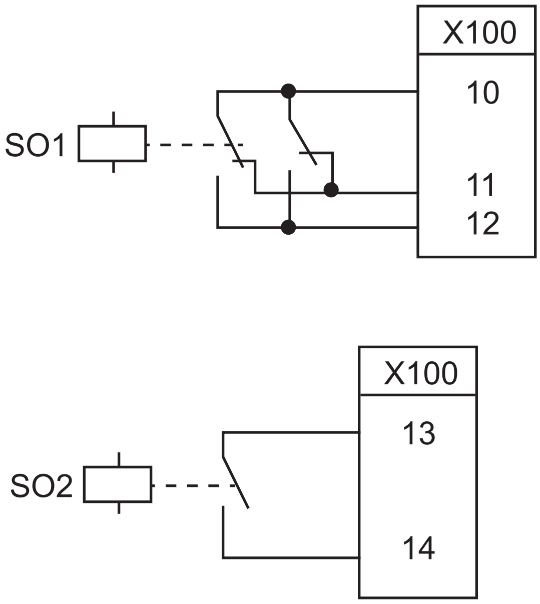


Figure 28: Signal outputs SO1 and SO2 in power supply module

3.10 SMV function blocks

SMV function blocks are used in the process bus applications with the sending of the sampled values of analog currents and voltages.

3.10.1 IEC 61850-9-2 LE sampled values sending SMVSENDER

3.10.1.1 Functionality

The SMVSENDER function block is used for activating the SMV sending functionality. It adds/removes the sampled value control block and the related data set into/from the sending device's configuration. It has no input or output signals.

SMVSENDER can be disabled with the *Operation* setting value “off”. If the SMVSENDER is disabled from the front port WHMI, it can only be enabled from the front port WHMI. When disabled, the sending of the samples values is disabled.

3.10.1.2 Settings

Table 40: SMVSENDER Settings

Parameter	Values (Range)	Unit	Step	Default	Description
Operation	1=on 5=off			1=on	Operation

3.10.2 xLTxTR function block

3.10.2.1 Function block

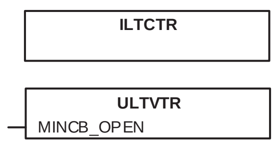


Figure 29: Function block

3.10.2.2 Operation principle

The MINCB_OPEN input signal is supposed to be connected through a binary input to the NC auxiliary contact of the miniature circuit breaker protecting the VT secondary circuit. The MINCB_OPEN signal sets the FUSEF_U output signal to block all the voltage-related functions when MCB is in the open state.

3.10.2.3 Signals

ULTVTR1_vt Input signals

Table 41: ULTVTR1_vt Input signals

Name	Type	Default	Description
MINCB_OPEN	BOOLEAN	0=False	Active when external MCB opens protected voltage circuit

3.10.2.4 Settings

ILTCTR1 Non group settings (Basic)

Table 42: ILTCTR1 Non group settings (Basic)

Parameter	Values (Range)	Unit	Step	Default	Description
Primary current	1.0...6000.0	A	0.1	100.0	Rated primary current
Secondary current	2=1A 3=5A			2=1A	Rated secondary current
Amplitude Corr A	0.9000...1.1000		0.0001	1.0000	Phase A amplitude correction factor
Amplitude Corr B	0.9000...1.1000		0.0001	1.0000	Phase B amplitude correction factor
Amplitude Corr C	0.9000...1.1000		0.0001	1.0000	Phase C amplitude correction factor
Nominal current	39...4000	A	1	1300	Network Nominal Current (In)
Rated secondary Val	1.000...150.000	mV/Hz	0.001	3000	Rated Secondary Value (RSV) ratio

ILTCTR1 Non group settings (Advanced)

Table 43: ILTCTR1 Non group settings (Advanced)

Parameter	Values (Range)	Unit	Step	Default	Description
Reverse polarity	0=False 1=True			0=False	Reverse the polarity of the phase CTs

ULTVTR1_vt Non group settings (Basic)

Table 44: ULTVTR1_vt Non group settings (Basic)

Parameter	Values (Range)	Unit	Step	Default	Description
Primary voltage	0.100...440.000	kV	0.001	20.000	Primary rated voltage
Secondary voltage	60...210	V	1	100	Secondary rated voltage
VT connection	1=Wye 2=Delta			2=Delta	Voltage transducer measurement connection
Amplitude Corr A	0.9000...1.1000		0.0001	1.0000	Phase A Voltage phasor magnitude correction of an external voltage transformer
Amplitude Corr B	0.9000...1.1000		0.0001	1.0000	Phase B Voltage phasor magnitude correction of an external voltage transformer
Amplitude Corr C	0.9000...1.1000		0.0001	1.0000	Phase C Voltage phasor magnitude correction of an external voltage transformer

Table continues on the next page

Parameter	Values (Range)	Unit	Step	Default	Description
Division ratio	1000...20000		1	10000	Voltage sensor division ratio
Voltage input type	1=Voltage trafo 3=CVD sensor			1=Voltage trafo	Type of the voltage input
Angle Corr A	-8.000 … 8.000 deg	deg	0.0001	0.0000	Phase A Voltage phasor angle correction of an external voltage transformer
Angle Corr B	-8.000 … 8.000 deg	deg	0.0001	0.0000	Phase B Voltage phasor angle correction of an external voltage transformer
Angle Corr C	-8.000 … 8.000 deg	deg	0.0001	0.0000	Phase C Voltage phasor angle correction of an external voltage transformer

3.10.3 RESTCTR function block

3.10.3.1 Function block

Figure 30: Function block

3.10.3.2 Settings

RESTCTR1_ct Non group settings (Basic)

Table 45: RESTCTR1_ct Non group settings (Basic)

Parameter	Values (Range)	Unit	Step	Default	Description
Primary current	1.0...6000.0	A	0.1	100.0	Primary current
Secondary current	1=0.2A 2=1A 3=5A			2=1A	Secondary current
Amplitude Corr	0.9000...1.1000		0.0001	1.0000	Amplitude correction

RESTCTR1_ct Non group settings (Advanced)

Table 46: RESTCTR1_ct Non group settings (Advanced)

Parameter	Values (Range)	Unit	Step	Default	Description
Reverse polarity	0=False 1=True			0=False	Reverse the polarity of the residual CT

3.11 GOOSE function blocks

GOOSE function blocks are used for connecting incoming GOOSE data to application. They support BOOLEAN, Dbpos, Enum, FLOAT32, INT8 and INT32 data types.

Common signals

The VALID output indicates the validity of received GOOSE data, which means in case of valid, that the GOOSE communication is working and received data quality bits (if configured) indicate good process data. Invalid status is caused either by bad data quality bits or GOOSE communication failure. See IEC 61850 engineering guide for details.

The OUT output passes the received GOOSE value for the application. Default value (0) is used if VALID output indicates invalid status. The IN input is defined in the GOOSE configuration and can always be seen in SMT sheet.

Settings

The GOOSE function blocks do not have any parameters available in PCM600.

3.11.1 GOOSERCV_BIN function block

3.11.1.1 Function block

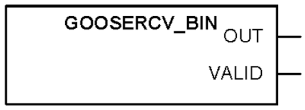


Figure 31: Function block

3.11.1.2 Functionality

The GOOSERCV_BIN function is used to connect the GOOSE binary inputs to the application.

3.11.1.3 Signals

GOOSERCV_BIN Output signals

Table 47: GOOSERCV_BIN Output signals

Name	Type	Description
OUT	BOOLEAN	Output signal
VALID	BOOLEAN	Output signal

3.11.2 GOOSERCV_DP function block

3.11.2.1 Function block

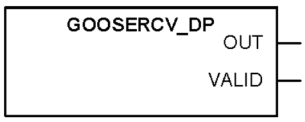


Figure 32: Function block

3.11.2.2 Functionality

The GOOSERCV_DP function is used to connect the GOOSE double binary inputs to the application.

3.11.2.3 Signals

GOOSERCV_DP Output signals

Table 48: GOOSERCV_DP Output signals

Name	Type	Description
OUT	Dbpos	Output signal
VALID	BOOLEAN	Output signal

3.11.3 GOOSERCV_INT8 function block

3.11.3.1 Function block

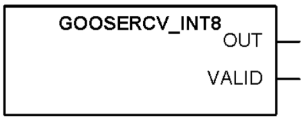


Figure 33: Function block

3.11.3.2 Functionality

The GOOSERCV_INT8 function is used to connect the GOOSE 8 bit integer inputs to the application.

3.11.3.3 Signals

GOOSERCV_INT8 Output signals

Table 49: GOOSERCV_INT8 Output signals

Name	Type	Description
OUT	INT8	Output signal
VALID	BOOLEAN	Output signal

3.11.4 GOOSERCV_INTL function block

3.11.4.1 Function block

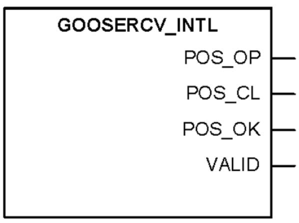


Figure 34: Function block

3.11.4.2 Functionality

The GOOSERCV_INTL function is used to connect the GOOSE double binary input to the application and extracting single binary position signals from the double binary position signal.

The OP output signal indicates that the position is open. Default value (0) is used if VALID output indicates invalid status.

The CL output signal indicates that the position is closed. Default value (0) is used if VALID output indicates invalid status.

The OK output signal indicates that the position is neither in faulty or intermediate state. The default value (0) is used if VALID output indicates invalid status.

3.11.4.3 Signals

GOOSERCV_INTL Output signals

Table 50: GOOSERCV_INTL Output signals

Name	Type	Description
POS_OP	BOOLEAN	Position open output signal
POS_CL	BOOLEAN	Position closed output signal
POS_OK	BOOLEAN	Position OK output signal
VALID	BOOLEAN	Output signal

3.11.5 GOOSERCV_ENUM function block

3.11.5.1 Function block

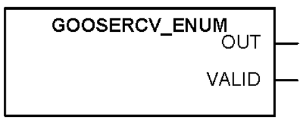


Figure 35: Function block

3.11.5.2 Functionality

The GOOSERCV_ENUM function block is used to connect GOOSE enumerator inputs to the application.

3.11.5.3 Signals

GOOSERCV_ENUM Output signals

Table 51: GOOSERCV_ENUM Output signals

Name	Type	Description
OUT	Enum	Output signal
VALID	BOOLEAN	Output signal

3.11.6 GOOSERCV_INT32 function block

3.11.6.1 Function block

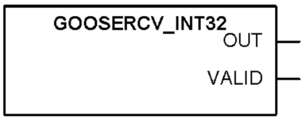


Figure 36: Function block

3.11.6.2 Functionality

The GOOSERCV_INT32 function block is used to connect GOOSE 32 bit integer inputs to the application.

3.11.6.3 Signals

GOOSERCV_INT32 Output signals

Table 52: GOOSERCV_INT32 Output signals

Name	Type	Description
OUT	INT32	Output signal
VALID	BOOLEAN	Output signal

3.12 Type conversion function blocks

3.12.1 QTY_GOOD function block

3.12.1.1 Function block

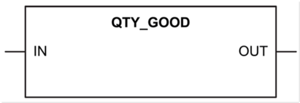


Figure 37: Function block

3.12.1.2 Functionality

The QTY_GOOD function block evaluates the quality bits of the input signal and passes it as a Boolean signal for the application.

The IN input can be connected to any logic application signal (logic function output, binary input, application function output or received GOOSE signal). Due to application logic quality bit propagation, each (simple and even combined) signal has quality which can be evaluated.

The OUT output indicates quality good of the input signal. Input signals that have no quality bits set or only test bit is set, will indicate quality good status.

3.12.1.3 Signals

QTY_GOOD Input signals

Table 53: QTY_GOOD Input signals

Name	Type	Default	Description
IN	Any	0	Input signal

QTY_GOOD Output signals

Table 54: QTY_GOOD Output signals

Name	Type	Description
OUT	BOOLEAN	Output signal

3.12.2 QTY_BAD function block

3.12.2.1 Function block

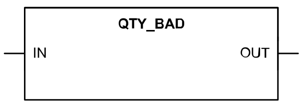


Figure 38: Function block

3.12.2.2 Functionality

The QTY_BAD function block evaluates the quality bits of the input signal and passes it as a Boolean signal for the application.

The IN input can be connected to any logic application signal (logic function output, binary input, application function output or received GOOSE signal). Due to application logic quality bit propagation, each (simple and even combined) signal has quality which can be evaluated.

The OUT output indicates quality bad of the input signal. Input signals that have any other than test bit set, will indicate quality bad status.

3.12.2.3 Signals

QTY_BAD Input signals

Table 55: QTY_BAD Input signals

Name	Type	Default	Description
IN	Any	0	Input signal

QTY_BAD Output signals

Table 56: QTY_BAD Output signals

Name	Type	Description
OUT	BOOLEAN	Output signal

3.12.3 QTY_GOOSE_COMM function block

3.12.3.1 Function block

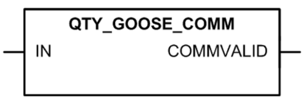


Figure 39: Function block

3.12.3.2 Functionality

The QTY_GOOSE_COMM function block evaluates the peer device communication status from the quality bits of the input signal and passes it as a Boolean signal to the application.

The IN input can be connected to any GOOSE application logic output signal, for example, GOOSERCV_BIN.

The OUT output indicates the communication status of the GOOSE function block. When the output is in the true (1) state, the GOOSE communication is active. The value false (0) indicates communication timeout.

3.12.3.3 Signals

QTY_GOOSE_COMM Input signals

Table 57: QTY_GOOSE_COMM Input signals

Name	Type	Default	Description
IN	Any	0	Input signal

QTY_GOOSE_COMM Output signals

Table 58: QTY_GOOSE_COMM Output signals

Name	Type	Description
COMMVALID	BOOLEAN	Output signal

3.12.4 T_HEALTH function block

3.12.4.1 Function block

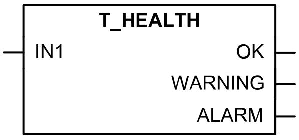


Figure 40: Function block

3.12.4.2 Functionality

The T_HEALTH function evaluates enumerated data of "Health" data attribute. This function block can only be used with GOOSE.

The IN input can be connected to GOOSERCV_ENUM function block, which is receiving the LD0.LLN0.Health.stVal data attribute sent by another device.

The outputs OK, WARNING and ALARM are extracted from the enumerated input value. Only one of the outputs can be active at a time. In case the GOOSERCV_ENUM function block does not receive the value from the sending device or it is invalid, the default value (0) is used and the ALARM is activated in the T_HEALTH function block.

3.12.4.3 Signals

T_HEALTH Input signals

Table 59: T_HEALTH Input signals

Name	Type	Default	Description
IN1	Any	0	Input signal

T_HEALTH Output signals

Table 60: T_HEALTH Output signals

Name	Type	Description
OK	BOOLEAN	Output signal
WARNING	BOOLEAN	Output signal
ALARM	BOOLEAN	Output signal

3.12.5 T_F32_INT8 function block

3.12.5.1 Function block

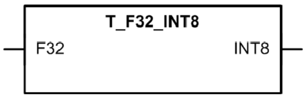


Figure 41: Function block

3.12.5.2 Functionality

The T_F32_INT8 function is used to convert 32-bit floating type values to 8-bit integer type. The rounding operation is included. Output value saturates if the input value is below the minimum or above the maximum value.

3.12.5.3 Signals

T_F32_INT8 Input signals

Table 61: T_F32_INT8 Input signals

Name	Type	Default	Description
F32	FLOAT32	0.0	Input signal

T_F32_INT8 Output signal

Table 62: T_F32_INT8 Output signal

Name	Type	Description
INT8	INT8	Output signal

3.12.6 T_DIR function block

3.12.6.1 Function block

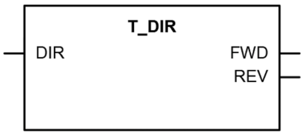


Figure 42: Function block

3.12.6.2 Functionality

The T_DIR function evaluates enumerated data of the FAULT_DIR data attribute of the directional functions. T_DIR can only be used with GOOSE.

The DIR input can be connected to the GOOSERCV_ENUM function block, which is receiving the LD0.<function>.Str.dirGeneral or LD0.<function>.Dir.dirGeneral data attribute sent by another device.

In case the GOOSERCV_ENUM function block does not receive the value from the sending device or it is invalid, the default value (0) is used in function outputs.

The outputs FWD and REV are extracted from the enumerated input value.

3.12.6.3 Signals

T_DIR Input signals

Table 63: T_DIR Input signals

Name	Type	Default	Description
DIR	Enum	0	Input signal

T_DIR Output signals

Table 64: T_DIR Output signals

Name	Type	Default	Description
FWD	BOOLEAN	0	Direction forward
REV	BOOLEAN	0	Direction backward

3.12.7 T_TCMD function block

3.12.7.1 Function block

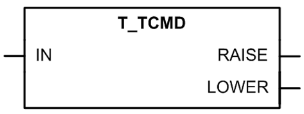


Figure 43: Function block

3.12.7.2 Functionality

The T_TCMD function is used to convert enumerated input signal to Boolean output signals.

Table 65: Conversion from enumerated to Boolean

IN	RAISE	LOWER
0	FALSE	FALSE
1	FALSE	TRUE
2	TRUE	FALSE
x	FALSE	FALSE

3.12.7.3 Signals

T_TCMD input signals

Table 66: T_TCMD input signals

Name	Type	Default	Description
IN	Enum	0	Input signal

T_TCMD output signals

Table 67: T_TCMD output signals

Name	Type	Description
RAISE	BOOLEAN	Raise command
LOWER	BOOLEAN	Lower command

3.12.8 T_TCMD_BIN function block

3.12.8.1 Function block

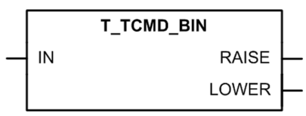


Figure 44: Function block

3.12.8.2 Functionality

The T_TCMD_BIN function is used to convert 32 bit integer input signal to Boolean output signals.

Table 68: Conversion from integer to Boolean

IN	RAISE	LOWER
0	FALSE	FALSE
1	FALSE	TRUE
2	TRUE	FALSE
x	FALSE	FALSE

3.12.8.3 Signals

T_TCMD_BIN input signals

Table 69: T_TCMD_BIN input signals

Name	Type	Default	Description
IN	INT32	0	Input signal

T_TCMD_BIN output signals

Table 70: T_TCMD_BIN output signals

Name	Type	Description
RAISE	BOOLEAN	Raise command
LOWER	BOOLEAN	Lower command

3.12.9 T_BIN_TCMD function block

3.12.9.1 Function block

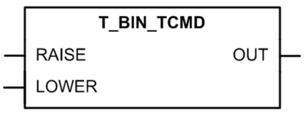


Figure 45: Function block

3.12.9.2 Functionality

The T_BIN_TCMD function is used to convert Boolean input signals to 32 bit integer output signals.

Table 71: Conversion from Boolean to integer

RAISE	LOWER	OUT
FALSE	FALSE	0
FALSE	TRUE	1
TRUE	FALSE	2

3.12.9.3 Signals

T_BIN_TCMD input signals

Table 72: T_BIN_TCMD input signals

Name	Type	Default	Description
RAISE	BOOLEAN	0	Raise command
LOWER	BOOLEAN	0	Lower command

T_BIN_TCMD output signals

Table 73: T_BIN_TCMD output signals

Name	Type	Description
OUT	INT32	Output signal

3.13 Configurable logic blocks

3.13.1 Standard configurable logic blocks

3.13.1.1 OR function block

Function block

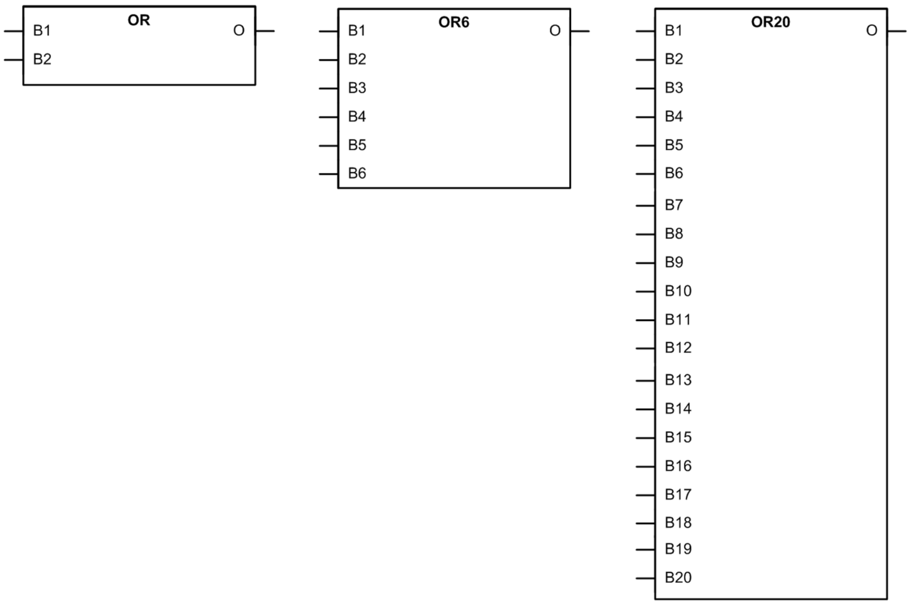


Figure 46: Function blocks

Functionality

OR, OR6 and OR20 are used to form general combinatory expressions with Boolean variables.

The O output is activated when at least one input has the value TRUE. The default value of all inputs is FALSE, which makes it possible to use only the required number of inputs and leave the rest disconnected.

OR has two inputs, OR6 six and OR20 twenty inputs.

Signals

OR Input signals

Table 74: OR Input signals

Name	Type	Default	Description
B1	BOOLEAN	0	Input signal 1
B2	BOOLEAN	0	Input signal 2

OR6 Input signals

Table 75: OR6 Input signals

Name	Type	Default	Description
B1	BOOLEAN	0	Input signal 1
B2	BOOLEAN	0	Input signal 2

Table continues on the next page

Name	Type	Default	Description
B3	BOOLEAN	0	Input signal 3
B4	BOOLEAN	0	Input signal 4
B5	BOOLEAN	0	Input signal 5
B6	BOOLEAN	0	Input signal 6

OR20 Input signals

Table 76: OR20 Input signals

Name	Type	Default	Description
B1	BOOLEAN	0	Input signal 1
B2	BOOLEAN	0	Input signal 2
B3	BOOLEAN	0	Input signal 3
B4	BOOLEAN	0	Input signal 4
B5	BOOLEAN	0	Input signal 5
B6	BOOLEAN	0	Input signal 6
B7	BOOLEAN	0	Input signal 7
B8	BOOLEAN	0	Input signal 8
B9	BOOLEAN	0	Input signal 9
B10	BOOLEAN	0	Input signal 10
B11	BOOLEAN	0	Input signal 11
B12	BOOLEAN	0	Input signal 12
B13	BOOLEAN	0	Input signal 13
B14	BOOLEAN	0	Input signal 14
B15	BOOLEAN	0	Input signal 15
B16	BOOLEAN	0	Input signal 16
B17	BOOLEAN	0	Input signal 17
B18	BOOLEAN	0	Input signal 18
B19	BOOLEAN	0	Input signal 19
B20	BOOLEAN	0	Input signal 20

OR Output signal

Table 77: OR Output signal

Name	Type	Description
O	BOOLEAN	Output signal

OR6 Output signal

Table 78: OR6 Output signal

Name	Type	Description
O	BOOLEAN	Output signal

OR20 Output signal

Table 79: OR20 Output signal

Name	Type	Description
O	BOOLEAN	Output signal

Settings

The function does not have any parameters available in PCM600.

3.13.1.2 AND Function block

AND Function block

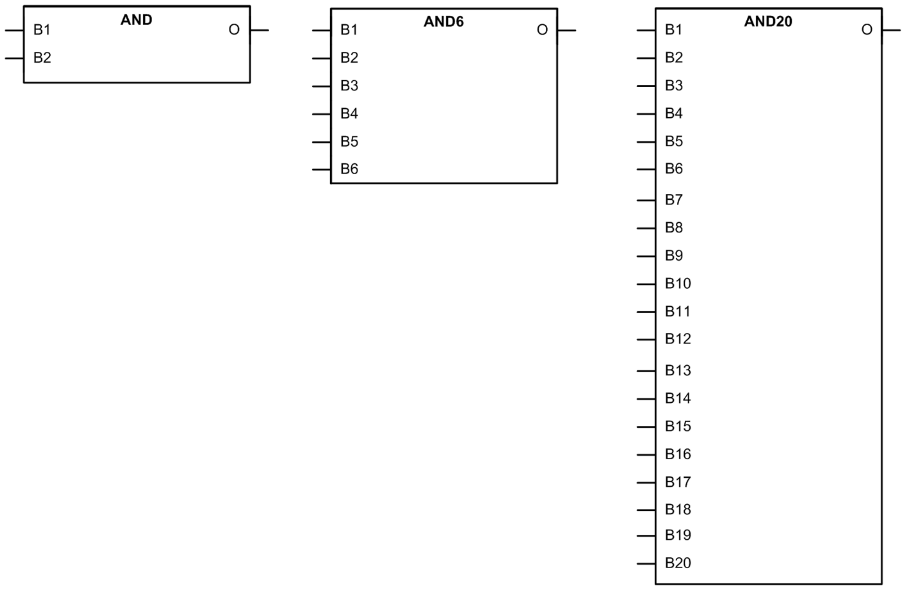


Figure 47: Function blocks

Functionality

AND, AND6 and AND20 are used to form general combinatory expressions with Boolean variables.

The default value in all inputs is logical true, which makes it possible to use only the required number of inputs and leave the rest disconnected.

AND has two inputs, AND6 six inputs and AND20 twenty inputs.

Signals

AND Input signals

Table 80: AND Input signals

Name	Type	Default	Description
B1	BOOLEAN	1	Input signal 1
B2	BOOLEAN	1	Input signal 2

AND6 Input signals

Table 81: AND6 Input signals

Name	Type	Default	Description
B1	BOOLEAN	1	Input signal 1
B2	BOOLEAN	1	Input signal 2
B3	BOOLEAN	1	Input signal 3
B4	BOOLEAN	1	Input signal 4
B5	BOOLEAN	1	Input signal 5
B6	BOOLEAN	1	Input signal 6

AND20 Input signals

Table 82: AND20 Input signals

Name	Type	Default	Description
B1	BOOLEAN	1	Input signal 1
B2	BOOLEAN	1	Input signal 2
B3	BOOLEAN	1	Input signal 3
B4	BOOLEAN	1	Input signal 4
B5	BOOLEAN	1	Input signal 5
B6	BOOLEAN	1	Input signal 6
B7	BOOLEAN	1	Input signal 7
B8	BOOLEAN	1	Input signal 8
B9	BOOLEAN	1	Input signal 9
B10	BOOLEAN	1	Input signal 10
B11	BOOLEAN	1	Input signal 11
B12	BOOLEAN	1	Input signal 12
B13	BOOLEAN	1	Input signal 13
B14	BOOLEAN	1	Input signal 14
B15	BOOLEAN	1	Input signal 15
B16	BOOLEAN	1	Input signal 16
B17	BOOLEAN	1	Input signal 17
B18	BOOLEAN	1	Input signal 18
B19	BOOLEAN	1	Input signal 19
B20	BOOLEAN	1	Input signal 20

AND Output signal

Table 83: AND Output signal

Name	Type	Description
O	BOOLEAN	Output signal

AND6 Output signal

Table 84: AND6 Output signal

Name	Type	Description
O	BOOLEAN	Output signal

AND20 Output signal

Table 85: AND20 Output signal

Name	Type	Description
O	BOOLEAN	Output signal

Settings

The function does not have any parameters available in PCM600.

3.13.1.3 XOR function block

Function block

Figure 48: Function block

Functionality

The exclusive OR function XOR is used to generate combinatory expressions with Boolean variables.

The output signal is TRUE if the input signals are different and FALSE if they are equal.

Signals

XOR Input signals

Table 86: XOR Input signals

Name	Type	Default	Description
B1	BOOLEAN	0	Input signal 1
B2	BOOLEAN	0	Input signal 2

XOR Output signal

Table 87: XOR Output signal

Name	Type	Description
O	BOOLEAN	Output signal

Settings

The function does not have any parameters available in PCM600.

3.13.1.4 NOT function block

Function block

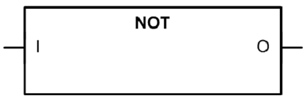


Figure 49: Function block

Functionality

NOT is used to generate combinatory expressions with Boolean variables.

NOT inverts the input signal.

Signals

NOT Input signal

Table 88: NOT Input signal

Name	Type	Default	Description
I	BOOLEAN	0	Input signal

NOT Output signal

Table 89: NOT Output signal

Name	Type	Description
O	BOOLEAN	Output signal

Settings

The function does not have any parameters available in PCM600.

3.13.1.5 MAX3 function block

Function block

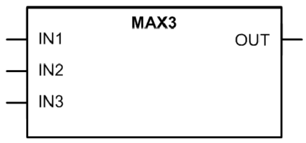


Figure 50: Function block

Functionality

The maximum function MAX3 selects the maximum value from three analog values. Disconnected inputs and inputs whose quality is bad are ignored. If all inputs are disconnected or the quality is bad, MAX3 output value is set to -2^21.

Signals

MAX3 Input signals

Table 90: MAX3 Input signals

Name	Type	Default	Description
IN1	FLOAT32	0	Input signal 1
IN2	FLOAT32	0	Input signal 2
IN3	FLOAT32	0	Input signal 3

MAX3 Output signal

Table 91: MAX3 Output signal

Name	Type	Description
OUT	FLOAT32	Output signal

Settings

The function does not have any parameters available in PCM600.

3.13.1.6 MIN3 function block

Function block

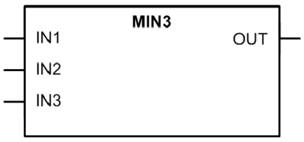


Figure 51: Function block

Functionality

The minimum function MIN3 selects the minimum value from three analog values. Disconnected inputs and inputs whose quality is bad are ignored. If all inputs are disconnected or the quality is bad, MIN3 output value is set to 2^21.

Signals

MIN3 Input signals

Table 92: MIN3 Input signals

Name	Type	Default	Description
IN1	FLOAT32	0	Input signal 1
IN2	FLOAT32	0	Input signal 2
IN3	FLOAT32	0	Input signal 3

MIN3 Output signal

Table 93: MIN3 Output signal

Name	Type	Description
OUT	FLOAT32	Output signal

Settings

The function does not have any parameters available in PCM600.

3.13.1.7 R_TRIG function block

Function block

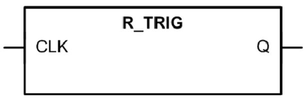


Figure 52: Function block

Functionality

R_TRIG is used as a rising edge detector.

R_TRIG detects the transition from FALSE to TRUE at the CLK input. When the rising edge is detected, the element assigns the output to TRUE. At the next execution round, the output is returned to FALSE despite the state of the input.

Signals

R_TRIG Input signals

Table 94: R_TRIG Input signals

Name	Type	Default	Description
CLK	BOOLEAN	0	Input signal

R_TRIG Output signal

Table 95: R_TRIG Output signal

Name	Type	Description
Q	BOOLEAN	Output signal

Settings

The function does not have any parameters available in PCM600.

3.13.1.8 F_TRIG function block

Function block

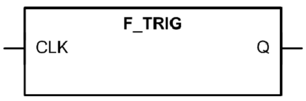


Figure 53: Function block

Functionality

F_TRIG is used as a falling edge detector.

The function detects the transition from TRUE to FALSE at the CLK input. When the falling edge is detected, the element assigns the Q output to TRUE. At the next execution round, the output is returned to FALSE despite the state of the input.

Signals

F_TRIG Input signals

Table 96: F_TRIG Input signals

Name	Type	Default	Description
CLK	BOOLEAN	0	Input signal

F_TRIG Output signal

Table 97: F_TRIG Output signal

Name	Type	Description
Q	BOOLEAN	Output signal

Settings

The function does not have any parameters available in PCM600.

3.13.1.9 T_POS_XX function blocks

Function block

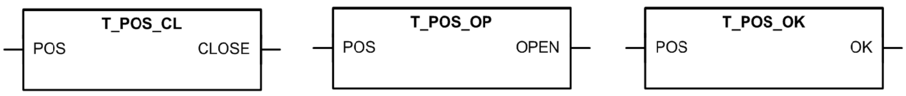


Figure 54: Function blocks

Functionality

The circuit breaker position information can be communicated with the IEC 61850 GOOSE messages. The position information is a double binary data type which is fed to the `POS` input.

T_POS_CL and T_POS_OP are used for extracting the circuit breaker status information. Respectively, T_POS_OK is used to validate the intermediate or faulty breaker position.

Table 98: Cross reference between circuit breaker position and the output of the function block

Circuit breaker position	Output of the function block		
	T_POS_CL	T_POS_OP	T_POS_OK
Intermediate '00'	FALSE	FALSE	FALSE
Close '01'	TRUE	FALSE	TRUE
Open '10'	FALSE	TRUE	TRUE
Faulty '11'	TRUE	TRUE	FALSE

Signals

T_POS_CL Input signals

Table 99: T_POS_CL Input signals

Name	Type	Default	Description
POS	Double binary	0	Input signal

T_POS_OP Input signals

Table 100: T_POS_OP Input signals

Name	Type	Default	Description
POS	Double binary	0	Input signal

T_POS_OK Input signals

Table 101: T_POS_OK Input signals

Name	Type	Default	Description
POS	Double binary	0	Input signal

T_POS_CL Output signal

Table 102: T_POS_CL Output signal

Name	Type	Description
CLOSE	BOOLEAN	Output signal

T_POS_OP Output signal

Table 103: T_POS_OP Output signal

Name	Type	Description
OPEN	BOOLEAN	Output signal

T_POS_OK Output signal

Table 104: T_POS_OK Output signal

Name	Type	Description
OK	BOOLEAN	Output signal

Settings

The function does not have any parameters available in PCM600.

3.13.1.10 SWITCHR function block

Function block

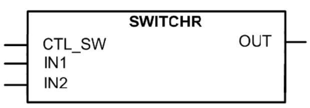


Figure 55: Function block

Functionality

SWITCHR switching block for REAL data type is operated by the `CTL_SW` input, selects the output value `OUT` between the `IN1` and `IN2` inputs.

CTL_SW	OUT
FALSE	IN2
TRUE	IN1

Signals

SWITCHR Input signals

Table 105: SWITCHR Input signals

Name	Type	Default	Description
CTL_SW	BOOLEAN	1	Control Switch
IN1	REAL	0.0	Real input 1
IN2	REAL	0.0	Real input 2

SWITCHR Output signals

Table 106: SWITCHR Output signals

Name	Type	Description
OUT	REAL	Real switch output

3.13.1.11 SWITCHI32 function block

Function block

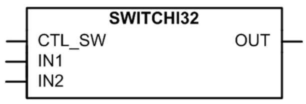


Figure 56: Function block

Functionality

SWITCHI32 switching block for 32-bit integer data type is operated by the `CTL_SW` input, which selects the output value `OUT` between the `IN1` and `IN2` inputs.

Table 107: SWITCHI32

CTL_SW	OUT
FALSE	IN2
TRUE	IN1

Signals

SWITCHI32 input signals

Table 108: SWITCHI32 input signals

Name	Type	Default	Description
CTL_SW	BOOLEAN	1	Control Switch
IN1	INT32	0	Input signal 1
IN2	INT32	0	Input signal 2

SWITCHI32 output signals

Table 109: SWITCHI32 output signals

Name	Type	Description
OUT	INT32	Output signal

3.13.1.12 SR function block

Function block

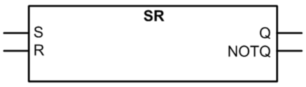


Figure 57: Function block

Functionality

The SR flip-flop output `Q` can be set or reset from the `S` or `R` inputs. `S` input has a higher priority over the `R` input. Output `NOTQ` is the negation of output `Q`.

The statuses of outputs `Q` and `NOTQ` are not retained in the nonvolatile memory.

Table 110: Truth table for SR flip-flop

S	R	Q
0	0	0[1]
0	1	0
1	0	1
1	1	1

Signals

[1] Keep state/no change

SR Input signals

Table 111: SR Input signals

Name	Type	Default	Description
S	BOOLEAN	0=False	Set Q output when set
R	BOOLEAN	0=False	Resets Q output when set

SR Output signals

Table 112: SR Output signals

Name	Type	Description
Q	BOOLEAN	Q status
NOTQ	BOOLEAN	NOTQ status

3.13.1.13 RS function block

Function block

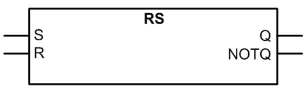


Figure 58: Function block

Functionality

The RS flip-flop output `Q` can be set or reset from the `S` or `R` inputs. R input has a higher priority over the S input. Output `NOTQ` is the negation of output `Q`.

The statuses of outputs `Q` and `NOTQ` are not retained in the nonvolatile memory.

Table 113: Truth table for RS flip-flop

S	R	Q
0	0	0[1]
0	1	0
1	0	1
1	1	0

Signals

1 Keep state/no change

RS Input signals

Table 114: RS Input signals

Name	Type	Default	Description
S	BOOLEAN	0=False	Set Q output when set
R	BOOLEAN	0=False	Resets Q output when set

RS Output signals

Table 115: RS Output signals

Name	Type	Description
Q	BOOLEAN	Q status
NOTQ	BOOLEAN	NOTQ status

Technical revision history

Table 116: RS Technical revision history

Technical revision	Change
L	The name of the function has been changed from SR to RS.

3.13.2 Minimum pulse timer

3.13.2.1 Minimum pulse timer TPGAPC

Function block

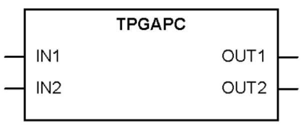


Figure 59: Function block

Functionality

The Minimum pulse timer function TPGAPC contains two independent timers. The function has a settable pulse length (in milliseconds). The timers are used for setting the minimum pulse length for example, the signal outputs. Once the input is activated, the output is set for a specific duration using the *Pulse time* setting. Both timers use the same setting parameter.

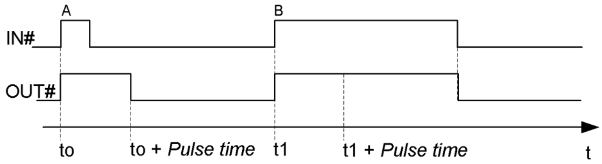


Figure 60: A = Trip pulse is shorter than Pulse time setting, B = Trip pulse is longer than Pulse time setting

Signals

TPGAPC Output signals

Table 117: TPGAPC Output signals

Name	Type	Description
OUT1	BOOLEAN	Output 1 status
OUT2	BOOLEAN	Output 2 status

Settings

TPGAPC Non group settings (Basic)

Table 118: TPGAPC Non group settings (Basic)

Parameter	Values (Range)	Unit	Step	Default	Description
Pulse time	0...60000	ms	1	150	Minimum pulse time

Technical revision history

Table 119: TPGAPC Technical revision history

Technical revision	Change
B	Outputs now visible in menu
C	Internal improvement

3.13.2.2 Minimum pulse timer TPSGAPC

Function block

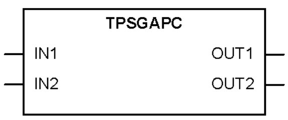


Figure 61: Function block

Functionality

The Minimum second pulse timer function TPSGAPC contains two independent timers. The function has a settable pulse length (in seconds). The timers are used for setting the minimum pulse length for example, the signal outputs. Once the input is activated, the output is set for a specific duration using the *Pulse time* setting. Both timers use the same setting parameter.

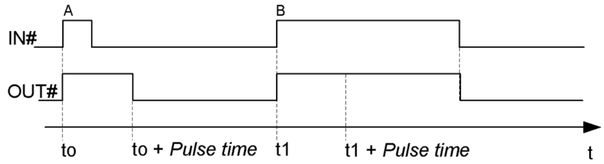


Figure 62: A = Trip pulse is shorter than Pulse time setting, B = Trip pulse is longer than Pulse time setting

Signals

TPSGAPC Input signals

Table 120: TPSGAPC Input signals

Name	Type	Default	Description
IN1	BOOLEAN	0=False	Input 1
IN2	BOOLEAN	0=False	Input 2

TPSGAPC Output signals

Table 121: TPSGAPC Output signals

Name	Type	Description
OUT1	BOOLEAN	Output 1 status
OUT2	BOOLEAN	Output 2 status

Settings

TPSGAPC Non group settings (Basic)

Table 122: TPSGAPC Non group settings (Basic)

Parameter	Values (Range)	Unit	Step	Default	Description
Pulse time	0...300	s	1	0	Minimum pulse time

Technical revision history

Table 123: TPSGAPC Technical revision history

Technical revision	Change
B	Outputs now visible in menu
C	Internal improvement

3.13.2.3 Minimum pulse timer TPMGAPC

Function block

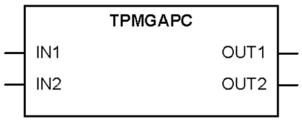


Figure 63: Function block

Functionality

The Minimum minute pulse timer function TPMGAPC contains two independent timers. The function has a settable pulse length (in minutes). The timers are used for setting the minimum pulse length for example, the signal outputs. Once the input is activated, the output is set for a specific duration using the *Pulse time* setting. Both timers use the same setting parameter.

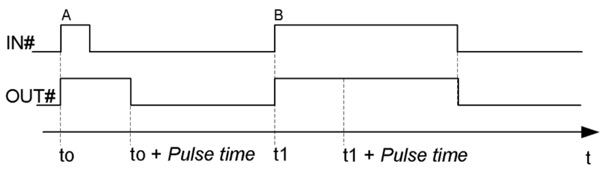


Figure 64: A = Trip pulse is shorter than Pulse time setting, B = Trip pulse is longer than Pulse time setting

Signals

TPMGAPC Input signals

Table 124: TPMGAPC Input signals

Name	Type	Default	Description
IN1	BOOLEAN	0=False	Input 1
IN2	BOOLEAN	0=False	Input 2

TPMGAPC Output signals

Table 125: TPMGAPC Output signals

Name	Type	Description
OUT1	BOOLEAN	Output 1 status
OUT2	BOOLEAN	Output 2 status

Settings

TPMGAPC Non group settings (Basic)

Table 126: TPMGAPC Non group settings (Basic)

Parameter	Values (Range)	Unit	Step	Default	Description
Pulse time	0...300	min	1	0	Minimum pulse time

3.13.3 Pulse timer PTGAPC

3.13.3.1 Function block

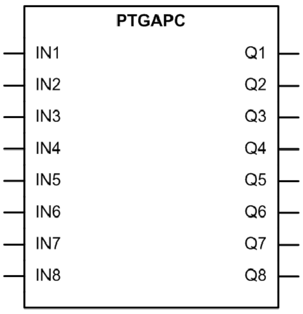


Figure 65: Function block

3.13.3.2 Functionality

The pulse timer function PTGAPC contains eight independent timers. The function has a settable pulse length. Once the input is activated, the output is set for a specific duration using the *Pulse delay time* setting.

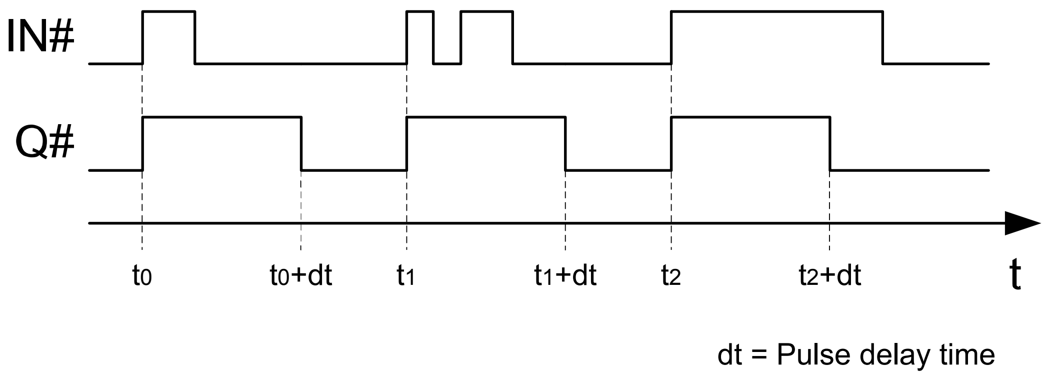


Figure 66: Timer operation

3.13.3.3 Signals

PTGAPC Input signals

Table 127: PTGAPC Input signals

Name	Type	Default	Description
IN1	BOOLEAN	0=False	Input 1 status
IN2	BOOLEAN	0=False	Input 2 status
IN3	BOOLEAN	0=False	Input 3 status
IN4	BOOLEAN	0=False	Input 4 status
IN5	BOOLEAN	0=False	Input 5 status
IN6	BOOLEAN	0=False	Input 6 status
IN7	BOOLEAN	0=False	Input 7 status
IN8	BOOLEAN	0=False	Input 8 status

PTGAPC Output signals

Table 128: PTGAPC Output signals

Name	Type	Description
Q1	BOOLEAN	Output 1 status
Q2	BOOLEAN	Output 2 status
Q3	BOOLEAN	Output 3 status
Q4	BOOLEAN	Output 4 status
Q5	BOOLEAN	Output 5 status
Q6	BOOLEAN	Output 6 status
Q7	BOOLEAN	Output 7 status
Q8	BOOLEAN	Output 8 status

3.13.3.4 Settings

PTGAPC Non group settings (Basic)

Table 129: PTGAPC Non group settings (Basic)

Parameter	Values (Range)	Unit	Step	Default	Description
Pulse time 1	0...3600000	ms	10	0	Pulse time
Pulse time 2	0...3600000	ms	10	0	Pulse time
Pulse time 3	0...3600000	ms	10	0	Pulse time
Pulse time 4	0...3600000	ms	10	0	Pulse time
Pulse time 5	0...3600000	ms	10	0	Pulse time
Pulse time 6	0...3600000	ms	10	0	Pulse time
Pulse time 7	0...3600000	ms	10	0	Pulse time
Pulse time 8	0...3600000	ms	10	0	Pulse time

3.13.3.5 Technical data

Table 130: PTGAPC Technical data

Characteristic	Value
Operate time accuracy	±1.0% of the set value or ±20 ms

3.13.4 Time delay off (8 pcs) TOFGAPC

3.13.4.1 Function block

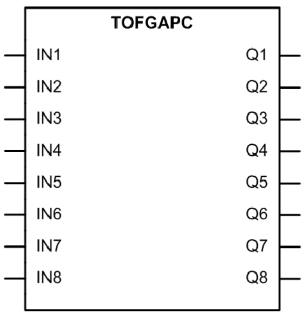


Figure 67: Function block

3.13.4.2 Functionality

The time delay off (8 pcs) function TOFGAPC can be used, for example, for a dropoff-delayed output related to the input signal. The function contains eight independent timers. There is a settable delay in the timer. Once the input is activated, the output is set immediately. When the input is cleared, the output stays on until the time set with the *Off delay time* setting has elapsed.

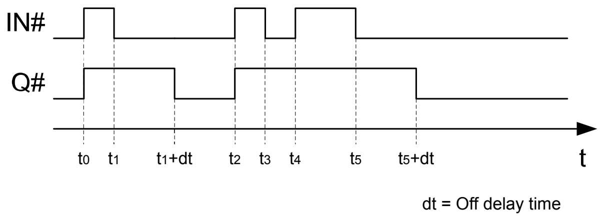


Figure 68: Timer operation

3.13.4.3 Signals

Table 131: TOFGAPC Input signals

Name	Type	Default	Description
IN1	BOOLEAN	0=False	Input 1 status
IN2	BOOLEAN	0=False	Input 2 status
IN3	BOOLEAN	0=False	Input 3 status
IN4	BOOLEAN	0=False	Input 4 status
IN5	BOOLEAN	0=False	Input 5 status
IN6	BOOLEAN	0=False	Input 6 status
IN7	BOOLEAN	0=False	Input 7 status
IN8	BOOLEAN	0=False	Input 8 status

Table 132: TOFGAPC Output signals

Name	Type	Description
Q1	BOOLEAN	Output 1 status
Q2	BOOLEAN	Output 2 status
Q3	BOOLEAN	Output 3 status
Q4	BOOLEAN	Output 4 status
Q5	BOOLEAN	Output 5 status
Q6	BOOLEAN	Output 6 status
Q7	BOOLEAN	Output 7 status
Q8	BOOLEAN	Output 8 status

3.13.4.4 Settings

Table 133: TOFGAPC Non group settings (Basic)

Parameter	Values (Range)	Unit	Step	Default	Description
Off delay time 1	0...3600000	ms	10	0	Off delay time
Off delay time 2	0...3600000	ms	10	0	Off delay time
Off delay time 3	0...3600000	ms	10	0	Off delay time
Off delay time 4	0...3600000	ms	10	0	Off delay time
Off delay time 5	0...3600000	ms	10	0	Off delay time

Table continues on the next page

Parameter	Values (Range)	Unit	Step	Default	Description
Off delay time 6	0...3600000	ms	10	0	Off delay time
Off delay time 7	0...3600000	ms	10	0	Off delay time
Off delay time 8	0...3600000	ms	10	0	Off delay time

3.13.4.5 Technical data

Table 134: TOFGAPC Technical data

Characteristic	Value
Operate time accuracy	±1.0% of the set value or ±20 ms

3.13.5 Time delay on (8 pcs) TONGAPC

3.13.5.1 Function block

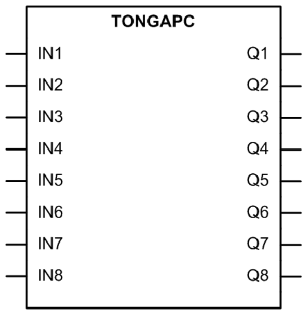


Figure 69: Function block

3.13.5.2 Functionality

The time delay on (8 pcs) function TONGAPC can be used, for example, for time delaying the output related to the input signal. TONGAPC contains eight independent timers. The timer has a settable time delay. Once the input is activated, the output is set after the time set by the *On delay time* setting has elapsed.

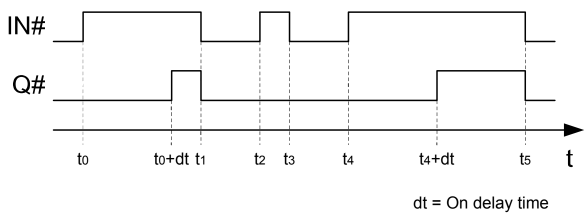


Figure 70: Timer operation

3.13.5.3 Signals

Table 135: TONGAPC Input signals

Name	Type	Default	Description
IN1	BOOLEAN	0=False	Input 1
IN2	BOOLEAN	0=False	Input 2
IN3	BOOLEAN	0=False	Input 3
IN4	BOOLEAN	0=False	Input 4
IN5	BOOLEAN	0=False	Input 5
IN6	BOOLEAN	0=False	Input 6
IN7	BOOLEAN	0=False	Input 7
IN8	BOOLEAN	0=False	Input 8

Table 136: TONGAPC Output signals

Name	Type	Description
Q1	BOOLEAN	Output 1
Q2	BOOLEAN	Output 2
Q3	BOOLEAN	Output 3
Q4	BOOLEAN	Output 4
Q5	BOOLEAN	Output 5
Q6	BOOLEAN	Output 6
Q7	BOOLEAN	Output 7
Q8	BOOLEAN	Output 8

3.13.5.4 Settings

Table 137: TONGAPC Non group settings (Basic)

Parameter	Values (Range)	Unit	Step	Default	Description
On delay time 1	0...3600000	ms	10	0	On delay time
On delay time 2	0...3600000	ms	10	0	On delay time
On delay time 3	0...3600000	ms	10	0	On delay time
On delay time 4	0...3600000	ms	10	0	On delay time
On delay time 5	0...3600000	ms	10	0	On delay time
On delay time 6	0...3600000	ms	10	0	On delay time
On delay time 7	0...3600000	ms	10	0	On delay time
On delay time 8	0...3600000	ms	10	0	On delay time

3.13.5.5 Technical data

Table 138: TONGAPC Technical data

Characteristic	Value
Operate time accuracy	±1.0% of the set value or ±20 ms

3.13.6 Set-reset (8 pcs) SRGAPC

3.13.6.1 Function block

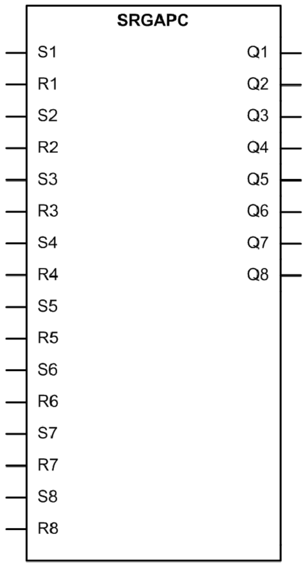


Figure 71: Function block

3.13.6.2 Functionality

The set-reset (8 pcs) function SRGAPC is a simple SR flip-flop with a memory that can be set or that can reset an output from the S# or R# inputs, respectively. The function contains eight independent set-reset flip-flop latches where the SET input has the higher priority over the RESET input. The status of each Q# output is retained in the nonvolatile memory. The individual reset for each Q# output is available on the WHMI or through tool via communication.

Table 139: Truth table for SRGAPC

S#	R#	Q#
0	0	0[1]
0	1	0
1	0	1
1	1	1

1 Keep state/no change

3.13.6.3 Signals

Table 140: SRGAPC Input signals

Name	Type	Default	Description
S1	BOOLEAN	0=False	Set Q1 output when set
R1	BOOLEAN	0=False	Resets Q1 output when set
S2	BOOLEAN	0=False	Set Q2 output when set
R2	BOOLEAN	0=False	Resets Q2 output when set
S3	BOOLEAN	0=False	Set Q3 output when set
R3	BOOLEAN	0=False	Resets Q3 output when set
S4	BOOLEAN	0=False	Set Q4 output when set
R4	BOOLEAN	0=False	Resets Q4 output when set
S5	BOOLEAN	0=False	Set Q5 output when set
R5	BOOLEAN	0=False	Resets Q5 output when set
S6	BOOLEAN	0=False	Set Q6 output when set
R6	BOOLEAN	0=False	Resets Q6 output when set
S7	BOOLEAN	0=False	Set Q7 output when set
R7	BOOLEAN	0=False	Resets Q7 output when set
S8	BOOLEAN	0=False	Set Q8 output when set
R8	BOOLEAN	0=False	Resets Q8 output when set

Table 141: SRGAPC Output signals

Name	Type	Description
Q1	BOOLEAN	Q1 status
Q2	BOOLEAN	Q2 status
Q3	BOOLEAN	Q3 status
Q4	BOOLEAN	Q4 status
Q5	BOOLEAN	Q5 status
Q6	BOOLEAN	Q6 status
Q7	BOOLEAN	Q7 status
Q8	BOOLEAN	Q8 status

3.13.6.4 Settings

Table 142: SRGAPC Non group settings (Basic)

Parameter	Values (Range)	Unit	Step	Default	Description
Reset Q1	0=Cancel 1=Reset			0=Cancel	Resets Q1 output when set
Reset Q2	0=Cancel 1=Reset			0=Cancel	Resets Q2 output when set
Reset Q3	0=Cancel 1=Reset			0=Cancel	Resets Q3 output when set
Reset Q4	0=Cancel 1=Reset			0=Cancel	Resets Q4 output when set
Reset Q5	0=Cancel 1=Reset			0=Cancel	Resets Q5 output when set
Reset Q6	0=Cancel 1=Reset			0=Cancel	Resets Q6 output when set
Reset Q7	0=Cancel 1=Reset			0=Cancel	Resets Q7 output when set
Reset Q8	0=Cancel 1=Reset			0=Cancel	Resets Q8 output when set

3.13.7 Move (8 pcs) MVGAPC

3.13.7.1 Function block

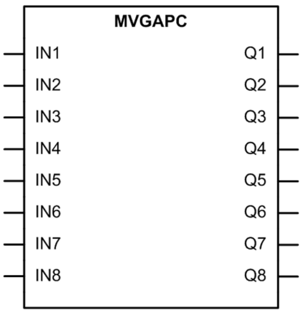


Figure 72: Function block

3.13.7.2 Functionality

The move (8 pcs) function MVGAPC is used for user logic bits. Each input state is directly copied to the output state. This allows the creating of events from advanced logic combinations.

3.13.7.3 Signals

Table 143: MVGAPC Output signals

Name	Type	Description
Q1	BOOLEAN	Q1 status
Q2	BOOLEAN	Q2 status
Q3	BOOLEAN	Q3 status
Q4	BOOLEAN	Q4 status
Q5	BOOLEAN	Q5 status
Q6	BOOLEAN	Q6 status
Q7	BOOLEAN	Q7 status
Q8	BOOLEAN	Q8 status

3.13.7.4 Settings

Table 144: MVGAPC Non group settings (Basic)

Parameter	Values (Range)	Unit	Step	Default	Description
Description				MVGAPC1 Q1	Output description
Description				MVGAPC1 Q2	Output description
Description				MVGAPC1 Q3	Output description
Description				MVGAPC1 Q4	Output description
Description				MVGAPC1 Q5	Output description
Description				MVGAPC1 Q6	Output description
Description				MVGAPC1 Q7	Output description
Description				MVGAPC1 Q8	Output description

3.13.8 Local/remote control function block CONTROL

3.13.8.1 Function block

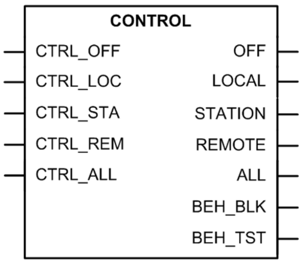


Figure 73: Function block

3.13.8.2 Functionality

Local/Remote control supports multilevel access for control operations in substations according to the IEC 61850 standard. Multilevel control access with separate station control access level is not supported by other protocols than IEC 61850.

The actual Local/Remote control state is evaluated by the priority scheme on the function block inputs. If more than one input is active, the input with the highest priority is selected. The priority order is “off”, “local”, “station”, “remote”, “all”.

The actual state is reflected on the CONTROL function outputs. Only one output is active at a time.

Table 145: Truth table for CONTROL

Input					**Output**
CTRL_OFF	**CTRL_LOC**	**CTRL_STA**	**CTRL_REM**	**CTRL_ALL**	
TRUE	N/A	N/A	N/A	N/A	OFF = TRUE
FALSE	TRUE	N/A	N/A	N/A	LOCAL = TRUE
FALSE	FALSE	TRUE	N/A	N/A	STATION = TRUE
FALSE	FALSE	FALSE	TRUE	TRUE	REMOTE = TRUE
FALSE	FALSE	FALSE	FALSE	TRUE	ALL = TRUE
FALSE	FALSE	FALSE	FALSE	FALSE	OFF = TRUE

3.13.8.3 L/R control access

Four different Local/Remote control access scenarios are possible depending on the selected station authority level: “L,R”, “L,R,L+R”, “L,S,R” and “L, S, S+R, L+S, L+S+R”. If control commands need to be allowed from multiple levels, multilevel access can be used. Multilevel access is possible only by using the station authority levels “L,R,L+R” and “L, S, S+R, L+S, L+S+R”. Multilevel access status is available from IEC 61850 data object CTRL.LLN0.MltLev.

Control access selection is made with CONTROL function block and IEC 61850 data object CTRL.LLN0.LocSta. When writing CTRL.LLN0.LocSta IEC 61850 data object, IEC 61850 command originator category station must be used by the client, and remote IEC 61850 control access must be allowed by the merging unit station authority. CTRL.LLN0.LocSta data object value is retained in the nonvolatile memory. The present control status can be monitored in the HMI or PCM600 via **Monitoring** > **Control command** with the *LR state* parameter or from the IEC 61850 data object CTRL.LLN0. LocKeyHMI.

IEC 61850 command originator category is always set by the IEC 61850 client. The merging unit supports station and remote IEC 61850 command originator categories, depending on the selected station authority level.

3.13.8.4 Station authority level “L,R"

In this scenario only local or remote control access is allowed. Control access with IEC 61850 command originator category station is interpreted as remote access. There is no multilevel access.

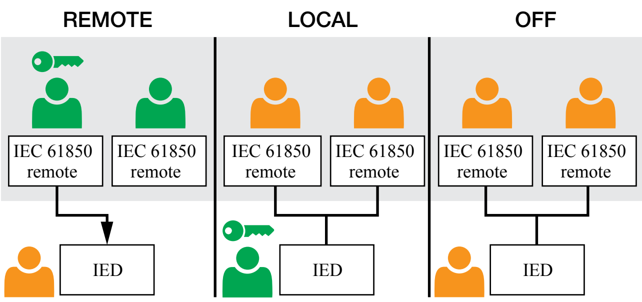


Figure 74: Station authority is “L,R”

When station authority level “L,R” is used, control access can be selected using the CONTROL function block. IEC 61850 data object CTRL.LLN0.LocSta and CONTROL function block inputs CTRL_STA and CTRL_ALL are not applicable for this station authority level.

Table 146: Station authority “L,R” using CONTROL function block

L/R control		L/R control status		Control access	
Control FB input	**CTRL.LLN0.LocSta**	**CTRL.LLN0.MltLev**	**L/R state CTRL.LLN0.LocKeyHMI**	**Local user**	**IEC 61850 client [1]**
CTRL_OFF	N/A	FALSE	0		
CTRL_LOC	N/A	FALSE	1	x	
CTRL_STA	N/A	FALSE	0		
CTRL_REM	N/A	FALSE	2		x
CTRL_ALL	N/A	FALSE	0		

[1] Client IEC 61850 command originator category check is not performed.

3.13.8.5 Station authority level "L,R,L+R"

Station authority level "L,R, L+R" adds multilevel access support. Control access can also be simultaneously permitted from local or remote location. Simultaneous local or remote control operation is not allowed as one client and location at time can access controllable objects and they remain reserved until the previously started control operation is first completed by the client. Control access with IEC 61850 originator category station is interpreted as remote access.

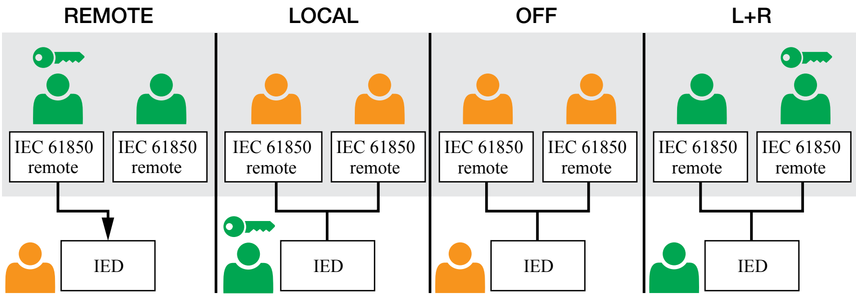


Figure 75: Station authority is "L,R,L+R"

When station authority level "L,R, L+R" is used, the control access can be selected using the CONTROL function block. IEC 61850 data object CTRL.LLN0.LocSta and CONTROL function block input `CTRL_STA` are not applicable for this station authority level.

Table 147: Station authority "L,R,L+R" using CONTROL function block

L/R Control		L/R Control status		Control access	
Control FB input	CTRL.LLN0.LocSta	CTRL.LLN0.MltLev	L/R state CTRL.LLN0.LocKey HMI	Local user	IEC 61850 client [1]
CTRL_OFF	N/A	FALSE	0		
CTRL_LOC	N/A	FALSE	1	x	
CTRL_STA	N/A	FALSE	0		
CTRL_REM	N/A	FALSE	2		x
CTRL_ALL	N/A	TRUE	4	x	x

3.13.8.6 Station authority level "L,S,R"

Station authority level "L,S,R" adds station control access. In this level IEC 61850 command originator category validation is performed to distinguish control commands with IEC 61850 command originator category set to "Remote" or "Station". There is no multilevel access.

[1] Client IEC 61850 command originator category check is not performed.

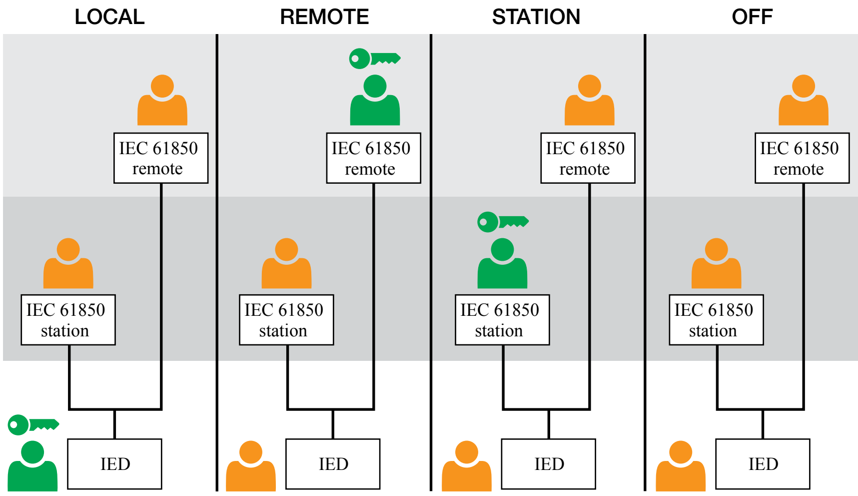


Figure 76: Station authority is "L,S,R"

When the station authority level “L,S,R” is used, the control access can be selected using the CONTROL function block. IEC 61850 data object CTRL.LLN0.LocSta and CONTROL function block input `CTRL_STA` are applicable for this station authority level.

Station control access can be reserved by using the CONTROL function block together with IEC 61850 data object CTRL.LLN0.LocSta.

Table 148: Station authority level “L,S,R” using CONTROL function block

L/R Control		L/R Control status		Control access		
Control FB input	**CTRL.LLN0.LocSta** [1]	**CTRL.LLN0.MltLev**	**L/R state CTRL.LLN0.LocKeyHMI**	**Local user**	**IEC 61850 client** [2]	**IEC 61850 client** [3]
CTRL_OFF	FALSE	FALSE	0			
CTRL_LOC	FALSE	FALSE	1	x		
CTRL_STA	TRUE	FALSE	3			x
CTRL_REM [4]	TRUE	FALSE	3			x
CTRL_REM	FALSE	FALSE	2		x	
CTRL_ALL	FALSE	FALSE	0			

3.13.8.7 Station authority level “L,S,S+R,L+S,L+S+R”

Merging unit's default station authority level is “L,S,S+R,L+S,L+S+R”. Station authority level “L,S,S+R,L+S,L+S+R” adds station control access together with several different multilevel access scenarios. Control access can also be simultaneously permitted from local, station or remote location. Simultaneous local, station or remote control operation is not allowed as one client and location at time can access controllable objects and they remain reserved until the previously started control operation is first completed by the client.

1 Station client reserves the control operating by writing controllable point LocSta.
2 Client IEC 61850 command originator category is remote.
3 Client IEC 61850 command originator category is station.
4 CTRL_STA unconnected in application configuration. Station client reserves the control operating by writing controllable point LocSta

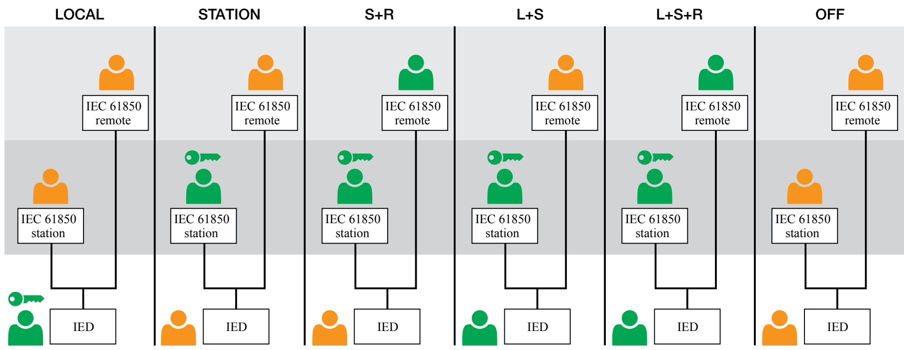


Figure 77: Station authority is "L,S,S+R,L+S,L+S+R"

When station authority level "L,S,S+R,L+S,L+S+R" is used, control access can be selected using the CONTROL function block. IEC 61850 data object CTRL.LLN0.LocSta and CONTROL function block input CTRL_STA are applicable for this station authority level.

"Station" and "Local + Station" control access can be reserved by using the CONTROL function block in combination with IEC 61850 data object CTRL.LLN0.LocSta.

Table 149: Station authority level "L,S,S+R,L+S,L+S+R" using CONTROL function block

L/R Control		L/R Control status		Control access		
Control FB input	CTRL.LLN0.LocSta [1]	CTRL.LLN0.MltLev	L/R state CTRL.LLN0.LocKeyHMI	Local user	IEC 61850 client [2]	IEC 61850 client [3]
CTRL_OFF	FALSE	FALSE	0			
CTRL_LOC	FALSE	FALSE	1	x		
CTRL_STA	FALSE	FALSE	3			x
CTRL_REM [4]	TRUE	TRUE	3			x
CTRL_REM	FALSE	TRUE	7		x	x
CTRL_ALL	FALSE	TRUE	6	x	x	x
CTRL_ALL [4]	TRUE	TRUE	5	x		x

3.13.8.8 Signals

CONTROL input signals

Table 150: CONTROL input signals

Name	Type	Default	Description
CTRL_OFF	BOOLEAN	0	Control input OFF
CTRL_LOC	BOOLEAN	0	Control input Local

Table continues on the next page

1 Station client reserves the control operating by writing controllable point LocSta.
2 Client IEC 61850 command originator category is remote.
3 Client IEC 61850 command originator category is station.
4 CTRL_STA unconnected in application configuration. Station client reserves the control operating by writing controllable point LocSta.

Name	Type	Default	Description
CTRL_STA	BOOLEAN	0	Control input Station
CTRL_REM	BOOLEAN	0	Control input Remote
CTRL_ALL	BOOLEAN	0	Control input All

CONTROL output signals

Table 151: CONTROL output signals

Name	Type	Description
OFF	BOOLEAN	Control output OFF
LOCAL	BOOLEAN	Control output Local
STATION	BOOLEAN	Control output Station
REMOTE	BOOLEAN	Control output Remote
ALL	BOOLEAN	Control output All
BEH_BLK	BOOLEAN	Logical device CTRL block status
BEH_TST	BOOLEAN	Logical device CTRL test status

3.13.8.9 Settings

Table 152: Non group settings

Parameter	Values (Range)	Unit	Step	Default	Description
Station authority	1=L,R 2=L,S,R 3=L,R,L+R 4=L,S,S+R,L+S,L+S+R			4=L,S,S+R,L+S,L+S+R	Control command originator category usage
Control mode	1=On 2=Blocked 5=Off			1=On	Enabling and disabling control

3.13.8.10 Monitored data

Table 153: Monitored data

Name	Type	Values (Range)	Unit	Description
Command response	Enum	0=No commands 1=Select open 2=Select close 3=Operate open 4=Operate close 5=Direct open		Latest command response

Table continues on the next page

Name	Type	Values (Range)	Unit	Description
		6=Direct close 7=Cancel 8=Position reached 9=Position timeout 10=Object status only 11=Object direct 12=Object select 13=RL local allowed 14=RL remote allowed 15=RL off 16=Function off 17=Function blocked 18=Command progress 19=Select timeout 20=Missing authority 21=Close not enabled 22=Open not enabled 23=Internal fault 24=Already close 25=Wrong client 26=RL station allowed 27=RL change 28=Abortion by trip		
LR state	Enum	0=Off 1=Local 2=Remote 3=Station 4=L+R 5=L+S 6=L+S+R 7=S+R		LR state monitoring

3.13.9 Generic control point (16 pcs) SPCGAPC

3.13.9.1 Function block

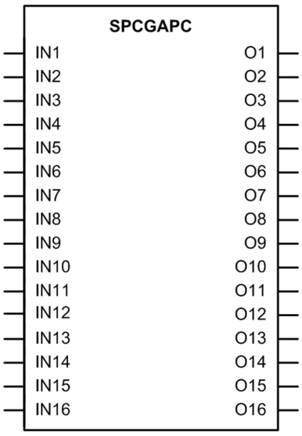


Figure 78: Function block

3.13.9.2 Functionality

The generic control points function SPCGAPC contains 16 independent control points. SPCGAPC offers the capability to activate its outputs through a local or remote control. The local control request can be issued through the buttons in the single-line diagram or via inputs and the remote control request through communication. The rising edge of the input signal is interpreted as a control request, and the output operation is triggered. When remote control requests are used the control points behaves as persistent.

The *Loc Rem restriction* setting is used for enabling or disabling the restriction for SPCGAPC to follow the R/L button state. If *Loc Rem restriction* is "True", as it is by default, the local or remote control operations are accepted according to the R/L button state.

Each of the 16 generic control point outputs has the *Operation mode*, *Pulse length* and *Description* setting. If *Operation mode* is "Toggle", the output state is toggled for every control request received. If Operation mode is "Pulsed", the output pulse of a preset duration (the *Pulse length* setting) is generated for every control request received. The *Description* setting can be used for storing information on the actual use of the control point in application, for instance.

For example, if the *Operation mode* is "Toggle", the output O# is initially “False”. The rising edge in IN# sets O# to “True”. The falling edge of IN# has no effect. Next rising edge of IN# sets O# to “False”.

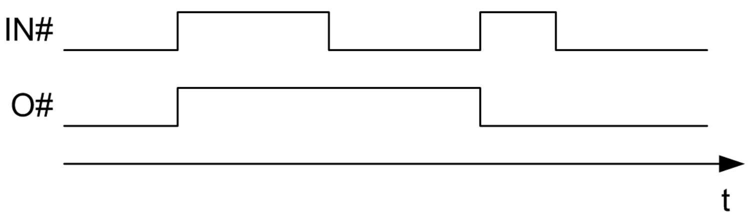


Figure 79: Operation in "Toggle" mode

The BLOCK input can be used for blocking the functionality of the outputs. The operation of the BLOCK input depends on the Operation mode setting. If Operation mode is "Toggle", the output state freezes and cannot be changed while the BLOCK input is active. If *Operation mode* is "Pulsed", the activation of the BLOCK input resets the outputs to the "False" state and further control requests are ignored while the BLOCK input is active.

From the remote communication point of view SPCGAPC toggled operation mode is always working as persistent mode. The output O# follows the value written to the input IN#.

3.13.9.3 Signals

SPCGAPC Input signals

Table 154: SPCGAPC Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0=False	Block signal for activating the blocking mode
IN1	BOOLEAN	0=False	Input of control point 1
IN2	BOOLEAN	0=False	Input of control point 2
IN3	BOOLEAN	0=False	Input of control point 3
IN4	BOOLEAN	0=False	Input of control point 4
IN5	BOOLEAN	0=False	Input of control point 5
IN6	BOOLEAN	0=False	Input of control point 6
IN7	BOOLEAN	0=False	Input of control point 7
IN8	BOOLEAN	0=False	Input of control point 8
IN9	BOOLEAN	0=False	Input of control point 9
IN10	BOOLEAN	0=False	Input of control point 10
IN11	BOOLEAN	0=False	Input of control point 11
IN12	BOOLEAN	0=False	Input of control point 12
IN13	BOOLEAN	0=False	Input of control point 13
IN14	BOOLEAN	0=False	Input of control point 14

Table continues on the next page

Name	Type	Default	Description
IN15	BOOLEAN	0=False	Input of control point 15
IN16	BOOLEAN	0=False	Input of control point 16

SPCGAPC Output signals

Table 155: SPCGAPC Output signals

Name	Type	Description
O1	BOOLEAN	Output 1 status
O2	BOOLEAN	Output 2 status
O3	BOOLEAN	Output 3 status
O4	BOOLEAN	Output 4 status
O5	BOOLEAN	Output 5 status
O6	BOOLEAN	Output 6 status
O7	BOOLEAN	Output 7 status
O8	BOOLEAN	Output 8 status
O9	BOOLEAN	Output 9 status
O10	BOOLEAN	Output 10 status
O11	BOOLEAN	Output 11 status
O12	BOOLEAN	Output 12 status
O13	BOOLEAN	Output 13 status
O14	BOOLEAN	Output 14 status
O15	BOOLEAN	Output 15 status
O16	BOOLEAN	Output 16 status

3.13.9.4 Settings

SPCGAPC Non group settings (Basic)

Table 156: SPCGAPC Non group settings (Basic)

Parameter	Values (Range)	Unit	Step	Default	Description
Loc Rem restriction	0=False 1=True			1=True	Local remote switch restriction
Operation mode	0=Pulsed 1=Toggle/Persis-tent -1=Off			-1=Off	Operation mode for generic control point
Pulse length	10...3600000	ms	10	1000	Pulse length for pulsed operation mode
Description				SPCGAPC1 Output 1	Generic control point description
Operation mode	0=Pulsed 1=Toggle/Persis-tent -1=Off			-1=Off	Operation mode for generic control point
Pulse length	10...3600000	ms	10	1000	Pulse length for pulsed operation mode
Description				SPCGAPC1 Output 2	Generic control point description
Operation mode	0=Pulsed 1=Toggle/Persis-tent -1=Off			-1=Off	Operation mode for generic control point
Pulse length	10...3600000	ms	10	1000	Pulse length for pulsed operation mode
Description				SPCGAPC1 Output 3	Generic control point description
Operation mode	0=Pulsed 1=Toggle/Persis-tent -1=Off			-1=Off	Operation mode for generic control point
Pulse length	10...3600000	ms	10	1000	Pulse length for pulsed operation mode
Description				SPCGAPC1 Output 4	Generic control point description
Operation mode	0=Pulsed 1=Toggle/Persis-tent -1=Off			-1=Off	Operation mode for generic control point
Pulse length	10...3600000	ms	10	1000	Pulse length for pulsed operation mode
Description				SPCGAPC1 Output 5	Generic control point description
Operation mode	0=Pulsed			-1=Off	Operation mode for generic control point

Table continues on the next page

Parameter	Values (Range)	Unit	Step	Default	Description
	1=Toggle/Persistent -1=Off				
Pulse length	10...3600000	ms	10	1000	Pulse length for pulsed operation mode
Description				SPCGAPC1 Output 6	Generic control point description
Operation mode	0=Pulsed 1=Toggle/Persistent -1=Off			-1=Off	Operation mode for generic control point
Pulse length	10...3600000	ms	10	1000	Pulse length for pulsed operation mode
Description				SPCGAPC1 Output 7	Generic control point description
Operation mode	0=Pulsed 1=Toggle/Persistent -1=Off			-1=Off	Operation mode for generic control point
Pulse length	10...3600000	ms	10	1000	Pulse length for pulsed operation mode
Description				SPCGAPC1 Output 8	Generic control point description
Operation mode	0=Pulsed 1=Toggle/Persistent -1=Off			-1=Off	Operation mode for generic control point
Pulse length	10...3600000	ms	10	1000	Pulse length for pulsed operation mode
Description				SPCGAPC1 Output 9	Generic control point description
Operation mode	0=Pulsed 1=Toggle/Persistent -1=Off			-1=Off	Operation mode for generic control point
Pulse length	10...3600000	ms	10	1000	Pulse length for pulsed operation mode
Description				SPCGAPC1 Output 10	Generic control point description
Operation mode	0=Pulsed 1=Toggle/Persistent -1=Off			-1=Off	Operation mode for generic control point
Pulse length	10...3600000	ms	10	1000	Pulse length for pulsed operation mode
Description				SPCGAPC1 Output 11	Generic control point description
Operation mode	0=Pulsed 1=Toggle/Persistent -1=Off			-1=Off	Operation mode for generic control point

Table continues on the next page

Parameter	Values (Range)	Unit	Step	Default	Description
Pulse length	10...3600000	ms	10	1000	Pulse length for pulsed operation mode
Description				SPCGAPC1 Output 12	Generic control point description
Operation mode	0=Pulsed 1=Toggle/Persis-tent -1=Off			-1=Off	Operation mode for generic control point
Pulse length	10...3600000	ms	10	1000	Pulse length for pulsed operation mode
Description				SPCGAPC1 Output 13	Generic control point description
Operation mode	0=Pulsed 1=Toggle/Persis-tent -1=Off			-1=Off	Operation mode for generic control point
Pulse length	10...3600000	ms	10	1000	Pulse length for pulsed operation mode
Description				SPCGAPC1 Output 14	Generic control point description
Operation mode	0=Pulsed 1=Toggle/Persis-tent -1=Off			-1=Off	Operation mode for generic control point
Pulse length	10...3600000	ms	10	1000	Pulse length for pulsed operation mode
Description				SPCGAPC1 Output 15	Generic control point description
Operation mode	0=Pulsed 1=Toggle/Persis-tent -1=Off			-1=Off	Operation mode for generic control point
Pulse length	10...3600000	ms	10	1000	Pulse length for pulsed operation mode
Description				SPCGAPC1 Output 16	Generic control point description

3.14 Factory settings restoration

In case of configuration data loss or any other file system error that prevents the merging unit from working properly, the whole file system can be restored to the original factory state. All default settings and configuration files stored in the factory are restored. For further information on restoring factory settings, see the operation manual.

3.15 ETHERNET channel supervision function blocks

3.15.1 Redundant Ethernet channel supervision RCHLCCH

3.15.1.1 Function block

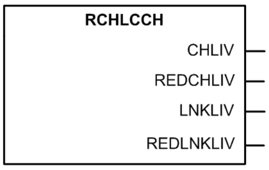


Figure 80: Function block

3.15.1.2 Functionality

Redundant Ethernet channel supervision RCHLCCH represents LAN A and LAN B redundant Ethernet channels.

3.15.1.3 Signals

RCHLCCH output signals

Table 157: RCHLCCH output signals

Parameter	Values (Range)	Unit	Step	Default	Description
CHLIV	True False				Status of redundant Ethernet channel LAN A. When *Redundant mode* is set to "HSR" or "PRP", value is "True" if the merging unit is receiving redundancy supervision frames. Otherwise value is "False".
REDCHLIV	True False				Status of redundant Ethernet channel LAN B. When *Redundant mode* is set to "HSR" or "PRP", value is "True" if the merging unit is receiving redundancy supervision frames. Otherwise value is "False".
LNKLIV	Up Down				Link status of redundant port LAN A. Valid only when *Redundant mode* is set to "HSR" or "PRP".
REDLNKLIV	Up Down				Link status of redundant port LAN B. Valid only when *Redundant mode* is set to "HSR" or "PRP".

3.15.1.4 Settings

Redundancy settings

Table 158: Redundancy settings

Parameter	Values (Range)	Unit	Step	Default	Description
Redundant mode	None PRP HSR			None	Mode selection for Ethernet switch on redundant communication modules. The "None" mode is used with normal and Self-healing Ethernet topologies.

3.15.1.5 Monitored data

Monitored data is available in four locations.

- **Monitoring** > **Communication** > **Ethernet** > **Activity** > **CHLIV_A**
- **Monitoring** > **Communication** > **Ethernet** > **Activity** > **REDCHLIV_B**
- **Monitoring** > **Communication** > **Ethernet** > **Link statuses** > **LNKLIV_A**
- **Monitoring** > **Communication** > **Ethernet** > **Link statuses** > **REDLNKLIV_B**

3.15.2 Ethernet channel supervision SCHLCCH

3.15.2.1 Function block

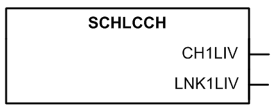


Figure 81: Function block

3.15.2.2 Functionality

Ethernet channel supervision SCHLCCH represents X1/LAN, X2/LAN and X3/LAN Ethernet channels.

An unused Ethernet port can be set "Off" with the setting **Configuration** > **Communication** > **Ethernet** > **Rear port(s)** > **Port x Mode**. This setting closes the port from software, disabling the Ethernet communication in that port. Closing an unused Ethernet port enhances the cyber security of the merging unit.

3.15.2.3 Signals

Output signals

Table 159: SCHLCCH1 output signals

Parameter	Values (Range)	Unit	Step	Default	Description
CH1LIV	True False				Status of Ethernet channel X1/LAN. Value is "True" if the port is receiving Ethernet frames. Valid only when *Redundant mode* is set to "None" or port is not one of the redundant ports (LAN A or LAN B).
LNK1LIV	Up Down				Link status of Ethernet port X1/LAN.

Table 160: SCHLCCH2 output signals

Parameter	Values (Range)	Unit	Step	Default	Description
CH2LIV	True False				Status of Ethernet channel X2/LAN. Value is "True" if the port is receiving Ethernet frames. Valid only when *Redundant mode* is set to "None" or port is not one of the redundant ports (LAN A or LAN B).
LNK2LIV	Up Down				Link status of Ethernet port X2/LAN.

Table 161: SCHLCCH3 output signals

Parameter	Values (Range)	Unit	Step	Default	Description
CH3LIV	True False				Status of Ethernet channel X3/LAN. Value is "True" if the port is receiving Ethernet frames. Valid only when *Redundant mode* is set to "None" or port is not one of the redundant ports (LAN A or LAN B).
LNK3LIV	Up Down				Link status of Ethernet port X3/LAN.

3.15.2.4 Settings

Port mode settings

Table 162: Port mode settings

Parameter	Values (Range)	Unit	Step	Default	Description
Port 1 Mode	Off On			On	Mode selection for rear port(s). If port is not used, it can be set to “Off”. Port cannot be set to “Off” when *Redundant mode* is “HSR” or “PRP” and port is one of the redundant ports (LAN A or LAN B) or

Table continues on the next page

Parameter	Values (Range)	Unit	Step	Default	Description
					when port is used for line differential communication.
Port 2 Mode	Off On			On	Mode selection for rear port(s). If port is not used, it can be set to “Off”. Port cannot be set to “Off” when *Redundant mode* is “HSR” or “PRP” and port is one of the redundant ports (LAN A or LAN B).
Port 3 Mode	Off On			On	Mode selection for rear port(s). If port is not used, it can be set to “Off”. Port cannot be set to “Off” when *Redundant mode* is “HSR” or “PRP” and port is one of the redundant ports (LAN A or LAN B).

3.15.2.5 Monitored data

Monitored data is available in six locations.

- **Monitoring** > **Communication** > **Ethernet** > **Activity** > **CH1LIV**
- **Monitoring** > **Communication** > **Ethernet** > **Activity** > **CH2LIV**
- **Monitoring** > **Communication** > **Ethernet** > **Activity** > **CH3LIV**
- **Monitoring** > **Communication** > **Ethernet** > **Link statuses** > **LNK1LIV**
- **Monitoring** > **Communication** > **Ethernet** > **Link statuses** > **LNK2LIV**
- **Monitoring** > **Communication** > **Ethernet** > **Link statuses** > **LNK3LIV**

4 Protection related functions

4.1 Master trip TRPPTRC

4.1.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Master trip	TRPPTRC	Master Trip	94/86

4.1.2 Function block

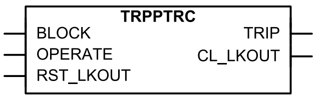


Figure 82: Function block

4.1.3 Functionality

The master trip function TRPPTRC is used as a trip command collector and handler after the protection functions. The features of this function influence the trip signal behavior of the circuit breaker. The minimum trip pulse length can be set when the non-latched mode is selected. It is also possible to select the latched or lockout mode for the trip signal.

4.1.4 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

When the TRPPTRC function is disabled, all trip outputs intended to go through the function to the circuit breaker trip coil are blocked.

The operation of TRPPTRC can be described with a module diagram. All the modules in the diagram are explained in the next sections.

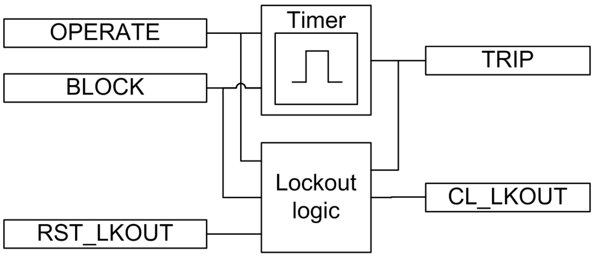


Figure 83: Functional module diagram

Timer

The duration of the TRIP output signal from TRPPTRC can be adjusted with the *Trip pulse time* setting when the "Non-latched" operation mode is used. The pulse length should be long enough to secure the opening of the breaker. For three-pole tripping, TRPPTRC has a single input OPERATE, through which all trip output signals are routed from the protection functions within the merging unit, or from external protection functions via one or more of the merging unit's binary inputs. The function has a single trip output TRIP for connecting the function to one or more of the merging unit's binary outputs, and also to other functions within the merging unit requiring this signal.

The BLOCK input blocks the TRIP output and resets the timer.

Lockout logic

TRPPTRC is provided with possibilities to activate a lockout. When activated, the lockout can be manually reset after checking the primary fault by activating the RST_LKOUT input or from the LHMI clear menu parameter. When using the "Latched" mode, the resetting of the TRIP output can be done similarly as when using the "Lockout" mode. It is also possible to reset the "Latched" mode remotely through a separate communication parameter.

The minimum pulse trip function is not active when using the "Lockout" or "Latched" modes but only when the "Non-latched" mode is selected.

The CL_LKOUT and TRIP outputs can be blocked with the BLOCK input.

Table 163: Operation modes for the TRPPTRC trip output

Mode	Operation
Non-latched	The *Trip pulse length* parameter gives the minimum pulse length for TRIP
Latched	TRIP is latched ; both local and remote clearing is possible.
Lockout	TRIP is locked and can be cleared only locally via menu or the RST_LKOUT input.

4.1.5 Application

All trip signals from GOOSE signals are routed through the trip logic. The most simplified application of the logic function is linking the trip signal and ensuring that the signal is long enough.

The tripping logic in the merging unit is intended to be used in the three-phase tripping for all fault types (3ph operating). To prevent the closing of a circuit breaker after a trip, TRPPTRC can block the CBXCBR closing.

TRPPTRC is intended to be connected to one trip coil of the corresponding circuit breaker. If tripping is needed for another trip coil or another circuit breaker which needs, for example, different trip pulse time, another trip logic function can be used. The two instances of the PTRC function are identical, only the names of the functions, TRPPTRC1 and TRPPTRC2, are different. Therefore, even if all references are made only to TRPPTRC1, they also apply to TRPPTRC2.

The inputs from the GOOSE signal are connected to the `OPERATE` input. The `TRIP` output is connected to the binary outputs on the IO board. This signal can also be used for other purposes within the merging unit, for example when starting the breaker failure protection.

TRPPTRC is used for simple three-phase tripping applications.

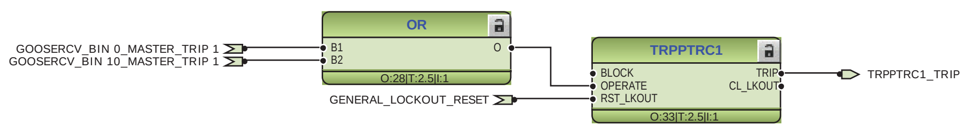


Figure 84: Typical TRPPTRC connection

4.1.6 Signals

4.1.6.1 TRPPTRC Input signals

Table 164: TRPPTRC Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0=False	Block of function
OPERATE	BOOLEAN	0=False	Operate
RST_LKOUT	BOOLEAN	0=False	Input for resetting the circuit breaker lockout function

4.1.6.2 TRPPTRC Output signals

Table 165: TRPPTRC Output signals

Name	Type	Description
TRIP	BOOLEAN	General trip output signal
CL_LKOUT	BOOLEAN	Circuit breaker lockout output (set until reset)

4.1.7 Settings

4.1.7.1 TRPPTRC Non group settings (Basic)

Table 166: TRPPTRC Non group settings (Basic)

Parameter	Values (Range)	Unit	Step	Default	Description
Operation	1=on 5=off			1=on	Operation Off / On
Trip pulse time	20...60000	ms	1	250	Minimum duration of trip output signal
Trip output mode	1=Non-latched 2=Latched 3=Lockout			1=Non-latched	Select the operation mode for trip output

4.1.8 Monitored data

4.1.8.1 TRPPTRC Monitored data

Table 167: TRPPTRC Monitored data

Name	Type	Values (Range)	Unit	Description
TRPPTRC	Enum	1=on 2=blocked 3=test 4=test/blocked 5=off		Status

4.1.9 Technical revision history

Table 168: TRPPTRC Technical revision history

Technical revision	Change
B	-
C	-
D	Internal improvement.
E	Setting *Trip output mode* default setting is changed to "Latched".
F	Internal improvement.

5 Supervision functions

5.1 Trip circuit supervision TCSSCBR

5.1.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Trip circuit supervision	TCSSCBR	TCS	TCM

5.1.2 Function block

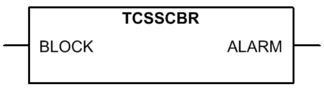


Figure 85: Function block

5.1.3 Functionality

The trip circuit supervision function TCSSCBR is designed to supervise the control circuit of the circuit breaker. The invalidity of a control circuit is detected by using a dedicated output contact that contains the supervision functionality. The failure of a circuit is reported to the corresponding function block in the merging unit's configuration.

The function starts and operates when TCSSCBR detects a trip circuit failure. The operating time characteristic for the function is DT. The function operates after a predefined operating time and resets when the fault disappears.

The function contains a blocking functionality. Blocking deactivates the `ALARM` output and resets the timer.

5.1.4 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of TCSSCBR can be described by using a module diagram. All the modules in the diagram are explained in the next sections.

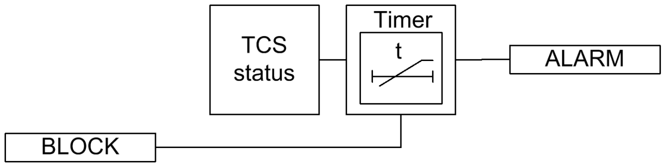


Figure 86: Functional module diagram

TCS status

This module receives the trip circuit status from the hardware. A detected failure in the trip circuit activates the timer.

Timer

Once activated, the timer runs until the set value of *Operate delay time* has elapsed. The time characteristic is according to DT. When the operation timer has reached the maximum time value, the ALARM output is activated. If a drop-off situation occurs during the operate time up counting, the fixed 0.5 s reset timer is activated. After that time, the operation timer is reset.

The BLOCK input can be controlled with a binary input, a horizontal communication input or an internal signal of the merging unit's program. The activation of the BLOCK input prevents the ALARM output to be activated.

5.1.5 Application

TCSSCBR detects faults in the electrical control circuit of the circuit breaker. The function can supervise both open and closed coil circuits. This supervision is necessary to find out the vitality of the control circuits continuously.

Figure 87 shows an application of the trip circuit supervision function use. The best solution is to connect an external R_{ext} shunt resistor in parallel with the circuit breaker internal contact. Although the circuit breaker internal contact is open, TCS can see the trip circuit through R_{ext}. The R_{ext} resistor should have such a resistance that the current through the resistance remains small, that is, it does not harm or overload the circuit breaker's trip coil.

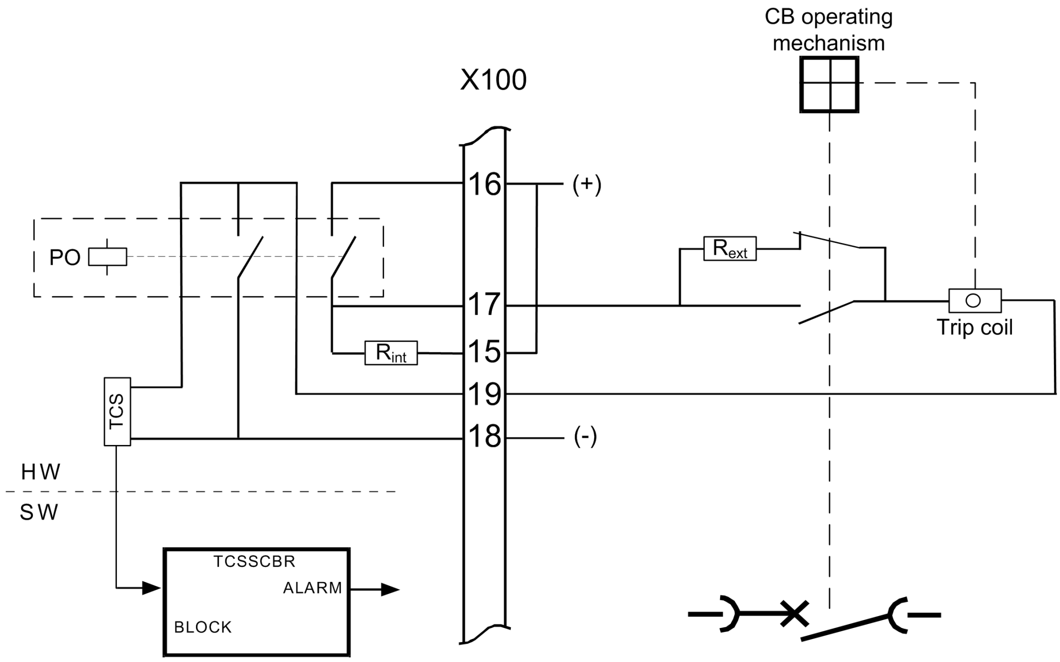


Figure 87: Operating principle of the trip-circuit supervision with an external resistor. The TCSSCBR blocking switch is not required since the external resistor is used.

If TCS is required only in a closed position, the external shunt resistance can be omitted. When the circuit breaker is in the open position, TCS sees the situation as a faulty circuit. One way to avoid TCS operation in this situation would be to block the supervision function whenever the circuit breaker is open.

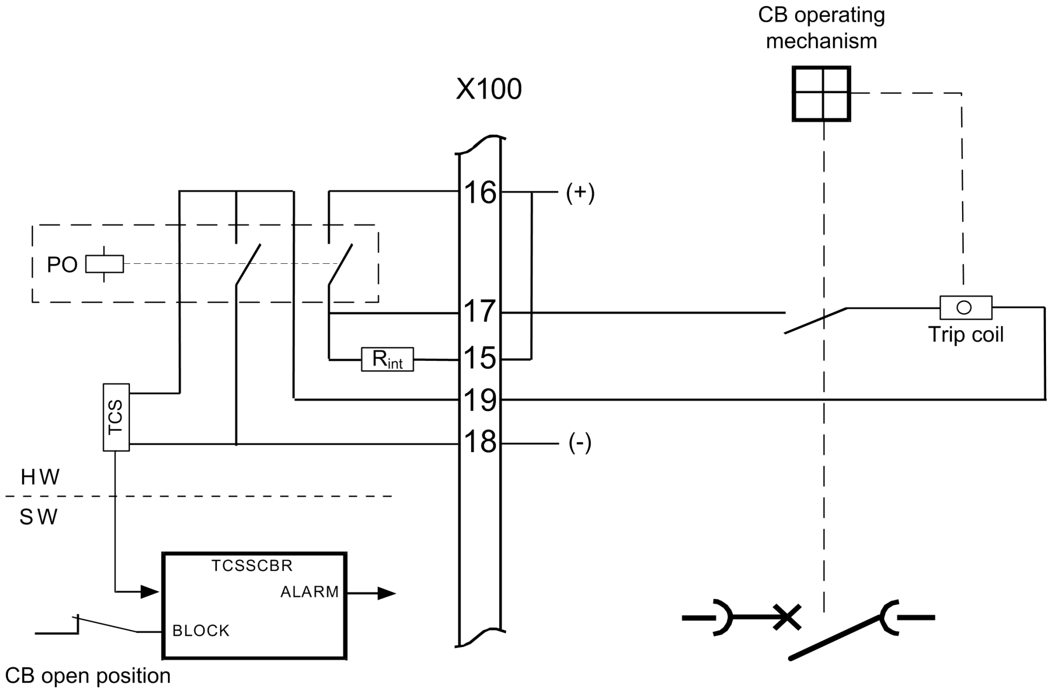


Figure 88: Operating principle of the trip-circuit supervision without an external resistor. The circuit breaker open indication is set to block TCSSCBR when the circuit breaker is open.

Trip circuit supervision and other trip contacts

It is typical that the trip circuit contains more than one trip contact in parallel, for example in transformer feeders where the trip of a Buchholz relay is connected in parallel with the feeder terminal and other relays involved. The supervising current cannot detect if one or all the other contacts connected in parallel are not connected properly.

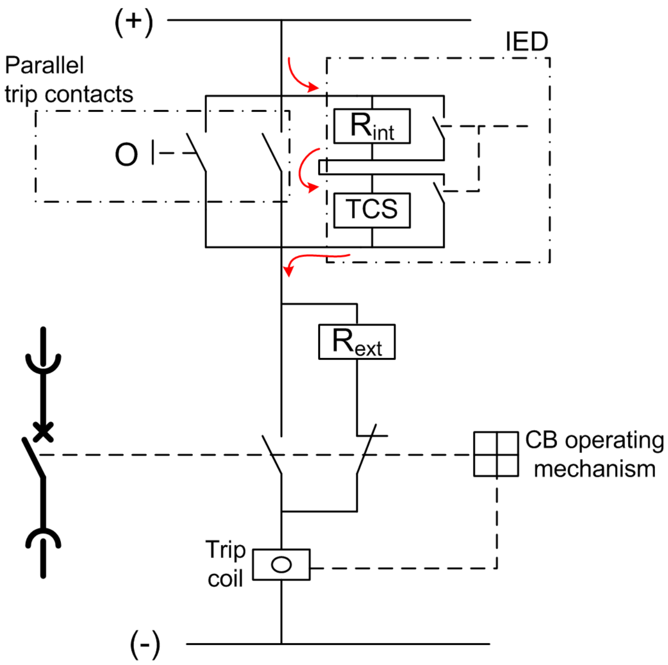


Figure 89: Constant test current flow in parallel trip contacts and trip circuit supervision

In case of parallel trip contacts, the recommended way to do the wiring is that the TCS test current flows through all wires and joints.

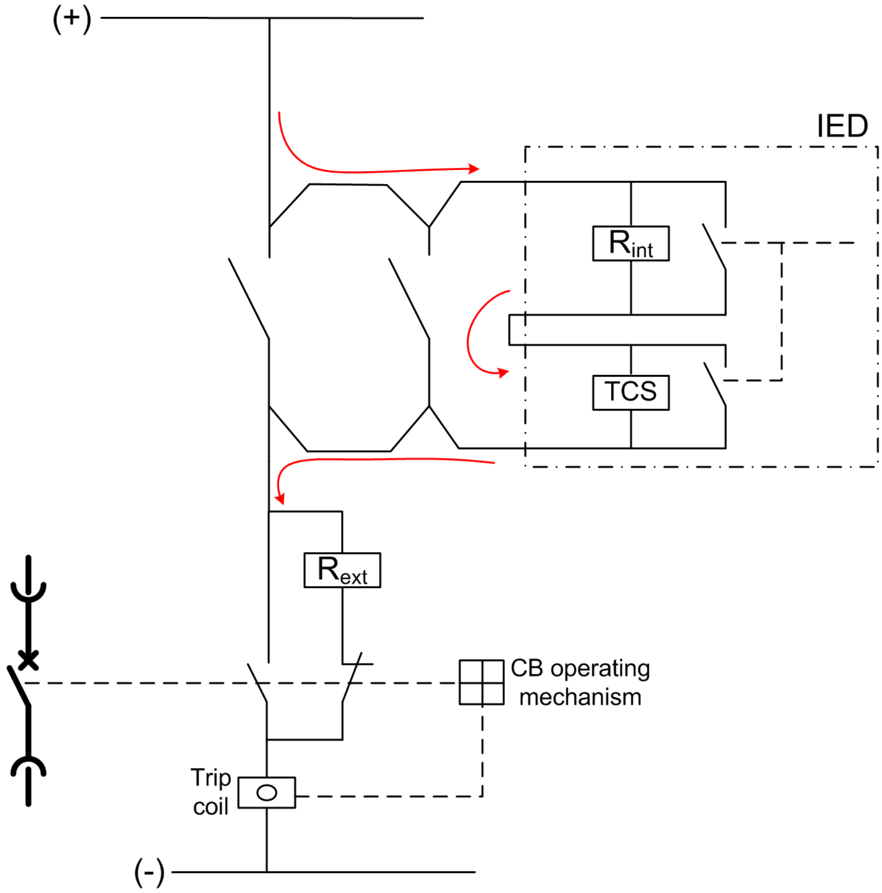


Figure 90: Improved connection for parallel trip contacts where the test current flows through all wires and joints

Several trip circuit supervision functions parallel in circuit

Not only the trip circuit often have parallel trip contacts, it is also possible that the circuit has multiple TCS circuits in parallel. Each TCS circuit causes its own supervising current to flow through the monitored coil and the actual coil current is a sum of all TCS currents. This must be taken into consideration when determining the resistance of R_{ext}.

Setting the TCS function in a merging unit not-in-use does not typically affect the supervising current injection.

Trip circuit supervision with auxiliary relays

Many retrofit projects are carried out partially, that is, the old electromechanical relays are replaced with new ones but the circuit breaker is not replaced. This creates a problem that the coil current of an old type circuit breaker can be too high for the merging unit trip contact to break.

The circuit breaker coil current is normally cut by an internal contact of the circuit breaker. In case of a circuit breaker failure, there is a risk that the merging unit trip contact is destroyed since the contact is obliged to disconnect high level of electromagnetic energy accumulated in the trip coil.

An auxiliary relay can be used between the merging unit trip contact and the circuit breaker coil. This way the breaking capacity question is solved, but the TCS circuit in the merging unit monitors the healthy auxiliary relay coil, not the circuit breaker coil. The separate trip circuit supervision relay is applicable for this to supervise the trip coil of the circuit breaker.

Dimensioning of the external resistor

Under normal operating conditions, the applied external voltage is divided between the relay's internal circuit and the external trip circuit so that at the minimum 20 V (15...20 V) remains over the relay's internal circuit. Should the external circuit's resistance be too high or the internal circuit's too low, for example due to welded relay contacts, a fault is detected.

Mathematically, the operation condition can be expressed as:

$$U_C - (R_{ext} + R_{int} + R_s) \times I_c \geq 20V \quad AC/DC$$

(Equation 4)

U_c	Operating voltage over the supervised trip circuit
I_c	Measuring current through the trip circuit, appr. 1.5 mA (0.99...1.72 mA)
R_{ext}	external shunt resistance
R_{int}	internal shunt resistance, 1 kΩ
R_s	trip coil resistance

If the external shunt resistance is used, it has to be calculated not to interfere with the functionality of the supervision or the trip coil. Too high a resistance causes too high a voltage drop, jeopardizing the requirement of at least 20 V over the internal circuit, while a resistance too low can enable false operations of the trip coil.

Table 169: Values recommended for the external resistor R ext

Operating voltage U_c	Shunt resistor R_{ext}
48 V AC/DC	1.2 kΩ, 5 W
60 V AC/DC	5.6 kΩ, 5 W
110 V AC/DC	22 kΩ, 5 W
220 V AC/DC	33 kΩ, 5 W

Due to the requirement that the voltage over the TCS contact must be 20 V or higher, the correct operation is not guaranteed with auxiliary operating voltages lower than 48 V DC because of the voltage drop in R_{int},R_{ext} and the operating coil or even voltage drop of the feeding auxiliary voltage system which can cause too low voltage values over the TCS contact. In this case, erroneous alarming can occur.

At lower (<48 V DC) auxiliary circuit operating voltages, it is recommended to use the circuit breaker position to block unintentional operation of TCS. The use of the position indication is described earlier in this chapter.

Using power output contacts without trip circuit supervision

If TCS is not used but the contact information of corresponding power outputs are required, the internal resistor can be by-passed. The output can then be utilized as a normal power output. When bypassing the internal resistor, the wiring between the terminals of the corresponding output X100:16-15(PO3) or X100:21-20(PO4) can be disconnected. The internal resistor is required if the complete TCS circuit is used.

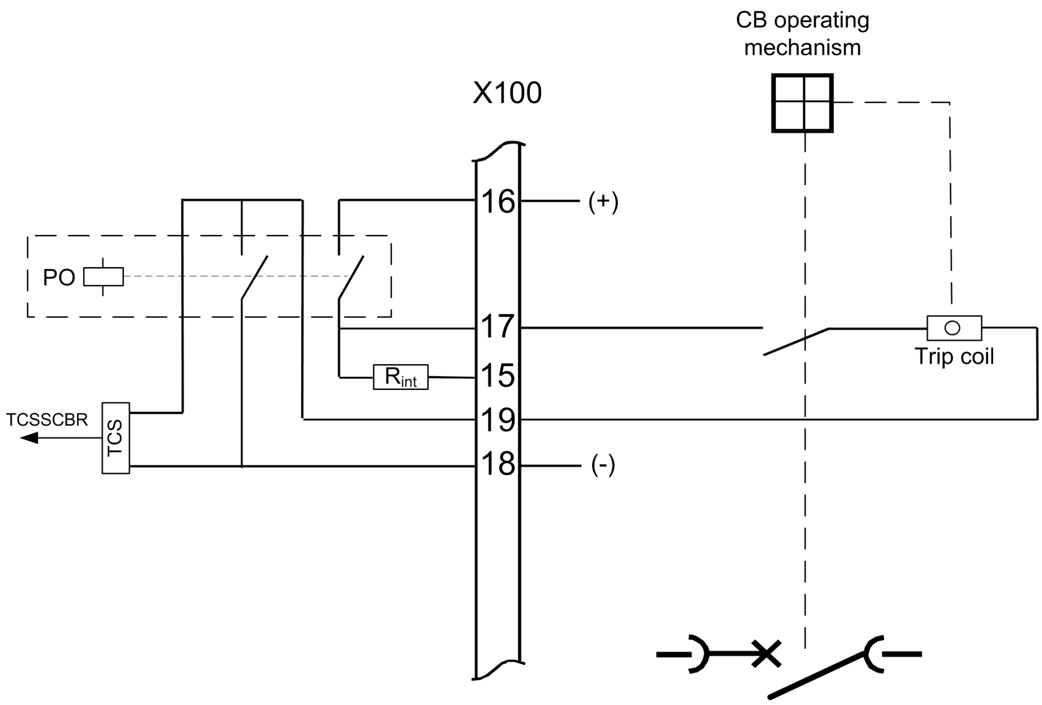


Figure 91: Connection of a power output in a case when TCS is not used and the internal resistor is disconnected

Incorrect connections and use of trip circuit supervision

Although the TCS circuit consists of two separate contacts, it must be noted that those are designed to be used as series connected to guarantee the breaking capacity given in the technical manual of the merging unit. In addition to the weak breaking capacity, the internal resistor is not dimensioned to withstand current without a TCS circuit. As a result, this kind of incorrect connection causes immediate burning of the internal resistor when the circuit breaker is in the close position and the voltage is applied to the trip circuit. The following figure shows incorrect usage of a TCS circuit when only one of the contacts is used.

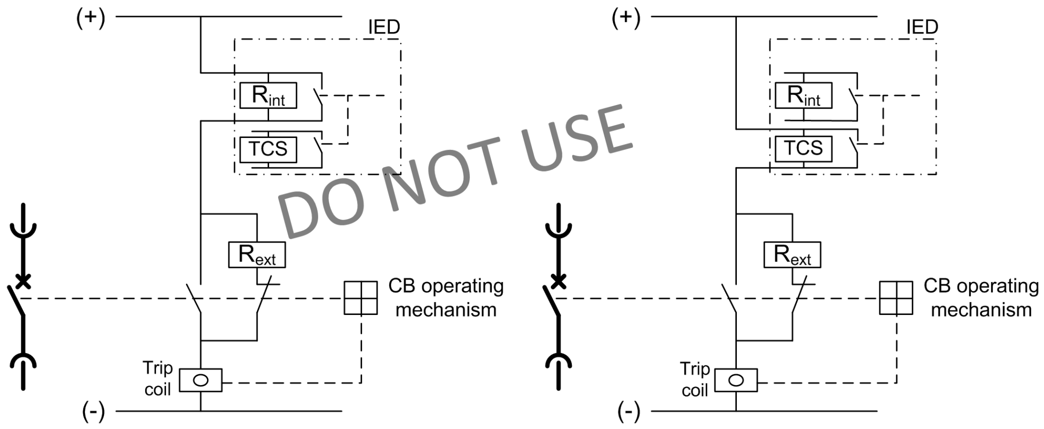


Figure 92: Incorrect connection of trip-circuit supervision

A connection of three merging units with a double pole trip circuit is shown in the following figure. Only the merging unit R3 has an internal TCS circuit. In order to test the operation of the merging unit R2, but not to trip the circuit breaker, the upper trip contact of the merging unit R2 is disconnected, as shown in the figure, while the lower contact is still connected. When the merging unit R2 operates, the coil current starts to flow through the internal resistor of the merging unit R3 and the resistor burns immediately. As proven with the previous examples, both trip contacts must operate together. Attention should also be paid for correct usage of the trip-circuit supervision while, for example, testing the merging unit.

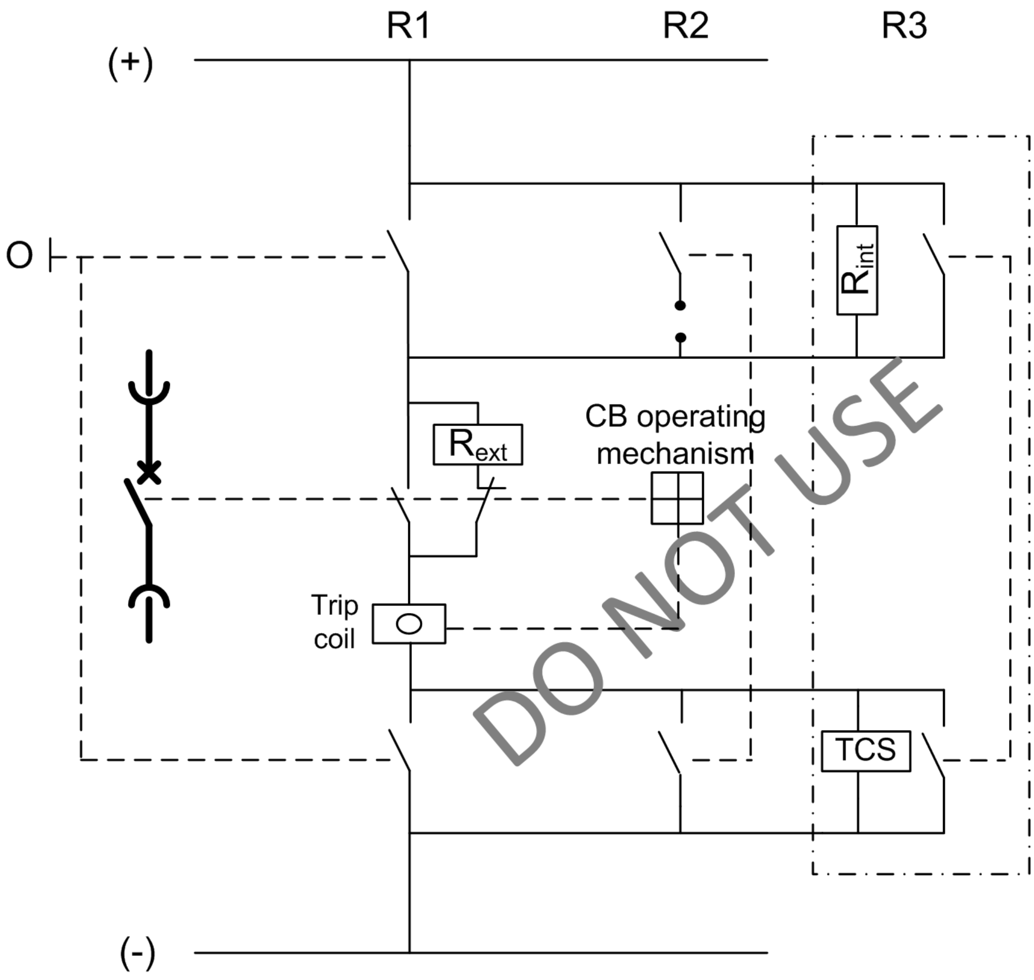


Figure 93: Incorrect testing of merging units

5.1.6 Signals

5.1.6.1 TCSSCBR Input signals

Table 170: TCSSCBR Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0=False	Block input status

5.1.6.2 TCSSCBR Output signals

Table 171: TCSSCBR Output signals

Name	Type	Description
ALARM	BOOLEAN	Alarm output

5.1.7 Settings

5.1.7.1 TCSSCBR Non group settings

Table 172: TCSSCBR Non group settings (Basic)

Parameter	Values (Range)	Unit	Step	Default	Description
Operation	1=on 5=off			5=off	Operation Off / On
Operate delay time	20...300000	ms	1	3000	Operate delay time

Table 173: TCSSCBR Non group settings (Advanced)

Parameter	Values (Range)	Unit	Step	Default	Description
Reset delay time	20...60000	ms	1	1000	Reset delay time

5.1.8 Monitored data

5.1.8.1 TCSSCBR Monitored data

Table 174: TCSSCBR Monitored data

Name	Type	Values (Range)	Unit	Description
TCSSCBR	Enum	1=on 2=blocked 3=test 4=test/blocked 5=off		Status

5.1.9 Technical revision history

Table 175: TCSSBR Technical revision history

Technical revision	Change
B	Internal improvement
C	Internal improvement

5.2 Current circuit supervision CCSPVC

5.2.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Current circuit supervision	CCSPVC	MCS 3I	MCS 3I

5.2.2 Function block

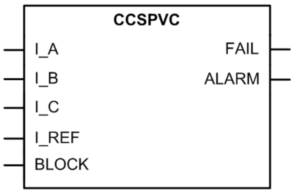


Figure 94: Function block

5.2.3 Functionality

The current circuit supervision function CCSPVC is used for monitoring current transformer secondary circuits.

CCSPVC calculates internally the sum of phase currents (I_A, I_B and I_C) and compares the sum against the measured single reference current (I_REF). The reference current must originate from other three-phase CT cores than the phase currents (I_A, I_B and I_C) and it is to be externally summated, that is, outside the merging unit.

CCSPVC detects a fault in the measurement circuit and issues an alarm or blocks the protection functions to avoid unwanted tripping.

It must be remembered that the blocking of protection functions at an occurring open CT circuit means that the situation remains unchanged and extremely high voltages stress the secondary circuit.

5.2.4 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of CCSPVC can be described with a module diagram. All the modules in the diagram are explained in the next sections.

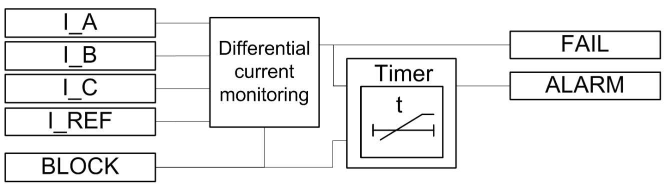


Figure 95: Functional module diagram

Differential current monitoring

Differential current monitoring supervises the difference between the summed phase currents I_A, I_B and I_C and the reference current I_REF.

The current operating characteristics can be selected with the *Start value* setting. When the highest phase current is less than 1.0 × In, the differential current limit is defined with *Start value*. When the highest phase current is more than 1.0 × In, the differential current limit is calculated with the equation.

$$MAX(I\_A, I\_B, I\_C) \times Start\ value$$

(Equation 5)

The differential current is limited to 1.0 × In.

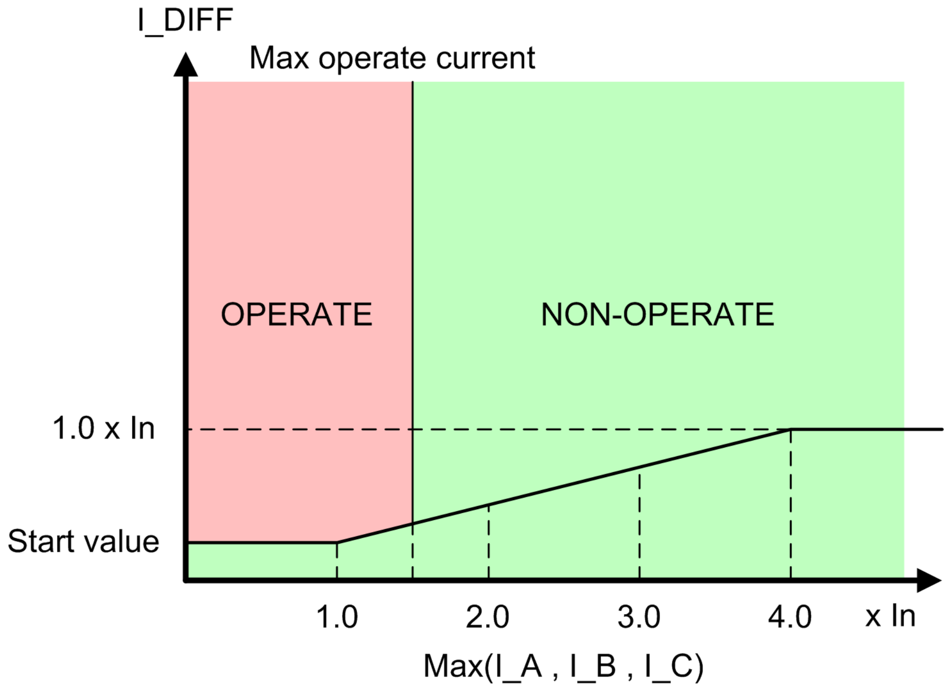


Figure 96: CCSPVC operating characteristics

When the differential current I_DIFF is in the operating region, the `FAIL` output is activated.

The function is internally blocked if any phase current is higher than the set *Max operate current*. When the internal blocking activates, the `FAIL` output is deactivated immediately. The internal blocking is used for avoiding false operation during a fault situation when the current transformers are saturated due to high fault currents.

The value of the differential current is available in the monitored data view on the WHMI or through other communication tools. The value is calculated with the equation.

$$I\_DIFF = \left| \overline{I\_A} + \overline{I\_B} + \overline{I\_C} \right| - \left| \overline{I\_REF} \right|$$

(Equation 6)

The *Start value* setting is given in units of ×In of the phase current transformer. The possible difference in the phase and reference current transformer ratios is internally compensated by scaling I_REF with the value derived from the *Primary current* setting values. These setting parameters can be found in the Basic functions section.

The activation of the BLOCK input deactivates the FAIL output immediately.

Timer

The timer is activated with the FAIL signal. The ALARM output is activated after a fixed 200 ms delay. FAIL needs to be active during the delay.

When the internal blocking is activated, the FAIL output is deactivated immediately immediately. However, the ALARM output is deactivated immediately after a fixed delay of three seconds.

The function resets when the differential current is below the start value and the highest phase current is more than 5 percent of the nominal current (0.05 × In).

If the current falls to zero when the FAIL or ALARM outputs are active, the deactivation of these outputs is prevented.

The activation of the BLOCK input deactivates the ALARM output.

5.2.5 Application

Open or short-circuited current transformer cores can cause unwanted operation in many protection functions such as differential, earth-fault current and negative-sequence current functions. When currents from two independent three-phase sets of CTs or CT cores measuring the same primary currents are available, reliable current circuit supervision can be arranged by comparing the currents from the two sets. When an error in any CT circuit is detected, the protection functions concerned can be blocked and an alarm given.

In case of high currents, the unequal transient saturation of CT cores with a different remanence or saturation factor can result in differences in the secondary currents from the two CT cores. An unwanted blocking of protection functions during the transient stage must then be avoided.

The supervision function must be sensitive and have a short operation time to prevent unwanted tripping from fast-acting, sensitive numerical protections in case of faulty CT secondary circuits.

Open CT circuits create extremely high voltages in the circuits, which may damage the insulation and cause further problems. This must be taken into consideration especially when the protection functions are blocked.

When the reference current is not connected to the merging unit, the function should be turned off. Otherwise, the FAIL output is activated when unbalance occurs in the phase currents even if there was nothing wrong with the measurement circuit.

Reference current measured with core-balanced current transformer

CCSPVC compares the sum of phase currents to the current measured with the core-balanced CT.

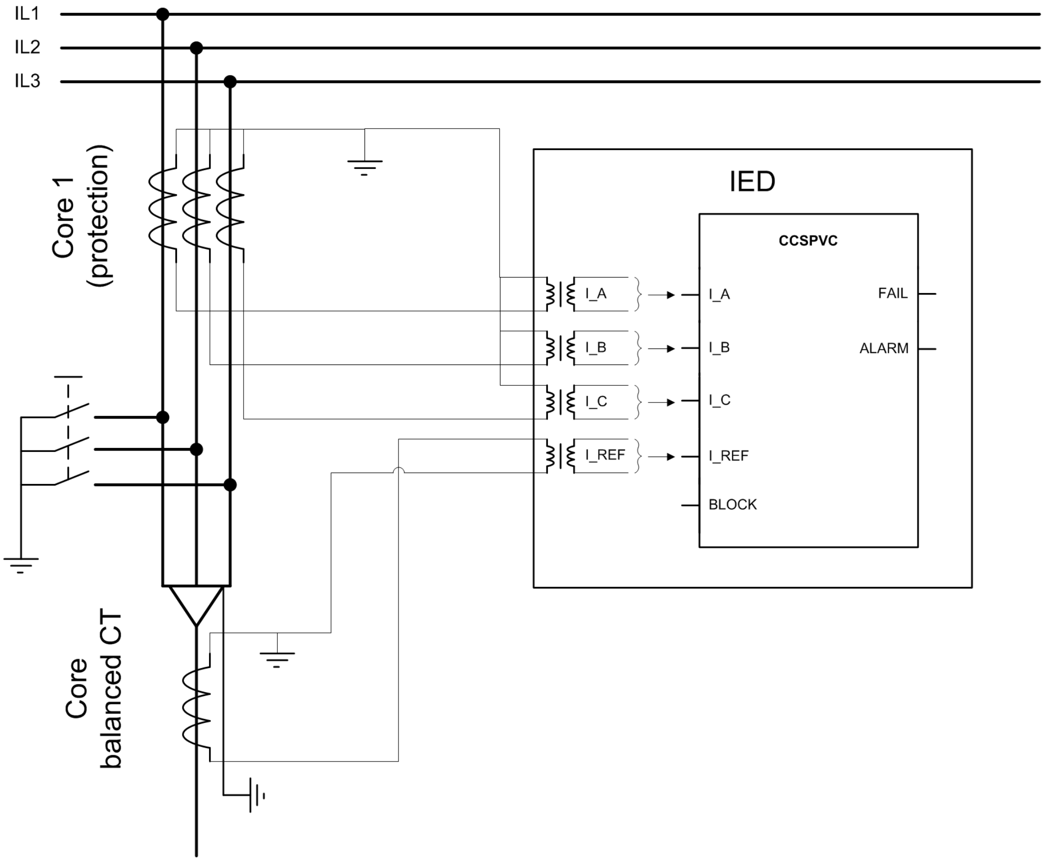


Figure 97: Connection diagram for reference current measurement with core-balanced current transformer

Current measurement with two independent three-phase sets of CT cores

Figure 98 and *Figure 99* show diagrams of connections where the reference current is measured with two independent three-phase sets of CT cores.

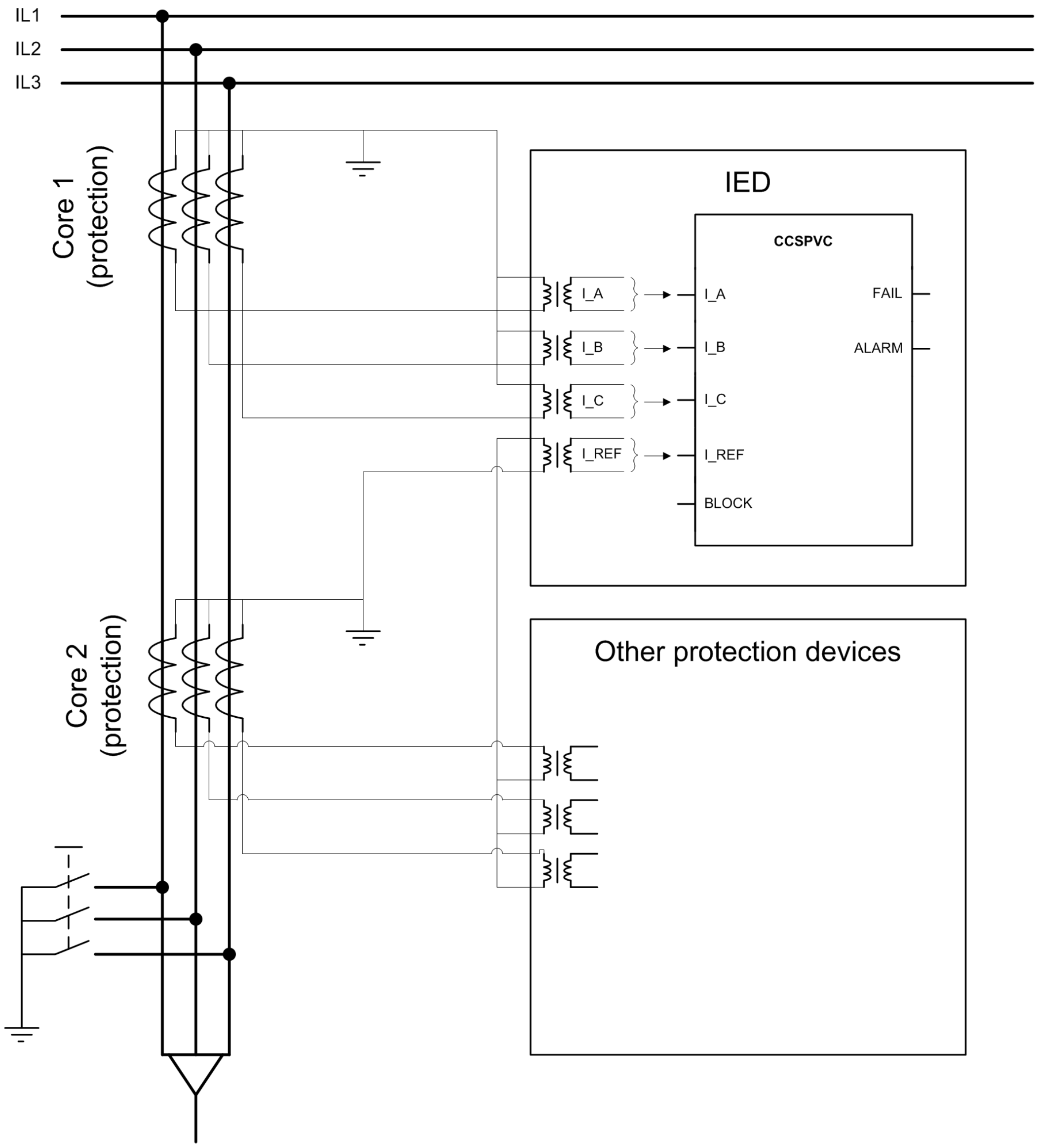


Figure 98: Connection diagram for current circuit supervision with two sets of three-phase current transformer protection cores

When using the measurement core for reference current measurement, it should be noted that the saturation level of the measurement core is much lower than with the protection core. This should be taken into account when setting the current circuit supervision function.

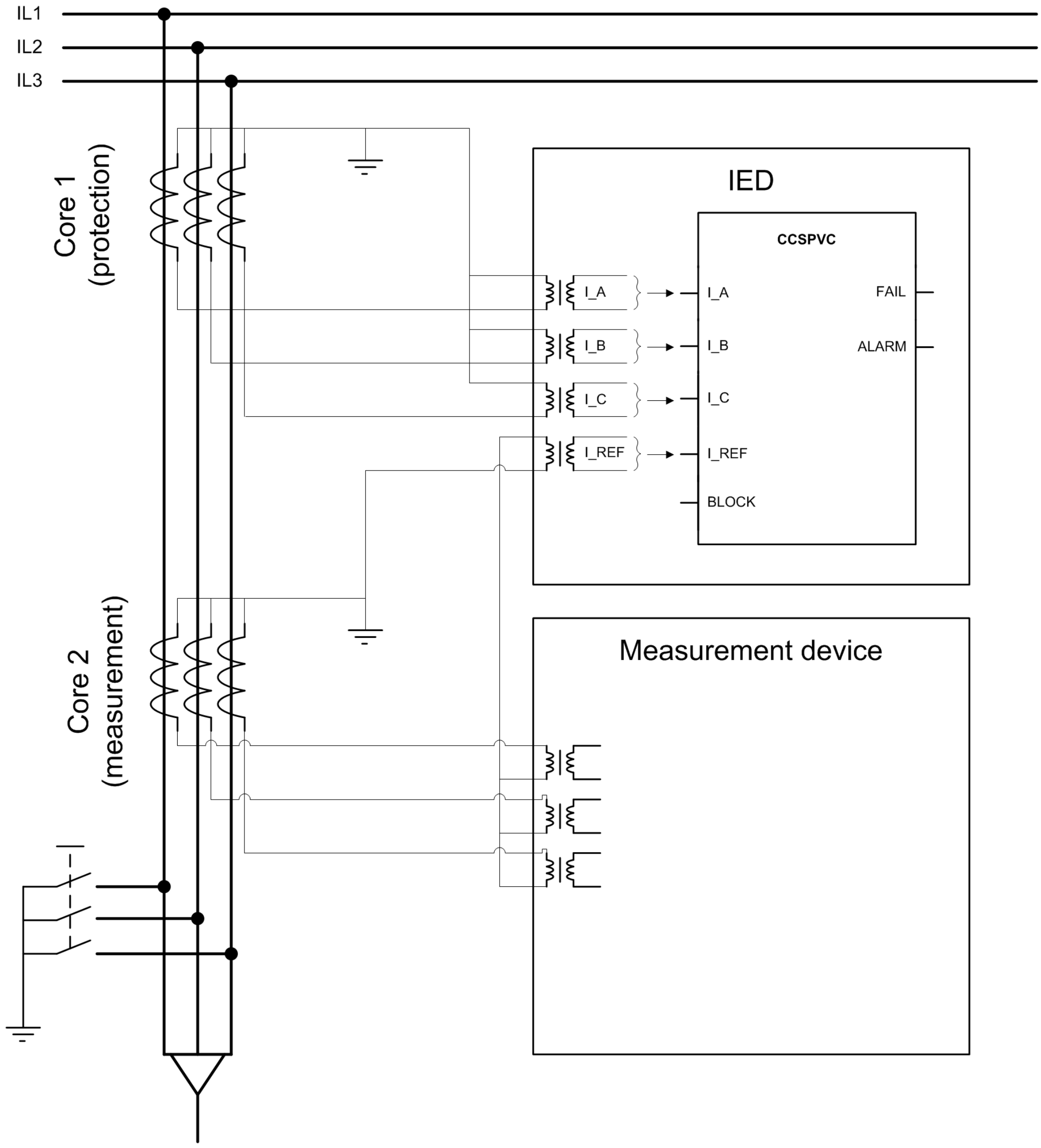


Figure 99: Connection diagram for current circuit supervision with two sets of three-phase current transformer cores (protection and measurement)

Example of incorrect connection

The currents must be measured with two independent cores, that is, the phase currents must be measured with a different core than the reference current. A connection diagram shows an example of a case where the phase currents and the reference currents are measured from the same core.

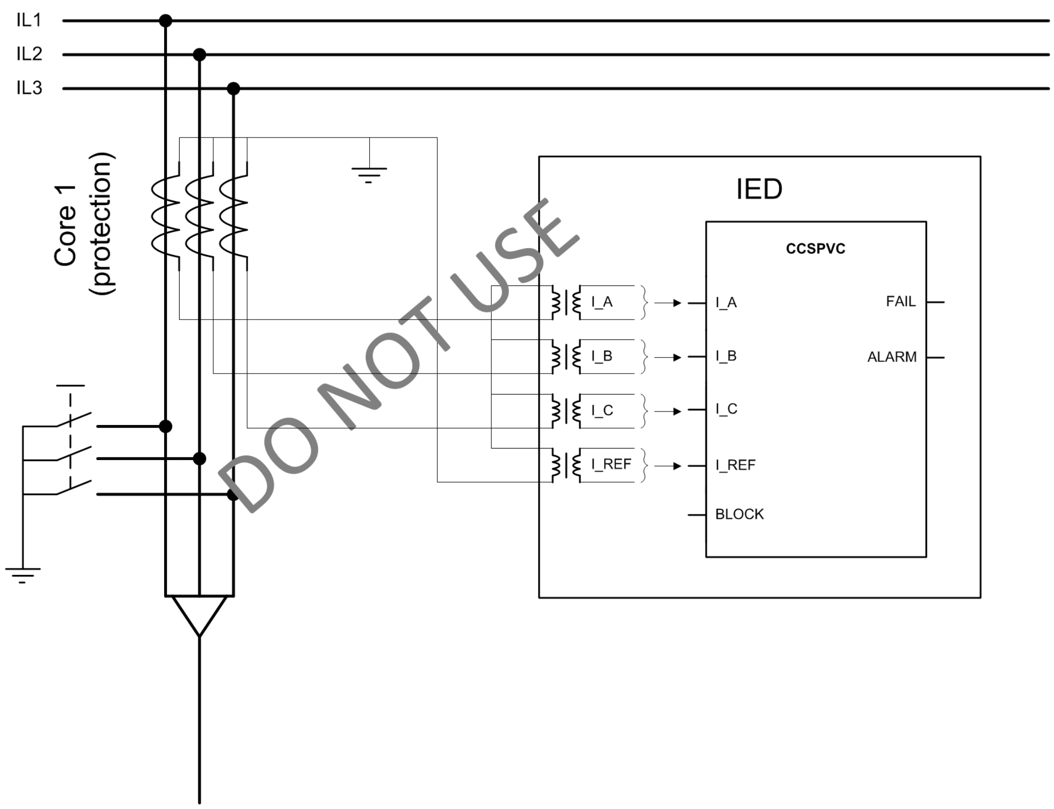


Figure 100: Example of incorrect reference current connection

5.2.6 Signals

5.2.6.1 CCSPVC Input signals

Table 176: CCSPVC Input signals

Name	Type	Default	Description
I_A	SIGNAL	0	Phase A current
I_B	SIGNAL	0	Phase B current
I_C	SIGNAL	0	Phase C current
I_REF	SIGNAL	0	Reference current
BLOCK	BOOLEAN	0=False	Block signal for all binary outputs

5.2.6.2 CCSPVC Output signals

Table 177: CCSPVC Output signals

Name	Type	Description
FAIL	BOOLEAN	Fail output
ALARM	BOOLEAN	Alarm output

5.2.7 Settings

5.2.7.1 CCSPVC Non group settings

Table 178: CCSPVC Non group settings (Basic)

Parameter	Values (Range)	Unit	Step	Default	Description
Operation	1=on 5=off			1=on	Operation On / Off
Start value	0.05...0.20	xIn	0.01	0.05	Minimum operate current differential level

Table 179: CCSPVC Non group settings (Advanced)

Parameter	Values (Range)	Unit	Step	Default	Description
Max operate current	1.00...5.00	xIn	0.01	1.50	Block of the function at high phase current

5.2.8 Monitored data

5.2.8.1 CCSPVC Monitored data

Table 180: CCSPVC Monitored data

Name	Type	Values (Range)	Unit	Description
IDIFF	FLOAT32	0.00...40.00	xIn	Differential current
CCSPVC	Enum	1=on 2=blocked 3=test 4=test/blocked 5=off		Status

5.2.9 Technical data

Table 181: CCSPVC Technical data

Characteristic	Value
Operate time [1]	<30 ms

5.2.10 Technical revision history

Table 182: CCSPVC Technical revision history

Technical revision	Change
B	Internal improvement
C	Internal improvement
D	Internal improvement

5.3 Fuse failure supervision SEQSPVC

5.3.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Fuse failure supervision	SEQSPVC	FUSEF	60

5.3.2 Function block

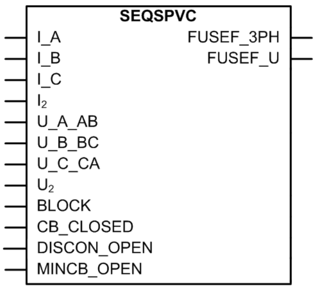


Figure 101: Function block

[1] Including the delay of the output contact

5.3.3 Functionality

The fuse failure supervision function SEQSPVC is used to block the voltage-measuring functions when failure occurs in the secondary circuits between the voltage transformer (or combi sensor or voltage sensor) and merging unit to avoid faulty operation of the voltage protection functions.

SEQSPVC has two algorithms, a negative sequence-based algorithm and a delta current and delta voltage algorithm.

A criterion based on the delta current and the delta voltage measurements can be activated to detect three-phase fuse failures which usually are more associated with the voltage transformer switching during station operations.

5.3.4 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of SEQSPVC can be described with a module diagram. All the modules in the diagram are explained in the next sections.

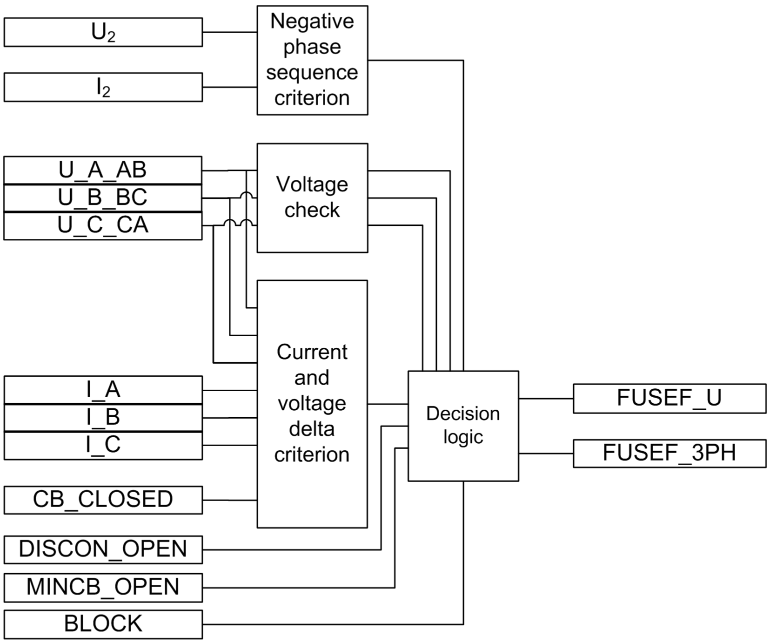


Figure 102: Functional module diagram

Negative phase-sequence criterion

A fuse failure based on the negative-sequence criterion is detected if the measured negative-sequence voltage exceeds the set *Neg Seq voltage Lev* value and the measured negative-sequence current is below the set *Neg Seq current Lev* value. The detected fuse failure is reported to the decision logic module.

Voltage check

The phase voltage magnitude is checked when deciding whether the fuse failure is a three, two or a single-phase fault.

The module makes a phase-specific comparison between each voltage input and the *Seal in voltage* setting. If the input voltage is lower than the setting, the corresponding phase is reported to the decision logic module.

Current and voltage delta criterion

The delta function can be activated by setting the *Change rate enable* parameter to "True". Once the function is activated, it operates in parallel with the negative sequence-based algorithm. The current and voltage are continuously measured in all three phases to calculate:

- Change of voltage dU/dt
- Change of current dI/dt

The calculated delta quantities are compared to the respective set values of the *Current change rate* and *Voltage change rate* settings.

The delta current and delta voltage algorithms detect a fuse failure if there is a sufficient negative change in the voltage amplitude without a sufficient change in the current amplitude in each phase separately. This is performed when the circuit breaker is closed. Information about the circuit breaker position is connected to the `CB_CLOSED` input.

There are two conditions for activating the current and voltage delta function.

- The magnitude of dU/dt exceeds the corresponding value of the *Voltage change rate* setting and magnitude of dI/dt is below the value of the *Current change rate* setting in any phase at the same time due to the closure of the circuit breaker (`CB_CLOSED` = TRUE).
- The magnitude of dU/dt exceeds the value of the *Voltage change rate* setting and the magnitude of dI/dt is below the *Current change rate* setting in any phase at the same time and the magnitude of the phase current in the same phase exceeds the *Min Op current delta* setting.

The first condition requires the delta criterion to be fulfilled in any phase at the same time as the circuit breaker is closed. Opening the circuit breaker at one end and energizing the line from the other end onto a fault could lead to an improper operation of SEQSPVC with an open breaker. If this is considered to be an important disadvantage, the `CB_CLOSED` input is to be connected to FALSE. In this way only the second criterion can activate the delta function.

The second condition requires the delta criterion to be fulfilled in one phase together with a high current for the same phase. The measured phase current is used to reduce the risk of a false fuse failure detection. If the current on the protected line is low, a voltage drop in the system (not caused by the fuse failure) is not followed by a current change and a false fuse failure can occur. To prevent this, the minimum phase current criterion is checked.

The fuse failure detection is active until the voltages return above the *Min Op voltage delta* setting. If a voltage in a phase is below the *Min Op voltage delta* setting, a new fuse failure detection for that phase is not possible until the voltage returns above the setting value.

Decision logic

If voltages are Wye-connected, it is recommended to scale the default values of voltage-based settings with 1/sqrt(3) because the default setting values apply for Delta-connected settings.

The fuse failure detection outputs FUSEF_U and FUSEF_3PH are controlled according to the detection criteria or external signals.

Table 183: Fuse failure output control

Fuse failure detection criterion	Conditions and function response
Negative-sequence criterion	If a fuse failure is detected based on the negative sequence criterion, the FUSEF_U output is activated.
	If the fuse failure detection is active for more than five seconds and at the same time all the phase voltage values are below the set value of the *Seal in voltage* setting with *Enable seal* in turned to "True", the function activates the FUSE_3PH output signal.
	The FUSEF_U output signal is also activated if all the phase voltages are above the *Seal in voltage* setting for more than 60 seconds and at the same time the negative sequence voltage is above *Neg Seq voltage Lev* for more than 5 seconds, all the phase currents are below the *Current dead Lin Val* setting and the circuit breaker is closed, that is,CB_CLOSED is TRUE.
Current and voltage delta function criterion	If the current and voltage delta criterion detects a fuse failure condition, but all the voltages are not below the *Seal in voltage* setting, only the FUSEF_U output is activated.
	If the fuse failure detection is active for more than five seconds and at the same time all the phase voltage values are below the set value of the *Seal in voltage* setting with Enable seal in turned to "True", the function activates the FUSE_3PH output signal.
External fuse failure detection	The MINCB_OPEN input signal is supposed to be connected through a merging unit binary input to the N.C. auxiliary contact of the miniature circuit breaker protecting the VT secondary circuit.The MINCB_OPEN signal sets the FUSEF_U output signal to block all the voltage-related functions when MCB is in the open state.
	The DISCON_OPEN input signal is supposed to be connected through a merging unit binary input to the N.C. auxiliary contact of the line disconnector.The DISCON_OPEN signal sets the FUSEF_U output signal to block the voltage- related functions when the line disconnector is in the open state.

It is recommended to always set *Enable seal in* to "True". This secures that the blocked protection functions remain blocked until normal voltage conditions are restored if the fuse failure has been active for 5 seconds, that is, the fuse failure outputs are deactivated when the normal voltage conditions are restored.

The activation of the BLOCK input deactivates both FUSEF_U and FUSEF_3PH outputs.

5.3.5 Application

Some protection functions operate on the basis of the measured voltage value in the merging unit point. These functions can fail if there is a fault in the measuring circuits between the voltage transformer (or combi sensor or voltage sensor) and merging unit.

A fault in the voltage-measuring circuit is called a fuse failure. This term is misleading since a blown fuse is just one of the many possible reasons for a broken circuit. Since incorrectly measured voltage can result in a faulty operation of some of the protection functions, it is important to detect the fuse failures. A fast fuse failure detection is one of the means to block voltage-based functions before they operate.

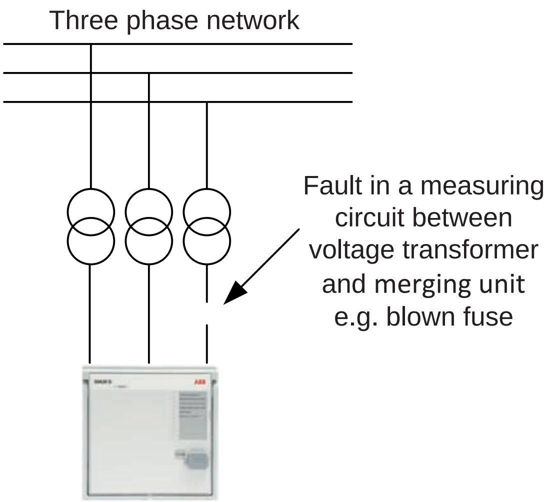


Figure 103: Fault in a circuit from the voltage transformer to the merging unit

A fuse failure occurs due to blown fuses, broken wires or intended substation operations. The negative sequence component-based function can be used to detect different types of single-phase or two-phase fuse failures. However, at least one of the three circuits from the voltage transformers must be intact. The supporting delta-based function can also detect a fuse failure due to three-phase interruptions.

In the negative sequence component-based part of the function, a fuse failure is detected by comparing the calculated value of the negative sequence component voltage to the negative sequence component current. The sequence entities are calculated from the measured current and voltage data for all three phases. The purpose of this function is to block voltage-dependent functions when a fuse failure is detected. Since the voltage dependence differs between these functions, SEQSPVC has two outputs for this purpose.

5.3.6 Signals

5.3.6.1 SEQRFUF Input signals

Table 184: SEQRFUF Input signals

Name	Type	Default	Description
I_A	SIGNAL	0	Phase A current
I_B	SIGNAL	0	Phase B current
I_C	SIGNAL	0	Phase C current
I_2	SIGNAL	0	Negative sequence current
U_A_AB	SIGNAL	0	Phase A voltage
U_B_BC	SIGNAL	0	Phase B voltage
U_C_CA	SIGNAL	0	Phase C voltage
U_2	SIGNAL	0	Negative phase sequence voltage
BLOCK	BOOLEAN	0=False	Block of function
CB_CLOSED	BOOLEAN	0=False	Active when circuit breaker is closed
DISCON_OPEN	BOOLEAN	0=False	Active when line disconnector is open
MINCB_OPEN	BOOLEAN	0=False	Active when external MCB opens protected voltage circuit

5.3.6.2 SEQRFUF Output signals

Table 185: SEQRFUF Output signals

Name	Type	Description
FUSEF_3PH	BOOLEAN	Three-phase start of function
FUSEF_U	BOOLEAN	General start of function

5.3.7 Settings

5.3.7.1 SEQRFUF Non group settings

Table 186: SEQRFUF Non group settings (Basic)

Parameter	Values (Range)	Unit	Step	Default	Description
Operation	1=on 5=off			1=on	Operation Off / On

Table 187: SEQRFUF Non group settings (Advanced)

Parameter	Values (Range)	Unit	Step	Default	Description
Neg Seq current Lev	0.03...0.20	xIn	0.01	0.03	Operate level of neg seq undercurrent element
Neg Seq voltage Lev	0.03...0.20	xUn	0.01	0.10	Operate level of neg seq overvoltage element
Current change rate	0.01...0.50	xIn	0.01	0.15	Operate level of change in phase current
Voltage change rate	0.25...0.90	xUn	0.01	0.40	Operate level of change in phase voltage
Change rate enable	0=False 1=True			0=False	Enabling operation of change based function
Min Op voltage delta	0.01...1.00	xUn	0.01	0.50	Minimum operate level of phase voltage for delta calculation
Min Op current delta	0.01...1.00	xIn	0.01	0.10	Minimum operate level of phase current for delta calculation
Seal in voltage	0.01...1.00	xUn	0.01	0.50	Operate level of seal-in phase voltage
Enable seal in	0=False 1=True			0=False	Enabling seal in functionality
Current dead Lin Val	0.05...1.00	xIn	0.01	0.05	Operate level for open phase current detection

5.3.8 Monitored data

5.3.8.1 SEQRFUF Monitored data

Table 188: SEQRFUF Monitored data

Name	Type	Values (Range)	Unit	Description
SEQRFUF	Enum	1=on 2=blocked 3=test 4=test/blocked 5=off		Status

5.3.9 Technical data

Table 189: SEQSPVC Technical data

Characteristic		Value	
Operate time [1]	NPS function	U_{Fault} = 1.1 × set *Neg Seq voltage Lev*	<33 ms
		U_{Fault} = 5.0 × set *Neg Seq voltage Lev*	<18 ms
	Delta function	ΔU = 1.1 × set *Voltage change rate*	<30 ms
		ΔU = 2.0 × set *Voltage change rate*	<24 ms

5.3.10 Technical revision history

Table 190: SEQSPVC Technical revision history

Technical revision	Change
B	Internal improvement
C	Internal improvement
D	Function name changed from SEQRFUF to SEQSPVC

[1] Includes the delay of the signal output contact, f_n = 50 Hz, fault voltage with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements

5.4 Arc detection ARCDSARC

5.4.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Arc detection	ARCDSARC	ARCD	AFD

5.4.2 Function block

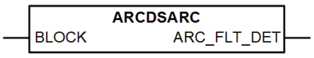


Figure 104: Function block

5.4.3 Functionality

The arc function ARCDSARC is used for detection of arc situations in air insulated metal-clad switchgears caused by, for example, human errors during maintenance or insulation breakdown during operation. The function monitors the light information from an arc and delivers a signal, if the arc is detected.

The function contains a blocking functionality. Blocking deactivates all outputs and resets timer.

5.4.4 Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are “On” and “Off”. The operation counters are cleared when *Operation* is set to “Off”.

The operation of ARCDSARC can be described with a module diagram.

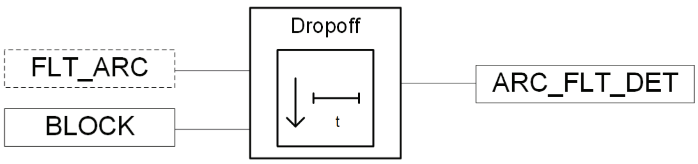


Figure 105: Functional module diagram

The functions receives the arc light information from the sensors. Input FLT_ARC activates the drop-off timer. Once activated, the timer remains active until the input is deactivated or at least during the drop-off time of 25 ms. The BLOCK signal can be used to block the arc detection output ARC_FLT_DET.

5.4.5 Application

The arc detection information from this function can be used in the standalone devices, for an alarm or protection logic. Also this information can be also be utilized in centralized solutions, for station-wide arc protection scheme. The arc detection consists of:

- Optional arc light detection hardware with automatic backlight compensation for lens type sensors
- Light signal output ARC_FLT_DET for routing indication of locally detected light signal to the protection device

The light from an arc is detected locally, by lens sensors connected to inputs Light sensor 1, Light sensor 2 or Light sensor 3 on the communication module of the merging unit. The lens sensors can be placed, for instance, in the busbar compartment, the breaker compartment and the cable compartment of the metal-clad cubicle.

The light detected by the lens sensors is compared to an automatically adjusted reference level. Inputs Light sensor 1, Light sensor 2 and Light sensor 3 have their own reference levels. When the reference level of one of the inputs is exceeded, light has been detected.

The light signal output from an arc detection stage ARC_FLT_DET is activated immediately in the detection of light in all situations. A centralized arc protection solution is realized by routing the light signal output to an output contact connected to a binary input of the protection device, or by routing the light signal output through the communication.

Cover unused inputs with dust caps.

5.4.6 Signals

5.4.6.1 ARCDSARC Input signals

Table 191: ARCDSARC Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0=False	Block signal for all binary outputs

5.4.6.2 ARCDSARC Output signals

Table 192: ARCDSARC Output signals

Name	Type	Description
ARC_FLT_DET	BOOLEAN	Fault arc detected=light signal output

5.4.7 Settings

5.4.7.1 ARCDSARC Non group settings

Table 193: ARCDSARC Non group settings (Basic)

Parameter	Values (Range)	Unit	Step	Default	Description
Operation	1=on 5=off			1=on	Operation Off / On

5.4.8 Monitored data

5.4.8.1 ARCDSARC Monitored data

Table 194: ARCDSARC Monitored data

Name	Type	Values (Range)	Unit	Description
ARCDSARC	Enum	1=on 2=blocked 3=test 4=test/blocked 5=off		Status

5.4.9 Technical data

Table 195: ARCDSARC Technical data

Characteristic	Value		
Operate time [1]	Minimum	Typical	Maximum
	9 ms [2] 4 ms [3]	10 ms [2] 6 ms [3]	12 ms [2] 7 ms [3]

1 Includes the delay of the heavy-duty output contact
2 Normal power output
3 High-speed power output

6 Condition monitoring functions

6.1 Circuit breaker condition monitoring SSCBR

6.1.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Circuit-breaker condition monitoring	SSCBR	CBCM	CBCM

6.1.2 Function block

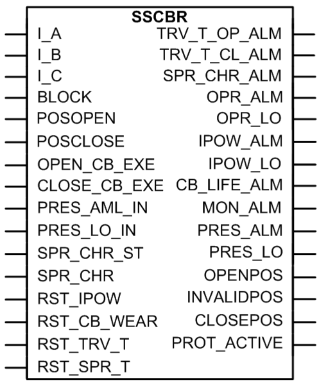


Figure 106: Function block

6.1.3 Functionality

The circuit-breaker condition monitoring function SSCBR is used to monitor different parameters of the circuit breaker. The breaker requires maintenance when the number of operations has reached a predefined value. The energy is calculated from the measured input currents as a sum of $I^{y}t$ values. Alarms are generated when the calculated values exceed the threshold settings.

The function contains a blocking functionality which can be used to block the function outputs.

6.1.4 Operation principle

The circuit breaker condition monitoring function includes different metering and monitoring sub-functions. The functions can be enabled and disabled with the *Operation* setting. The corresponding parameter values are “On” and “Off”. The operation counters are cleared when *Operation* is set to “Off”.

The operation of SSCBR can be described with a module diagram. All the modules in the diagram are explained in the next sections.

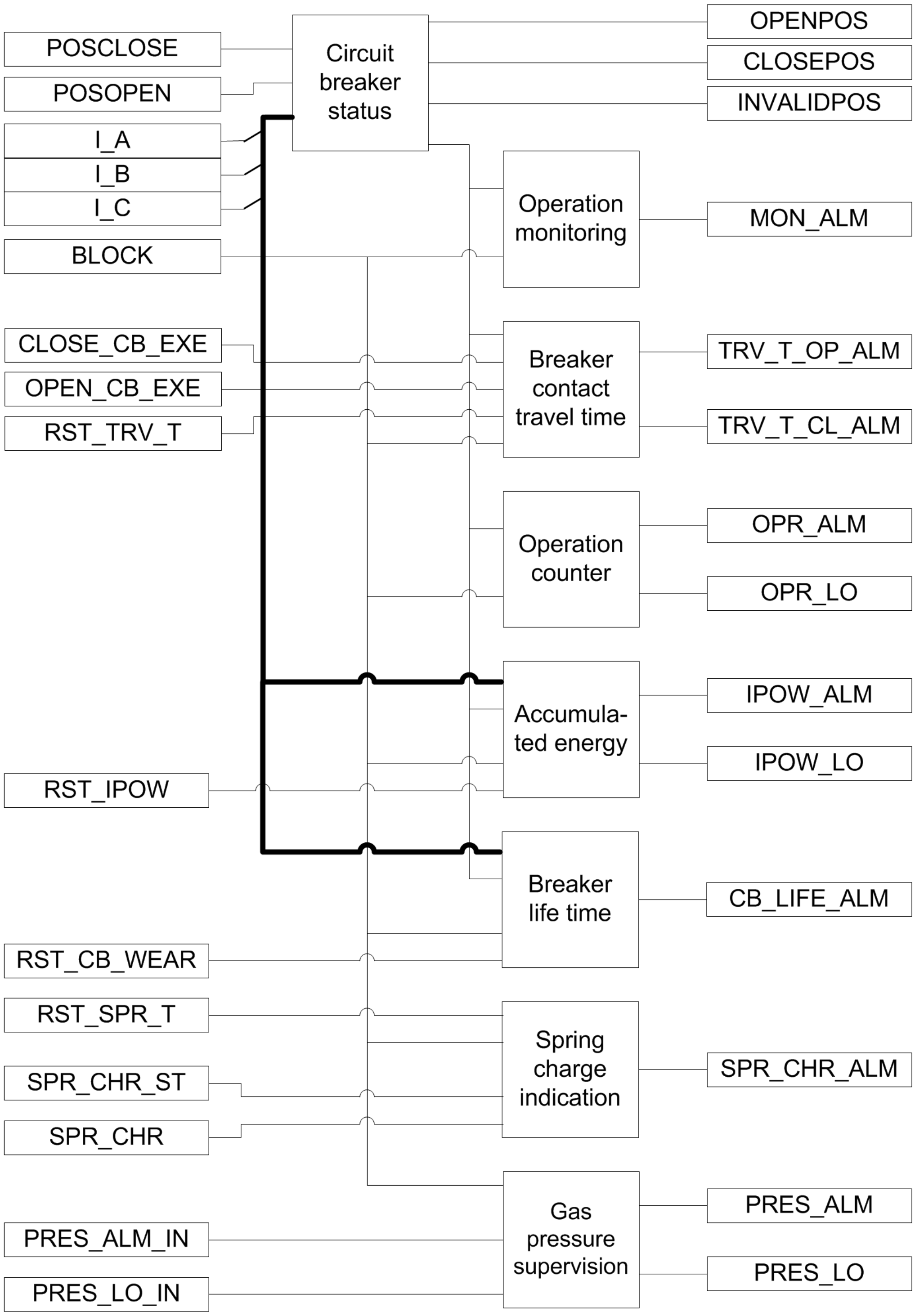


Figure 107: Functional module diagram

6.1.4.1 Circuit breaker status

The Circuit breaker status sub-function monitors the position of the circuit breaker, that is, whether the breaker is in open, closed or invalid position. The operation of the breaker status monitoring can be described by using a module diagram. All the modules in the diagram are explained in the next sections.

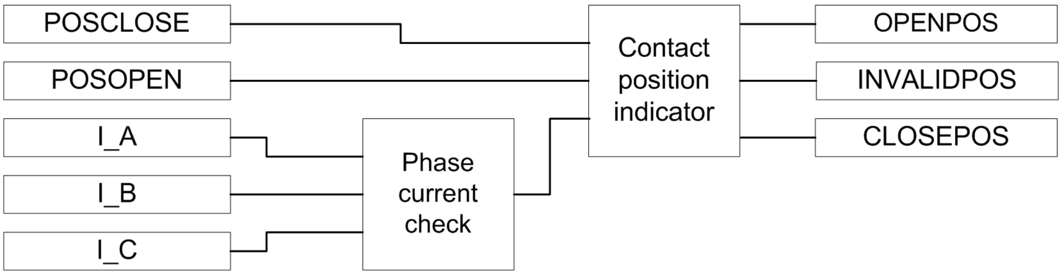


Figure 108: Functional module diagram for monitoring circuit breaker status

Phase current check

This module compares the three phase currents to the setting *Acc stop current*. If the current in a phase exceeds the set level, information about the phase is reported to the contact position indicator module.

Contact position indicator

The OPENPOS output is activated when the auxiliary input contact POSCLOSE is FALSE, the POSOPEN input is TRUE and all the phase currents are below the setting *Acc stop current*.

The CLOSEPOS output is activated when the auxiliary POSOPEN input is FALSE and the POSCLOSE input is TRUE.

The INVALIDPOS output is activated when both the auxiliary contacts have the same value, that is, both are in the same logical level, or if the auxiliary input contact POSCLOSE is FALSE and the POSOPEN input is TRUE and any of the phase currents exceed the setting Acc stop current.

The status of the breaker is indicated by the binary outputs OPENPOS, INVALIDPOS and CLOSEPOS for open, invalid and closed position respectively.

6.1.4.2 Circuit breaker operation monitoring

The purpose of the circuit breaker operation monitoring subfunction is to indicate if the circuit breaker has not been operated for a long time.

The operation of the circuit breaker operation monitoring can be described with a module diagram. All the modules in the diagram are explained in the next sections.

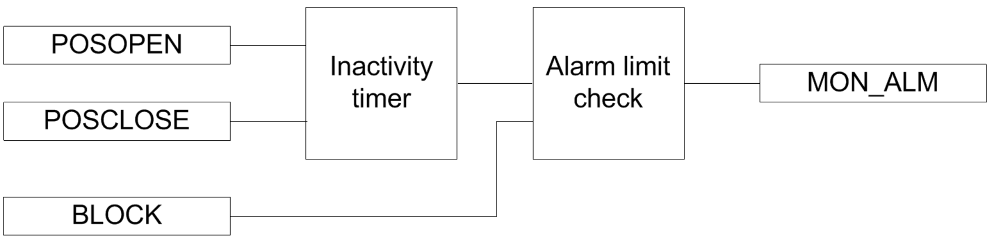


Figure 109: Functional module diagram for calculating inactive days and alarm for circuit breaker operation monitoring

Inactivity timer

The module calculates the number of days the circuit breaker has remained inactive, that is, has stayed in the same open or closed state. The calculation is done by monitoring the states of the POSOPEN and POSCLOSE auxiliary contacts.

The inactive days INA_DAYS is available in the monitored data view. It is also possible to set the initial inactive days with the *Ini inactive days* parameter.

Alarm limit check

When the inactive days exceed the limit value defined with the *Inactive Alm days* setting, the MON_ALM alarm is initiated. The time in hours at which this alarm is activated can be set with the *Inactive Alm hours* parameter as coordinates of UTC. The alarm signal MON_ALM can be blocked by activating the binary input BLOCK.

6.1.4.3 Breaker contact travel time

The Breaker contact travel time module calculates the breaker contact travel time for the closing and opening operation. The operation of the breaker contact travel time measurement can be described with a module diagram. All the modules in the diagram are explained in the next sections.

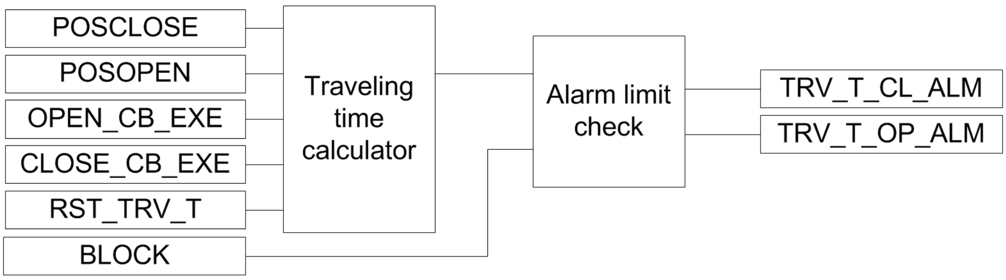


Figure 110: Functional module diagram for breaker contact travel time

Traveling time calculator

The travel time can be calculated using two different methods based on the setting *Travel time Clc mode*.

When the setting *Travel time Clc mode* is “From Pos to Pos”, the contact travel time of the breaker is calculated from the time between auxiliary contacts' state change. The opening travel time is measured between the opening of the POSCLOSE auxiliary contact and the closing of the POSOPEN auxiliary contact. The travel time is also measured between the opening of the POSOPEN auxiliary contact and the closing of the POSCLOSE auxiliary contact.

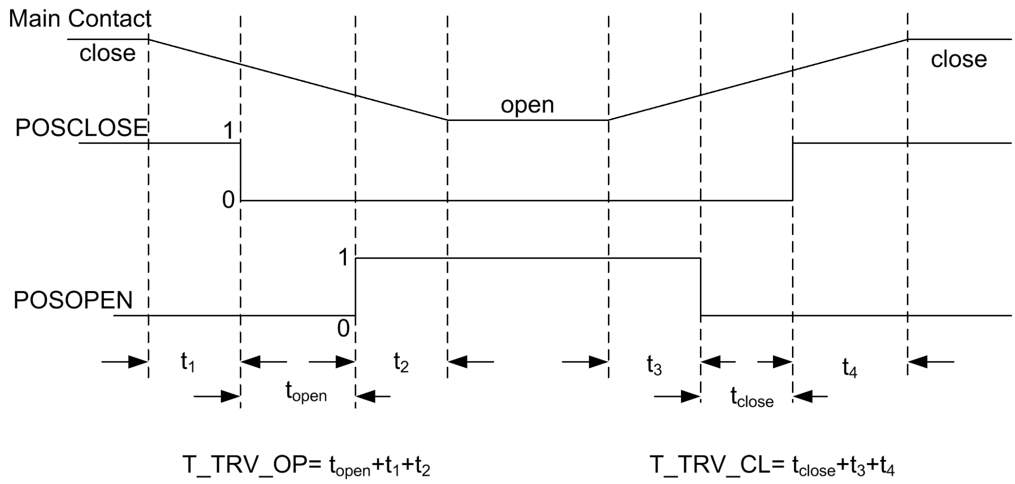


Figure 111: Travel time calculation when Travel time Clc mode is “From Pos to Pos”

There is a time difference t_1 between the start of the main contact opening and the opening of the POSCLOSE auxiliary contact. Similarly, there is a time gap t_2 between the time when the POSOPEN auxiliary contact opens and the main contact is completely open. To incorporate the time $t_1 + t_2$, a correction factor needs to be added with t_{open} to get the actual opening time. This factor is added with the *Opening time Cor* (= $t_1 + t_2$) setting. The closing time is calculated by adding the value set with the *Closing time Cor* ($t_3 + t_4$) setting to the measured closing time.

When the setting *Travel time Clc mode* is “From Cmd to Pos”, the contact travel time of the breaker is calculated from the time between the circuit breaker opening or closing command and the auxiliary contacts’ state change. The opening travel time is measured between the rising edge of the OPEN_CB_EXE command and the POSOPEN auxiliary contact. The closing travel time is measured between the rising edge of the CLOSE_CB_EXEC command and the POSCLOSE auxiliary contact.

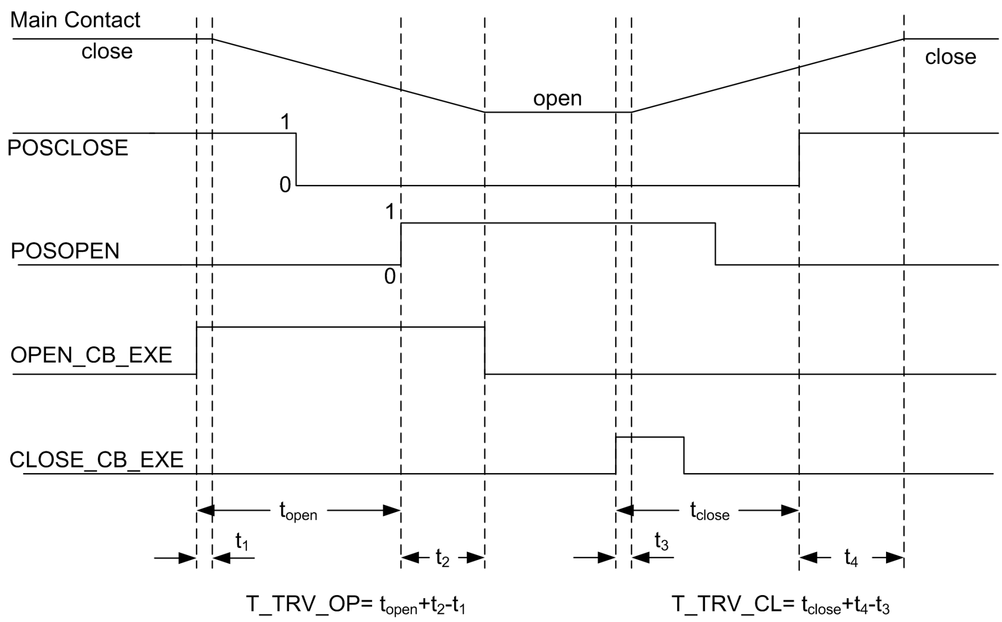


Figure 112: Travel time calculation when Travel time Clc mode is “From Cmd to Pos”

There is a time difference t_1 between the start of the main contact opening and the OPEN_CB_EXE command. Similarly, there is a time gap t_2 between the time when the POSOPEN auxiliary contact opens and the main contact is completely open. Therefore, to incorporate the times t_1 and t_2, a correction factor needs to be added with t_{open} to get the actual opening time. This factor is added with the *Opening time Cor* (= $t_2 - t_1$) setting. The closing time is calculated by adding the value set with the *Closing time Cor*($t_4 - t_3$) setting to the measured closing time.

The last measured opening travel time T_TRV_OP and the closing travel time T_TRV_CL are available in the monitored data view on the LHMI or through tools via communications.

Alarm limit check

When the measured opening travel time is longer than the value set with the *Open alarm time* setting, the TRV_T_OP_ALM output is activated. Respectively, when the measured closing travel time is longer than the value set with the *Close alarm time* setting, the TRV_T_CL_ALM output is activated.

It is also possible to block the TRV_T_CL_ALM and TRV_T_OP_ALM alarm signals by activating the BLOCK input.

6.1.4.4 Operation counter

The operation counter subfunction calculates the number of breaker operation cycles. The opening and closing operations are both included in one operation cycle. The operation counter value is updated after each opening operation.

The operation of the subfunction can be described with a module diagram. All the modules in the diagram are explained in the next sections.

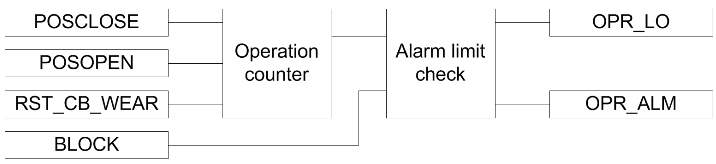


Figure 113: Functional module diagram for counting circuit breaker operations

Operation counter

The operation counter counts the number of operations based on the state change of the binary auxiliary contacts inputs POSCLOSE and POSOPEN.

The number of operations NO_OPR is available in the monitored data view on the WHMI or through tools via communications. The old circuit breaker operation counter value can be taken into use by writing the value to the *Counter initial Val* parameter and by setting the parameter *Initial CB Rmn life* in the clear menu from WHMI or LHMI.

Alarm limit check

The OPR_ALM operation alarm is generated when the number of operations exceeds the value set with the *Alarm Op number* threshold setting. However, if the number of operations increases further and exceeds the limit value set with the *Lockout Op number* setting, the OPR_LO output is activated.

The binary outputs OPR_LO and OPR_ALM are deactivated when the BLOCK input is activated.

6.1.4.5 Accumulation of $I^y t$

Accumulation of the $I^y t$ module calculates the accumulated energy.

The operation of the module can be described with a module diagram. All the modules in the diagram are explained in the next sections.

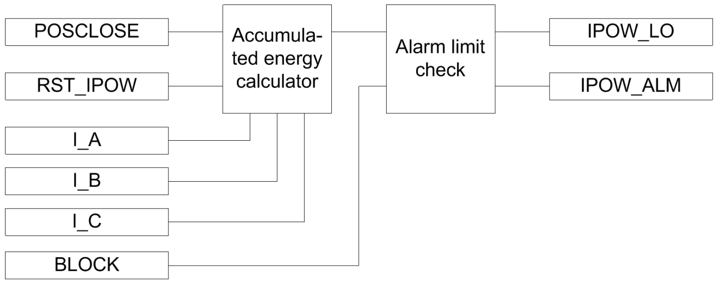


Figure 114: Functional module diagram for calculating accumulative energy and alarm

Accumulated energy calculator

This module calculates the accumulated energy $I^y t$ [(kA)^{y}s]. The factor y is set with the *Current exponent* setting.

The calculation is initiated with the POSCLOSE input opening events. It ends when the RMS current becomes lower than the *Acc stop current* setting value.

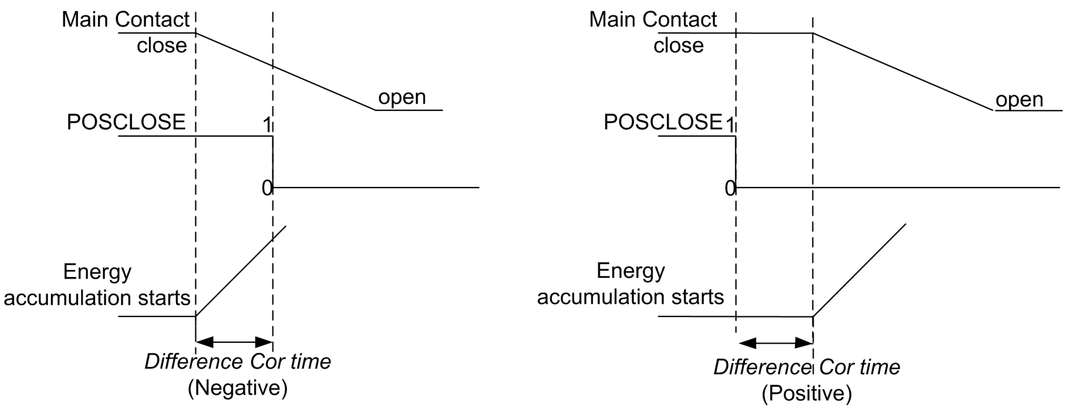


Figure 115: Significance of the Difference Cor time setting

The *Difference Cor time* setting is used instead of the auxiliary contact to accumulate the energy from the time the main contact opens. If the setting is positive, the calculation of energy starts after the auxiliary contact has opened and when the delay is equal to the value set with the *Difference Cor time* setting. When the setting is negative, the calculation starts in advance by the correction time before the auxiliary contact opens.

The accumulated energy outputs IPOW_A (_B, _C) are available in the monitored data view on the WHMI or through tools via communications. The values can be reset by setting the parameter *CB accum. currents power* setting to true in the clear menu from WHMI.

Alarm limit check

The IPOW_ALM alarm is activated when the accumulated energy exceeds the value set with the *Alm Acc currents Pwr* threshold setting. However, when the energy exceeds the limit value set with the *LO Acc currents Pwr* threshold setting, the IPOW_LO output is activated.

The IPOW_ALM and IPOW_LO outputs can be blocked by activating the binary input BLOCK.

6.1.4.6 Remaining life of circuit breaker

Every time the breaker operates, the life of the circuit breaker reduces due to wearing. The wearing in the breaker depends on the tripping current, and the remaining life of the breaker is estimated from the circuit breaker trip curve provided by the manufacturer. The remaining life is decremented at least with one when the circuit breaker is opened.

The operation of the remaining life of the circuit breaker subfunction can be described with a module diagram. All the modules in the diagram are explained in the next sections.

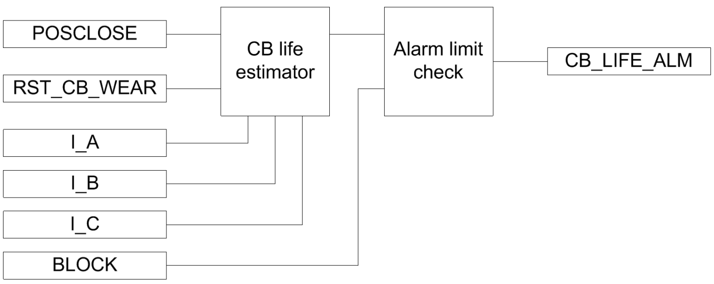


Figure 116: Functional module diagram for estimating the life of the circuit breaker

Circuit breaker life estimator

The circuit breaker life estimator module calculates the remaining life of the circuit breaker. If the tripping current is less than the rated operating current set with the *Rated Op current* setting, the remaining operation of the breaker reduces by one operation. If the tripping current is more than the rated fault current set with the *Rated fault current* setting, the possible operations are zero. The remaining life of the tripping current in between these two values is calculated based on the trip curve given by the manufacturer. The *Op number rated* and *Op number fault* parameters set the number of operations the breaker can perform at the rated current and at the rated fault current, respectively.

The remaining life is calculated separately for all three phases and it is available as a monitored data value CB_LIFE_A (_B,_C). The values can be cleared by setting the parameter *CB wear values* in the clear menu from WHMI.

Clearing *CB wear values* also resets the operation counter.

Alarm limit check

When the remaining life of any phase drops below the *Life alarm level* threshold setting, the corresponding circuit breaker life alarm CB_LIFE_ALM is activated.

It is possible to deactivate the CB_LIFE_ALM alarm signal by activating the binary input BLOCK. The old circuit breaker operation counter value can be taken into use by writing the value to the *Initial CB Rmn life* parameter and resetting the value via the clear menu from WHMI.

6.1.4.7 Circuit breaker spring-charged indication

The circuit breaker spring-charged indication subfunction calculates the spring charging time.

The operation of the subfunction can be described with a module diagram. All the modules in the diagram are explained in the next sections.

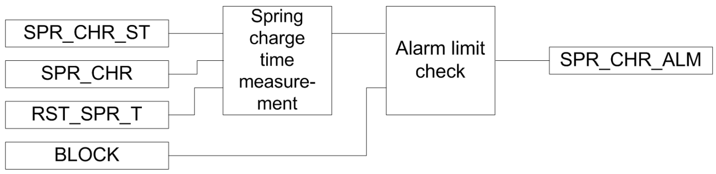


Figure 117: Functional module diagram for circuit breaker spring-charged indication and alarm

Spring charge time measurement

Two binary inputs, SPR_CHR_ST and SPR_CHR, indicate spring charging started and spring charged, respectively. The spring-charging time is calculated from the difference of these two signal timings.

The spring charging time T_SPR_CHR is available in the monitored data view on the WHMI or through tools via communications.

Alarm limit check

If the time taken by the spring to charge is more than the value set with the *Spring charge time* setting, the subfunction generates the SPR_CHR_ALM alarm.

It is possible to block the SPR_CHR_ALM alarm signal by activating the BLOCK binary input.

6.1.4.8 Gas pressure supervision

The gas pressure supervision subfunction monitors the gas pressure inside the arc chamber.

The operation of the subfunction can be described with a module diagram. All the modules in the diagram are explained in the next sections.

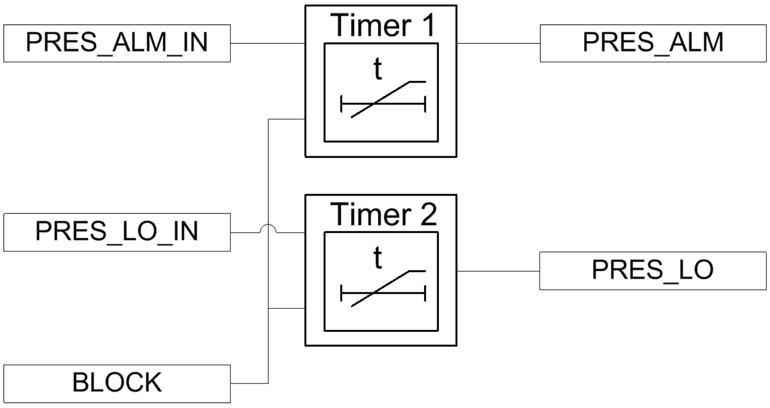


Figure 118: Functional module diagram for circuit breaker gas pressure alarm

The gas pressure is monitored through the binary input signals PRES_LO_IN and PRES_ALM_IN.

Timer 1

When the PRES_ALM_IN binary input is activated, the PRES_ALM alarm is activated after a time delay set with the *Pressure alarm time* setting. The PRES_ALM alarm can be blocked by activating the BLOCK input.

Timer 2

If the pressure drops further to a very low level, the PRES_LO_IN binary input becomes high, activating the lockout alarm PRES_LO after a time delay set with the *Pres lockout time* setting. The PRES_LO alarm can be blocked by activating the BLOCK input.

6.1.5 Application

SSCBR includes different metering and monitoring subfunctions.

Circuit breaker status

Circuit breaker status monitors the position of the circuit breaker, that is, whether the breaker is in an open, closed or intermediate position.

Circuit breaker operation monitoring

The purpose of the circuit breaker operation monitoring is to indicate that the circuit breaker has not been operated for a long time. The function calculates the number of days the circuit breaker has remained inactive, that is, has stayed in the same open or closed state. There is also the possibility to set an initial inactive day.

Breaker contact travel time

High traveling times indicate the need for the maintenance of the circuit breaker mechanism. Therefore, detecting excessive traveling time is needed. During the opening cycle operation, the main contact starts opening. The auxiliary contact A opens, the auxiliary contact B closes and the main contact reaches its opening position. During the closing cycle, the first main contact starts closing. The auxiliary contact B opens, the auxiliary contact A closes and the main contact reaches its closed position. The travel times are calculated based on the state changes of the auxiliary contacts and the adding correction factor to consider the time difference of the main contact's and the auxiliary contact's position change.

Operation counter

Routine maintenance of the breaker, such as lubricating breaker mechanism, is generally based on a number of operations. A suitable threshold setting to raise an alarm when the number of operation cycle exceeds the set limit helps preventive maintenance. This can also be used to indicate the requirement for oil sampling for dielectric testing in case of an oil circuit breaker.

The change of state can be detected from the binary input of the auxiliary contact. There is a possibility to set an initial value for the counter which can be used to initialize this functionality after a period of operation or in case of refurbished primary equipment.

Accumulation of I y t

Accumulation of $I^{y}t$ calculates the accumulated energy $\Sigma I^{y}t$, where the factor y is known as the current exponent. The factor y depends on the type of the circuit breaker. For oil circuit breakers, the factor y is normally 2. In case of a high-voltage system, the factor y can be 1.4...1.5.

Remaining life of the breaker

Every time the breaker operates, the life of the circuit breaker reduces due to wearing. The wearing in the breaker depends on the tripping current, and the remaining life of the breaker is estimated from the circuit breaker trip curve provided by the manufacturer.

Example for estimating the remaining life of a circuit breaker

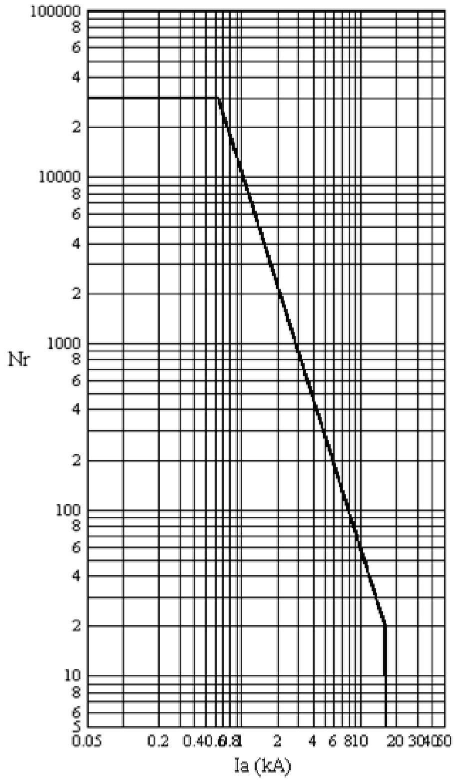


Figure 119: Trip Curves for a typical 12 kV, 630 A, 16 kA vacuum interrupter

Nr	the number of closing-opening operations allowed for the circuit breaker
Ia	the current at the time of tripping of the circuit breaker

Calculation of Directional Coef

The directional coefficient is calculated according to the formula:

$$Directional\,Coef = \frac{\log\left(\frac{B}{A}\right)}{\log\left(\frac{I_f}{I_r}\right)} = -2.2609$$

(Equation 7)

I_r	Rated operating current = 630 A
I_f	Rated fault current = 16 kA
A	Op number rated = 30000
B	Op number fault = 20

Calculation for estimating the remaining life

Figure 119 shows that there are 30,000 possible operations at the rated operating current of 630 A and 20 operations at the rated fault current 16 kA. Therefore, if the tripping current is 10 kA, one operation at 10 kA is equivalent to 30,000/60=500 operations at the rated current. It is also assumed that prior to this tripping, the remaining life of the circuit breaker is 15,000 operations. Therefore, after one operation of 10 kA, the remaining life of the circuit breaker is 15,000-500=14,500 at the rated operating current.

$$Remaining\ \ life\ \ reduction = \left(\frac{I}{I_r}\right)^{-Directional\ Coef}$$

(Equation 8)

Spring-charged indication

For normal operation of the circuit breaker, the circuit breaker spring should be charged within a specified time. Therefore, detecting long spring-charging time indicates that it is time for the circuit breaker maintenance. The last value of the spring-charging time can be used as a service value.

Gas pressure supervision

The gas pressure supervision monitors the gas pressure inside the arc chamber. When the pressure becomes too low compared to the required value, the circuit breaker operations are locked. A binary input is available based on the pressure levels in the function, and alarms are generated based on these inputs.

6.1.6 Signals

6.1.6.1 SSCBR Input signals

Table 196: SSCBR Input signals

Name	Type	Default	Description
I_A	SIGNAL	0	Phase A current
I_B	SIGNAL	0	Phase B current
I_C	SIGNAL	0	Phase C current
BLOCK	BOOLEAN	0=False	Block input status
POSOPEN	BOOLEAN	0=False	Signal for open position of apparatus from I/O
POSCLOSE	BOOLEAN	0=False	Signal for close position of apparatus from I/O
OPEN_CB_EXE	BOOLEAN	0=False	Signal for open command to coil
CLOSE_CB_EXE	BOOLEAN	0=False	Signal for close command to coil
PRES_ALM_IN	BOOLEAN	0=False	Binary pressure alarm input
PRES_LO_IN	BOOLEAN	0=False	Binary pressure input for lockout indication

Table continues on the next page

Name	Type	Default	Description
SPR_CHR_ST	BOOLEAN	0=False	CB spring charging started input
SPR_CHR	BOOLEAN	0=False	CB spring charged input
RST_IPOW	BOOLEAN	0=False	Reset accumulation energy
RST_CB_WEAR	BOOLEAN	0=False	Reset input for CB remaining life and operation counter
RST_TRV_T	BOOLEAN	0=False	Reset input for CB closing and opening travel times
RST_SPR_T	BOOLEAN	0=False	Reset input for the charging time of the CB spring

6.1.6.2 SSCBR Output signals

Table 197: SSCBR Output signals

Name	Type	Description
TRV_T_OP_ALM	BOOLEAN	CB open travel time exceeded set value
TRV_T_CL_ALM	BOOLEAN	CB close travel time exceeded set value
SPR_CHR_ALM	BOOLEAN	Spring charging time has crossed the set value
OPR_ALM	BOOLEAN	Number of CB operations exceeds alarm limit
OPR_LO	BOOLEAN	Number of CB operations exceeds lockout limit
IPOW_ALM	BOOLEAN	Accumulated currents power (Iyt),exceeded alarm limit
IPOW_LO	BOOLEAN	Accumulated currents power (Iyt),exceeded lockout limit
CB_LIFE_ALM	BOOLEAN	Remaining life of CB exceeded alarm limit
MON_ALM	BOOLEAN	CB 'not operated for long time' alarm
PRES_ALM	BOOLEAN	Pressure below alarm level
PRES_LO	BOOLEAN	Pressure below lockout level
OPENPOS	BOOLEAN	CB is in open position
INVALIDPOS	BOOLEAN	CB is in invalid position (not positively open or closed)
CLOSEPOS	BOOLEAN	CB is in closed position

6.1.7 Settings

6.1.7.1 SSCBR Non group settings

Table 198: SSCBR Non group settings (Basic)

Parameter	Values (Range)	Unit	Step	Default	Description
Operation	1=on 5=off			1=on	Operation Off / On
Acc stop current	5.00...500.00	A	0.01	10.00	RMS current setting below which engy acm stops
Open alarm time	0...200	ms	1	40	Alarm level setting for open travel time in ms
Close alarm time	0...200	ms	1	40	Alarm level Setting for close travel time in ms
Spring charge time	0...60000	ms	10	15000	Setting of alarm for spring charging time of CB in ms
Alarm Op number	0...99999		1	200	Alarm limit for number of operations
Lockout Op number	0...99999		1	300	Lock out limit for number of operations
Current exponent	0.00...2.00		0.01	2.00	Current exponent setting for energy calculation
Difference Cor time	-10...10	ms	1	5	Corr. factor for time dif in aux. and main contacts open time
Alm Acc currents Pwr	0.00...20000.00		0.01	2500.00	Setting of alarm level for accumulated currents power
LO Acc currents Pwr	0.00...20000.00		0.01	2500.00	Lockout limit setting for accumulated currents power
Directional Coef	-3.00...-0.50		0.01	-1.50	Directional coefficient for CB life calculation
Initial CB Rmn life	0...99999		1	5000	Initial value for the CB remaining life
Rated Op current	100.00...5000.00	A	0.01	1000.00	Rated operating current of the breaker
Rated fault current	500.00...75000.00	A	0.01	5000.00	Rated fault current of the breaker
Op number rated	1...99999		1	10000	Number of operations possible at rated current
Op number fault	1...10000		1	1000	Number of operations possible at rated fault current
Inactive Alm days	0...9999		1	2000	Alarm limit value of the inactive days counter
Travel time Clc mode	1=From Cmd to Pos 2=From Pos to Pos			2=From Pos to Pos	Travel time calculation mode selection

Table 199: SSCBR Non group settings (Advanced)

Parameter	Values (Range)	Unit	Step	Default	Description
Opening time Cor	-100...100	ms	1	10	Correction factor for open travel time in ms
Closing time Cor	-100...100	ms	1	10	Correction factor for CB close travel time in ms
Counter initial Val	0...99999		1	0	The operation numbers counter initialization value
Ini Acc currents Pwr	0.00...20000.00		0.01	0.00	Initial value for accumulation energy (Iyt)
Life alarm level	0...99999		1	500	Alarm level for CB remaining life
Pressure alarm time	0...60000	ms	1	10	Time delay for gas pressure alarm in ms
Pres lockout time	0...60000	ms	10	10	Time delay for gas pressure lockout in ms
Ini inactive days	0...9999		1	0	Initial value of the inactive days counter
Inactive Alm hours	0...23	h	1	0	Alarm time of the inactive days counter in hours

6.1.8 Monitored data

6.1.8.1 SSCBR Monitored data

Table 200: SSCBR Monitored data

Name	Type	Values (Range)	Unit	Description
T_TRV_OP	FLOAT32	0...60000	ms	Travel time of the CB during opening operation
T_TRV_CL	FLOAT32	0...60000	ms	Travel time of the CB during closing operation
T_SPR_CHR	FLOAT32	0.00...99.99	s	The charging time of the CB spring
NO_OPR	INT32	0...99999		Number of CB operation cycle
INA_DAYS	INT32	0...9999		The number of days CB has been inactive

Table continues on the next page

Name	Type	Values (Range)	Unit	Description
CB_LIFE_A	INT32	-99999...99999		CB Remaining life phase A
CB_LIFE_B	INT32	-99999...99999		CB Remaining life phase B
CB_LIFE_C	INT32	-99999...99999		CB Remaining life phase C
IPOW_A	FLOAT32	0.000...30000.000		Accumulated currents power (Iyt), phase A
IPOW_B	FLOAT32	0.000...30000.000		Accumulated currents power (Iyt), phase B
IPOW_C	FLOAT32	0.000...30000.000		Accumulated currents power (Iyt), phase C
SSCBR	Enum	1=on 2=blocked 3=test 4=test/blocked 5=off		Status

6.1.9 Technical data

Table 201: SSCBR Technical data

Characteristic	Value
Current measuring accuracy	±1.5 % or ±0.002 × I_n (at currents in the range of 0.1…10 × I_n) ±5.0 % (at currents in the range of 10…40 × I_n)
Operate time accuracy	±1.0 % of the set value or ±20 ms
Travelling time measurement	+10 ms / -0 ms

6.1.10 Technical revision history

Table 202: SSCBR Technical revision history

Technical revision	Change
B	Added the possibility to reset spring charge time and breaker travel times
C	Removed the DIFTRVTOPALM and DIFTRVT-CLALM outputs and the corresponding *Open Dif alarm time* and *Close Dif alarm time* setting parameters
D	The *Operation cycle* setting parameter renamed to *Initial CB Rmn life*. The IPOW_A (_B, _C) range changed.
E	Maximum value of initial circuit breaker remaining life time setting (*Initial CB Rmn life*) changed from 9999 to 99999. Added support for measuring circuit breaker travelling time from opening/closing command and auxiliary contact state signal change.
F	*Alarm Op number* range increased from 9999 to 99999. *Lockout Op* number setting range increased from 9999 to 99999. *Counter initial value* setting range increased from 9999 to 99999.

7 Measurement functions

7.1 Basic measurements

7.1.1 Functions

The three-phase current measurement function CMMXU is used for monitoring and metering the phase currents of the power system.

The three-phase voltage measurement function VMMXU is used for monitoring and metering the phase-to-phase voltages of the power system. The phase-to-earth voltages are also available in VMMXU.

The residual current measurement function RESCMMXU is used for monitoring and metering the residual current of the power system.

The sequence current measurement CSMSQI is used for monitoring and metering the phase sequence currents.

The sequence voltage measurement VSMSQI is used for monitoring and metering the phase sequence voltages.

The frequency measurement FMMXU is used for monitoring and metering the power system frequency.

The three-phase power and energy measurement PEMMXU is used for monitoring and metering active power (P), reactive power (Q), apparent power (S) and power factor (PF) and for calculating the accumulated energy separately as forward active, reversed active, forward reactive and reversed reactive. PEMMXU calculates these quantities using the fundamental frequency phasors, that is, the DFT values of the measured phase current and phase voltage signals.

The information of the measured quantity is available for the operator both locally in WHMI and remotely to a network control center with communication.

If the measured data in WHMI is within parentheses, there are some problems to express the data.

7.1.2 Measurement functionality

The functions can be enabled or disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

Some of the measurement functions operate on two alternative measurement modes: "DFT" and "RMS". The measurement mode is selected with the *X Measurement mode* setting. Depending on the measuring function if the measurement mode cannot be selected, the measuring mode is "DFT".

Demand value calculation

The demand values are calculated separately for each measurement function and per phase when applicable. The available measurement modes are "Linear" and "Logarithmic". The "Logarithmic" measurement mode is only effective for phase current and residual current demand value calculations. The demand value calculation mode is selected with the setting parameter **Configuration** > **Measurements** > **A demand Av mode**. The time interval for all demand value calculations is selected with the setting parameter **Configuration** > **Measurements** > **Demand interval**.

If the *Demand interval* setting is set to "15 minutes", for example, the demand values are updated every quarter of an hour. The demand time interval is synchronized to the real-time clock of the merging unit. When the demand time interval or calculation mode is changed, it initializes the demand value calculation. For the very first demand value calculation interval, the values are stated as invalid until the first refresh is available.

The "Linear" calculation mode uses the periodic sliding average calculation of the measured signal over the demand time interval. A new demand value is obtained once in a minute, indicating the analog signal demand over the demand time interval proceeding the update time. The actual rolling demand values are stored in the memory until the value is updated at the end of the next time interval.

The "Logarithmic" calculation mode uses the periodic calculation using a log10 function over the demand time interval to replicate thermal demand ammeters. The logarithmic demand calculates a snapshot of the analog signal every 1/15 x demand time interval.

Each measurement function has its own recorded data values. In merging unit, these are found in **Monitoring** > **Recorded data** > **Measurements**. In the technical manual these are listed in the monitored data section of each measurement function. These values are periodically updated with the maximum and minimum demand values. The time stamps are provided for both values.

Reset of Recorded data initializes a present demand value to the minimum and maximum demand values.

Value reporting

The measurement functions are capable of reporting new values for network control center (SCADA system) based on various functions.

- Zero-point clamping
- Deadband supervision
- Limit value supervision

In the three-phase voltage measurement function VMMXU the supervision functions are based on the phase-to-phase voltages. However, the phase-to-earth voltage values are also reported with the phase-to-phase voltages.

GOOSE is an event based protocol service. Analog GOOSE uses the same event generation functions as vertical SCADA communication for updating the measurement values. Update interval of 500 ms is used for data that do not have zero-point clamping, deadband supervision or limit value supervision.

Zero-point clamping

A measured value under the zero-point clamping limit is forced to zero. This allows the noise in the input signal to be ignored. The active clamping function forces both the actual measurement value and the angle value of the measured signal to zero. In the three-phase or sequence measuring functions, each phase or sequence component has a separate zero-point clamping function. The zero-value detection operates so that once the measured value exceeds or falls below the value of the zero-clamping limit, new values are reported.

Table 203: Zero-point clamping limits

Function	Zero-clamping limit
Three-phase current measurement (CMMXU)	1% of nominal (In)
Three-phase voltage measurement (VMMXU)	1% of nominal (Un)
Residual current measurement (RESCMMXU)	1% of nominal (In)
Phase sequence current measurement (CSMSQI)	1% of the nominal (In)
Phase sequence voltage measurement (VSMSQI)	1% of the nominal (Un)
Three-phase power and energy measurement (PEMMXU)	1.5% of the nominal (Sn)

When the frequency measurement function FMMXU is unable to measure the network frequency in the undervoltage situation, the measured values are set to the nominal and also the quality information of the data set accordingly. The undervoltage limit is fixed to 10 percent of the nominal for the frequency measurement.

Limit value supervision

The limit value supervision function indicates whether the measured value of X_INST exceeds or falls below the set limits. The measured value has the corresponding range information X_RANGE and has a value in the range of 0 to 4:

- 0: "normal"
- 1: "high"
- 2: "low"
- 3: "high-high"
- 4: "low-low"

The range information changes and the new values are reported.

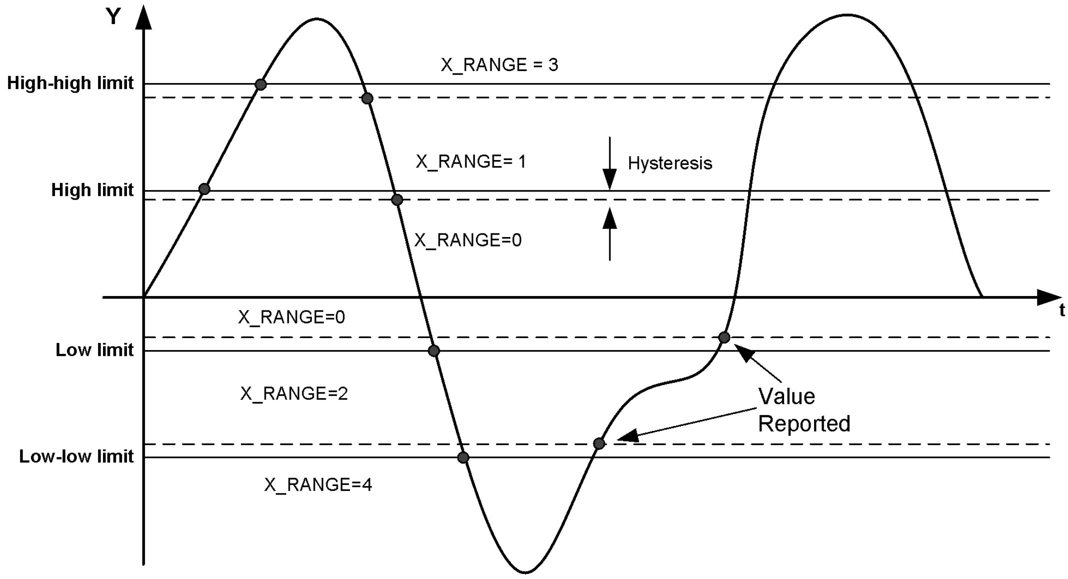


Figure 120: Presentation of operating limits

The range information can also be decoded into boolean output signals on some of the measuring functions and the number of phases required to exceed or undershoot the limit before activating the outputs and can be set with the *Num of phases* setting in the three-phase measurement functions CMMXU and VMMXU. The limit supervision boolean alarm and warning outputs can be blocked.

Table 204: Settings for limit value supervision

Function	Settings for limit value supervision	
Three-phase current measurement (CMMXU)	High limit	*A high limit*
	Low limit	*A low limit*
	High-high limit	*A high high limit*
	Low-low limit	*A low low limit*
Three-phase voltage measurement (VMMXU)	High limit	*V high limit*
	Low limit	*V low limit*
	High-high limit	*V high high limit*
	Low-low limit	*V low low limit*
Residual current measurement (RE-SCMMXU)	High limit	*A high limit res*
	Low limit	-
	High-high limit	*A Hi high limit res*
	Low-low limit	-

Table continues on the next page

Function	Settings for limit value supervision	
Frequency measurement (FMMXU)	High limit	*F high limit*
	Low limit	*F low limit*
	High-high limit	*F high high limit*
	Low-low limit	*F low low limit*
Low limit	-	*Ps Seq A high limit, Ng Seq A high limit, Zro A high limit*
High-high limit	V Hi high limit res	*Ps Seq A low limit, Ng Seq A low limit, Zro A low limit*
Low-low limit	-	
Phase sequence current measurement (CSMSQI)	High limit	
	Low limit	
	High-high limit	*Ps Seq A Hi high Lim, Ng Seq A Hi high Lim, Zro A Hi high Lim*
	Low-low limit	*Ps Seq A low low Lim, Ng Seq A low low Lim, Zro A low low Lim*
Phase sequence voltage measurement (VSMSQI)	High limit	*Ps Seq V high limit, Ng Seq V high limit, Zro V high limit*
	Low limit	*Ps Seq V low limit, Ng Seq V low limit, Zro V low limit*
	High-high limit	*Ps Seq V Hi high Lim, Ng Seq V Hi high Lim, Zro V Hi high Lim*
	Low-low limit	*Ps Seq V low low Lim, Ng Seq V low low Lim,*
Three-phase power and energy measurement (PEMMXU)	High limit	-
	Low limit	-
	High-high limit	-
	Low-low limit	-

Deadband supervision

The deadband supervision function reports the measured value according to integrated changes over a time period.

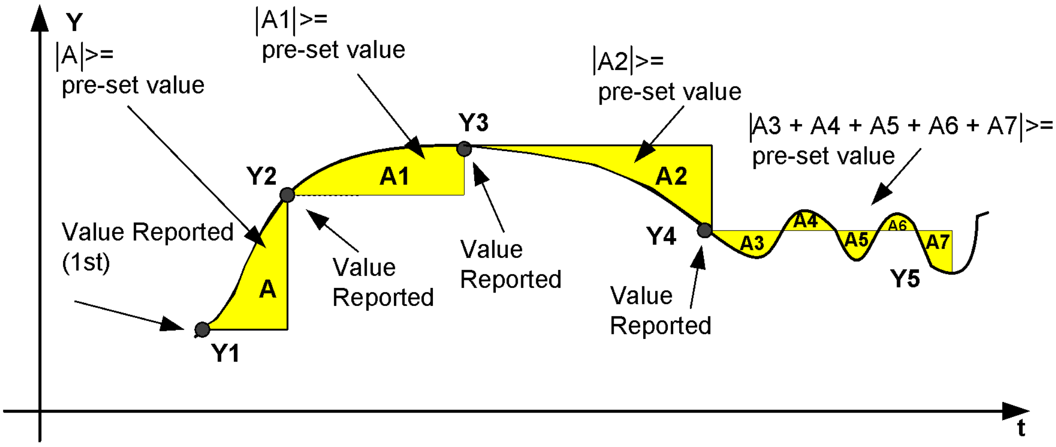


Figure 121: Integral deadband supervision

The deadband value used in the integral calculation is configured with the *X deadband* setting. The value represents the percentage of the difference between the maximum and minimum limit in the units of 0.001 percent x seconds.

The reporting delay of the integral algorithms in seconds is calculated with the formula:

$$t(s) = \frac{(\max - \min) \times deadband / 1000}{|\Delta Y| \times 100\%}$$

(Equation 9)

Example for CMMXU:

A deadband = 2500 (2.5% of the total measuring range of 40)

I_INST_A = I_DB_A = 0.30

If I_INST_A changes to 0.40, the reporting delay is:

$$t(s) = \frac{(40 - 0) \times 2500 / 1000}{|0.40 - 0.30| \times 100\%} = 10s$$

Table 205: Parameters for deadband calculation

Function	Settings	Maximum/ minimum (=range)
Three-phase current measurement (CMMXU)	*A deadband*	*40/0 (=40xIn)*
Three-phase voltage measurement (VMMXU)	*V Deadband*	*4/0 (=4xUn)*
Residual current measurement (RESCMMXU)	*A deadband res*	*40/0 (=40xIn)*

Table continues on the next page

Function	Settings	Maximum/ minimum (=range)
Frequency measurement (FMMXU)	*F deadband*	*75/35 (=40 Hz)*[1]
Phase sequence current measurement (CSMSQI)	*Ps Seq A deadband, Ng Seq A deadband, Zro A deadband*	*40/0 (=40xIn)*
Phase sequence voltage measurement (VSMSQI)	*Ps Seq V deadband, Ng Seq V deadband, Zro V deadband*	*4/0 (=4xUn)*
Three-phase power and energy measurement (PEMMXU)	-	

In the three-phase power and energy measurement function PEMMXU, the deadband supervision is done separately for apparent power S, with the preset value of fixed 10 percent of the Sn, and the power factor PF, with the preset values fixed at 0.10.. All the power measurement-related values P, Q, S and PF are reported simultaneously when either one of the S or PF values exceeds the preset limit.

Power and energy calculation

The three-phase power is calculated from the phase-to-earth voltages and phase-to-earth currents. The power measurement function is capable of calculating a complex power based on the fundamental frequency component phasors (DFT).

$$\overline{S} = (\overline{U}_A \cdot \overline{I}^*_A + \overline{U}_B \cdot \overline{I}^*_B + \overline{U}_C \cdot \overline{I}^*_C)$$

(Equation 10)

Once the complex apparent power is calculated, P, Q, S and PF are calculated with the equations:

$$P = \mathrm{Re}(\overline{S})$$

(Equation 11)

$$Q = \mathrm{Im}(\overline{S})$$

(Equation 12)

$$S = |\overline{S}| = \sqrt{P^2 + Q^2}$$

(Equation 13)

$$Cos\varphi = \frac{P}{S}$$

(Equation 14)

Depending on the unit multiplier selected with *Power unit Mult*, the calculated power values are presented in units of kVA/kW/kVAr or in units of MVA/MW/MVAr.

1 The value provided is for 50 Hz network. The value for 60 Hz network is 90/36 (=54 Hz)

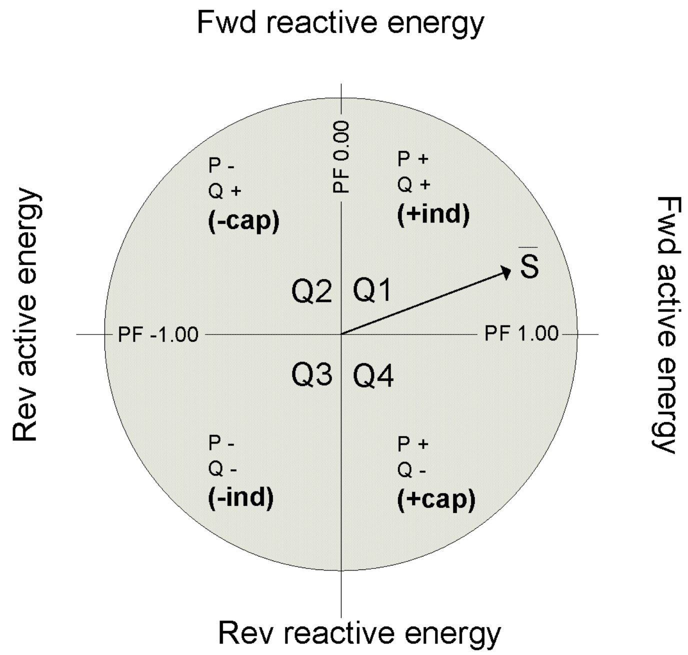


Figure 122: Complex power and power quadrants

Table 206: Power quadrants

Quadrant	Current	P	Q	PF	Power
Q1	Lagging	+	+	0…+1.00	+ind
Q2	Lagging	-	+	0…-1.00	-cap
Q3	Leading	-	-	0…-1.00	-ind
Q4	Leading	+	-	0…+1.00	+cap

The active power P direction can be selected between forward and reverse with *Active power Dir* and correspondingly the reactive power Q direction can be selected with *Reactive power Dir*. This affects also the accumulated energy directions.

The accumulated energy is calculated separately as forward active (`EA_FWD_ACM`), reverse active (`EA_RV_ACM`), forward reactive (`ER_FWD_ACM`) and reverse reactive (`ER_RV_ACM`). Depending on the value of the unit multiplier selected with *Energy unit Mult*, the calculated power values are presented in units of kWh/kVArh or in units of MWh/MVArh.

When the energy counter reaches its defined maximum value, the counter value is reset and restarted from zero. Changing the value of the *Energy unit Mult* setting resets the accumulated energy values to the initial values, that is, `EA_FWD_ACM` to *Forward Wh Initial*, `EA_RV_ACM` to *Reverse Wh Initial*, `ER_FWD_ACM` to *Forward VArh Initial* and `ER_RV_ACM` to *Reverse VArh Initial*. It is also possible to reset the accumulated energy to initial values through a parameter or with the `RSTACM` input.

Sequence components

The phase-sequence components are calculated using the phase currents and phase voltages. More information on calculating the phase-sequence components can be found in *Chapter 9.3 Calculated measurements* in this manual.

7.1.3 Measurement function applications

The measurement functions are used for power system measurement, supervision and reporting to a monitoring tool within PCM600, or to the station level, for example, with IEC 61850. The possibility to continuously monitor the measured values of active power, reactive power, currents, voltages, power factors and so on, is vital for efficient production, transmission, and distribution of electrical energy. It provides a fast and easy overview of the present status of the power system to the system operator. Additionally, it can be used during testing and commissioning of merging units to verify the proper operation and connection of instrument transformers, that is, the current transformers (CTs) and voltage transformers (VTs). The proper operation of the merging unit analog measurement chain can be verified during normal service by a periodic comparison of the measured value from the merging unit to other independent meters.

When the zero signal is measured, the noise in the input signal can still produce small measurement values. The zero point clamping function can be used to ignore the noise in the input signal and, hence, prevent the noise to be shown in the user display. The zero clamping is done for the measured analog signals and angle values.

The demand values are used to neglect sudden changes in the measured analog signals when monitoring long time values for the input signal. The demand values are linear average values of the measured signal over a settable demand interval. The demand values are calculated for the measured analog three-phase current signals.

The limit supervision indicates, if the measured signal exceeds or goes below the set limits. Depending on the measured signal type, up to two high limits and up to two low limits can be set for the limit supervision.

The deadband supervision reports a new measurement value if the input signal has gone out of the deadband state. The deadband supervision can be used in value reporting between the measurement point and operation control. When the deadband supervision is properly configured, it helps in keeping the communication load in minimum and yet measurement values are reported frequently enough.

7.1.4 Three-phase current measurement CMMXU

7.1.4.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Three-phase current measurement	CMMXU	3I	3I

7.1.4.2 Function block

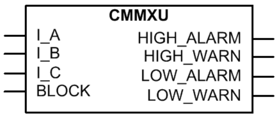


Figure 123: Function block

7.1.4.3 Signals

CMMXU Input signals

Table 207: CMMXU Input signals

Name	Type	Default	Description
I_A	SIGNAL	0	Phase A current
I_B	SIGNAL	0	Phase B current
I_C	SIGNAL	0	Phase C current
BLOCK	BOOLEAN	0=False	Block signal for all binary outputs

CMMXU Output signals

Table 208: CMMXU Output signals

Name	Type	Description
HIGH_ALARM	BOOLEAN	High alarm
HIGH_WARN	BOOLEAN	High warning
LOW_WARN	BOOLEAN	Low warning
LOW_ALARM	BOOLEAN	Low alarm

7.1.4.4 Settings

CMMXU Non group settings

Table 209: CMMXU Non group settings (Basic)

Parameter	Values (Range)	Unit	Step	Default	Description
Operation	1=on 5=off			1=on	Operation Off / On
Num of phases	1=1 out of 3 2=2 out of 3 3=3 out of 3			1=1 out of 3	Number of phases required by limit supervision
A high high limit	0.00...40.00	xIn	1	1.40	High alarm current limit

Table continues on the next page

Parameter	Values (Range)	Unit	Step	Default	Description
A high limit	0.00...40.00	xIn	1	1.20	High warning current limit
A low limit	0.00...40.00	xIn	1	0.00	Low warning current limit
A low low limit	0.00...40.00	xIn	1	0.00	Low alarm current limit
A deadband	100...100000		1	2500	Deadband configuration value for integral calculation. (percentage of difference between min and max as 0,001 % s)

Table 210: CMMXU Non group settings (Advanced)

Parameter	Values (Range)	Unit	Step	Default	Description
Measurement mode	1=RMS 2=DFT			2=DFT	Selects used measurement mode

7.1.4.5 Monitored data

CMMXU Monitored data

Table 211: CMMXU Monitored data

Name	Type	Values (Range)	Unit	Description
IL1-A	FLOAT32	0.00...40.00	xIn	Measured current amplitude phase A
IL2-A	FLOAT32	0.00...40.00	xIn	Measured current amplitude phase B
IL3-A	FLOAT32	0.00...40.00	xIn	Measured current amplitude phase C
Max demand IL1	FLOAT32	0.00...40.00	xIn	Maximum demand for Phase A
Max demand IL2	FLOAT32	0.00...40.00	xIn	Maximum demand for Phase B
Max demand IL3	FLOAT32	0.00...40.00	xIn	Maximum demand for Phase C
Min demand IL1	FLOAT32	0.00...40.00	xIn	Minimum demand for Phase A

Table continues on the next page

Name	Type	Values (Range)	Unit	Description
Min demand IL2	FLOAT32	0.00...40.00	xIn	Minimum demand for Phase B
Min demand IL3	FLOAT32	0.00...40.00	xIn	Minimum demand for Phase C
Time max demand IL1	Timestamp			Time of maximum demand phase A
Time max demand IL2	Timestamp			Time of maximum demand phase B
Time max demand IL3	Timestamp			Time of maximum demand phase C
Time min demand IL1	Timestamp			Time of minimum demand phase A
Time min demand IL2	Timestamp			Time of minimum demand phase B
Time min demand IL3	Timestamp			Time of minimum demand phase C
BLOCK	BOOLEAN	0=False 1=True		Block signal for all binary outputs
HIGH_ALARM	BOOLEAN	0=False 1=True		High alarm
HIGH_WARN	BOOLEAN	0=False 1=True		High warning
LOW_WARN	BOOLEAN	0=False 1=True		Low warning
LOW_ALARM	BOOLEAN	0=False 1=True		Low alarm
I_INST_A	FLOAT32	0.00...40.00	xIn	IL1 Amplitude, magnitude of instantaneous value
I_ANGL_A	FLOAT32	-180.00...180.00	deg	IL1 current angle
I_DB_A	FLOAT32	0.00...40.00	xIn	IL1 Amplitude, magnitude of reported value

Table continues on the next page

Name	Type	Values (Range)	Unit	Description
I_DMD_A	FLOAT32	0.00...40.00	xIn	Demand value of IL1 current
I_RANGE_A	Enum	0=normal 1=high 2=low 3=high-high 4=low-low		IL1 Amplitude range
I_INST_B	FLOAT32	0.00...40.00	xIn	IL2 Amplitude, magnitude of instantaneous value
I_ANGL_B	FLOAT32	-180.00...180.00	deg	IL2 current angle
I_DB_B	FLOAT32	0.00...40.00	xIn	IL2 Amplitude, magnitude of reported value
I_DMD_B	FLOAT32	0.00...40.00	xIn	Demand value of IL2 current
I_RANGE_B	Enum	0=normal 1=high 2=low 3=high-high 4=low-low		IL2 Amplitude range
I_INST_C	FLOAT32	0.00...40.00	xIn	IL3 Amplitude, magnitude of instantaneous value
I_ANGL_C	FLOAT32	-180.00...180.00	deg	IL3 current angle
I_DB_C	FLOAT32	0.00...40.00	xIn	IL3 Amplitude, magnitude of reported value
I_DMD_C	FLOAT32	0.00...40.00	xIn	Demand value of IL3 current
I_RANGE_C	Enum	0=normal 1=high 2=low 3=high-high 4=low-low		IL3 Amplitude range

7.1.4.6 Technical data

Table 212: CMMXU Technical data

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current: f_n ±2 Hz
	±0.5 % or ±0.002 × I_n (at currents in the range of 0.01...4.00 × I_n)
Suppression of harmonics	DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,… RMS: No suppression

7.1.4.7 Technical revision history

Table 213: CMMXU Technical revision history

Technical revision	Change
B	Menu changes
C	Phase current angle values added to Monitored data view. Minimum demand value and time added to recorded data. Logarithmic demand calculation mode added and demand interval setting moved under Measurement menu as general setting to all demand calculations.
D	Internal improvement.
E	Internal improvement.

7.1.5 Three-phase voltage measurement VMMXU

7.1.5.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Three-phase voltage measurement	VMMXU	3U	3V

7.1.5.2 Function block

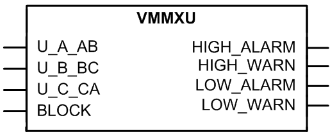


Figure 124: Function block

7.1.5.3 Signals

VMMXU Input signals

Table 214: VMMXU Input signals

Name	Type	Default	Description
U_A_AB	SIGNAL	0	Phase to earth voltage A or phase to phase voltage AB
U_B_BC	SIGNAL	0	Phase to earth voltage B or phase to phase voltage BC
U_C_CA	SIGNAL	0	Phase to earth voltage C or phase to phase voltage CA
BLOCK	BOOLEAN	0=False	Block signal for all binary outputs

VMMXU Output signals

Table 215: VMMXU Output signals

Name	Type	Description
HIGH_ALARM	BOOLEAN	High alarm
HIGH_WARN	BOOLEAN	High warning
LOW_WARN	BOOLEAN	Low warning
LOW_ALARM	BOOLEAN	Low alarm

7.1.5.4 Settings

VMMXU Non group settings

Table 216: VMMXU Non group settings (Basic)

Parameter	Values (Range)	Unit	Step	Default	Description
Operation	1=on			1=on	Operation Off / On

Table continues on the next page

Parameter	Values (Range)	Unit	Step	Default	Description
	5=off				
Num of phases	1=1 out of 3 2=2 out of 3 3=3 out of 3			1=1 out of 3	Number of phases required by limit supervision
V high high limit	0.00...4.00	xUn	1	1.40	High alarm voltage limit
V high limit	0.00...4.00	xUn	1	1.20	High warning voltage limit
V low limit	0.00...4.00	xUn	1	0.00	Low warning voltage limit
V low low limit	0.00...4.00	xUn	1	0.00	Low alarm voltage limit
V deadband	100...100000		1	10000	Deadband configuration value for integral calculation. (percentage of difference between min and max as 0,001 % s)

Table 217: VMMXU Non group settings (Advanced)

Parameter	Values (Range)	Unit	Step	Default	Description
Measurement mode	1=RMS 2=DFT			2=DFT	Selects used measurement mode

7.1.5.5 Monitored data

VMMXU Monitored data

Table 218: VMMXU Monitored data

Name	Type	Values (Range)	Unit	Description
U12-kV	FLOAT32	0.00...4.00	xUn	Measured phase to phase voltage amplitude phase AB
U23-kV	FLOAT32	0.00...4.00	xUn	Measured phase to phase voltage amplitude phase BC
U31-kV	FLOAT32	0.00...4.00	xUn	Measured phase to phase voltage amplitude phase CA
BLOCK	BOOLEAN	0=False 1=True		Block signal for all binary outputs
HIGH_ALARM	BOOLEAN	0=False 1=True		High alarm

Table continues on the next page

Name	Type	Values (Range)	Unit	Description
HIGH_WARN	BOOLEAN	0=False 1=True		High warning
LOW_WARN	BOOLEAN	0=False 1=True		Low warning
LOW_ALARM	BOOLEAN	0=False 1=True		Low alarm
U_INST_AB	FLOAT32	0.00...4.00	xUn	U12 Amplitude, magnitude of instantaneous value
U_ANGL_AB	FLOAT32	-180.00...180.00	deg	U12 angle
U_DB_AB	FLOAT32	0.00...4.00	xUn	U12 Amplitude, magnitude of reported value
U_DMD_AB	FLOAT32	0.00...4.00	xUn	Demand value of U12 voltage
U_RANGE_AB	Enum	0=normal 1=high 2=low 3=high-high 4=low-low		U12 Amplitude range
U_INST_BC	FLOAT32	0.00...4.00	xUn	U23 Amplitude, magnitude of instantaneous value
U_ANGL_BC	FLOAT32	-180.00...180.00	deg	U23 angle
U_DB_BC	FLOAT32	0.00...4.00	xUn	U23 Amplitude, magnitude of reported value
U_DMD_BC	FLOAT32	0.00...4.00	xUn	Demand value of U23 voltage
U_RANGE_BC	Enum	0=normal 1=high 2=low 3=high-high 4=low-low		U23 Amplitude range
U_INST_CA	FLOAT32	0.00...4.00	xUn	U31 Amplitude, magnitude of instantaneous value

Table continues on the next page

Name	Type	Values (Range)	Unit	Description
U_ANGL_CA	FLOAT32	-180.00...180.00	deg	U31 angle
U_DB_CA	FLOAT32	0.00...4.00	xUn	U31 Amplitude, magnitude of reported value
U_DMD_CA	FLOAT32	0.00...4.00	xUn	Demand value of U31 voltage
U_RANGE_CA	Enum	0=normal 1=high 2=low 3=high-high 4=low-low		U31 Amplitude range
U_INST_A	FLOAT32	0.00...5.00	xUn	UL1 Amplitude, magnitude of instantaneous value
U_ANGL_A	FLOAT32	-180.00...180.00	deg	UL1 angle
U_DMD_A	FLOAT32	0.00...5.00	xUn	Demand value of UL1 voltage
U_INST_B	FLOAT32	0.00...5.00	xUn	UL2 Amplitude, magnitude of instantaneous value
U_ANGL_B	FLOAT32	-180.00...180.00	deg	UL2 angle
U_DMD_B	FLOAT32	0.00...5.00	xUn	Demand value of UL2 voltage
U_INST_C	FLOAT32	0.00...5.00	xUn	UL3 Amplitude, magnitude of instantaneous value
U_ANGL_C	FLOAT32	-180.00...180.00	deg	UL3 angle
U_DMD_C	FLOAT32	0.00...5.00	xUn	Demand value of UL3 voltage

7.1.5.6 Technical data

Table 219: VMMXU Technical data

Characteristic	Value
Operation accuracy	Depending on the frequency of the voltage measured: f_n ±2 Hz At voltages in range 0.01…1.15 × U_n
	±0.5 % or ±0.002 × U_n
Suppression of harmonics	DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,…

Characteristic	Value
	RMS: No suppression

7.1.5.7 Technical revision history

Table 220: VMMXU Technical revision history

Technical revision	Change
B	Phase and phase-to-phase voltage angle values and demand values added to Monitored data view.
C	Internal improvement.
D	Internal improvement.

7.1.6 Residual current measurement RESCMMXU

7.1.6.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Residual current measurement	RESCMMXU	Io	In

7.1.6.2 Function block

Figure 125: Function block

7.1.6.3 Signals

RESCMMXU Input signals

Table 221: RESCMMXU Input signals

Name	Type	Default	Description
Io	SIGNAL	0	Residual current
BLOCK	BOOLEAN	0=False	Block signal for all binary outputs

RESCMMXU Output signals

Table 222: RESCMMXU Output signals

Name	Type	Description
HIGH_ALARM	BOOLEAN	High alarm
HIGH_WARN	BOOLEAN	High warning

7.1.6.4 Settings

RESCMMXU Non group settings

Table 223: RESCMMXU Non group settings (Basic)

Parameter	Values (Range)	Unit	Step	Default	Description
Operation	1=on 5=off			1=on	Operation Off / On
A Hi high limit res	0.00...40.00	xIn	1	0.20	High alarm current limit
A high limit res	0.00...40.00	xIn	1	0.05	High warning current limit
A deadband res	100...100000		1	2500	Deadband configuration value for integral calculation. (percentage of difference between min and max as 0,001 % s)

Table 224: RESCMMXU Non group settings (Advanced)

Parameter	Values (Range)	Unit	Step	Default	Description
Measurement mode	1=RMS 2=DFT			2=DFT	Selects used measurement mode

7.1.6.5 Monitored data

RESCMMXU Monitored data

Table 225: RESCMMXU Monitored data

Name	Type	Values (Range)	Unit	Description
Io-A	FLOAT32	0.00...40.00	xIn	Measured residual current
BLOCK	BOOLEAN	0=False 1=True		Block signal for all binary outputs
HIGH_ALARM	BOOLEAN	0=False 1=True		High alarm

Table continues on the next page

Name	Type	Values (Range)	Unit	Description
HIGH_WARN	BOOLEAN	0=False 1=True		High warning
I_INST_RES	FLOAT32	0.00...40.00	xIn	Residual current Amplitude, magnitude of instantaneous value
I_ANGL_RES	FLOAT32	-180.00...180.00	deg	Residual current angle
I_DB_RES	FLOAT32	0.00...40.00	xIn	Residual current Amplitude, magnitude of reported value
I_DMD_RES	FLOAT32	0.00...40.00	xIn	Demand value of residual current
I_RANGE_RES	Enum	0=normal 1=high 2=low 3=high-high 4=low-low		Residual current Amplitude range
Max demand Io	FLOAT32	0.00...40.00	xIn	Maximum demand for residual current
Min demand Io	FLOAT32	0.00...40.00	xIn	Minimum demand for residual current
Time max demand Io	Timestamp			Time of maximum demand residual current
Time min demand Io	Timestamp			Time of minimum demand residual current

7.1.6.6 Technical data

Table 226: RESCMMXU Technical data

Characteristic	Value
Operation accuracy	At the frequency $f = f_n$
	±0.5 % or ±0.002 × I_n (at currents in the range of 0.01...4.00 × I_n)
Suppression of harmonics	DFT: -50 dB at $f = n \times f_n$, where n = 2, 3, 4, 5,… RMS: No suppression

7.1.6.7 Technical revision history

Table 227: RESCMMXU Technical revision history

Technical revision	Change
B	-
C	Residual current angle and demand value added to Monitored data view. Recorded data added for minimum and maximum values with timestamps.
D	Monitored data Min demand Io maximum value range (RESCMSTA2.MinAmps.maxVal.f) is corrected to 40.00.
E	Internal improvement

7.1.7 Frequency measurement FMMXU

7.1.7.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Frequency measurement	FMMXU	f	f

7.1.7.2 Function block

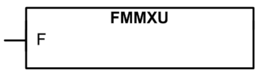


Figure 126: Function block

7.1.7.3 Functionality

The frequency measurement range is 35...75 Hz. The measured frequencies outside the measurement range are considered to be out of range and the minimum and maximum values are then shown in parentheses.

When *Frequency adaptivity* is enabled, the measurement range is extended to 10...75 Hz in a 50 Hz network and 12...90 Hz in a 60 Hz network. The measured frequencies outside 35...75 Hz are shown in parentheses.

When the frequencies cannot be measured, for example, due to too low voltage amplitude, the default value for frequency measurement can be selected with the *Def frequency Sel* setting parameter. In the “Nominal” mode the frequency is set to 50 Hz (or 60 Hz) and in “Zero” mode the frequency is set to zero and shown in parentheses.

7.1.7.4 Signals

FMMXU Input signals

Table 228: FMMXU Input signals

Name	Type	Default	Description
F	SIGNAL	-	Measured system frequency

7.1.7.5 Settings

FMMXU Non group settings

Table 229: FMMXU Non group settings (Basic)

Parameter	Values (Range)	Unit	Step	Default	Description
Operation	1=on 5=off			1=on	Operation Off / On
F high high limit	35.00...75.00	Hz	1	60.00	High alarm frequency limit
F high limit	35.00...75.00	Hz	1	55.00	High warning frequency limit
F low limit	35.00...75.00	Hz	1	45.00	Low warning frequency limit
F low low limit	35.00...75.00	Hz	1	40.00	Low alarm frequency limit
F deadband	100...100000		1	1000	Deadband configuration value for integral calculation (percentage of difference between min and max as 0,001 % s)

Table 230: FMMXU Non group settings (Advanced)

Parameter	Values (Range)	Unit	Step	Default	Description
Def frequency Sel	1=Nominal 2=Zero			1=Nominal	Default frequency selection

7.1.7.6 Monitored data

FMMXU Monitored data

Table 231: FMMXU Monitored data

Name	Type	Values (Range)	Unit	Description
f-Hz	FLOAT32	35.00...75.00	Hz	Measured frequency
F_INST	FLOAT32	35.00...75.00	Hz	Frequency, instantaneous value

Table continues on the next page

Name	Type	Values (Range)	Unit	Description
F_DB	FLOAT32	35.00...75.00	Hz	Frequency, re-ported value
F_RANGE	Enum	0=normal 1=high 2=low 3=high-high 4=low-low		Measured fre-quency range

7.1.7.7 Technical data

Table 232: FMMXU Technical data

Characteristic	Value
Operation accuracy	±5 mHz (in measurement range 35...75 Hz)

7.1.7.8 Technical revision history

Table 233: FMMXU Technical revision history

Technical revision	Change
B	Added new setting *Def frequency Sel*. Fre-quency measurement range lowered from 35 Hz to 10 Hz.

7.1.8 Sequence current measurement CSMSQI

7.1.8.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Sequence current measurement	CSMSQI	I1, I2, I0	I1, I2, I0

7.1.8.2 Function block

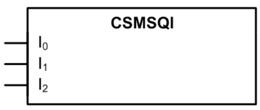


Figure 127: Function block

7.1.8.3 Signals

CSMSQI Input signals

Table 234: CSMSQI Input signals

Name	Type	Default	Description
I_0	SIGNAL	0	Zero sequence current
I_1	SIGNAL	0	Positive sequence current
I_2	SIGNAL	0	Negative sequence current

7.1.8.4 Settings

CSMSQI Non group settings

Table 235: CSMSQI Non group settings (Basic)

Parameter	Values (Range)	Unit	Step	Default	Description
Operation	1=on 5=off			1=on	Operation Off / On
Ps Seq A Hi high Lim	0.00...40.00	xIn	1	1.40	High alarm current limit for positive sequence current
Ps Seq A high limit	0.00...40.00	xIn	1	1.20	High warning current limit for positive sequence current
Ps Seq A low limit	0.00...40.00	xIn	1	0.00	Low warning current limit for positive sequence current
Ps Seq A low low Lim	0.00...40.00	xIn	1	0.00	Low alarm current limit for positive sequence current
Ps Seq A deadband	100...100000		1	2500	Deadband configuration value for positive sequence current for integral calculation. (percentage of difference between min and max as 0,001 % s)
Ng Seq A Hi high Lim	0.00...40.00	xIn	1	0.20	High alarm current limit for negative sequence current
Ng Seq A High limit	0.00...40.00	xIn	1	0.05	High warning current limit for negative sequence current
Ng Seq A low limit	0.00...40.00	xIn	1	0.00	Low warning current limit for negative sequence current

Table continues on the next page

Parameter	Values (Range)	Unit	Step	Default	Description
Ng Seq A low low Lim	0.00...40.00	xIn	1	0.00	Low alarm current limit for negative sequence current
Ng Seq A deadband	100...100000		1	2500	Deadband configuration value for negative sequence current for integral calculation. (percentage of difference between min and max as 0,001 % s)
Zro A Hi high Lim	0.00...40.00	xIn	1	0.20	High alarm current limit for zero sequence current
Zro A High limit	0.00...40.00	xIn	1	0.05	High warning current limit for zero sequence current
Zro A low limit	0.00...40.00	xIn	1	0.00	Low warning current limit for zero sequence current
Zro A low low Lim	0.00...40.00	xIn	1	0.00	Low alarm current limit for zero sequence current
Zro A deadband	100...100000		1	2500	Deadband configuration value for zero sequence current for integral calculation. (percentage of difference between min and max as 0,001 % s)

7.1.8.5 Monitored data

CSMSQI Monitored data

Table 236: CSMSQI Monitored data

Name	Type	Values (Range)	Unit	Description
NgSeq-A	FLOAT32	0.00...40.00	xIn	Measured negative sequence current
PsSeq-A	FLOAT32	0.00...40.00	xIn	Measured positive sequence current
ZroSeq-A	FLOAT32	0.00...40.00	xIn	Measured zero sequence current
I2_INST	FLOAT32	0.00...40.00	xIn	Negative sequence current amplitude, instantaneous value
I2_ANGL	FLOAT32	-180.00...180.00	deg	Negative sequence current angle

Table continues on the next page

Name	Type	Values (Range)	Unit	Description
I2_DB	FLOAT32	0.00...40.00	xIn	Negative sequence current amplitude, reported value
I2_RANGE	Enum	0=normal 1=high 2=low 3=high-high 4=low-low		Negative sequence current amplitude range
I1_INST	FLOAT32	0.00...40.00	xIn	Positive sequence current amplitude, instantaneous value
I1_ANGL	FLOAT32	-180.00...180.00	deg	Positive sequence current angle
I1_DB	FLOAT32	0.00...40.00	xIn	Positive sequence current amplitude, reported value
I1_RANGE	Enum	0=normal 1=high 2=low 3=high-high 4=low-low		Positive sequence current amplitude range
I0_INST	FLOAT32	0.00...40.00	xIn	Zero sequence current amplitude, instantaneous value
I0_ANGL	FLOAT32	-180.00...180.00	deg	Zero sequence current angle
I0_DB	FLOAT32	0.00...40.00	xIn	Zero sequence current amplitude, reported value
I0_RANGE	Enum	0=normal 1=high 2=low 3=high-high 4=low-low		Zero sequence current amplitude range

7.1.8.6 Technical data

Table 237: CSMSQI Technical data

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current: f/f_n = ±2 Hz
	±1.0 % or ±0.002 × I_n at currents in the range of 0.01...4.00 × I_n
Suppression of harmonics	DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,…

7.1.8.7 Technical revision history

Table 238: CSMSQI Technical revision history

Technical revision	Change
A	-
B	Sequence current angle values added to the Monitored data view.
C	Internal improvement.

7.1.9 Sequence voltage measurement VSMSQI

7.1.9.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Sequence voltage measurement	VSMSQI	U1, U2, U0	V1, V2, V0

7.1.9.2 Function block

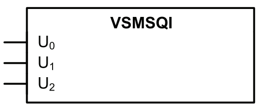


Figure 128: Function block

7.1.9.3 Signals

VSMSQI Input signals

Table 239: VSMSQI Input signals

Name	Type	Default	Description
U_0	SIGNAL	0	Zero sequence voltage
U_1	SIGNAL	0	Positive phase sequence voltage
U_2	SIGNAL	0	Negative phase sequence voltage

7.1.9.4 Settings

VSMSQI Non group settings

Table 240: VSMSQI Non group settings (Basic)

Parameter	Values (Range)	Unit	Step	Default	Description
Operation	1=on 5=off			1=on	Operation Off / On
Ps Seq V Hi high Lim	0.00...4.00	xUn	1	1.40	High alarm voltage limit for positive sequence voltage
Ps Seq V high limit	0.00...4.00	xUn	1	1.20	High warning voltage limit for positive sequence voltage
Ps Seq V low limit	0.00...4.00	xUn	1	0.00	Low warning voltage limit for positive sequence voltage
Ps Seq V low low Lim	0.00...4.00	xUn	1	0.00	Low alarm voltage limit for positive sequence voltage
Ps Seq V deadband	100...100000		1	10000	Deadband configuration value for positive sequence voltage for integral calculation. (percentage of difference between min and max as 0,001 % s)
Ng Seq V Hi high Lim	0.00...4.00	xUn	1	0.20	High alarm voltage limit for negative sequence voltage
Ng Seq V High limit	0.00...4.00	xUn	1	0.05	High warning voltage limit for negative sequence voltage
Ng Seq V low limit	0.00...4.00	xUn	1	0.00	Low warning voltage limit for negative sequence voltage
Ng Seq V low low Lim	0.00...4.00	xUn	1	0.00	Low alarm voltage limit for negative sequence voltage
Ng Seq V deadband	100...100000		1	10000	Deadband configuration value for negative sequence voltage for integral calculation.

Table continues on the next page

Parameter	Values (Range)	Unit	Step	Default	Description
					(percentage of difference between min and max as 0,001 % s)
Zro V Hi high Lim	0.00...4.00	xUn	1	0.20	High alarm voltage limit for zero sequence voltage
Zro V High limit	0.00...4.00	xUn	1	0.05	High warning voltage limit for zero sequence voltage
Zro V low limit	0.00...4.00	xUn	1	0.00	Low warning voltage limit for zero sequence voltage
Zro V low low Lim	0.00...4.00	xUn	1	0.00	Low alarm voltage limit for zero sequence voltage
Zro V deadband	100...100000		1	10000	Deadband configuration value for zero sequence voltage for integral calculation. (percentage of difference between min and max as 0,001 % s)

7.1.9.5 Monitored data

VSMSQI Monitored data

Table 241: VSMSQI Monitored data

Name	Type	Values (Range)	Unit	Description
NgSeq-kV	FLOAT32	0.00...4.00	xUn	Measured negative sequence voltage
PsSeq-kV	FLOAT32	0.00...4.00	xUn	Measured positive sequence voltage
ZroSeq-kV	FLOAT32	0.00...4.00	xUn	Measured zero sequence voltage
U2_INST	FLOAT32	0.00...4.00	xUn	Negative sequence voltage amplitude, instantaneous value
U2_ANGL	FLOAT32	-180.00...180.00	deg	Negative sequence voltage angle
U2_DB	FLOAT32	0.00...4.00	xUn	Negative sequence voltage amplitude, reported value

Table continues on the next page

Name	Type	Values (Range)	Unit	Description
U2_RANGE	Enum	0=normal 1=high 2=low 3=high-high 4=low-low		Negative sequence voltage amplitude range
U1_INST	FLOAT32	0.00...4.00	xUn	Positive sequence voltage amplitude, instantaneous value
U1_ANGL	FLOAT32	-180.00...180.00	deg	Positive sequence voltage angle
U1_DB	FLOAT32	0.00...4.00	xUn	Positive sequence voltage amplitude, reported value
U1_RANGE	Enum	0=normal 1=high 2=low 3=high-high 4=low-low		Positive sequence voltage amplitude range
U0_INST	FLOAT32	0.00...4.00	xUn	Zero sequence voltage amplitude, instantaneous value
U0_ANGL	FLOAT32	-180.00...180.00	deg	Zero sequence voltage angle
U0_DB	FLOAT32	0.00...4.00	xUn	Zero sequence voltage amplitude, reported value
U0_RANGE	Enum	0=normal 1=high 2=low 3=high-high 4=low-low		Zero sequence voltage amplitude range

7.1.9.6 Technical data

Table 242: VSMSQI Technical data

Characteristic	Value
Operation accuracy	Depending on the frequency of the voltage measured: f_n ±2 Hz At voltages in range 0.01…1.15 × U_n
	±1.0 % or ±0.002 × U_n
Suppression of harmonics	DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,…

7.1.10 Three-phase power and energy measurement PEMMXU

7.1.10.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Three-phase power and energy measurement	PEMMXU	P, E	P, E

7.1.10.2 Function block

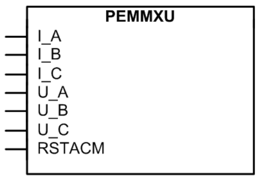


Figure 129: Function block

7.1.10.3 Signals

PEMMXU Input signals

Table 243: PEMMXU Input signals

Name	Type	Default	Description
I_A	SIGNAL	0	Phase A current
I_B	SIGNAL	0	Phase B current
I_C	SIGNAL	0	Phase C current
U_A	SIGNAL	0	Phase A voltage
U_B	SIGNAL	0	Phase B voltage

Table continues on the next page

Name	Type	Default	Description
U_C	SIGNAL	0	Phase C voltage
RSTACM	BOOLEAN	0=False	Reset of accumulated energy reading

7.1.10.4 Settings

PEMMXU Non group settings

Table 244: PEMMXU Non group settings (Basic)

Parameter	Values (Range)	Unit	Step	Default	Description
Operation	1=on 5=off			1=on	Operation Off / On
Power unit Mult	3=Kilo 6=Mega			3=Kilo	Unit multiplier for presentation of the power related values
Energy unit Mult	3=Kilo 6=Mega			3=Kilo	Unit multiplier for presentation of the energy related values
Active power Dir	1=Forward 2=Reverse			1=Forward	Direction of active power flow: Forward, Reverse
Reactive power Dir	1=Forward 2=Reverse			1=Forward	Direction of reactive power flow: Forward, Reverse

Table 245: PEMMXU Non group settings (Advanced)

Parameter	Values (Range)	Unit	Step	Default	Description
Forward Wh Initial	0...999999999		1	0	Preset Initial value for forward active energy
Reverse Wh Initial	0...999999999		1	0	Preset Initial value for reverse active energy
Forward VArh Initial	0...999999999		1	0	Preset Initial value for forward reactive energy
Reverse VArh Initial	0...999999999		1	0	Preset Initial value for reverse reactive energy

7.1.10.5 Monitored data

PEMMXU Monitored data

Table 246: PEMMXU Monitored data

Name	Type	Values (Range)	Unit	Description
S-kVA	FLOAT32	-999999.9...999999.9	kVA	Total Apparent Power
P-kW	FLOAT32	-999999.9...999999.9	kW	Total Active Power
Q-kVAr	FLOAT32	-999999.9...999999.9	kVAr	Total Reactive Power
PF	FLOAT32	-1.00...1.00		Average Power factor
RSTACM	BOOLEAN	0=False 1=True		Reset of accumulated energy reading
S_INST	FLOAT32	-999999.9...999999.9	kVA	Apparent power, magnitude of instantaneous value
S_DB	FLOAT32	-999999.9...999999.9	kVA	Apparent power, magnitude of reported value
S_DMD	FLOAT32	-999999.9...999999.9	kVA	Demand value of apparent power
P_INST	FLOAT32	-999999.9...999999.9	kW	Active power, magnitude of instantaneous value
P_DB	FLOAT32	-999999.9...999999.9	kW	Active power, magnitude of reported value
P_DMD	FLOAT32	-999999.9...999999.9	kW	Demand value of active power
Q_INST	FLOAT32	-999999.9...999999.9	kVAr	Reactive power, magnitude of instantaneous value
Q_DB	FLOAT32	-999999.9...999999.9	kVAr	Reactive power, magnitude of reported value
Q_DMD	FLOAT32	-999999.9...999999.9	kVAr	Demand value of reactive power
PF_INST	FLOAT32	-1.00...1.00		Power factor, magnitude of instantaneous value

Table continues on the next page

Name	Type	Values (Range)	Unit	Description
PF_DB	FLOAT32	-1.00...1.00		Power factor, magnitude of reported value
PF_DMD	FLOAT32	-1.00...1.00		Demand value of power factor
EA_RV_ACM	INT64	0...999999999	kWh	Accumulated reverse active energy value
ER_RV_ACM	INT64	0...999999999	kVArh	Accumulated reverse reactive energy value
EA_FWD_ACM	INT64	0...999999999	kWh	Accumulated forward active energy value
ER_FWD_ACM	INT64	0...999999999	kVArh	Accumulated forward reactive energy value
Max demand S	FLOAT32	-999999.9...999999.9	kVA	Maximum demand value of apparent power
Min demand S	FLOAT32	-999999.9...999999.9	kVA	Minimum demand value of apparent power
Max demand P	FLOAT32	-999999.9...999999.9	kW	Maximum demand value of active power
Min demand P	FLOAT32	-999999.9...999999.9	kW	Minimum demand value of active power
Max demand Q	FLOAT32	-999999.9...999999.9	kVAr	Maximum demand value of reactive power
Min demand Q	FLOAT32	-999999.9...999999.9	kVAr	Minimum demand value of reactive power
Time max dmd S	Timestamp			Time of maximum demand
Time min dmd S	Timestamp			Time of minimum demand
Time max dmd P	Timestamp			Time of maximum demand
Time min dmd P	Timestamp			Time of minimum demand

Table continues on the next page

Name	Type	Values (Range)	Unit	Description
Time max dmd Q	Timestamp			Time of maximum demand
Time min dmd Q	Timestamp			Time of minimum demand

7.1.10.6 Technical data

Table 247: PEMMXU Technical data

Characteristic	Value
Operation accuracy	At all three currents in range 0.10…1.20 × In At all three voltages in range 0.50…1.15 × Un At the frequency fn ±1 Hz
	±1.5% for apparent power S ±1.5% for active power P and active energy [1] ±1.5% for reactive power Q and reactive energy [2] ±0.015 for power factor
Suppression of harmonics	DFT: -50 dB at f = n × fn, where n = 2, 3, 4, 5,…

7.1.10.7 Technical revision history

Table 248: PEMMXU Technical revision history

Technical revision	Change
B	Demand values added to Monitored data. Recorded data added to store minimum and maximum demand values with timestamps.
C	Internal improvement.
D	Internal improvement.

7.2 Disturbance recorder RDRE

[1] |PF| >0.5 which equals |cosφ| >0.5
[2] |PF| <0.86 which equals |sinφ| >0.5

7.2.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Disturbance recorder	RDRE	DR	DFR

7.2.2 Functionality

The merging unit is provided with a disturbance recorder featuring up to 12 analog and 64 binary signal channels.

The analog channels can be set to trigger the recording function when the measured value falls below or exceeds the set values. The binary signal channels can be set to start a recording either on the rising or the falling edge of the binary signal or on both.

By default, the binary channels are set to record external or internal signals, for example, the start or trip signals of the merging unit stages, or external blocking or control signals. Binary signals, such as protection start and trip signals, or an external control signal via a binary input, can be set to trigger the recording. Recorded information is stored in a nonvolatile memory and can be uploaded for subsequent fault analysis.

7.2.2.1 Recorded analog inputs

The user can map any analog signal type of the merging unit to each analog channel of the disturbance recorder by setting the *Channel selection* parameter of the corresponding analog channel. In addition, the user can enable or disable each analog channel of the disturbance recorder by setting the *Operation* parameter of the corresponding analog channel to "on" or "off".

All analog channels of the disturbance recorder that are enabled and have a valid signal type mapped are included in the recording.

7.2.2.2 Triggering alternatives

The recording can be triggered by any or several of the following alternatives:

- Triggering according to the state change of any or several of the binary channels of the disturbance recorder. The user can set the level sensitivity with the *Level trigger mode* parameter of the corresponding binary channel.
- Triggering on limit violations of the analog channels of the disturbance recorder (high and low limit)
- Manual triggering via the *Trig recording* parameter (communication)
- Periodic triggering.

Regardless of the triggering type, each recording generates the Recording started and Recording made events. The Recording made event indicates that the recording has been stored to the non-volatile memory. In addition, every analog channel and binary channel of the disturbance recorder has its own *Channel triggered* parameter. Manual trigger has the *Manual triggering* parameter and periodic trigger has the *Periodic triggering* parameter.

Triggering by binary channels

Input signals for the binary channels of the disturbance recorder can be formed from any of the digital signals that can be dynamically mapped. A change in the status of a monitored signal triggers the recorder according to the configuration and settings. Triggering on the rising edge of a digital input signal means that the recording sequence starts when the input signal is activated. Correspondingly, triggering on the falling edge means that the recording sequence starts when the active input signal resets. It is also possible to trigger from both edges. In addition, if preferred, the monitored signal can be non-triggering. The trigger setting can be set individually for each binary channel of the disturbance recorder with the *Level trigger mode* parameter of the corresponding binary channel.

Triggering by analog channels

The trigger level can be set for triggering in a limit violation situation. The user can set the limit values with the *High trigger level* and *Low trigger level* parameters of the corresponding analog channel. Both high level and low level violation triggering can be active simultaneously for the same analog channel. If the duration of the limit violation condition exceeds the filter time of approximately 50 ms, the recorder triggers. In case of a low level limit violation, if the measured value falls below approximately 0.05 during the filter time, the situation is considered to be a circuit-breaker operation and therefore, the recorder does not trigger. This is useful especially in undervoltage situations. The filter time of approximately 50 ms is common to all the analog channel triggers of the disturbance recorder. The value used for triggering is the calculated peak-to-peak value. Either high or low analog channel trigger can be disabled by setting the corresponding trigger level parameter to zero.

Manual triggering

The recorder can be triggered manually via communication by setting the *Trig recording* parameter to TRUE.

Periodic triggering

Periodic triggering means that the recorder automatically makes a recording at certain time intervals. The user can adjust the interval with the *Periodic trig time* parameter. If the value of the parameter is changed, the new setting takes effect when the next periodic triggering occurs. Setting the parameter to zero disables the triggering alternative and the setting becomes valid immediately. If a new non-zero setting needs to be valid immediately, the user should first set the *Periodic trig time* parameter to zero and then to the new value. The user can monitor the time remaining to the next triggering with the Time to trigger monitored data which counts downwards.

7.2.2.3 Length of recordings

The user can define the length of a recording with the *Record length* parameter. The length is given as the number of fundamental cycles.

According to the memory available and the number of analog channels used, the disturbance recorder automatically calculates the remaining amount of recordings that fit into the available recording memory. The user can see this information with the Rem. amount of rec monitored data. The fixed memory size allocated for the recorder can fit in two recordings that are ten seconds long. The recordings contain data from all analog and binary channels of the disturbance recorder, at the sample rate of 32 samples per fundamental cycle.

The user can view the number of recordings currently in memory with the Number of recordings monitored data. The currently used memory space can be viewed with the Rec. memory used monitored data. It is shown as a percentage value.

The maximum number of recordings is 100.

7.2.2.4 Sampling frequencies

The sampling frequency of the disturbance recorder analog channels depends on the set rated frequency. One fundamental cycle always contains the amount of samples set with the *Storage rate* parameter. Since the states of the binary channels are sampled once per task execution of the disturbance recorder, the sampling frequency of binary channels is 400 Hz at the rated frequency of 50 Hz and 480 Hz at the rated frequency of 60 Hz.

Table 249: Sampling frequencies of the disturbance recorder analog channels

Storage rate (samples per fundamental cycle)	Recording length	Sampling frequency of analog channels, when the rated frequency is 50 Hz	Sampling frequency of binary channels, when the rated frequency is 50 Hz	Sampling frequency of analog channels, when the rated frequency is 60 Hz	Sampling frequency of binary channels, when the rated frequency is 60 Hz
32	1* Record length	1600 Hz	400 Hz	1920 Hz	480 Hz
16	2* Record length	800 Hz	400 Hz	960 Hz	480 Hz
8	4 * Record length	400 Hz	400 Hz	480 Hz	480 Hz

7.2.2.5 Uploading of recordings

The merging unit stores COMTRADE files to the C:\COMTRADE\ folder. The files can be uploaded with the PCM600 or any appropriate computer software that can access the C:\COMTRADE\ folder.

One complete disturbance recording consists of two COMTRADE file types: the configuration file and the data file. The file name is the same for both file types. The configuration file has .CFG and the data file .DAT as the file extension.

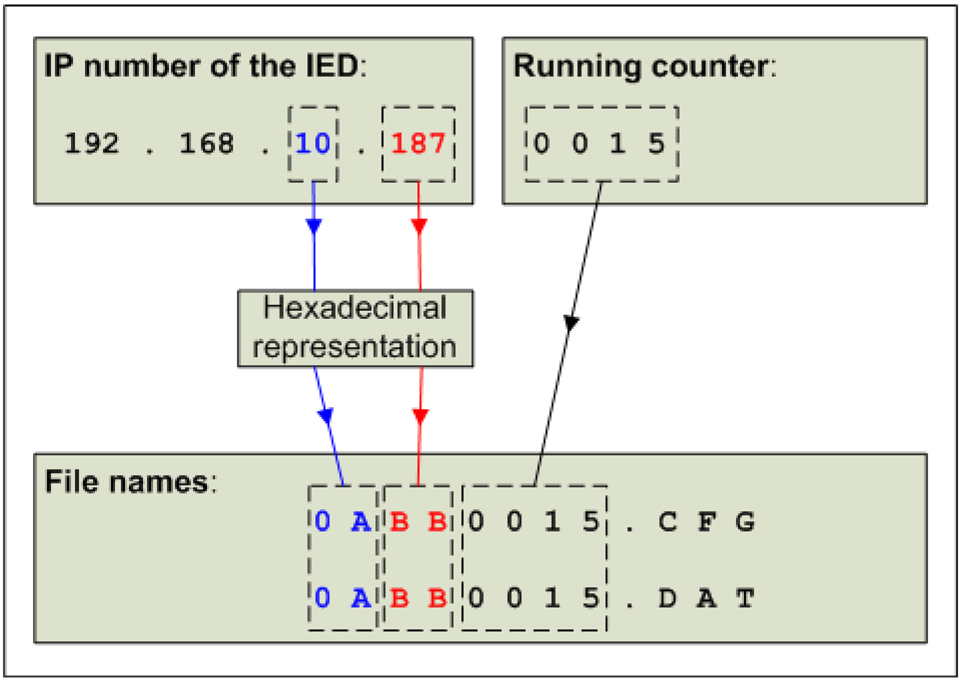


Figure 130: Disturbance recorder file naming

The naming convention of 8+3 characters is used in COMTRADE file naming. The file name is composed of the last two octets of the merging unit's IP number and a running counter, which has a range of 1...9999. A hexadecimal representation is used for the IP number octets. The appropriate file extension is added to the end of the file name.

7.2.2.6 Deletion of recordings

There are several ways to delete disturbance recordings. The recordings can be deleted individually or all at once.

Individual disturbance recordings can be deleted with PCM600 or any appropriate computer software, which can access the merging unit's C:\COMTRADE folder. The disturbance recording is not removed from the merging unit's memory until both of the corresponding COMTRADE files, .CFG and .DAT, are deleted. The user may have to delete both of the files types separately, depending on the software used.

Deleting all disturbance recordings at once is done either with PCM600 or any appropriate computer software, or from the WHMI via the **Clear** > **Disturbance records** menu. Deleting all disturbance recordings at once also clears the pre-trigger recording in progress.

7.2.2.7 Storage mode

The disturbance recorder can capture data in two modes: waveform and trend mode. The user can set the storage mode individually for each trigger source with the *Storage mode* parameter of the corresponding analog channel or binary channel, the *Stor. mode manual* parameter for manual trigger and the *Stor. mode periodic* parameter for periodic trigger.

In the waveform mode, the samples are captured according to the *Storage rate* and *Pre-trg length* parameters.

In the trend mode, one value is recorded for each enabled analog channel, once per fundamental cycle. The recorded values are RMS values, which are scaled to peak level. The binary channels of the disturbance recorder are also recorded once per fundamental cycle in the trend mode.

Only post-trigger data is captured in trend mode.

The trend mode enables recording times of 32 * *Record length*.

7.2.2.8 Pre-trigger and post-trigger data

The waveforms of the disturbance recorder analog channels and the states of the disturbance recorder binary channels are constantly recorded into the history memory of the recorder. The user can adjust the percentage of the data duration preceding the triggering, that is, the so-called pre-trigger time, with the *Pre-trg length* parameter. The duration of the data following the triggering, that is, the so-called post-trigger time, is the difference between the recording length and the pre-trigger time. Changing the pre-trigger time resets the history data and the current recording under collection.

7.2.2.9 Operation modes

Disturbance recorder has two operation modes: saturation and overwrite mode. The user can change the operation mode of the disturbance recorder with the *Operation mode* parameter.

Saturation mode

In saturation mode, the captured recordings cannot be overwritten with new recordings. Capturing the data is stopped when the recording memory is full, that is, when the maximum number of recordings is reached. In this case, the event is sent via the state change (TRUE) of the *Memory full* parameter. When there is memory available again, another event is generated via the state change (FALSE) of the *Memory full* parameter.

Overwrite mode

When the operation mode is "Overwrite" and the recording memory is full, the oldest recording is overwritten with the pre-trigger data collected for the next recording. Each time a recording is overwritten, the event is generated via the state change of the *Overwrite of rec.* parameter. The overwrite mode is recommended, if it is more important to have the latest recordings in the memory. The saturation mode is preferred, when the oldest recordings are more important.

New triggerings are blocked in both the saturation and the overwrite mode until the previous recording is completed. On the other hand, a new triggering can be accepted before all pre-trigger samples are collected for the new recording. In such a case, the recording is as much shorter as there were pre-trigger samples lacking.

7.2.2.10 Exclusion mode

Exclusion mode is on, when the value set with the *Exclusion time* parameter is higher than zero. During the exclusion mode, new triggerings are ignored if the triggering reason is the same as in the previous recording. The *Exclusion time* parameter controls how long the exclusion of triggerings of same type is active after a triggering. The exclusion mode only applies to the analog and binary channel triggerings, not to periodic and manual triggerings.

When the value set with the *Exclusion time* parameter is zero, the exclusion mode is disabled and there are no restrictions on the triggering types of the successive recordings.

The exclusion time setting is global for all inputs, but there is an individual counter for each analog and binary channel of the disturbance recorder, counting the remaining exclusion time. The user can monitor the remaining exclusion time with the *Exclusion time rem* parameter (only visible via communication, IEC 61850 data ExclTmRmn) of the corresponding analog or binary channel. The *Exclusion time rem* parameter counts downwards.

7.2.3 Configuration

The disturbance recorder can be configured with PCM600 or any tool supporting the IEC 61850 standard.

The disturbance recorder can be enabled or disabled with the *Operation* parameter under the **Configuration** > **Disturbance recorder** > **General** menu.

One analog signal type of the merging unit can be mapped to each of the analog channels of the disturbance recorder. The mapping is done with the *Channel selection* parameter of the corresponding analog channel. The name of the analog channel is user-configurable. It can be modified by writing the new name to the *Channel id text* parameter of the corresponding analog channel.

Any external or internal digital signal of the merging unit which can be dynamically mapped can be connected to the binary channels of the disturbance recorder. These signals can be, for example, the start and trip signals from protection function blocks or the external binary inputs of the merging unit. The connection is made with dynamic mapping to the binary channel of the disturbance recorder using, for example, SMT of PCM600. It is also possible to connect several digital signals to one binary channel of the disturbance recorder. In that case, the signals can be combined with logical functions, for example AND and OR. The name of the binary channel can be configured and modified by writing the new name to the *Channel id text* parameter of the corresponding binary channel.

Note that the *Channel id text* parameter is used in COMTRADE configuration files as a channel identifier.

The recording always contains all binary channels of the disturbance recorder. If one of the binary channels is disabled, the recorded state of the channel is continuously FALSE and the state changes of the corresponding channel are not recorded. The corresponding channel name for disabled binary channels in the COMTRADE configuration file is Unused BI.

To enable or disable an analog or a binary channel of the disturbance recorder, the *Operation* parameter of the corresponding analog or binary channel is set to "on" or "off".

The states of manual triggering and periodic triggering are not included in the recording, but they create a state change to the *Periodic triggering* and *Manual triggering* status parameters, which in turn create events.

The `TRIGGERED` output can be used to control the indication LEDs of the merging unit. The `TRIGGERED` output is TRUE due to the triggering of the disturbance recorder, until all the data for the corresponding recording has been recorded.

The IP number of the merging unit and the content of the *Bay name* parameter are both included in the COMTRADE configuration file for identification purposes.

7.2.4 Application

The disturbance recorder is used for post-fault analysis and for verifying the correct operation of merging units and circuit breakers. It can record both analog and binary signal information. The analog inputs are recorded as instantaneous values and converted to primary peak value units when the merging unit converts the recordings to the COMTRADE format.

COMTRADE is the general standard format used in storing disturbance recordings.

The binary channels are sampled once per task execution of the disturbance recorder. The task execution interval for the disturbance recorder is the same as for the protection functions. During the COMTRADE conversion, the digital status values are repeated so that the sampling frequencies of the analog and binary channels correspond to each other. This is required by the COMTRADE standard.

The disturbance recorder follows the 1999 version of the COMTRADE standard and uses the binary data file format.

7.2.5 Settings

7.2.5.1 RDRE settings

Table 250: RDRE Non-group general settings

Parameter	Values (Range)	Unit	Step	Default	Description
Operation	1=on 5=off		1	1=on	Disturbance recorder on/off
Record length	10...500	fundamental cycles	1	50	Size of the re-cording in fundamental cycles

Table continues on the next page

Parameter	Values (Range)	Unit	Step	Default	Description
Pre-trg length	0...100	%	1	50	Length of the recording preceding the triggering
Operation mode	1=Saturation 2=Overwrite		1	1	Operation mode of the recorder
Exclusion time	0...1 000 000	ms	1	0	The time during which triggerings of same type are ignored
Storage rate	32, 16, 8	samples per fundamental cycle		32	Storage rate of the waveform recording
Periodic trig time	0...604 800	s	10	0	Time between periodic triggerings
Stor. mode periodic	0=Waveform 1=Trend / cycle		1	0	Storage mode for periodic triggering
Stor. mode manual	0=Waveform 1=Trend / cycle		1	0	Storage mode for manual triggering

Table 251: RDRE Non-group binary channel settings

Parameter	Values (Range)	Unit	Step	Default	Description
Operation	1=on 5=off		1	5=off	Binary channel is enabled or disabled
Level trigger mode	1=Positive or Rising 2=Negative or Falling 3=Both 4=Level trigger off		1	1=Rising	Level trigger mode for the binary channel
Storage mode	0=Waveform 1=Trend / cycle		1	0	Storage mode for the binary channel
Channel id text	0 to 64 characters, alphanumeric			DR binary channel X	Identification text for the analog channel used in the COMTRADE format

Table 252: RDRE Control data

Parameter	Values (Range)	Unit	Step	Default	Description
Trig recording	0=Cancel 1=Trig				Trigger the disturbance recording
Clear recordings	0=Cancel 1=Clear				Clear all recordings currently in memory

Table 253: RDRE Non-group channel settings

Parameter	Values (Range)	Unit	Step	Default	Description
Operation	1=on 5=off		1	1=on	Analog channel is enabled or disabled
Channel selection	0=Disabled 1=Io 2=IL1 3=IL2 4=IL3 5=IoB 6=IL1B 7=IL2B 8=IL3B 9=Uo 10=U1 11=U2 12=U3 13=UoB 14=U1B 15=U2B 16=U3B 17=CIo 18=SI1 [1] 19=SI2 [1] 20=SU0 21=SU1 [1] 22=SU2 [1] 23=CIoB 24=SI1B [1] 25=SI2B [1] 26=SUoB 27=SU1B [1] 28=SU2B [1] 29=U12 30=U23 31=U31		0	0=Disabled	Select the signal to be recorded by this channel. Applicable values for this parameter are product variant dependent. Every product variant includes only the values that are applicable to that particular variant

Table continues on the next page

1 Recordable values are available only in trend mode. In waveform mode, samples for this signal type are constant zeroes. However, these signal types can be used to trigger the recorder on limit violations of the corresponding analog channel.

Parameter	Values (Range)	Unit	Step	Default	Description
	32=UL1 33=UL2 34=UL3 35=U12B 36=U23B 37=U31B 38=UL1B 39=UL2B 40=UL3B				
Channel id text	0 to 64 characters, alphanumeric			DR analog channel X	Identification text for the analog channel used in the COMTRADE format
High trigger level	0.00...60.00	pu	0.01	10.00	High trigger level for the analog channel
Low trigger level	0.00...2.00	pu	0.01	0.00	Low trigger level for the analog channel
Storage mode	0=Waveform 1=Trend / cycle		1	0	Storage mode for the analog channel

7.2.6 Monitored data

7.2.6.1 Monitored data

Table 254: RDRE Monitored data

Parameter	Values (Range)	Unit	Step	Default	Description
Number of recordings	0...100				Number of recordings currently in memory
Rem. amount of rec.	0...100				Remaining amount of recordings that fit into the available recording memory, when current settings are used
Rec. memory used	0...100	%			Storage mode for the binary channel
Time to trigger	0...604 800	s			Time remaining to the next periodic triggering

7.2.7 Technical revision history

Table 255: RDRE Technical revision history

Technical revision	Change
B	ChNum changed to EChNum (RADR's) RADR9...12 added (Analog channels 9...12) RBDR33...64 added (Binary channels 33...64)
C	New channels added to parameter *Channel selection* Selection names for *Trig Recording* and *Clear Recordings updated*
D	Symbols in the *Channel selection* setting are updated
E	New channels IL1C, IL2C and IL3C added to *Channel selection* parameter
F	Internal improvement
G	Internal improvement

8 Control functions

8.1 Circuit breaker control CBXCBR, Disconnector control DCXSWI and Earthing switch control ESXSWI

8.1.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Circuit breaker control	CBXCBR	I<->O CB	I<->O CB
Disconnector control	DCXSWI	I<->O DCC	I<->O DCC
Earthing switch control	ESXSWI	I<->O ESC	I<->O ESC

8.1.2 Function block

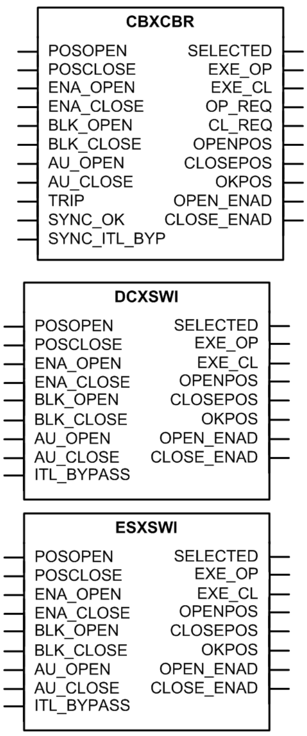


Figure 131: Function block

8.1.3 Functionality

CBXCBR, DCXSWI and ESXSWI are intended for circuit breaker, disconnector and earthing switch control and status information purposes. These functions execute commands and evaluate block conditions and different time supervision conditions. The functions perform an execution command only if all conditions indicate that a switch operation is allowed. If erroneous conditions occur, the functions indicate an appropriate cause value. The functions are designed according to the IEC 61850-7-4 standard with logical nodes CILO, CSWI and XSWI/XCBR.

The circuit breaker, disconnector and earthing switch control functions have an operation counter for closing and opening cycles. The counter value can be read and written remotely from the place of operation.

8.1.4 Operation principle

Status indication and validity check

The object state is defined by two digital inputs, `POSOPEN` and `POSCLOSE`, which are also available as outputs `OPENPOS` and `CLOSEPOS` together with the `OKPOS` according to *Table 256*. The debouncing and short disturbances in an input are eliminated by filtering. The binary input filtering time can be adjusted separately for each digital input used by the function block. The validity of the digital inputs that indicate the object state is used as additional information in indications and event logging. The reporting of faulty or intermediate position of the apparatus occurs after the *Event delay* setting, assuming that the circuit breaker is still in a corresponding state.

Table 256: Status indication

Input		Status	Output		
POSOPEN	**POSCLOSE**	**POSITION (Monitored data)**	**OKPOS**	**OPENPOS**	**CLOSEPOS**
1=True	0=False	1=Open	1=True	1=True	0=False
0=False	1=True	2=Closed	1=True	0=False	1=True
1=True	1=True	3=Faulty/Bad (11)	0=False	0=False	0=False
0=False	0=False	0=Intermedi-ate (00)	0=False	0=False	0=False

Enabling and blocking

CBXCBR, DCXSWI and ESXSWI have an enabling and blocking functionality for interlocking and synchrocheck purposes.

Circuit breaker control CBXCBR

Normally, the CB closing is enabled (that is, `CLOSE_ENAD` signal is TRUE) by activating both `ENA_CLOSE` and `SYNC_OK` inputs. Typically, the `ENA_CLOSE` comes from the interlocking, and `SYNC_OK` comes from the synchronism and energizing check. The input SYNC_ITL_BYP can be used for bypassing this control. The SYNC_ITL_BYP input can be used to activate CLOSE_ENAD discarding the ENA_CLOSE and SYNC_OK input states. However, the BLK_CLOSE input always blocks the CLOSE_ENAD output.

The CB opening (OPEN_ENAD) logic is the same as CB closing logic, except that SYNC_OK is used only in closing. The SYNC_ITL_BYP input is used in both CLOSE_ENAD and OPEN_ENAD logics.

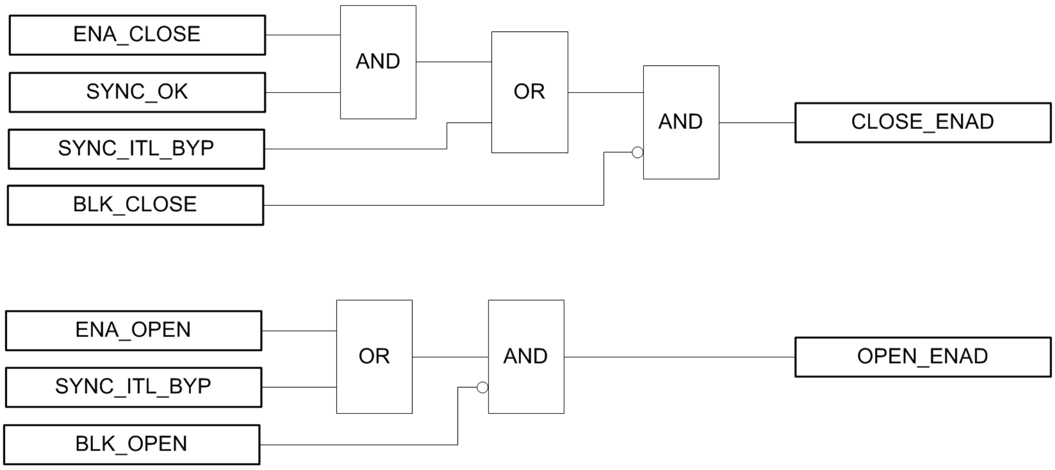


Figure 132: Enabling and blocking logic for CLOSE_ENAD and OPEN_ENAD signals

Opening and closing operations

The opening and closing operations are available via communication, binary inputs or commands. As a prerequisite for control commands, there are enabling and blocking functionalities for both opening and closing commands (CLOSE_ENAD and OPEN_ENAD signals). If the control command is executed against the blocking or if the enabling of the corresponding command is not valid, CBXCBR, DCXSWI and ESXSWI generate an error message.

When close command is given from communication by activating the AU_CLOSE input, it is carried out (the EXE_CL output) only if CLOSE_ENAD is TRUE.

If the SECRSYN function is used in “Command” mode, the CL_REQ output can be used in CBXCBR. Initially, the SYNC_OK input is FALSE. When the close command given, it activates the CL_REQ output, which should be routed to SECRSYN. The close command is then processed only after SYNC_OK is received from SECRSYN.

When using SECRSYN in the “Command” mode, the CBXCBR setting *Operation timeout* should be set longer than SECRSYN setting *Maximum Syn time*.

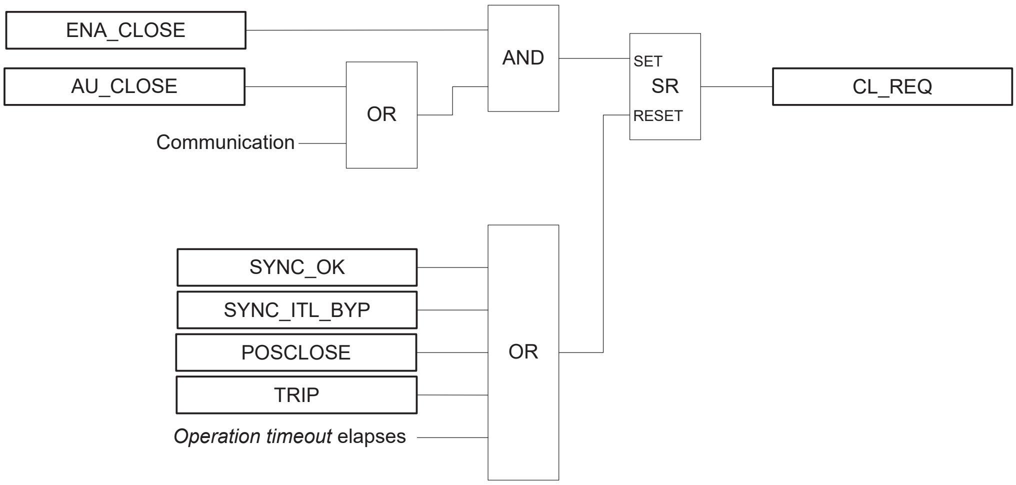


Figure 133: Condition for enabling the close request (CL_REQ) for CBXCBR

When the open command is given from communication, by activating the AU_OPEN input, it is processed only if OPEN_ENAD is TRUE. OP_REQ output is also available.

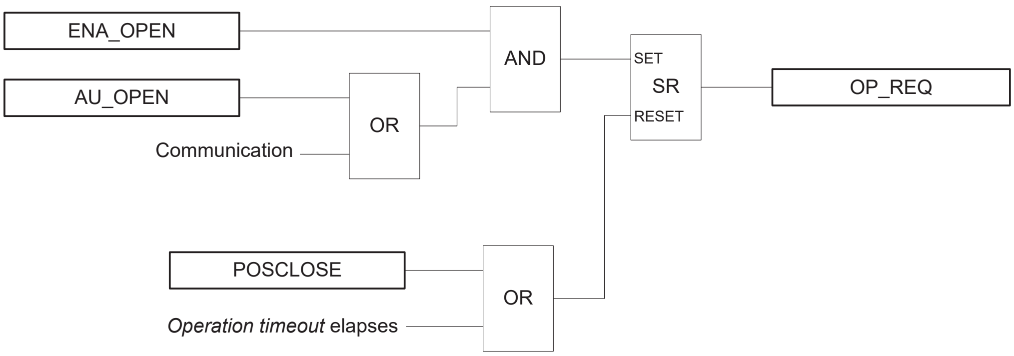


Figure 134: Condition for enabling the open request (OP_REQ) for CBXCBR

OPEN and CLOSE outputs

The EXE_OP output is activated when the open command is given (AU_OPEN, via communication) and OPEN_ENAD signal is TRUE. In addition, the protection trip commands can be routed through the CBXCBR function by using the TRIP input. When the TRIP input is TRUE, the EXE_OP output is activated immediately and bypassing all enabling or blocking conditions.

The EXE_CL output is activated when the close command is given (AU_CLOSE, via communication) and CLOSE_ENAD signal is TRUE. When the TRIP input is “TRUE”, CB closing is not allowed.

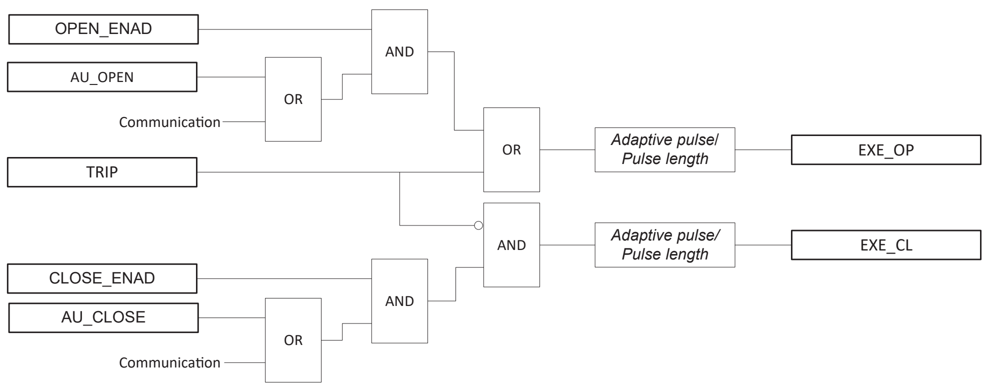


Figure 135: OPEN and CLOSE outputs logic for CBXCBR

Opening and closing pulse widths

The pulse width type can be defined with the *Adaptive pulse* setting. The function provides two modes to characterize the opening and closing pulse widths. When the *Adaptive pulse* is set to “TRUE”, it causes a variable pulse width, which means that the output pulse is deactivated when the object state shows that the apparatus has entered the correct state. If apparatus fails to enter the correct state, the output pulse is deactivated after the set *Operation timeout* setting, and an error message is displayed. When the *Adaptive pulse* is set to “FALSE”, the functions always use the maximum pulse width, defined by the user-configurable *Pulse length* setting. The *Pulse length* setting is the same for both the opening and closing commands. When the apparatus already is in the right position, the maximum pulse length is given.

The *Pulse length* setting does not affect the length of the trip pulse.

Control methods

The command execution mode can be set with the *Control model* setting. The alternatives for command execution are direct control and secured object control, which can be used to secure controlling.

The secured object control SBO is an important feature of the communication protocols that support horizontal communication, because the command reservation and interlocking signals can be transferred with a bus. All secured control operations require two-step commands: a selection step and an execution step. The secured object control is responsible for the several tasks.

- Command authority: ensures that the command source is authorized to operate the object
- Mutual exclusion: ensures that only one command source at a time can control the object
- Interlocking: allows only safe commands
- Execution: supervises the command execution
- Command canceling: cancels the controlling of a selected object.

In direct operation, a single message is used to initiate the control action of a physical device. The direct operation method uses less communication network capacity and bandwidth than the SBO method, because the procedure needs fewer messages for accurate operation.

The “status-only” mode means that control is not possible (non-controllable) via communication. However, it is possible to control a disconnector (DCXSWI) from `AU_OPEN` and `AU_CLOSE` inputs.

`AU_OPEN` and `AU_CLOSE` control the object directly regardless of the set *Control model*. These inputs can be used when control is wanted to be implemented purely based on ACT logic and no additional exception handling is needed. However, in case of simultaneous open and close control, the open control is always prioritized.

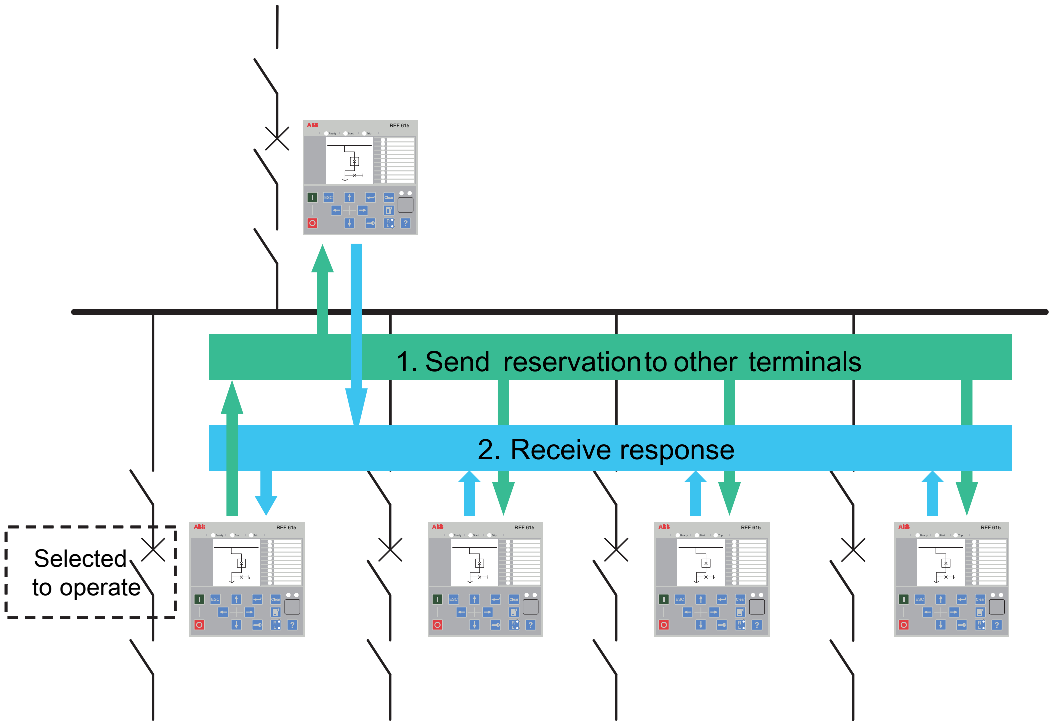


Figure 136: Control procedure in the SBO method

Local/Remote operations

The local/remote selection affects CBXCBR, DCXSWI and ESXSWI.

- Local: the opening and closing via communication is disabled.
- Remote: the opening and closing via communication is enabled.
- `AU_OPEN` and `AU_CLOSE` inputs function regardless of the local/remote selection.

8.1.5 Application

In the field of distribution and sub-transmission automation, reliable control and status indication of primary switching components both locally and remotely is in a significant role. They are needed especially in modern remotely controlled substations.

Control and status indication facilities are implemented in the same package with CBXCBR, DCXSWI and ESXSWI. When primary components are controlled in the energizing phase, for example, the correct execution sequence of the control commands must be ensured. This can be achieved, for example, with interlocking based on the status indication of the related primary components. The interlocking on substation level can be applied using the IEC 61850 GOOSE messages between feeders.

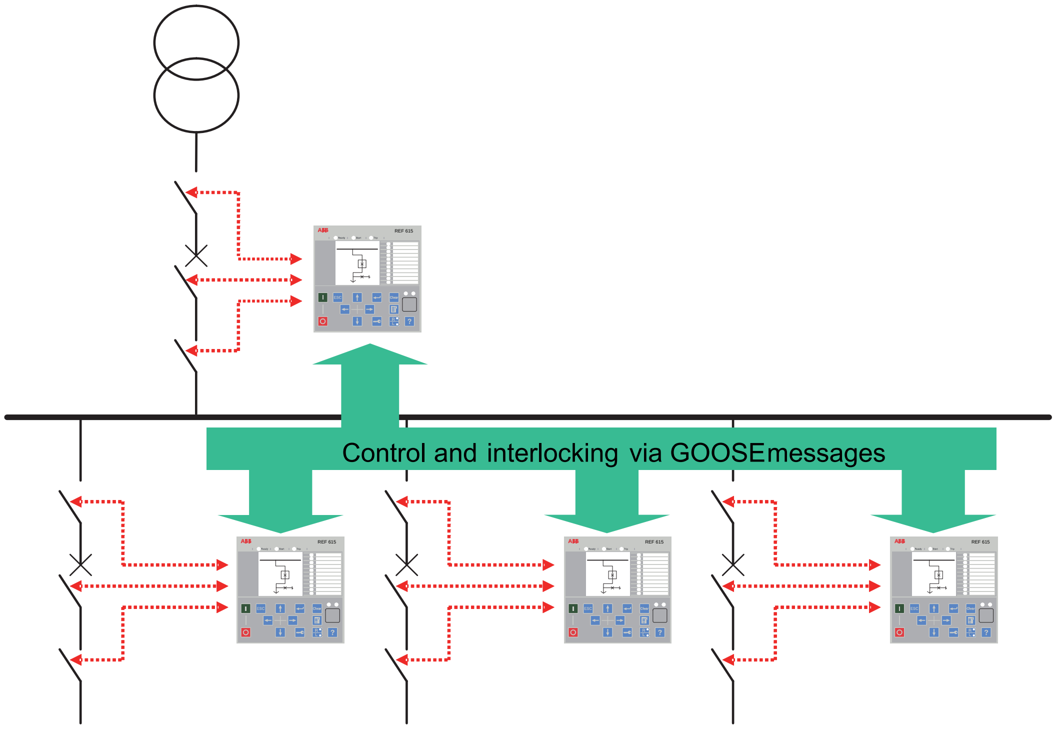


Figure 137: Status indication-based interlocking via the GOOSE messaging

8.1.6 Signals

8.1.6.1 CBXCBR Input signals

Table 257: CBXCBR Input signals

Name	Type	Default	Description
POSOPEN	BOOLEAN	0=False	Signal for open position of apparatus from I/O [1]
POSCLOSE	BOOLEAN	0=False	Signal for close position of apparatus from I/O [1]
ENA_OPEN	BOOLEAN	1=True	Enables opening
ENA_CLOSE	BOOLEAN	1=True	Enables closing

Table continues on the next page

[1] Not available for monitoring

Name	Type	Default	Description
BLK_OPEN	BOOLEAN	0=False	Blocks opening
BLK_CLOSE	BOOLEAN	0=False	Blocks closing
AU_OPEN	BOOLEAN	0=False	Auxiliary open [1] [2]
AU_CLOSE	BOOLEAN	0=False	Auxiliary close [1] [2]
TRIP	BOOLEAN	0=False	Trip signal
SYNC_OK	BOOLEAN	1=True	Synchronism-check OK
SYNC_ITL_BYP	BOOLEAN	0=False	Discards ENA_OPEN and ENA_CLOSE interlocking when TRUE

8.1.6.2 DCXSWI Input signals

Table 258: DCXSWI Input signals

Name	Type	Default	Description
POSOPEN	BOOLEAN	0=False	Apparatus open position
POSCLOSE	BOOLEAN	0=False	Apparatus close position
ENA_OPEN	BOOLEAN	1=True	Enables opening
ENA_CLOSE	BOOLEAN	1=True	Enables closing
BLK_OPEN	BOOLEAN	0=False	Blocks opening
BLK_CLOSE	BOOLEAN	0=False	Blocks closing
AU_OPEN	BOOLEAN	0=False	Executes the command for open direction [1] [2]
AU_CLOSE	BOOLEAN	0=False	Executes the command for close direction [1] [2]
ITL_BYPASS	BOOLEAN	0=False	Discards ENA_OPEN and ENA_CLOSE interlocking when TRUE

[2] Always direct operation
[1] Not available for monitoring

8.1.6.3 ESXSWI Input signals

Table 259: ESXSWI Input signals

Name	Type	Default	Description
POSOPEN	BOOLEAN	0=False	Apparatus open position
POSCLOSE	BOOLEAN	0=False	Apparatus close position
ENA_OPEN	BOOLEAN	1=True	Enables opening
ENA_CLOSE	BOOLEAN	1=True	Enables closing
BLK_OPEN	BOOLEAN	0=False	Blocks opening
BLK_CLOSE	BOOLEAN	0=False	Blocks closing
AU_OPEN	BOOLEAN	0=False	Executes the command for open direction [1] [2]
AU_CLOSE	BOOLEAN	0=False	Executes the command for close direction [1] [2]
ITL_BYPASS	BOOLEAN	0=False	Discards ENA_OPEN and ENA_CLOSE interlocking when TRUE

8.1.6.4 DCXSWI Output signals

Table 260: DCXSWI Output signals

Name	Type	Description
SELECTED	BOOLEAN	Object selected
EXE_OP	BOOLEAN	Executes the command for open direction
EXE_CL	BOOLEAN	Executes the command for close direction
OPENPOS	BOOLEAN	Apparatus open position
CLOSEPOS	BOOLEAN	Apparatus closed position
OKPOS	BOOLEAN	Apparatus position is ok
OPEN_ENAD	BOOLEAN	Opening is enabled based on the input status
CLOSE_ENAD	BOOLEAN	Closing is enabled based on the input status

[1] Not available for monitoring
[2] Always direct operation

8.1.6.5 ESXSWI Output signals

Table 261: ESXSWI Output signals

Name	Type	Description
SELECTED	BOOLEAN	Object selected
EXE_OP	BOOLEAN	Executes the command for open direction
EXE_CL	BOOLEAN	Executes the command for close direction
OPENPOS	BOOLEAN	Apparatus open position
CLOSEPOS	BOOLEAN	Apparatus closed position
OKPOS	BOOLEAN	Apparatus position is ok
OPEN_ENAD	BOOLEAN	Opening is enabled based on the input status
CLOSE_ENAD	BOOLEAN	Closing is enabled based on the input status

8.1.7 Settings

8.1.7.1 CBXCBR Non group settings

Table 262: CBXCBR Non group settings (Basic)

Parameter	Values (Range)	Unit	Step	Default	Description
Operation	1=on 5=off			1=on	Operation mode on/off
Select timeout	10000...300000	ms	10000	30000	Select timeout in ms
Pulse length	10...60000	ms	1	200	Open and close pulse length
Control model	0=status-only 1=direct-with-normal-security 4=sbo-with-enhanced-security			4=sbo-with-enhanced-security	Select control model
Operation timeout	10...60000	ms	1	500	Timeout for negative termination
Identification				CBXCBR1 switch position	Control Object identification

Table 263: CBXCBR Non group settings (Advanced)

Parameter	Values (Range)	Unit	Step	Default	Description
Operation counter	0...10000		1	0	Breaker operation cycles
Adaptive pulse	0=False 1=True			1=True	Stop in right position

Table continues on the next page

Parameter	Values (Range)	Unit	Step	Default	Description
Event delay	0...10000	ms	1	200	Event delay of the intermediate position
Vendor				0	External equipment vendor
Serial number				0	External equipment serial number
Model				0	External equipment model

8.1.7.2 DCXSWI Non group settings

Table 264: DCXSWI Non group settings (Basic)

Parameter	Values (Range)	Unit	Step	Default	Description
Operation	1=on 5=off			1=on	Operation mode on/off
Select timeout	10000...300000	ms	10000	30000	Select timeout in ms
Pulse length	10...60000	ms	1	100	Open and close pulse length
Control model	0=status-only 1=direct-with-normal-security 4=sbo-with-enhanced-security			4=sbo-with-enhanced-security	Select control model
Operation timeout	10...60000	ms	1	30000	Timeout for negative termination
Identification				DCXSWI1 switch position	Control Object identification

Table 265: DCXSWI Non group settings (Advanced)

Parameter	Values (Range)	Unit	Step	Default	Description
Operation counter	0...10000		1	0	Breaker operation cycles
Adaptive pulse	0=False 1=True			1=True	Stop in right position
Event delay	0...60000	ms	1	10000	Event delay of the intermediate position
Vendor				0	External equipment vendor
Serial number				0	External equipment serial number
Model				0	External equipment model

8.1.7.3 ESXSWI Non group settings

Table 266: ESXSWI Non group settings (Basic)

Parameter	Values (Range)	Unit	Step	Default	Description
Operation	1=on			1=on	Operation mode on/off

Table continues on the next page

Parameter	Values (Range)	Unit	Step	Default	Description
	5=off				
Select timeout	10000...300000	ms	10000	30000	Select timeout in ms
Pulse length	10...60000	ms	1	100	Open and close pulse length
Control model	0=status-only 1=direct-with-normal-security 4=sbo-with-enhanced-security			4=sbo-with-enhanced-security	Select control model
Operation timeout	10...60000	ms	1	30000	Timeout for negative termination
Identification				ESXSWI1 switch position	Control Object identification

Table 267: ESXSWI Non group settings (Advanced)

Parameter	Values (Range)	Unit	Step	Default	Description
Operation counter	0...10000		1	0	Breaker operation cycles
Adaptive pulse	0=False 1=True			1=True	Stop in right position
Event delay	0...60000	ms	1	10000	Event delay of the intermediate position
Vendor				0	External equipment vendor
Serial number				0	External equipment serial number
Model				0	External equipment model

8.1.8 Monitored data

8.1.8.1 CBXCBR Monitored data

Table 268: CBXCBR Monitored data

Name	Type	Values (Range)	Unit	Description
POSITION	Dbpos	0=intermediate 1=open 2=closed 3=faulty		Apparatus position indication

8.1.8.2 DCXSWI Monitored data

Table 269: DCXSWI Monitored data

Name	Type	Values (Range)	Unit	Description
POSITION	Dbpos	0=intermediate 1=open 2=closed 3=faulty		Apparatus position indication

8.1.8.3 ESXSWI Monitored data

Table 270: ESXSWI Monitored data

Name	Type	Values (Range)	Unit	Description
POSITION	Dbpos	0=intermediate 1=open 2=closed 3=faulty		Apparatus position indication

8.1.9 Technical revision history

Table 271: CBXCBR Technical revision history

Technical revision	Change
B	Interlocking bypass input (`ITL_BYPASS`) and opening enabled (`OPEN_ENAD`)/closing enabled (`CLOSE_ENAD`) outputs added. `ITL_BYPASS` bypasses the `ENA_OPEN` and `ENA_CLOSE` states.
C	Internal improvement.
D	Added inputs `TRIP` and `SYNC_OK`. Renamed input `ITL_BYPASS` to `SYNC_ITL_BYP`. Added outputs `CL_REQ` and `OP_REQ`. Outputs `OPENPOS` and `CLOSEPOS` are forced to “FALSE” in case status is Faulty (11).

Table 272: DCXSWI Technical revision history

Technical revision	Change
B	Maximum and default values changed to 60 s and 10 s respectively for *Event delay* settings.

Table continues on the next page

Technical revision	Change
	Default value changed to 30 s for *Operation timeout* setting.
C	Outputs OPENPOS and CLOSEPOS are forced to “FALSE” in case status is Faulty (11).

Table 273: ESXSWI Technical revision history

Technical revision	Change
B	Maximum and default values changed to 60 s and 10 s respectively for *Event delay* settings. Default value changed to 30 s for *Operation timeout* setting.
C	Outputs OPENPOS and CLOSEPOS are forced to “FALSE” in case status is Faulty (11).

8.2 Disconnector position indication DCSXSWI and Earthing switch indication ESSXSWI

8.2.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Disconnector position indication	DCSXSWI	I<->O DC	I<->O DC
Earthing switch indication	ESSXSWI	I<->O ES	I<->O ES

8.2.2 Function block

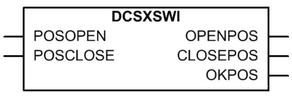


Figure 138: Function block

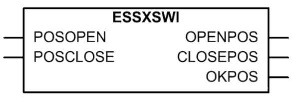


Figure 139: Function block

8.2.3 Functionality

The functions DCSXSWI and ESSXSWI indicate remotely and locally the open, close and undefined states of the disconnector and earthing switch. The functionality of both is identical, but each one is allocated for a specific purpose visible in the function names. For example, the status indication of disconnectors or circuit breaker truck can be monitored with the DCSXSWI function.

The functions are designed according to the IEC 61850-7-4 standard with the logical node XSWI.

8.2.4 Operation principle

Status indication and validity check

The object state is defined by the two digital inputs POSOPEN and POSCLOSE, which are also available as outputs OPENPOS and CLOSEPOS together with the OKPOS according to *Table 274*. The debounces and short disturbances in an input are eliminated by filtering. The binary input filtering time can be adjusted separately for each digital input used by the function block. The validity of digital inputs that indicate the object state is used as additional information in indications and event logging.

Table 274: Status indication

Input		Status	Output		
POSOPEN	**POSCLOSE**	**POSITION (Monitored data)**	**OKPOS**	**OPENPOS**	**CLOSEPOS**
1=True	0=False	1=Open	1=True	1=True	0=False
0=False	1=True	2=Closed	1=True	0=False	1=True
1=True	1=True	3=Faulty/Bad (11)	0=False	0=False	0=False
0=False	0=False	0=Intermedi-ate (00)	0=False	0=False	0=False

8.2.5 Application

In the field of distribution and sub-transmission automation, the reliable control and status indication of primary switching components both locally and remotely is in a significant role. These features are needed especially in modern remote controlled substations. The application area of DCSXSWI and ESSXSWI functions covers remote and local status indication of, for example, disconnectors, air-break switches and earthing switches, which represent the lowest level of power switching devices without short-circuit breaking capability.

8.2.6 Signals

8.2.6.1 DCSXSWI Input signals

Table 275: DCSXSWI Input signals

Name	Type	Default	Description
POSOPEN	BOOLEAN	0=False	Signal for open position of apparatus from I/O [1]
POSCLOSE	BOOLEAN	0=False	Signal for close position of apparatus from I/O [1]

8.2.6.2 ESSXSWI Input signals

Table 276: ESSXSWI Input signals

Name	Type	Default	Description
POSOPEN	BOOLEAN	0=False	Signal for open position of apparatus from I/O [1]
POSCLOSE	BOOLEAN	0=False	Signal for close position of apparatus from I/O [1]

8.2.6.3 DCSXSWI Output signals

Table 277: DCSXSWI Output signals

Name	Type	Description
OPENPOS	BOOLEAN	Apparatus open position
CLOSEPOS	BOOLEAN	Apparatus closed position
OKPOS	BOOLEAN	Apparatus position is ok

8.2.6.4 ESSXSWI Output signals

Table 278: ESSXSWI Output signals

Name	Type	Description
OPENPOS	BOOLEAN	Apparatus open position
CLOSEPOS	BOOLEAN	Apparatus closed position
OKPOS	BOOLEAN	Apparatus position is ok

[1] Not available for monitoring

8.2.7 Settings

8.2.7.1 DCSXSWI Non group settings

Table 279: DCSXSWI Non group settings (Basic)

Parameter	Values (Range)	Unit	Step	Default	Description
Identification				DCSXSWI1 switch position	Control Object identification

Table 280: DCSXSWI Non group settings (Advanced)

Parameter	Values (Range)	Unit	Step	Default	Description
Event delay	0...60000	ms	1	30000	Event delay of the intermediate position
Vendor				0	External equipment vendor
Serial number				0	External equipment serial number
Model				0	External equipment model

8.2.7.2 ESSXSWI Non group settings

Table 281: ESSXSWI Non group settings (Basic)

Parameter	Values (Range)	Unit	Step	Default	Description
Identification				ESSXSWI1 switch position	Control Object identification

Table 282: ESSXSWI Non group settings (Advanced)

Parameter	Values (Range)	Unit	Step	Default	Description
Event delay	0...60000	ms	1	30000	Event delay of the intermediate position
Vendor				0	External equipment vendor
Serial number				0	External equipment serial number
Model				0	External equipment model

8.2.8 Monitored data

8.2.8.1 DCSXSWI Monitored data

Table 283: DCSXSWI Monitored data

Name	Type	Values (Range)	Unit	Description
POSITION	Dbpos	0=intermediate		Apparatus position indication

Name	Type	Values (Range)	Unit	Description
		1=open 2=closed 3=faulty		

8.2.8.2 ESSXSWI Monitored data

Table 284: ESSXSWI Monitored data

Name	Type	Values (Range)	Unit	Description
POSITION	Dbpos	0=intermediate 1=open 2=closed 3=faulty		Apparatus position indication

8.2.9 Technical revision history

Table 285: DCSXSWI Technical revision history

Technical revision	Change
B	Maximum and default values changed to 60 s and 30 s respectively for *Event delay* settings.
C	Outputs OPENPOS and CLOSEPOS are forced to “FALSE” in case status is Faulty (11).

Table 286: ESSXSWI Technical revision history

Technical revision	Change
B	Maximum and default values changed to 60 s and 30 s respectively for *Event delay* settings.
C	Outputs OPENPOS and CLOSEPOS are forced to “FALSE” in case status is Faulty (11).

9 General function block features

9.1 Frequency measurement

All the function blocks that use frequency quantity as their input signal share the common features related to the frequency measurement algorithm. The frequency estimation is done from one phase (phase-to-phase or phase voltage) or from the positive phase sequence (PPS). The voltage groups with three-phase inputs use PPS as the source. The frequency measurement range is 0.6...1.5 × F_n. The df/dt measurement range always starts from 0.6 × F_n. When the frequency exceeds these limits, it is regarded as out of range and a minimum or maximum value is held as the measured value respectively with appropriate quality information. The frequency estimation requires 160 ms to stabilize after a bad quality signal. Therefore, a delay of 160 ms is added to the transition from the bad quality. The bad quality of the signal can be due to restrictions like:

- The source voltage is below 0.02 × U_n at F_n.
- The source voltage waveform is discontinuous.
- The source voltage frequency rate of change exceeds 15 Hz/s (including stepwise frequency changes).

When the bad signal quality is obtained, the nominal or zero (depending on the *Def frequency Sel* setting) frequency value is shown with appropriate quality information in the measurement view. The frequency protection functions are blocked when the quality is bad, thus the timers and the function outputs are reset. When the frequency is out of the function block's setting range but within the measurement range, the protection blocks are running. However, the `OPERATE` outputs are blocked until the frequency restores to a valid range.

9.2 Measurement modes

RMS

The RMS measurement principle is selected with the *Measurement mode* setting using the value "RMS". RMS consists of both AC and DC components. The AC component is the effective mean value of the positive and negative peak values. RMS is used in applications where the effect of the DC component must be taken into account.

RMS is calculated according to the formula:

$$I_{RMS} = \sqrt{\frac{1}{n}\sum_{i=1}^{n} I_i^2}$$

(Equation 15)

n	The number of samples in a calculation cycle
I_i	The current sample value

DFT

The DFT measurement principle is selected with the *Measurement mode* setting using the value "DFT". In the DFT mode, the fundamental frequency component of the measured signal is numerically calculated from the samples. In some applications, for example, it can be difficult to accomplish sufficiently sensitive settings and accurate operation of the low stage, which may be due to a considerable amount of harmonics on the primary side currents. In such a case, the operation can be based solely on the fundamental frequency component of the current. In addition, the DFT mode has slightly higher CT requirements than the peak-to-peak mode, if used with high and instantaneous stages.

9.3 Calculated measurements

Calculated residual current and voltage

The residual current is calculated from the phase currents according to equation:

$$\overline{Io} = -(\overline{I}_A + \overline{I}_B + \overline{I}_C)$$

(Equation 16)

The residual voltage is calculated from the phase-to-earth voltages when the VT connection is selected as “Wye” with the equation:

$$\overline{Uo} = (\overline{U}_A + \overline{U}_B + \overline{U}_C)/3$$

(Equation 17)

Sequence components

The phase-sequence current components are calculated from the phase currents according to:

$$\overline{I}_0 = (\overline{I}_A + \overline{I}_B + \overline{I}_C)/3$$

(Equation 18)

$$\overline{I}_1 = (\overline{I}_A + a \cdot \overline{I}_B + a^2 \cdot \overline{I}_C)/3$$

(Equation 19)

$$\overline{I}_2 = (\overline{I}_A + a^2 \cdot \overline{I}_B + a \cdot \overline{I}_C)/3$$

(Equation 20)

The phase-sequence voltage components are calculated from the phase-to-earth voltages when *VT connection* is selected as “Wye” with the equations:

$$\overline{U}_0 = (\overline{U}_A + \overline{U}_B + \overline{U}_C)/3$$

(Equation 21)

$$\overline{U}_1 = (\overline{U}_A + a \cdot \overline{U}_B + a^2 \cdot \overline{U}_C)/3$$

(Equation 22)

$$\overline{U}_2 = (\overline{U}_A + a^2 \cdot \overline{U}_B + a \cdot \overline{U}_C)/3$$

(Equation 23)

When *VT connection* is selected as “Delta”, the positive and negative phase sequence voltage components are calculated from the phase-to-phase voltages according to the equations:

$$\overline{U}_1 = (\overline{U}_{AB} - a^2 \cdot \overline{U}_{BC})/3$$

(Equation 24)

$$\overline{U}_2 = (\overline{U}_{AB} - a \cdot \overline{U}_{BC})/3$$

(Equation 25)

The phase-to-earth voltages are calculated from the phase-to-phase voltages when *VT connection* is selected as "Delta" according to the equations.

$$\overline{U}_A = \overline{U}_0 + \left(\overline{U}_{AB} - \overline{U}_{CA}\right)/3$$

(Equation 26)

$$\overline{U}_B = \overline{U}_0 + \left(\overline{U}_{BC} - \overline{U}_{AB}\right)/3$$

(Equation 27)

$$\overline{U}_C = \overline{U}_0 + \left(\overline{U}_{CA} - \overline{U}_{BC}\right)/3$$

(Equation 28)

If the $\overline{U}_0$ channel is not valid, it is assumed to be zero.

The phase-to-phase voltages are calculated from the phase-to-earth voltages when *VT connection* is selected as "Wye" according to the equations.

$$\overline{U}_{AB} = \overline{U}_A - \overline{U}_B$$

(Equation 29)

$$\overline{U}_{BC} = \overline{U}_B - \overline{U}_C$$

(Equation 30)

$$\overline{U}_{CA} = \overline{U}_C - \overline{U}_A$$

(Equation 31)

10 Merging unit's physical connections

10.1 Module slot numbering

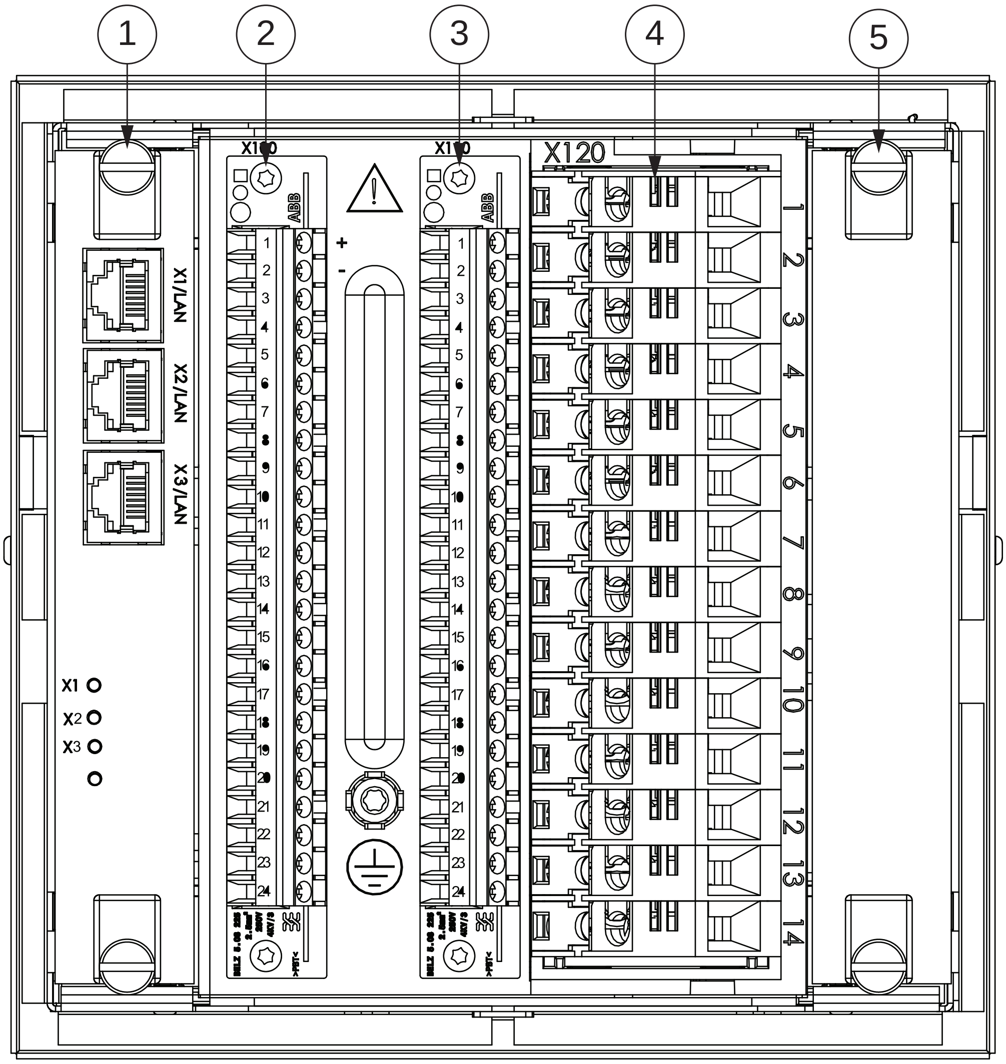


Figure 140: Module slot numbering

1	X000
2	X100
3	X110
4	X120
5	X130

10.2 Protective earth connections

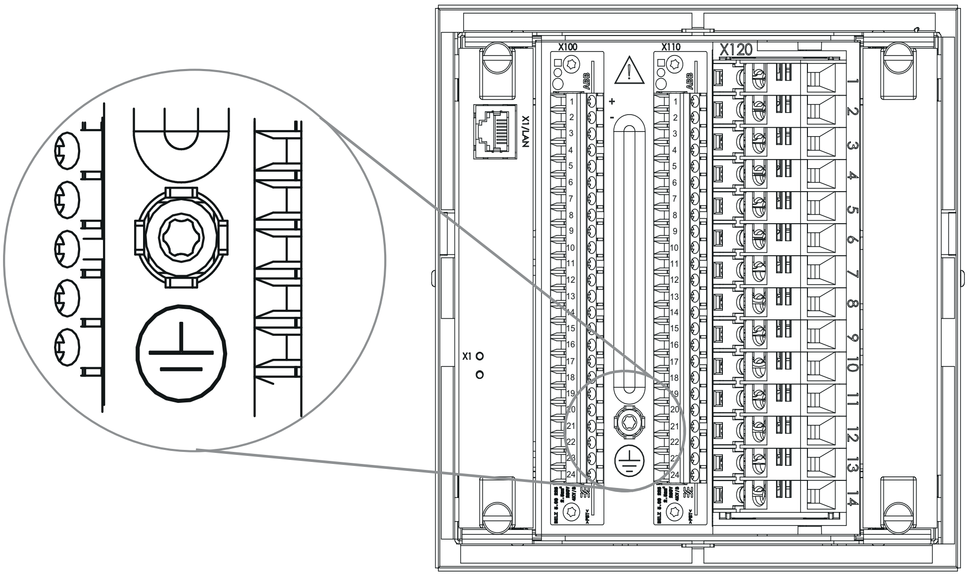


Figure 141: The protective earth screw is located between connectors X100 and X110

The earth lead must be at least 6.0 mm ^{2} and as short as possible.

10.3 Binary and analog connections

All binary and analog connections are described in the product specific application manuals.

10.4 Communication connections

The front communication connection is an RJ-45 type connector used mainly for configuration and setting.

Two optional communication connections are available.

- Galvanic RJ-45 Ethernet connection
- Optical LC Ethernet connection

Never touch the end face of an optical fiber connector.

Always install dust caps on unplugged fiber connectors.

If contaminated, clean optical connectors only with fiber-optic cleaning products.

10.4.1 Ethernet RJ-45 front connection

The merging unit is provided with an RJ-45 connector on the LHMI. The connector is intended for configuration and setting purposes. The interface on the PC side has to be configured in a way that it obtains the IP address automatically. There is a DHCP server inside merging unit for the front interface only.

The events and setting values and all input data such as memorized values and disturbance records can be read via the front communication port.

Only one of the possible clients can be used for parametrization at a time.

- PCM600
- WHMI

The default IP address of the merging unit through this port is 192.168.0.254.

The front port supports TCP/IP protocol. A standard Ethernet CAT 5 crossover cable is used with the front port.

The speed of the front connector interface is limited to 10 Mbps.

10.4.2 Ethernet rear connections

The Ethernet station bus communication module is provided with either galvanic RJ-45 connection or optical multimode LC type connection, depending on the product variant and the selected communication interface option. A shielded twisted-pair cable CAT 5e is used with the RJ-45 connector and an optical multi-mode cable (≤2 km) with the LC type connector.

In addition, communication modules with multiple Ethernet connectors enable the forwarding of Ethernet traffic. These variants include an internal Ethernet switch that handles the Ethernet traffic between a merging unit and a station bus. In this case, the used network can be a ring or daisy-chain type of network topology. In loop type topology, a self-healing Ethernet loop is closed by a managed switch supporting rapid spanning tree protocol. In daisy-chain type of topology, the network is bus type and it is either without switches, where the station bus starts from the station client, or with a switch to connect some devices and the merging units of this product series to the same network. Internal Ethernet switch MAC table size is 512 entries. All Ethernet ports share this one common MAC table.

Communication modules including Ethernet connectors X1, X2, and X3 can utilize the third port for connecting any other device to a station bus.

The merging unit's default IP address through rear Ethernet port is 192.168.2.10 with the TCP/IP protocol. The data transfer rate is 10 or 100 Mbps full duplex.

10.4.3 Communication interfaces and protocols

The communication protocols supported depend on the optional rear communication module.

Table 287: Supported station communication interfaces and protocols

Interfaces/ Protocols	Ethernet	
	100BASE-TX RJ-45	100BASE-FX LC
IEC 61850-8-1	●	●
IEC 61850-9-2 LE	●	●
● = Supported		

10.4.4 Rear communication modules

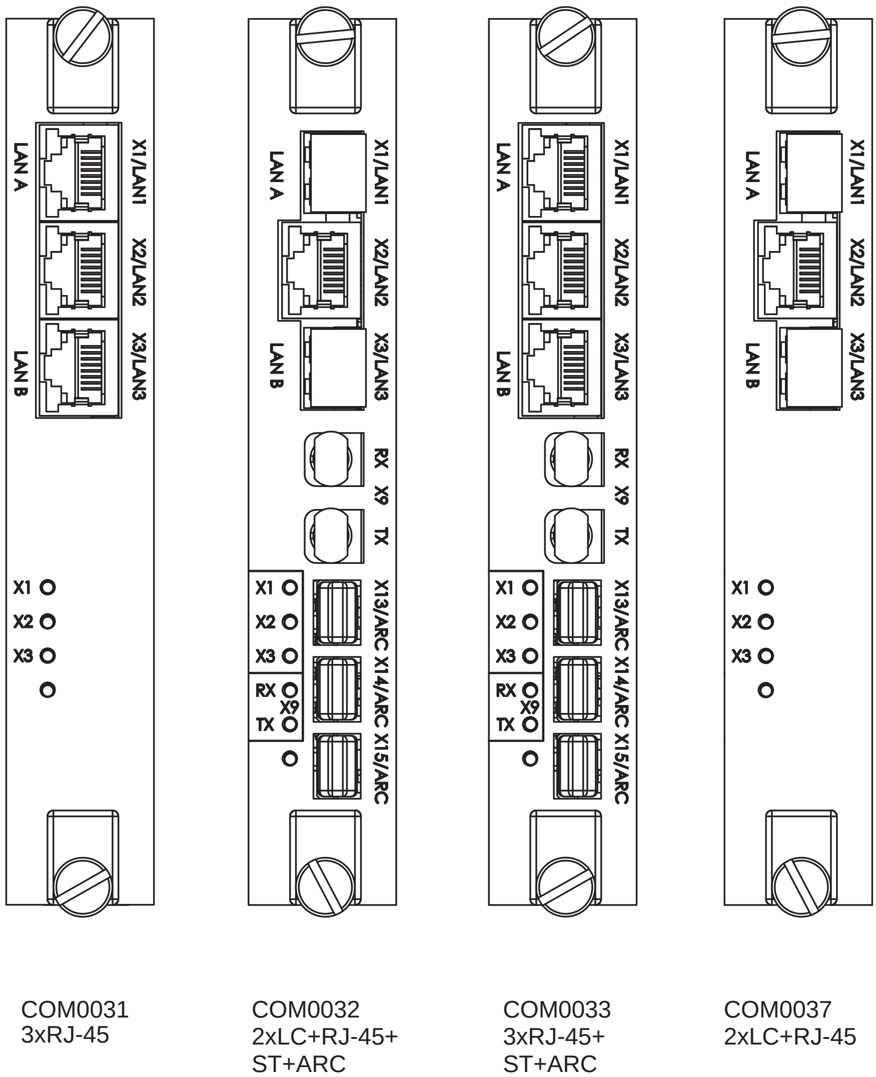


Figure 142: Communication module options

Ethernet ports marked with LAN A and LAN B are used with redundant Ethernet protocols HSR and PRP. The third port without the LAN A or LAN B label is an interlink port which is used as a redundancy box connector with redundant Ethernet protocols.

Table 288: Station bus communication interfaces included in communication modules

Module ID	RJ-45	LC	EIA-485	EIA-232	ST [1]
COM0031	3	-	-	-	-
COM0032	1	2	-	-	1
COM0033	3	-	-	-	1
COM0037	1	2	-	-	-

Table 289: LED descriptions for COM0031-COM0033 and COM0037

LED	Connector	Description
X1	X1	X1/LAN1 link status and activity
X2	X2	X2/LAN2 link status and activity
X3	X3	X3/LAN3 link status and activity
RX	X9	COM1 fiber-optic receive activity
TX	X9	COM1 fiber-optic transmit activity

[1] Not supported

11 Technical data

11.1 Dimensions

Table 290: Dimensions

Description	Value	
Width	Frame	177 mm
	Case	164 mm
Height	Frame	177 mm (4U)
	Case	160 mm
Depth		201 mm (153 + 48 mm)
Weight	Complete merging unit	4.1 kg
	Plug-in unit only	2.1 kg

11.2 Power supply

Table 291: Power supply

Description	Type 1	Type 2
Nominal auxiliary voltage U_n	100, 110, 120, 220, 240 V AC, 50 and 60 Hz	24, 30, 48, 60 V DC
	48, 60, 110, 125, 220, 250 V DC	
Maximum interruption time in the auxiliary DC voltage without resetting the merging unit	50 ms at U_n	
Auxiliary voltage variation	38...110% of U_n (38...264 V AC)	50...120% of U_n (12...72 V DC)
	80...120% of U_n (38.4...300 V DC)	
Start-up threshold		19.2 V DC (24 V DC × 80%)
Burden of auxiliary voltage supply under quiescent (P_q)/ operating condition	DC <13.0 W (nominal)/<18.0 W (max.) AC <16.0 W (nominal)/<21.0 W (max.)	DC <13.0 W (nominal)/<18.0 W (max.)
Ripple in the DC auxiliary voltage	Max 15% of the DC value (at frequency of 100 Hz)	
Fuse type	T4A/250 V	

11.3 Energizing inputs

Table 292: Energizing inputs

Description		Value	
Rated frequency		50/60 Hz	
Current inputs	Rated current, I_n	0.2/1 A	1/5 A
	Thermal withstand capability: • Continuously • For 1 s	 4 A 100 A	 20 A 500 A
	Dynamic current withstand: • Half-wave value	 250 A	 1250 A
	Input impedance	<100 mΩ	<20 mΩ
Voltage inputs	Rated voltage	60...210 V AC	
	Voltage withstand: • Continuous • For 10 s	 240 V AC 360 V AC	
	Burden at rated voltage	<0.05 VA	

11.4 Energizing Inputs (SIM0002)

Table 293: Table 9: Energizing Inputs (SIM0002)

Description		Value
Current sensor input	Rated current voltage (in secondary side)	75 mV ... 9000 mV [1]
	Continuous voltage withstand	125 V
	Input impedance at 50/60Hz	2...3 MΩ [2]
Voltage sensor input	Rated voltage	6 kV … 30 kV [3]
	Continuous voltage withstand	50 V
	Input impedance at 50/60Hz	3 MΩ

[1] Equals the current range of 40….4000 A with 80A, 3mV/Hz Rogowski
[2] Depending on the used nominal current (hardware gain)
[3] This range is covered (up to 2*rated) with sensor division ratio of 10 000:1

11.5 Energizing Inputs (SIM0005)

Table 294: Table 9: Energizing Inputs (SIM0005)

Description		Value
Current sensor input	Rated current voltage (in secondary side)	75 mV ... 9000 mV [4]
	Continuous voltage withstand	125 V
	Input impedance at 50/60Hz	2 MΩ
Voltage sensor input	Rated voltage	6 kV … 40,5 kV [5]
	Continuous voltage withstand	50 V
	Input impedance at 50/60Hz	2 MΩ

11.6 Binary inputs

Table 295: Binary inputs

Description	Value
Operating range	±20% of the rated voltage
Rated voltage	24...250 V DC
Current drain	1.6...1.9 mA
Power consumption	31.0...570.0 mW
Threshold voltage	16...176 V DC
Reaction time	<3 ms

Adjust the binary input threshold voltage correctly. The threshold voltage should be set to 70% of the nominal auxiliary voltage. The factory default is 16 V to ensure the binary inputs' operation regardless of the auxiliary voltage used (24, 48, 60, 110, 125, 220 or 250 V DC). However, the default value is not optimal for the higher auxiliary voltages. The binary input threshold voltage should be set as high as possible to prevent any inadvertent activation of the binary inputs due to possible external disturbances. At the same time, the threshold should be set so that the correct operation is not jeopardized in case of undervoltage of the auxiliary voltage.

[4] Equals the current range of 40….40000 A with 80A, 3mV/Hz Rogowski
[5] Covers 6 kV…40.5 kV sensors with division ratio of 10 000:1. Secondary voltages 600mV/√3 … 4,05V / √3. Range up to 2 x Rated

11.7 Signal outputs

Table 296: Signal output X100: SO1

Description	Value
Rated voltage	250 V AC/DC
Continuous contact carry	5 A
Make and carry for 3.0 s	15 A
Make and carry for 0.5 s	30 A
Breaking capacity when the control-circuit time constant L/R<40 ms, at 48/110/220 V DC	1 A/0.25 A/0.15 A
Minimum contact load	100 mA at 24 V AC/DC

Table 297: Signal outputs and IRF output

Description	Value
Rated voltage	250 V AC/DC
Continuous contact carry	5 A
Make and carry for 3.0 s	10 A
Make and carry 0.5 s	15 A
Breaking capacity when the control-circuit time constant L/R<40 ms, at 48/110/220 V DC	1 A/0.25 A/0.15 A
Minimum contact load	10 mA at 5 V AC/DC

11.8 Double-pole power output relays with TCS function

Table 298: Double-pole power output relays with TCS function

Description	Value
Rated voltage	250 V AC/DC
Continuous contact carry	8 A
Make and carry for 3.0 s	15 A
Make and carry for 0.5 s	30 A
Breaking capacity when the control-circuit time constant L/R<40 ms, at 48/110/220 V DC (two contacts connected in series)	5 A/3 A/1 A
Minimum contact load	100 mA at 24 V AC/DC
Trip-circuit supervision (TCS): • Control voltage range	 20...250 V AC/DC

Table continues on the next page

Description	Value
• Current drain through the supervision circuit	~1.5 mA
• Minimum voltage over the TCS contact	20 V AC/DC (15...20 V)

11.9 Single-pole power output relays

Table 299: Single-pole power output relays

Description	Value
Rated voltage	250 V AC/DC
Continuous contact carry	8 A
Make and carry for 3.0 s	15 A
Make and carry for 0.5 s	30 A
Breaking capacity when the control-circuit time constant L/R<40 ms, at 48/110/220 V DC	5 A/3 A/1 A
Minimum contact load	100 mA at 24 V AC/DC

11.10 High-speed output HSO with BIO0007

Table 300: High-speed output HSO with BIO0007

Description	Value
Rated voltage	250 V AC/DC
Continuous contact carry	6 A
Make and carry for 3.0 s	15 A
Make and carry for 0.5 s	30 A
Breaking capacity when the control-circuit time constant L/R <40 ms, at 48/110/220 V DC	5 A/3 A/1 A
Operate time	<1 ms
Reset	<20 ms, resistive load

11.11 Ethernet interfaces

Table 301: Ethernet interfaces

Ethernet interface	Protocol	Cable	Data transfer rate
Front	TCP/IP protocol	Standard Ethernet CAT 5 cable with RJ-45 connector	10 MBits/s
Rear	TCP/IP protocol	Shielded twisted pair CAT 5e cable with RJ-45 connector or fiber optic cable with LC connector	100 MBits/s

11.12 Fiber optic communication link

Table 302: Fiber optic communication link

Connector	Fiber type	Wave length	Typical max. length [1]	Permitted path attenuation [2]
LC	MM 62.5/125 or 50/125 μm glass fiber core	1300 nm	2 km	<8 dB

11.13 Degree of protection of flush-mounted merging unit

Table 303: Degree of protection of flush-mounted merging unit

Description	Value
Front side	IP 54[3]
Rear side, connection terminals	IP 20[3]

[1] Maximum length depends on the cable attenuation and quality, the amount of splices and connectors in the path.
[2] Maximum allowed attenuation caused by connectors and cable together
[3] According to IEC 60529

11.14 Sampled measured values accuracy

Table 304: Sampled measured values accuracy

Description	Value
Phase current	20%...6000%I_n [1] Amplitude: 1% or ±0.003×I_n Angle: ±2º
Residual current	1%...5%I_n Amplitude: 0.001×I_n Angle: ±4º
	5%...6000%I_n Amplitude: ±1% Angle: ±1º
Phase voltage	80%...120% of U_n Amplitude: ±0.5% Angle: ±1º
Residual voltage (calculated)	1%...100% of U_n Amplitude: ±0.5% or ±0.001×U_n Angle: ±2º

[1] In the 80 A/0.150 V at 50 Hz sensor applications the maximum range depends on the application nominal:

….833 A (...31.237 mV/Hz) corresponds to 6000%I_n

833...1250 A (31.237...46.875 mV/Hz) corresponds to 4000%I_n

1250...2500 A (46.875...93.750 mV/Hz) corresponds to 2000%I_n

2500...4000 A (93.750...150.000 mV/Hz) corresponds to 1250%I_n

11.15 Environmental conditions

Table 305: Environmental conditions

Description	Value
Operating temperature range	-25...+55°C (continuous)
Short-time service temperature range	-40...+85°C (<16 h) [1] [2]
Relative humidity	<93%, non-condensing
Atmospheric pressure	86...106 kPa
Altitude	Up to 2000 m
Transport and storage temperature range	-40...+85°C

[1] Degradation in MTBF and HMI performance outside the temperature range of -25...+55 °C
[2] For marging units with an LC communication interface the maximum operating temperature is +70 °C

12 Merging unit and functionality tests

12.1 Electromagnetic compatibility tests

Table 306: Electromagnetic compatibility tests

Description	Type test value	Reference
Slow damped oscillatory wave immunity test • Common mode • Differential mode	2.5 kV 2.5 kV	IEC 60255-26 IEC 61000-4-18 ANSI/IEEE C37.90.1-2012 GB 14598.26-2015
Electrostatic discharge test • Contact discharge • Air discharge	8 kV 15 kV	IEC 60255-26 IEC 61000-4-2 GB 14598.26-2015
Conducted immunity test	10 V (rms) f = 150 kHz...80 MHz	IEC 60255-26 IEC 61000-4-6 GB 14598.26-2015
Radiated electromagnetic field immunity test	20 V/m (rms) f = 80 MHz...1 GHz; 1.4...2.7 GHz	IEC 60255-26 IEC 61000-4-3 ANSI/IEEE C37.90.2-2004 GB 14598.26-2015
Electrical fast transient/burst immunity test	4 kV	IEC 60255-26 IEC 61000-4-4 ANSI/IEEE C37.90.1-2012 GB 14598.26-2015
Surge immunity test • Communication • Other ports	0.5 kV, line-to-earth 1 kV, line-to-earth 2 kV, line-to-earth 0.5 kV, line-to-earth 1 kV, line-to-earth 2 kV, line-to-earth 0.5 kV, line-to-line 1 kV, line-to-line	IEC 60255-26 IEC 61000-4-5 GB 14598.26-2015

Table continues on the next page

Description	Type test value	Reference
Power frequency magnetic field immunity test • Continuous • 1...3 s	300 A/m 1000 A/m	IEC 61000-4-8 GB 14598.26-2015
Pulse magnetic field immunity test	1000 A/m 6.4/16 µs	IEC 61000-4-9 GB 14598.26-2015
Damped oscillatory magnetic field immunity test • 2 s • 1 MHz	100 A/m 400 transients/s	IEC 61000-4-10 GB 14598.26-2015
A.C. and D.C. voltage dips and interruptions test	30%/10 ms 60%/100 ms 60%/1000 ms >95%/5000 ms	IEC 61000-4-11 IEC 61000-4-29 GB 14598.26-2015
Power frequency immunity test • Common mode • Differential mode	Binary inputs only 300 V rms 150 V rms	IEC 60255-26, class A IEC 61000-4-16 GB 14598.26-2015
Emission tests • Conducted 0.15...0.50 MHz 0.5...30 MHz • Radiated 30...230 MHz 230...1000 MHz 1…3 GHz 3…6 GHz	<79 dB (µV) quasi peak <66 dB (µV) average <73 dB (µV) quasi peak <60 dB (µV) average <40 dB (µV/m) quasi peak, measured at 10m distance <47 dB (µV/m) quasi peak, measured at 10m distance <76 dB (µV/m) peak <56 dB (µV/m) average, measured at 3m distance <80 dB (µV/m) peak <60 dB (µV/m) average, measured at 3m distance	EN 55011, class A IEC 60255-26 CISPR 11:2009+A1:2010 CISPR 22：2008 GB 14598.26-2015

12.2 Insulation tests

Table 307: Insulation tests

Description	Type test value	Reference
Dielectric tests	2 kV, 50 Hz, 1 min	IEC 60255-27

Table continues on the next page

Description	Type test value	Reference
	500 V, 50 Hz, 1 min, communication	
Impulse voltage test	5 kV, 1.2/50 μs, 0.5 J 1 kV, 1.2/50 μs, 0.5 J, communication	IEC 60255-27
Insulation resistance measurements	>100 MΩ, 500 V DC	IEC 60255-27

12.3 Mechanical tests

Table 308: Mechanical tests

Description	Reference	Requirement
Vibration tests (sinusoidal)	IEC 60068-2-6 (test Fc) IEC 60255-21-1	Class 2
Shock and bump test	IEC 60068-2-27 (test Ea shock) IEC 60068-2-29 (test Eb bump) IEC 60255-21-2	Class 2

12.4 Environmental tests

Table 309: Environmental tests

Description	Type test value	Reference
Dry heat test	• 96 h at +55ºC • 16 h at +85ºC	IEC 60068-2-2
Dry cold test	• 96 h at -25ºC • 16 h at -40ºC	IEC 60068-2-1
Damp heat test	• 6 cycles (12 h + 12 h) at +25°C… +55°C, humidity >93%	IEC 60068-2-30
Change of temperature test	• 5 cycles (3 h + 3 h) at -25°C...+55°C	IEC 60068-2-14

12.5 Product safety

Description	Reference
LV directive	2014/35/EU
Standard	EN 60255-27 EN 60255-1

12.6 EMC compliance

Description	Reference
EMC directive	2014/30/EU
Standard	EN 60255-26

13 Applicable standards and regulations

EU CE:

- EMC Directive 2014/30/EU
- Low-voltage directive 2014/35/EU
- RoHS Directive 2011/65/EU
- WEEE directive 2012/19/EU

- EN 60255-1
- EN 60255-26
- EN 60255-27
- EN 61000-6-2
- EN 61000-6-4

UK UKCA:

- Electromagnetic Compatibility Regulations 2016
- Electrical Equipment (Safety) Regulations 2016
- The Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment Regulations 2012

- BS EN 60255-1
- BS EN 60255-26
- BS EN 60255-27
- BS EN 61000-6-2
- BS EN 61000-6-4

IEC:

- IEC 60255-1
- IEC 60255-26
- IEC 60255-27
- IEC 61000-6-2
- IEC 61000-6-4
- IEC 61850

14 Glossary

100BASE-FX	A physical medium defined in the IEEE 802.3 Ethernet standard for local area networks (LANs) that uses fiber optic cabling
100BASE-TX	A physical medium defined in the IEEE 802.3 Ethernet standard for local area networks (LANs) that uses twisted-pair cabling category 5 or higher with RJ-45 connectors
AC	Alternating current
ACT	1. Application Configuration tool in PCM600 2. Trip status in IEC 61850
CAT 5	A twisted pair cable type designed for high signal integrity
CAT 5e	An enhanced version of CAT 5 that adds specifications for far end cross-talk
COMTRADE	Common format for transient data exchange for power systems. Defined by the IEEE Standard.
CPU	Central processing unit
CT	Current transformer
DAN	Doubly attached node
DC	1. Direct current 2. Disconnector 3. Double command
DHCP	Dynamic Host Configuration Protocol
DPC	Double-point control
DT	Definite time
EEPROM	Electrically erasable programmable read-only memory
EMC	Electromagnetic compatibility
Ethernet	A standard for connecting a family of frame-based computer networking technologies into a LAN
FIFO	First in, first out
FPGA	Field-programmable gate array
FTP	File transfer protocol
FTPS	FTP Secure
GPS	Global Positioning System
HMI	Human-machine interface
HSO	High-speed output
HSR	High-availability seamless redundancy
HTTPS	Hypertext Transfer Protocol Secure
IEC	International Electrotechnical Commission

Table continues on the next page

IEC 61850	International standard for substation communication and modeling
IEC 61850-8-1	A communication protocol based on the IEC 61850 standard series
IEC 61850-9-2	A communication protocol based on the IEC 61850 standard series
IEC 61850-9-2 LE	Lite Edition of IEC 61850-9-2 offering process bus interface
IED	Intelligent electronic device
IEEE 1686	Standard for Substation Intelligent Electronic Devices' (IEDs') Cyber Security Capabilities
IP	Internet protocol
IP address	A set of four numbers between 0 and 255, separated by periods. Each server connected to the Internet is assigned a unique IP address that specifies the location for the TCP/IP protocol.
IRF	1. Internal fault 2. Internal relay fault
LAN	Local area network
LC	Connector type for glass fiber cable, IEC 61754-20
LE	Light Edition
LED	Light-emitting diode
LHMI	Local human-machine interface
MCB	Miniature circuit breaker
MM	1. Multimode 2. Multimode optical fiber
MMS	1. Manufacturing message specification 2. Metering management system
P2P	peer-to-peer
PC	1. Personal computer 2. Polycarbonate
PCM600	Protection and Control IED Manager
PPS	Pulse per second
PRP	Parallel redundancy protocol
PTP	Precision Time Protocol
RAM	Random access memory
RJ-45	Galvanic connector type
RMS	Root-mean-square (value)
ROM	Read-only memory
RTC	Real-time clock
SAN	Single attached node
SBO	Select-before-operate
SCADA	Supervision, control and data acquisition

Table continues on the next page

SCL	XML-based substation description configuration language defined by IEC 61850
SMT	Signal Matrix tool in PCM600
SMU615	Substation merging unit
SMV	Sampled measured values
SW	Software
TCP/IP	Transmission Control Protocol/Internet Protocol
TCS	Trip-circuit supervision
TLV	Type length value
UTC	Coordinated universal time
VT	Voltage transformer
WAN	Wide area network
WHMI	Web human-machine interface

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