Relion® 670 series

Busbar protection REB670
Technical reference manual

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Document ID: 1MRK 505 208-UEN
Issued: August 2011
Revision: B
Product version: 1.2

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ABB AB

Substation Automation Products

SE-721 59 Västerås

Sweden

Telephone: +46 (0) 21 32 50 00

Facsimile: +46 (0) 21 14 69 18

http://www.abb.com/substationautomation

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Conformity

This product complies with the directive of the Council of the European Communities on the approximation of the laws of the Member States relating to electromagnetic compatibility (EMC Directive 2004/108/EC) and concerning electrical equipment for use within specified voltage limits (Low-voltage directive 2006/95/EC). This conformity is the result of tests conducted by ABB in accordance with the product standards EN 50263 and EN 60255-26 for the EMC directive, and with the product standards EN 60255-1 and EN 60255-27 for the low voltage directive. The IED is designed in accordance with the international standards of the IEC 60255 series.

Table of contents

Section 1 Introduction

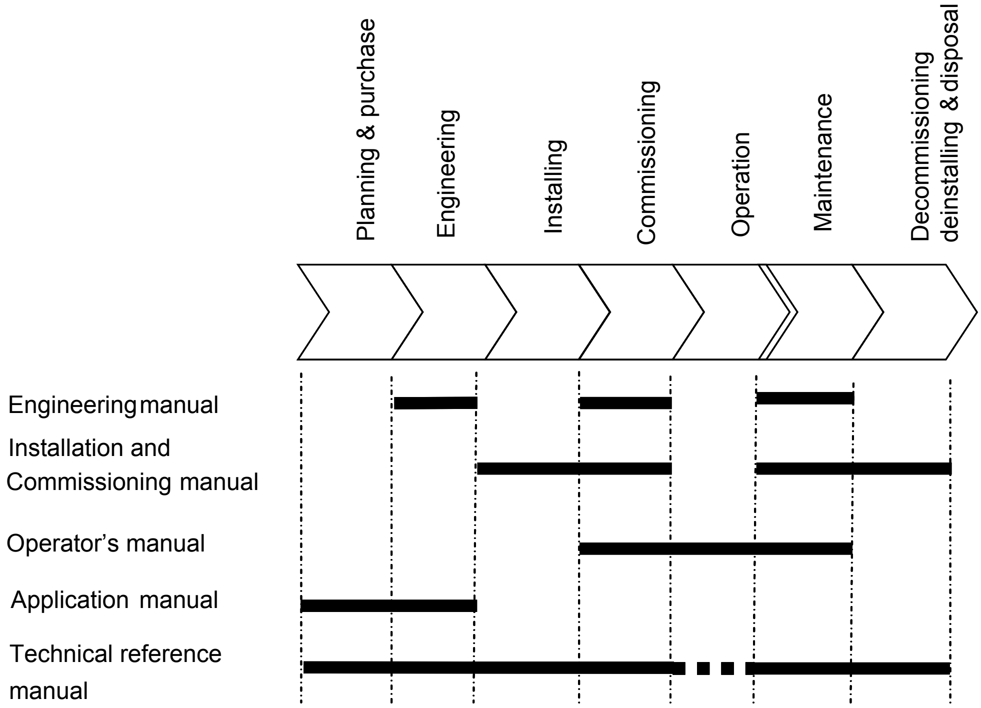
About this chapter

This chapter explains concepts and conventions used in this manual and provides information necessary to understand the contents of the manual.

1.1 Introduction to the technical reference manual

1.1.1 About the complete set of manuals for an IED

The user's manual (UM) is a complete set of five different manuals:



IEC09000744-1-en.vsd

The Application Manual (AM) contains application descriptions, setting guidelines and setting parameters sorted per function. The application manual should be used to find out when and for what purpose a typical protection function could be used. The manual should also be used when calculating settings.

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

The Installation and Commissioning Manual (ICM) contains instructions on how to install and commission the protection IED. The manual can also be used as a reference during periodic testing. The manual covers procedures for mechanical and electrical installation, energizing and checking of external circuitry, setting and configuration as well as verifying settings and performing directional tests. The chapters are organized in the chronological order (indicated by chapter/section numbers) in which the protection IED should be installed and commissioned.

The Operator's Manual (OM) contains instructions on how to operate the protection IED during normal service once it has been commissioned. The operator's manual can be used to find out how to handle disturbances or how to view calculated and measured network data in order to determine the cause of a fault.

The Engineering Manual (EM) contains instructions on how to engineer the IEDs using the different tools in PCM600. The manual provides instructions on how to set up a PCM600 project and insert IEDs to the project structure. The manual also recommends a sequence for engineering of protection and control functions, LHMI functions as well as communication engineering for IEC 61850 and DNP3.

1.1.2 About the technical reference manual

The following chapters are included in the technical reference manual.

- *Local HMI* describes the control panel on the IED and explains display characteristics, control keys and various local HMI features.
- *Basic IED functions* presents functions for all protection types that are included in all IEDs, for example, time synchronization, self supervision with event list, test mode and other general functions.
- *Current protection* describes functions, for example, over current protection, breaker failure protection and pole discordance.
- *Voltage protection* describes functions for under voltage and over voltage protection and residual over voltage protection.
- *Frequency protection* describes functions for over frequency, under frequency and rate of change of frequency protection.
- *Multipurpose protection* describes the general protection function for current and voltage.
- *Control* describes control functions, for example, synchronization and energizing check and other product specific functions.
- *Logic* describes trip logic and related functions.
- *Monitoring* describes measurement related functions that are used to provide data regarding relevant quantities, events and faults, for example.
- *Metering* describes pulse counter logic.
- *Station communication* describes Ethernet based communication in general, including the use of IEC 61850 and horizontal communication via GOOSE.
- *Remote communication* describes binary and analog signal transfer, and the associated hardware.
- *Hardware* describes the IED and its components.

- *Connection diagrams* provides terminal wiring diagrams and information regarding connections to and from the IED.
- *Inverse time characteristics* describes and explains inverse time delay, inverse time curves and their effects.
- *Glossary* is a list of terms, acronyms and abbreviations used in ABB technical documentation.

1.1.3 This manual

The description of each IED related function follows the same structure (where applicable). The different sections are outlined below.

1.1.3.1 Introduction

Outlines the implementation of a particular protection function.

1.1.3.2 Principle of operation

Describes how the function works, presents a general background to algorithms and measurement techniques. Logic diagrams are used to illustrate functionality.

Logic diagrams

Logic diagrams describe the signal logic inside the function block and are bordered by dashed lines.

Signal names

Input and output logic signals consist of two groups of letters separated by two dashes. The first group consists of up to four letters and presents the abbreviated name for the corresponding function. The second group presents the functionality of the particular signal. According to this explanation, the meaning of the signal BLKTR in figure 4 is as follows:

- BLKTR informs the user that the signal will BLOCK the TRIP command from the under-voltage function, when its value is a logical one (1).

Input signals are always on the left hand side, and output signals on the right hand side. Settings are not displayed.

Input and output signals

In a logic diagram, input and output signal paths are shown as a lines that touch the outer border of the diagram.

Input and output signals can be configured using the ACT tool. They can be connected to the inputs and outputs of other functions and to binary inputs and outputs. Examples of input signals are BLKTR, BLOCK and VTSU. Examples output signals are TRIP, START, STL1, STL2, STL3.

Setting parameters

Signals in frames with a shaded area on their right hand side represent setting parameter signals. These parameters can only be set via the PST or LHMI. Their values are high (1) only when the corresponding setting parameter is set to the symbolic value specified within the frame. Example is the signal Block TUV=Yes. Their logical values correspond automatically to the selected setting value.

Internal signals

Internal signals are illustrated graphically and end approximately 2 mm from the frame edge. If an internal signal path cannot be drawn with a continuous line, the suffix -int is added to the signal name to indicate where the signal starts and continues, see figure 1.

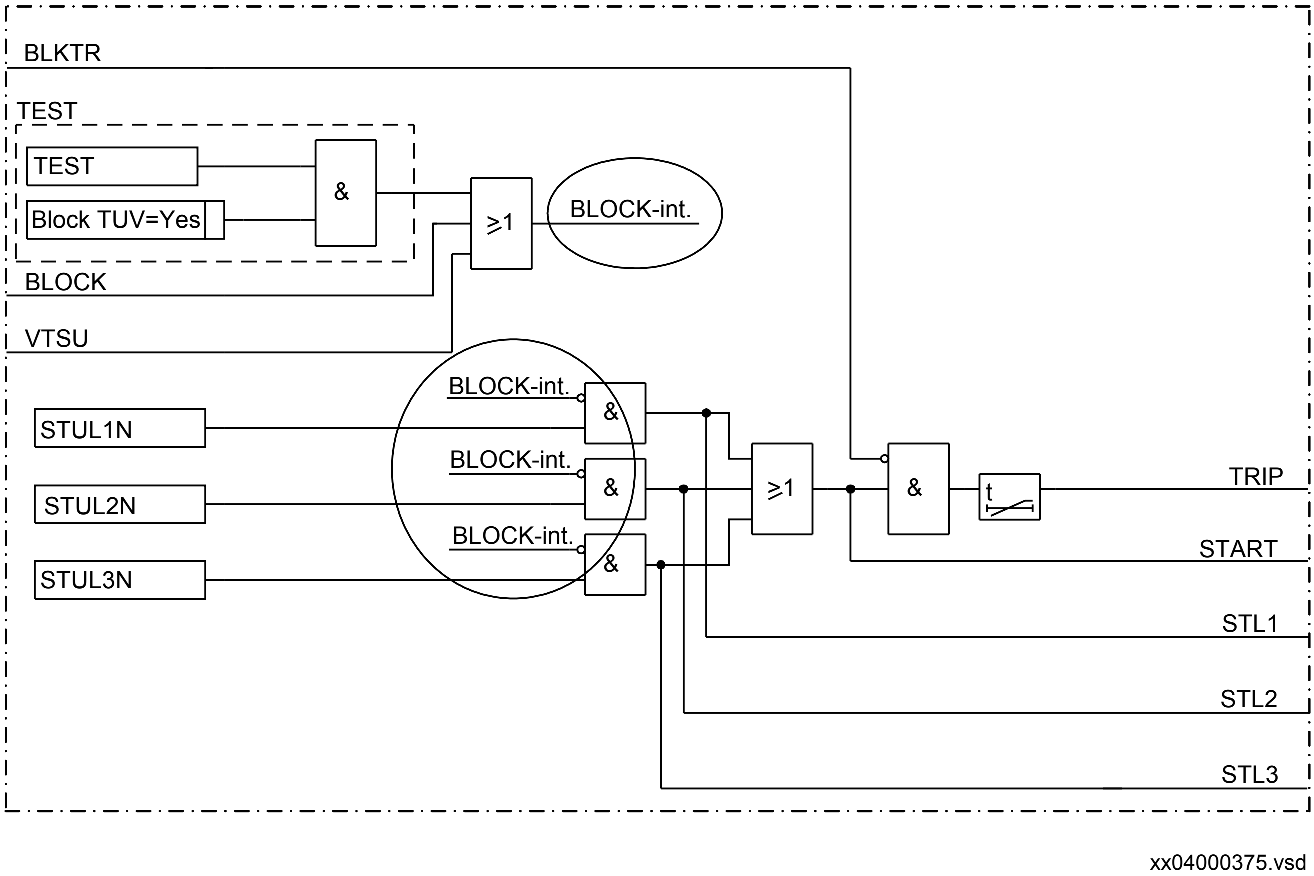


Figure 1: Logic diagram example with -int signals

External signals

Signal paths that extend beyond the logic diagram and continue in another diagram have the suffix “-cont.”, see figure 2 and figure 3.

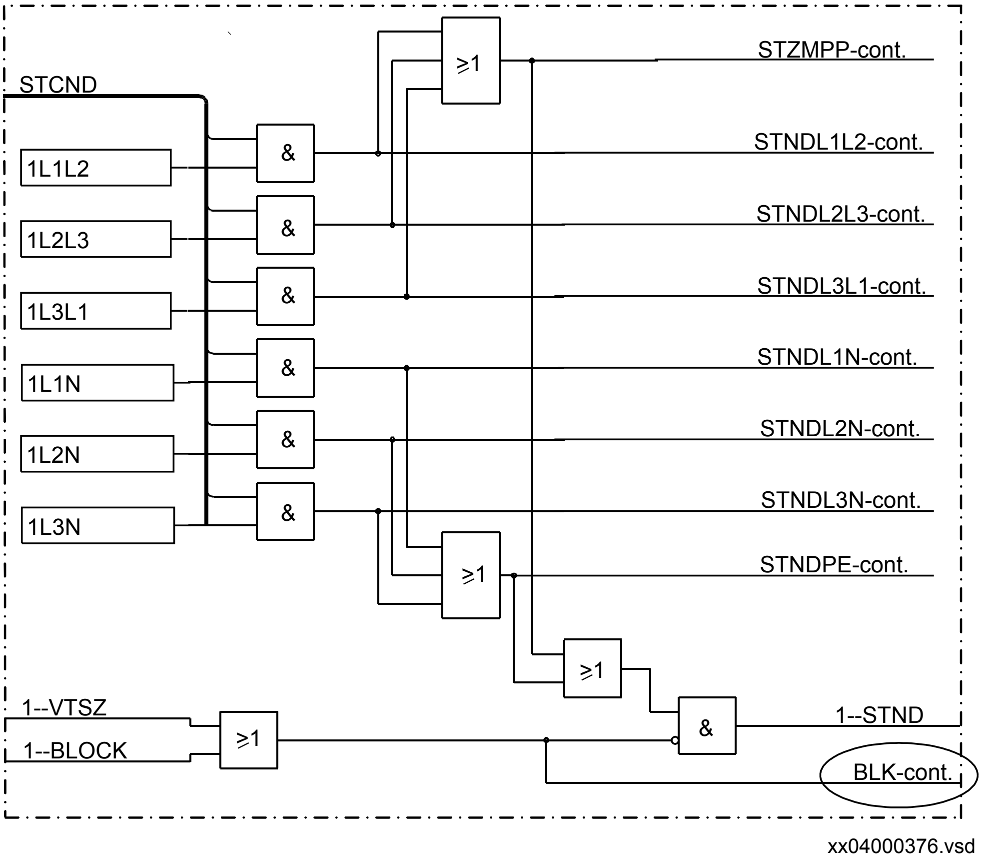


Figure 2: Logic diagram example with an outgoing -cont signal

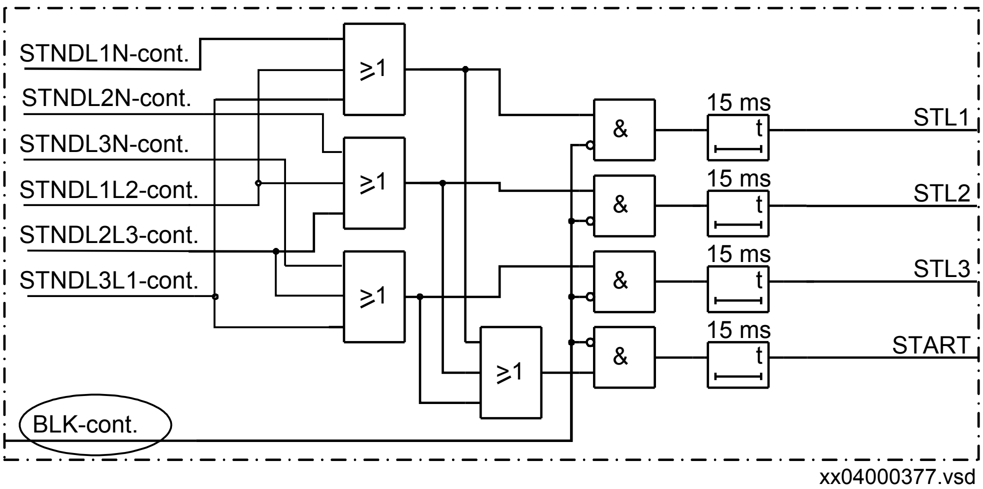


Figure 3: Logic diagram example with an incoming -cont signal

1.1.3.3 Input and output signals

Input and output signals are presented in two separate tables. Each table consists of two columns. The first column contains the name of the signal and the second column contains the description of the signal.

1.1.3.4 Function block

Each function block is illustrated graphically.

Input signals are always on the left hand side and output signals on the right hand side. Settings are not displayed. Special kinds of settings are sometimes available. These are supposed to be connected to constants in the configuration scheme and are therefore depicted as inputs. Such signals will be found in the signal list but described in the settings table.

- The ^ character in front of an input or output signal name in the function block symbol given for a function, indicates that the user can set a signal name of their own in PCM600.
- The * character after an input or output signal name in the function block symbol given for a function, indicates that the signal must be connected to another function block in the application configuration to achieve a valid application configuration.

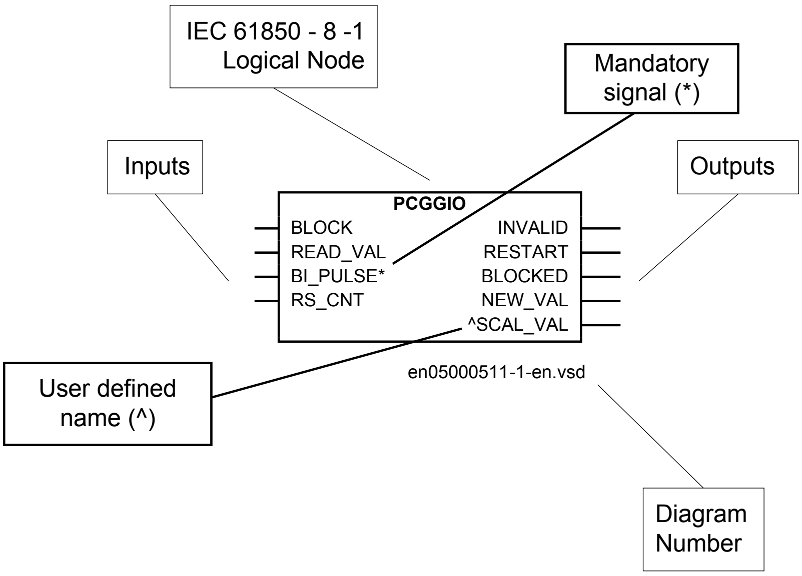


Figure 4: Example of a function block

1.1.3.5 Setting parameters

These are presented in tables and include all parameters associated with the function in question.

1.1.3.6 Technical data

The technical data section provides specific technical information about the function or hardware described.

1.1.4 Intended audience

General

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

Requirements

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

Documents related to REB670	Identity number
Operator's manual	1MRK 505 209-UEN
Installation and commissioning manual	1MRK 505 210-UEN
Technical reference manual	1MRK 505 208-UEN
Application manual	1MRK 505 211-UEN
Product guide pre-configured	1MRK 505 212-BEN
Connection and Installation components	1MRK 513 003-BEN
Test system, COMBITEST	1MRK 512 001-BEN
Accessories for 670 series IEDs	1MRK 514 012-BEN
670 series SPA and signal list	1MRK 500 092-WEN
IEC 61850 Data objects list for 670 series	1MRK 500 091-WEN
Engineering manual 670 series	1MRK 511 240-UEN
Communication set-up for Relion 670 series	1MRK 505 260-UEN

More information can be found on www.abb.com/substationautomation.

1.1.5 Revision notes

Revision	Description
A	Minor corrections made
B	Updates made for REB670 1.2.4

Section 2 Analog inputs

2.1 Introduction

Analog input channels must be configured and set properly to get correct measurement results and correct protection operations. For power measuring and all directional and differential functions the directions of the input currents must be defined properly. Measuring and protection algorithms in the IED use primary system quantities. Set values are done in primary quantities as well and it is important to set the data about the connected current and voltage transformers properly.

A reference *PhaseAngleRef* can be defined to facilitate service values reading. This analog channels phase angle will always be fixed to zero degree and all other angle information will be shown in relation to this analog input. During testing and commissioning of the IED the reference channel can be changed to facilitate testing and service values reading.

The availability of VT inputs depends on the ordered transformer input module (TRM) type.

2.2 Operation principle

The direction of a current to the IED depends on the connection of the CT. The main CTs are typically star connected and can be connected with the star point to the object or from the object. This information must be set to the IED.

Directional conventions for current or power, for example

- Positive value of current or power means quantity direction into the object.
- Negative value of current or power means quantity direction out from the object.

Directional conventions for directional functions (see figure 5)

- *Forward* means direction into the object.
- *Reverse* means direction out from the object.

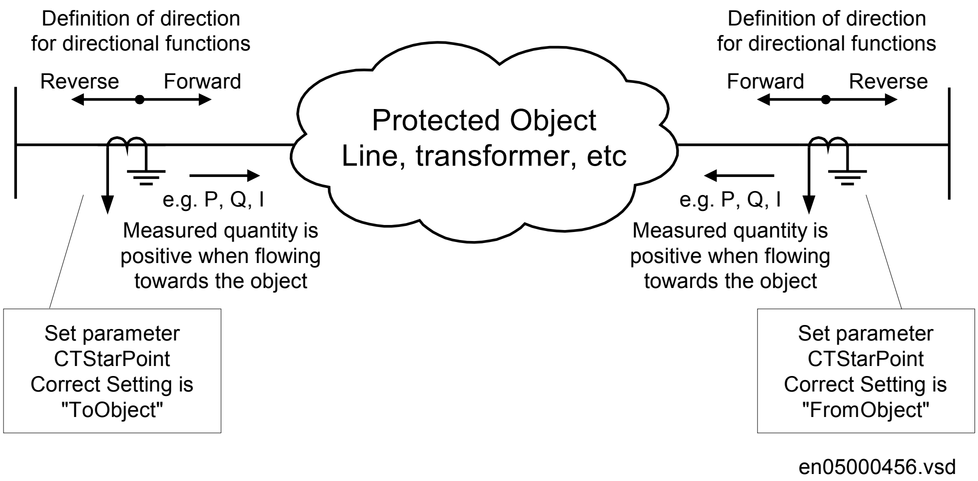


Figure 5: Internal convention of the directionality in the IED

The correct setting of the primary CT direction

- *CTStarPoint* is set to *FromObject* or *ToObject*.
- Positive quantities flow towards the object.
- Direction is defined as *Forward* and looks towards the object.

The ratios of the main CTs and VTs must be known to use primary system quantities for settings and calculation in the IED, The user has to set the rated secondary and primary currents and voltages of the CTs and VTs to provide the IED with this information.

The CT and VT ratio and the name on respective channel is done under **Main menu/Hardware/Analog modules** in the Parameter Settings tool.

2.3 Function block

The function blocks are not represented in the configuration tool. The signals appear only in the SMT tool when a TRM is included in the configuration with the function selector tool. In the SMT tool they can be mapped to the desired virtual input (SMAI) of the IED and used internally in the configuration.

2.4 Setting parameters

Dependent on ordered IED type.

Table 1: AISVBAS Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
PhaseAngleRef	TRM40-Ch1 TRM40-Ch2 TRM40-Ch3 TRM40-Ch4 TRM40-Ch5 TRM40-Ch6 TRM40-Ch7 TRM40-Ch8 TRM40-Ch9 TRM40-Ch10 TRM40-Ch11 TRM40-Ch12 TRM41-Ch1 TRM41-Ch2 TRM41-Ch3 TRM41-Ch4 TRM41-Ch5 TRM41-Ch6 TRM41-Ch7 TRM41-Ch8 TRM41-Ch9 TRM41-Ch10 TRM41-Ch11 TRM41-Ch12 MU1-L1I MU1-L2I MU1-L3I MU1-L4I MU1-L1U MU1-L2U MU1-L3U MU1-L4U MU2-L1I MU2-L2I MU2-L3I MU2-L4I MU2-L1U MU2-L2U MU2-L3U MU2-L4U MU3-L1I MU3-L2I MU3-L3I MU3-L4I MU3-L1U MU3-L2U MU3-L3U MU3-L4U	-	-	TRM40-Ch1	Reference channel for phase angle presentation

Section 3 Local HMI

About this chapter

This chapter describes the structure and use of local HMI, which is the control panel at the IED.

3.1 Human machine interface

The local HMI is equipped with a LCD that is used among other things to locally display the following crucial information:

- Connection of each bay, respecting the two differential protection zones and the check zone. In the Parameter Setting Tool the user sets individual bay names to facilitate the identification of each primary bay for station personnel.
- Status of each individual primary switchgear device, for example, open, closed, 00 as intermediate state and 11 as bad state. In PCM600 the user sets the individual primary switchgear object names to facilitate the identification of each switchgear device for the station personnel.

The local HMI is divided into zones with different functionality.

- Status indication LEDs.
- Alarm indication LEDs, which consist of 15 LEDs (6 red and 9 yellow) with user printable label. All LEDs are configurable from PCM600.
- Liquid crystal display (LCD).
- Keypad with push buttons for control and navigation purposes, switch for selection between local and remote control and reset.
- Isolated RJ45 communication port.

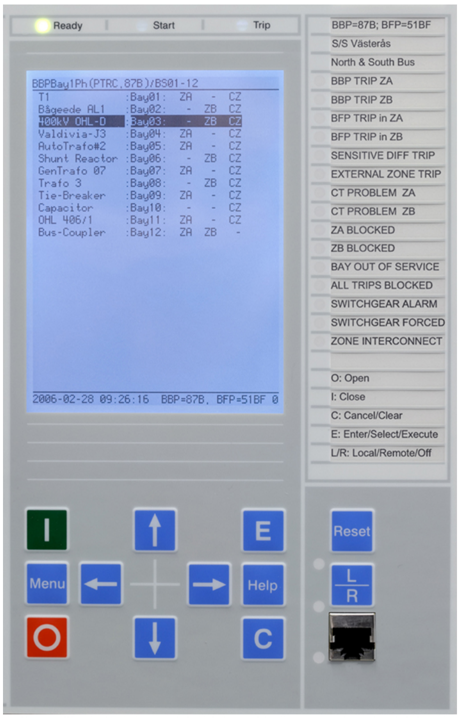


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Figure 6: Example of medium graphic HMI

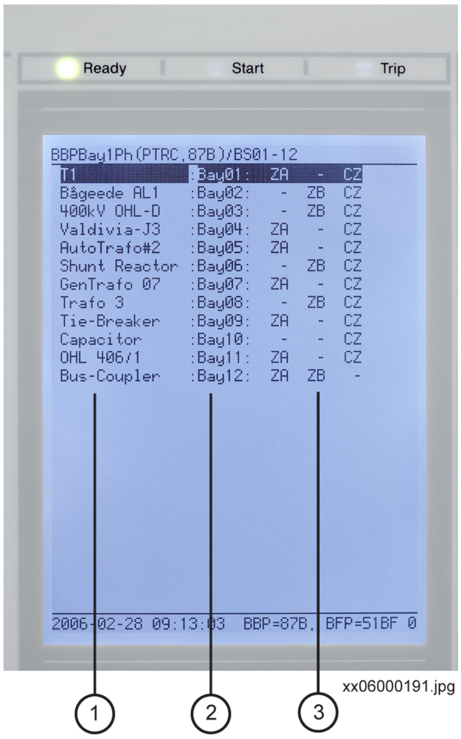


Figure 7: Bay to zone connection example

1 User settable bay name

2 Internally used bay FB

3 Connections to internal zones

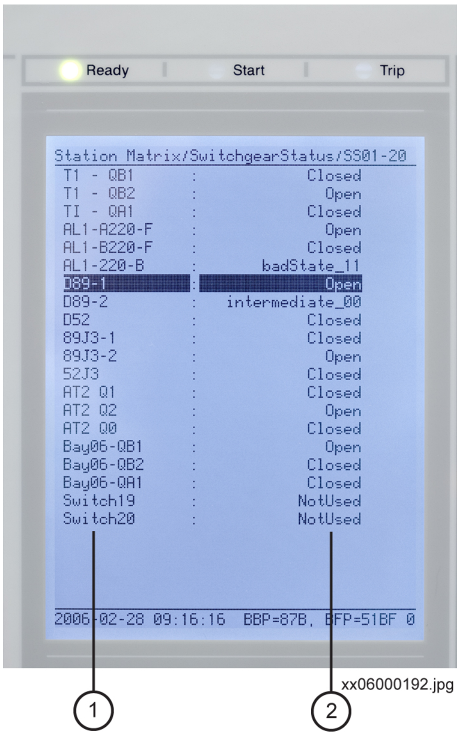


Figure 8: Example of status of primary switchgear objects

1 User settable switchgear names

2 Switchgear object status

3.2 Small size HMI

3.2.1 Small

The small sized HMI is available for 1/2, 3/4 and 1/1 x 19” case. The LCD on the small HMI measures 32 x 90 mm and displays 7 lines with up to 40 characters per line. The first line displays the product name and the last line displays date and time. The remaining 5 lines are dynamic. This LCD has no graphic display potential.

3.2.2 Design

The local HMI is identical for both the 1/2, 3/4 and 1/1 cases. The different parts of the small local HMI are shown in figure 9

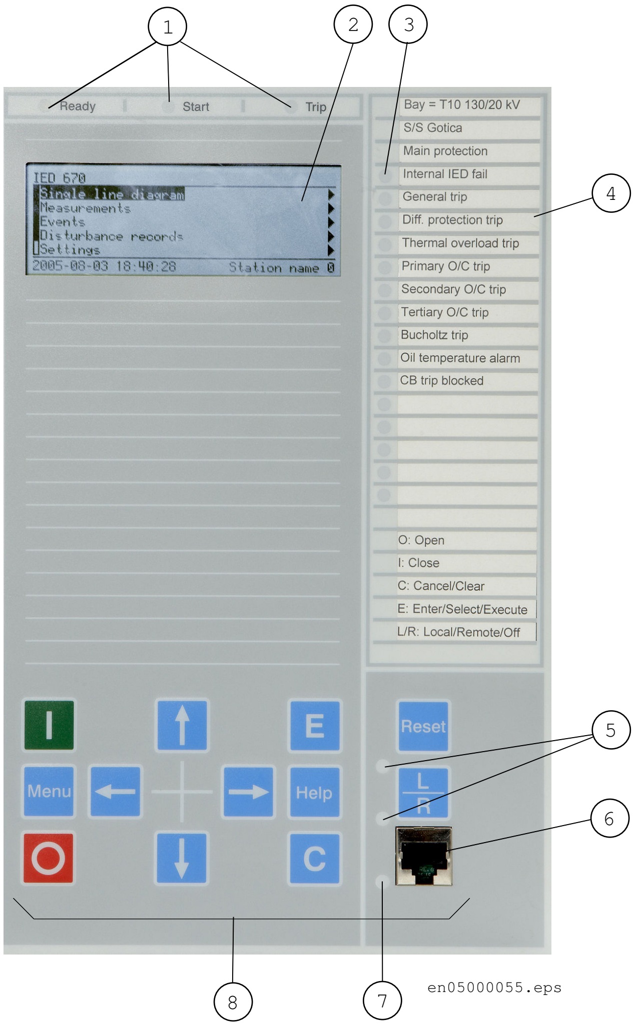


Figure 9: Small graphic HMI

1 Status indication LEDs

2 LCD

3 Indication LEDs

4 Label

5 Local/Remote LEDs

6 RJ45 port

7 Communication indication LED

8 Keypad

3.3 Medium size graphic HMI

3.3.1 Medium

The following case sizes can be equipped with the medium size LCD:

- 1/2 x 19”
- 3/4 x 19”
- 1/1 x 19”

This is a fully graphical monochrome LCD which measures 120 x 90 mm. It has 28 lines with up to 40 characters per line. To display the single line diagram, this LCD is required. To display the station matrix, this LCD is required.

3.3.2 Design

The different parts of the medium size local HMI are shown in figure 10. The local HMI exists in an IEC version and in an ANSI version. The difference is on the keypad operation buttons and the yellow LED designation.

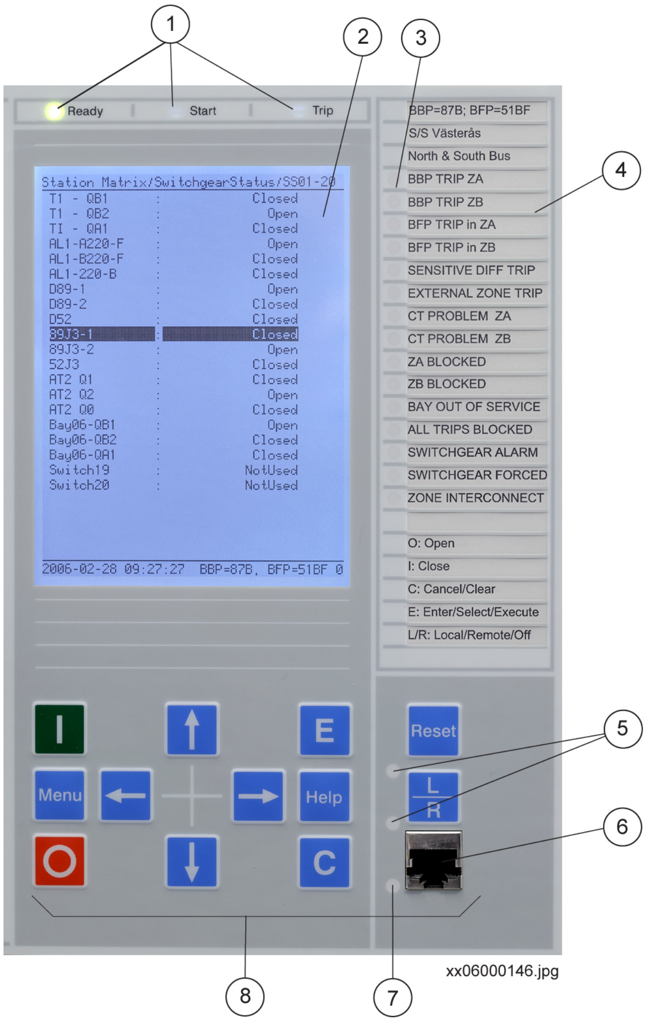


Figure 10: *Medium size graphic HMI*

1 Status indication LEDs

2 LCD

3 Indication LEDs

4 Label

5 Local/Remote LEDs

6 RJ45 port

7 Communication indication LED

8 Keypad

3.4 Keypad

The keypad is used to monitor and operate the IED. The keypad has the same look and feel in all IEDs. LCD screens and other details may differ but the way the keys function is identical.

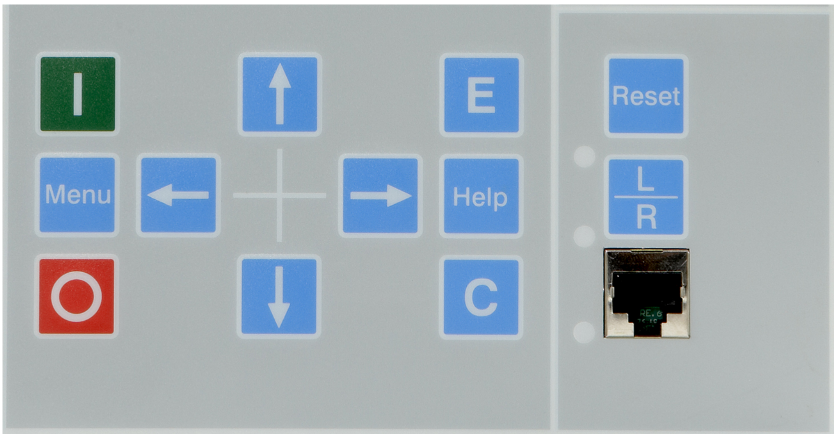


Figure 11: The HMI keypad.

Table 2 describes the HMI keys that are used to operate the IED.

Table 2: HMI keys on the front of the IED

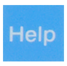
Key	Function
	Press to close or energize a breaker or disconnector.
	Press to open a breaker or disconnector.
	Press to open two sub menus: Key operation and IED information.
	Press to clear entries, cancel commands or edit.
	Press to open the main menu and to move to the default screen.
	Press to set the IED in local or remote control mode.
	Press to open the reset screen.
	Press to start the editing mode and confirm setting changes, when in editing mode.

Table continues on next page

Key	Function
	Press to navigate forward between screens and move right in editing mode.
	Press to navigate backwards between screens and move left in editing mode.
	Press to move up in the single line diagram and in the menu tree.
	Press to move down in the single line diagram and in the menu tree.

3.5 LED

3.5.1 Introduction

The LED module is a *unidirectional means of communicating*. This means that events may occur that activate a LED in order to draw the operators attention to something that has occurred and needs some sort of action.

3.5.2 Status indication LEDs

The three LEDs above the LCD provide information as shown in the table below.

LED Indication	Information
Green:	
Steady	In service
Flashing	Internal failure
Dark	No power supply
Yellow:	
Steady	Dist. rep. triggered
Flashing	Terminal in test mode
Red:	
Steady	Trip command issued

3.5.3 Indication LEDs

The LED indication module comprising 15 LEDs is standard in 670 series. Its main purpose is to present an immediate visual information for protection indications or alarm signals.

Alarm indication LEDs and hardware associated LEDs are located on the right hand side of the front panel. Alarm LEDs are located on the right of the LCD screen and show steady or flashing light.

- Steady light indicates normal operation.
- Flashing light indicates alarm.

Alarm LEDs can be configured in PCM600 and depend on the binary logic. Therefore they can not be configured on the local HMI.

Typical examples of alarm LEDs

- Bay controller failure
- CB close blocked
- Interlocking bypassed
- SF6 Gas refill
- Position error
- CB spring charge alarm
- Oil temperature alarm
- Thermal overload trip

The RJ45 port has a yellow LED indicating that communication has been established between the IED and a computer.

The Local/Remote key on the front panel has two LEDs indicating whether local or remote control of the IED is active.

3.6 Local HMI related functions

3.6.1 Introduction

The local HMI can be adapted to the application configuration and to user preferences.

- Function block LocalHMI
- Function block LEDGEN
- Setting parameters

3.6.2 General setting parameters

Table 3: SCREEN Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Language	English OptionalLanguage	-	-	English	Local HMI language
DisplayTimeout	10 - 120	Min	10	60	Local HMI display timeout
AutoRepeat	Off On	-	-	On	Activation of auto-repeat (On) or not (Off)
ContrastLevel	-10 - 20	%	1	0	Contrast level for display
DefaultScreen	0 - 0	-	1	0	Default screen
EvListSrtOrder	Latest on top Oldest on top	-	-	Latest on top	Sort order of event list
SymbolFont	IEC ANSI	-	-	IEC	Symbol font for Single Line Diagram

3.6.3 Status LEDs

3.6.3.1 Design

The function block LocalHMI controls and supplies information about the status of the status indication LEDs. The input and output signals of local HMI are configured with PCM600.

The function block can be used if any of the signals are required in a configuration logic.

See section "Status indication LEDs" for information about the LEDs.

3.6.3.2 Function block

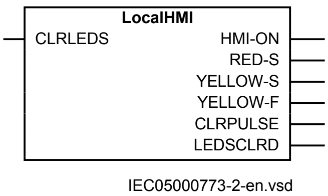


Figure 12: LocalHMI function block

3.6.3.3 Input and output signals

Table 4: LocalHMI Input signals

Name	Type	Default	Description
CLRLEDS	BOOLEAN	0	Input to clear the LCD-HMI LEDs

Table 5: LocalHMI Output signals

Name	Type	Description
HMI-ON	BOOLEAN	Backlight of the LCD display is active
RED-S	BOOLEAN	Red LED on the LCD-HMI is steady
YELLOW-S	BOOLEAN	Yellow LED on the LCD-HMI is steady
YELLOW-F	BOOLEAN	Yellow LED on the LCD-HMI is flashing
CLRPULSE	BOOLEAN	A pulse is provided when the LEDs on the LCD-HMI are cleared
LEDSCLRD	BOOLEAN	Active when the LEDs on the LCD-HMI are not active

3.6.4 Indication LEDs

3.6.4.1 Introduction

The function block LEDGEN controls and supplies information about the status of the indication LEDs. The input and output signals of LEDGEN are configured with PCM600. The input signal for each LED is selected individually with the Signal Matrix Tool in PCM600.

- LEDs (number 1–6) for trip indications are red.
- LEDs (number 7–15) for start indications are yellow.

Each indication LED on the local HMI can be set individually to operate in six different sequences

- Two sequences operate as follow type.
- Four sequences operate as latch type.
    - Two of the latching sequence types are intended to be used as a protection indication system, either in collecting or restarting mode, with reset functionality.
    - Two of the latching sequence types are intended to be used as signaling system in collecting (coll) mode with an acknowledgment functionality.

The light from the LEDs can be steady (-S) or flashing (-F). See the technical reference manual for more information.

3.6.4.2 Design

The information on the LEDs is stored at loss of the auxiliary power to the IED in some of the modes of LEDGEN. The latest LED picture appears immediately after the IED is successfully restarted.

Operating modes

- Collecting mode

    - LEDs which are used in collecting mode of operation are accumulated continuously until the unit is acknowledged manually. This mode is suitable when the LEDs are used as a simplified alarm system.

- Re-starting mode
    - In the re-starting mode of operation each new start resets all previous active LEDs and activates only those which appear during one disturbance. Only LEDs defined for re-starting mode with the latched sequence type 6 (LatchedReset-S) will initiate a reset and a restart at a new disturbance. A disturbance is defined to end a settable time after the reset of the activated input signals or when the maximum time limit has elapsed.

Acknowledgment/reset

- From local HMI
    - Active indications can be acknowledged or reset manually. Manual acknowledgment and manual reset have the same meaning and is a common signal for all the operating sequences and LEDs. The function is positive edge triggered, not level triggered. The acknowledged or reset is performed via the reset button and menus on the local HMI. See the operator's manual for more information.

- From function input
    - Active indications can also be acknowledged or reset from an input, RESET, to the function. This input can, for example, be configured to a binary input operated from an external push button. The function is positive edge triggered, not level triggered. This means that even if the button is continuously pressed, the acknowledgment or reset only affects indications active at the moment when the button is first pressed.

- Automatic reset
    - Automatic reset can only be performed for indications defined for re-starting mode with the latched sequence type 6 (LatchedReset-S). When automatic reset of the LEDs has been performed, still persisting indications will be indicated with a steady light.

Operating sequences

The operating sequences can be of type Follow or Latched.

- For the Follow type the LED follows the input signal completely.
- For the Latched type each LED latches to the corresponding input signal until it is reset.

Figure 13 show the function of available sequences that are selectable for each LED separately.

- The acknowledgment or reset function is not applicable for sequence 1 and 2 (Follow type).
- Sequence 3 and 4 (Latched type with acknowledgement) are only working in collecting mode.
- Sequence 5 is working according to Latched type and collecting mode.
- Sequence 6 is working according to Latched type and re-starting mode.

The letters S and F in the sequence names have the meaning S = Steady and F = Flashing.

At the activation of the input signal, the indication operates according to the selected sequence diagrams.

In the sequence diagrams the LEDs have the characteristics as shown in figure 13.

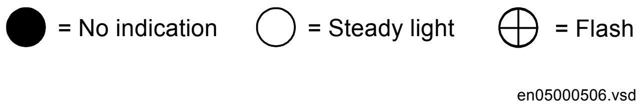


Figure 13: Symbols used in the sequence diagrams

Sequence 1 (Follow-S)

This sequence follows all the time, with a steady light, the corresponding input signals. It does not react on acknowledgment or reset. Every LED is independent of the other LEDs in its operation.

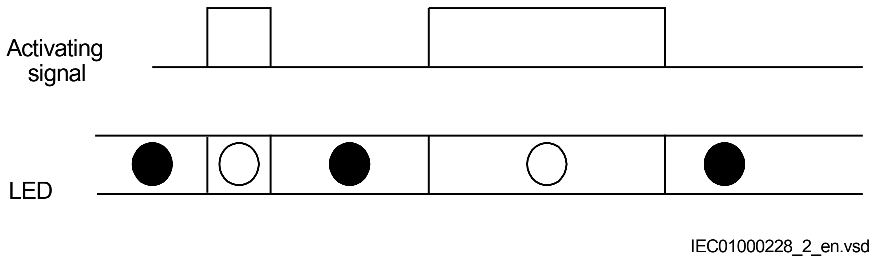


Figure 14: Operating sequence 1 (Follow-S)

Sequence 2 (Follow-F)

This sequence is the same as sequence 1, Follow-S, but the LEDs are flashing instead of showing steady light.

Sequence 3 (LatchedAck-F-S)

This sequence has a latched function and works in collecting mode. Every LED is independent of the other LEDs in its operation. At the activation of the input signal, the indication starts flashing. After acknowledgment the indication disappears if the signal is not present any more. If the signal is still present after acknowledgment it gets a steady light.

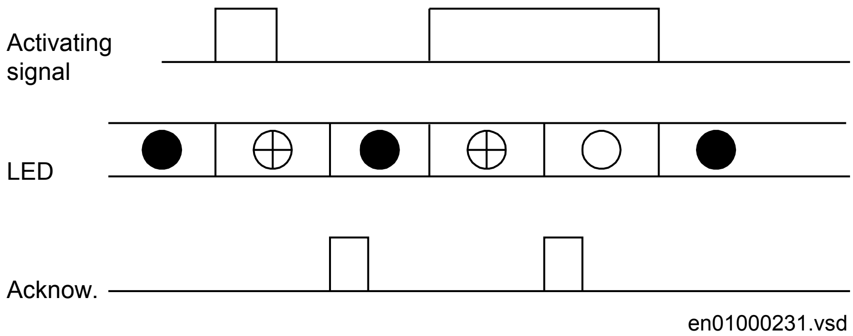


Figure 15: Operating sequence 3 (LatchedAck-F-S)

Sequence 4 (LatchedAck-S-F)

This sequence has the same functionality as sequence 3, but steady and flashing light have been alternated.

Sequence 5 (LatchedColl-S)

This sequence has a latched function and works in collecting mode. At the activation of the input signal, the indication will light up with a steady light. The difference to sequence 3 and 4 is that indications that are still activated will not be affected by the reset that is, immediately after the positive edge of the reset has been executed a new reading and storing of active signals is performed. Every LED is independent of the other LEDs in its operation.

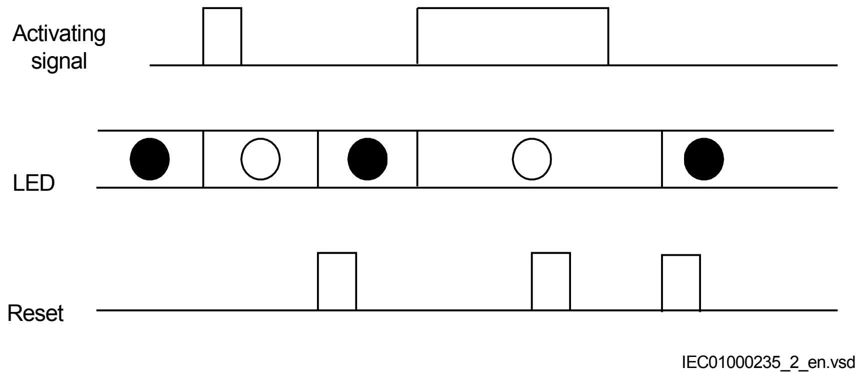


Figure 16: Operating sequence 5 (LatchedColl-S)

Sequence 6 (LatchedReset-S)

In this mode all activated LEDs, which are set to sequence 6 (LatchedReset-S), are automatically reset at a new disturbance when activating any input signal for other LEDs set to sequence 6 (LatchedReset-S). Also in this case indications that are still activated will not be affected by manual reset, that is, immediately after the positive edge of that the manual reset has been executed a new reading and storing of active signals is performed. LEDs set for sequence 6 are completely independent in its operation of LEDs set for other sequences.

Definition of a disturbance

A disturbance is defined to last from the first LED set as LatchedReset-S is activated until a settable time, tRestart, has elapsed after that all activating signals for the LEDs set as LatchedReset-S have reset. However if all activating signals have reset and some signal again becomes active before tRestart has elapsed, the tRestart timer does not restart the timing sequence. A new disturbance start will be issued first when all signals have reset after tRestart has elapsed. A diagram of this functionality is shown in figure 17.

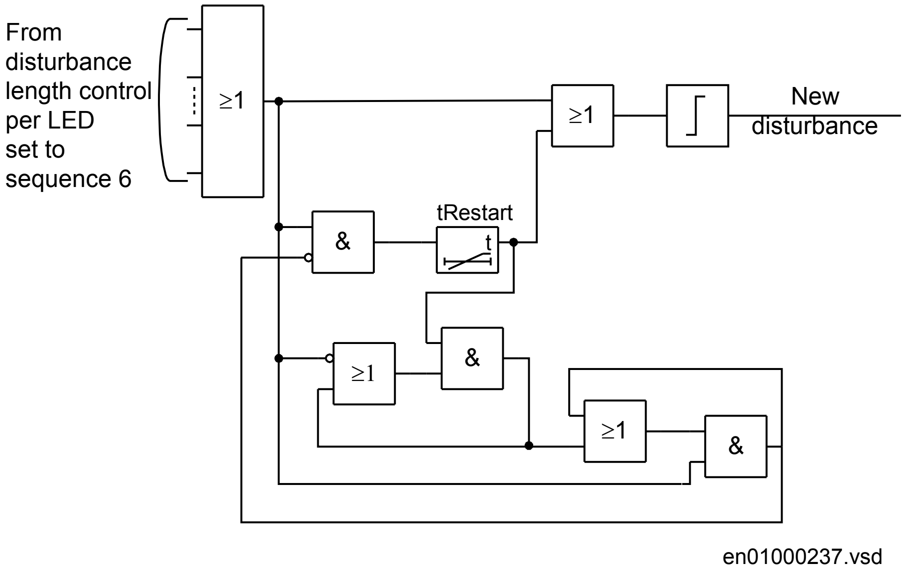


Figure 17: Activation of new disturbance

In order not to have a lock-up of the indications in the case of a persisting signal each LED is provided with a timer, tMax, after which time the influence on the definition of a disturbance of that specific LED is inhibited. This functionality is shown i diagram in figure 18.

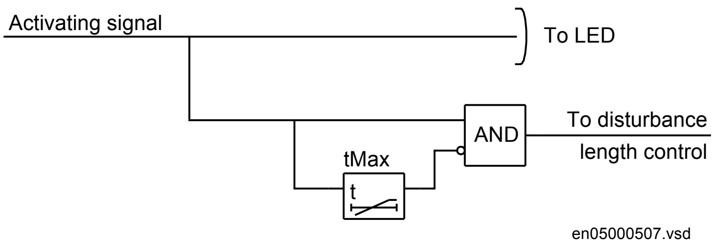


Figure 18: Length control of activating signals

Timing diagram for sequence 6

Figure 19 shows the timing diagram for two indications within one disturbance.

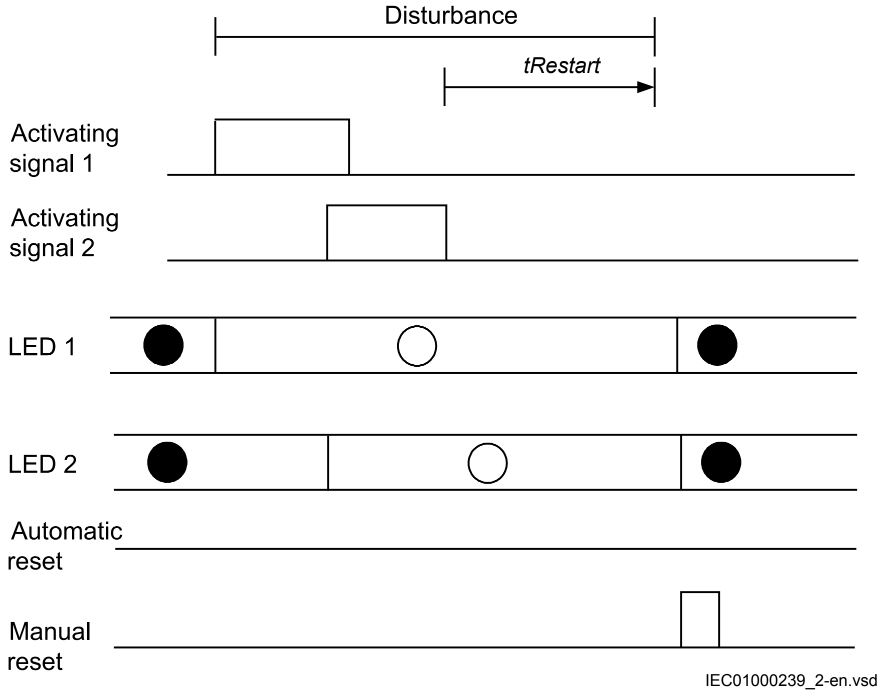


Figure 19: Operating sequence 6 (LatchedReset-S), two indications within same disturbance

Figure 20 shows the timing diagram for a new indication after *tRestart* time has elapsed.

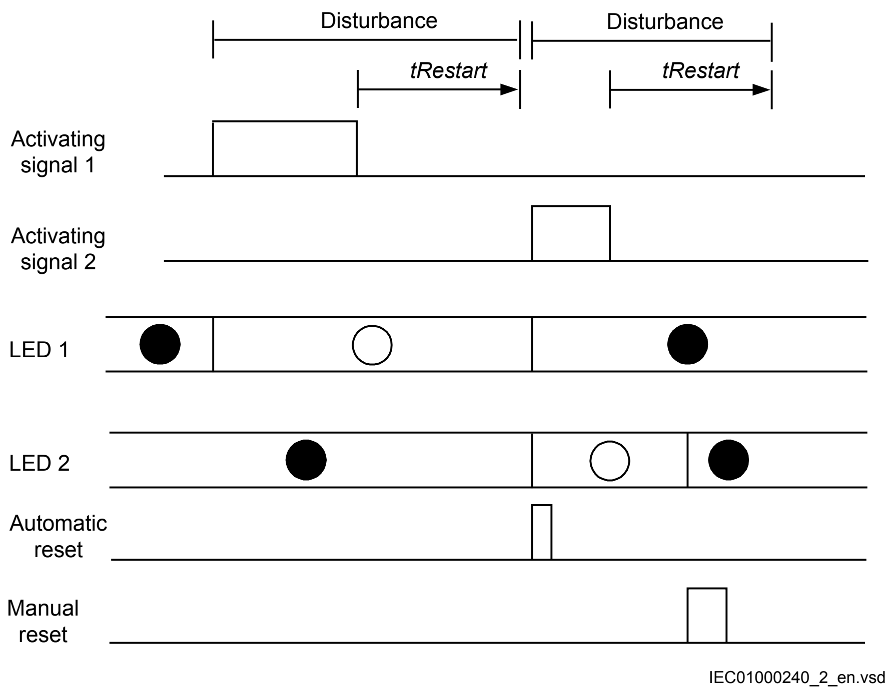


Figure 20: Operating sequence 6 (LatchedReset-S), two different disturbances

Figure 21 shows the timing diagram when a new indication appears after the first one has reset but before *tRestart* has elapsed.

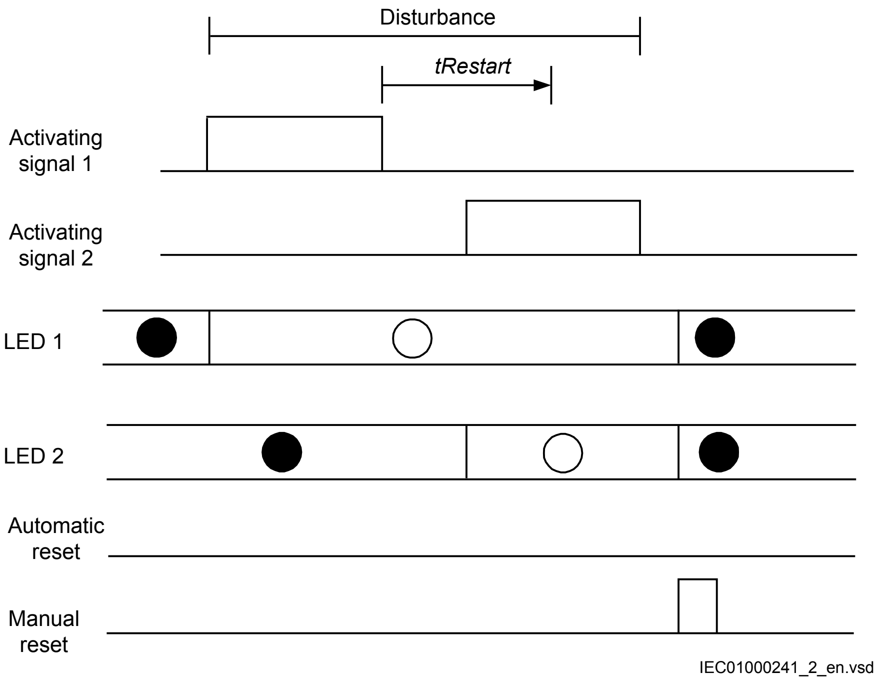


Figure 21: Operating sequence 6 (LatchedReset-S), two indications within same disturbance but with reset of activating signal between

Figure 22 shows the timing diagram for manual reset.

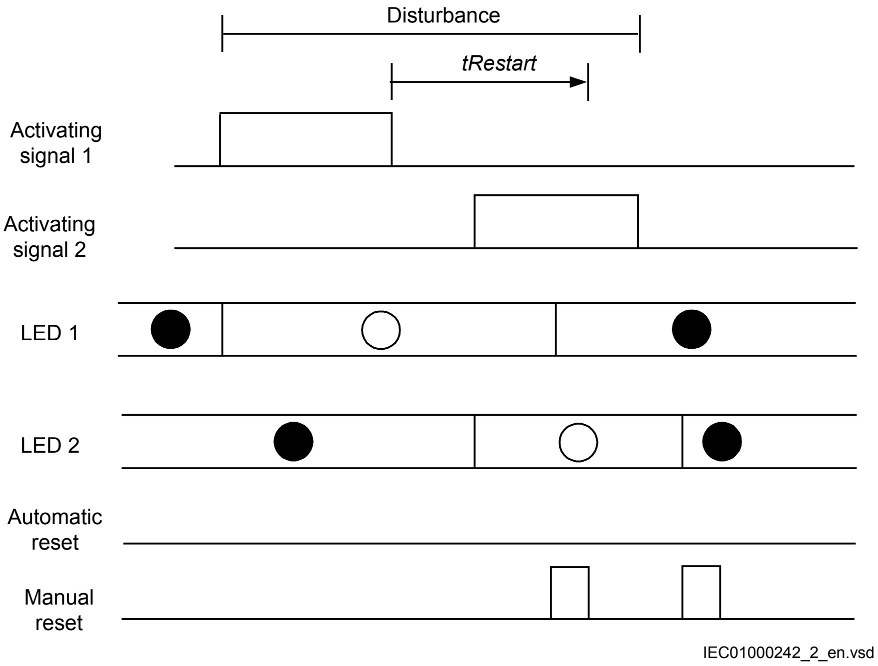
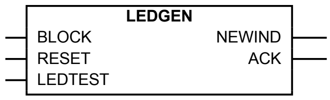


Figure 22: Operating sequence 6 (LatchedReset-S), manual reset

3.6.4.3 Function block



IEC05000508_2_en.vsd

Figure 23: LEDGEN function block

3.6.4.4 Input and output signals

Table 6: LEDGEN Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Input to block the operation of the LED-unit
RESET	BOOLEAN	0	Input to acknowledge/reset the indications of the LED-unit
LEDTEST	BOOLEAN	0	Input for external LED test

Table 7: LEDGEN Output signals

Name	Type	Description
NEWIND	BOOLEAN	A new signal on any of the indication inputs occurs
ACK	BOOLEAN	A pulse is provided when the LEDs are acknowledged

3.6.4.5 Setting parameters

Table 8: LEDGEN Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation mode for the LED function
tRestart	0.0 - 100.0	s	0.1	0.0	Defines the disturbance length
tMax	0.0 - 100.0	s	0.1	0.0	Maximum time for the definition of a disturbance
SeqTypeLED1	Follow-S Follow-F LatchedAck-F-S LatchedAck-S-F LatchedColl-S LatchedReset-S	-	-	Follow-S	Sequence type for LED 1
SeqTypeLED2	Follow-S Follow-F LatchedAck-F-S LatchedAck-S-F LatchedColl-S LatchedReset-S	-	-	Follow-S	Sequence type for LED 2

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
SeqTypeLED3	Follow-S Follow-F LatchedAck-F-S LatchedAck-S-F LatchedColl-S LatchedReset-S	-	-	Follow-S	Sequence type for LED 3
SeqTypeLED4	Follow-S Follow-F LatchedAck-F-S LatchedAck-S-F LatchedColl-S LatchedReset-S	-	-	Follow-S	Sequence type for LED 4
SeqTypeLED5	Follow-S Follow-F LatchedAck-F-S LatchedAck-S-F LatchedColl-S LatchedReset-S	-	-	Follow-S	Sequence type for LED 5
SeqTypeLED6	Follow-S Follow-F LatchedAck-F-S LatchedAck-S-F LatchedColl-S LatchedReset-S	-	-	Follow-S	Sequence type for LED 6
SeqTypeLED7	Follow-S Follow-F LatchedAck-F-S LatchedAck-S-F LatchedColl-S LatchedReset-S	-	-	Follow-S	Sequence type for LED 7
SeqTypeLED8	Follow-S Follow-F LatchedAck-F-S LatchedAck-S-F LatchedColl-S LatchedReset-S	-	-	Follow-S	sequence type for LED 8
SeqTypeLED9	Follow-S Follow-F LatchedAck-F-S LatchedAck-S-F LatchedColl-S LatchedReset-S	-	-	Follow-S	Sequence type for LED 9
SeqTypeLED10	Follow-S Follow-F LatchedAck-F-S LatchedAck-S-F LatchedColl-S LatchedReset-S	-	-	Follow-S	Sequence type for LED 10
SeqTypeLED11	Follow-S Follow-F LatchedAck-F-S LatchedAck-S-F LatchedColl-S LatchedReset-S	-	-	Follow-S	Sequence type for LED 11

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
SeqTypeLED12	Follow-S Follow-F LatchedAck-F-S LatchedAck-S-F LatchedColl-S LatchedReset-S	-	-	Follow-S	Sequence type for LED 12
SeqTypeLED13	Follow-S Follow-F LatchedAck-F-S LatchedAck-S-F LatchedColl-S LatchedReset-S	-	-	Follow-S	Sequence type for LED 13
SeqTypeLED14	Follow-S Follow-F LatchedAck-F-S LatchedAck-S-F LatchedColl-S LatchedReset-S	-	-	Follow-S	Sequence type for LED 14
SeqTypeLED15	Follow-S Follow-F LatchedAck-F-S LatchedAck-S-F LatchedColl-S LatchedReset-S	-	-	Follow-S	Sequence type for LED 15

Section 4 Basic IED functions

About this chapter

This chapter presents functions that are basic to all 670 series IEDs. Typical functions in this category are time synchronization, self supervision and test mode.

4.1 Authorization

To safeguard the interests of our customers, both the IED and the tools that are accessing the IED are protected, subject of authorization handling. The concept of authorization, as it is implemented in the IED and in PCM600 is based on the following facts:

There are two types of access points to the IED:

- local, through the local HMI
- remote, through the communication ports

4.1.1 Principle of operation

There are different levels (or types) of users that can access or operate different areas of the IED and tools functionality. The pre-defined user types are given in table below.

Be sure that the user logged on to the IED has the access required when writing particular data to the IED from PCM600.

The meaning of the legends used in the table:

- R= Read
- W= Write
- - = No access rights

Table 9: Pre-defined user types

Access rights	Guest	Super User	SPA Guest	System Operator	Protection Engineer	Design Engineer	User Administrator
Basic setting possibilities (change setting group, control settings, limit supervision)	R	R/W	R	R/W	R/W	R/W	R
Advanced setting possibilities (for example protection settings)	R	R/W	R	R	R/W	R/W	R
Basic control possibilities (process control, no bypass)	R	R/W	R/W	R/W	R/W	R/W	R
Advanced control possibilities (process control including interlock trigg)	R	R/W	R/W	R/W	R/W	R/W	R
Basic command handling (for example clear LEDs, manual trigg)	R	R/W	R	R/W	R/W	R/W	R
Advanced command handling (for example clear disturbance record)	R	R/W	R	R	R/W	R/W	R/W
Basic configuration possibilities (I/O-configuration in SMT)	R	R/W	R	R	R	R/W	R/W
Advanced configuration possibilities (application configuration including SMT, GDE and CMT)	R	R/W	R	R	R	R/W	R/W
File loading (database loading from XML-file)	-	R/W	-	-	-	R/W	R/W
File dumping (database dumping to XML-file)	-	R/W	-	-	-	R/W	R/W
File transfer (FTP file transfer)	-	R/W	-	R/W	R/W	R/W	R/W
File transfer (limited) (FTP file transfer)	R	R/W	R	R/W	R/W	R/W	R/W
File Transfer (SPA File Transfer)	-	R/W	-	-	-	R/W	-
Database access for normal user	R	R/W	R	R/W	R/W	R/W	R/W
User administration (user management – FTP File Transfer)	R	R/W	R	R	R	R	R/W
User administration (user management – SPA File Transfer)	-	R/W	-	-	-	-	-

The IED users can be created, deleted and edited only with the User Management Tool (UMT) within PCM600. The user can only LogOn or LogOff on the local HMI on the IED, there are no users, groups or functions that can be defined on local HMI.

Only characters A - Z, a - z and 0 - 9 should be used in user names and passwords.

At least one user must be included in the UserAdministrator group to be able to write users, created in PCM600, to IED.

4.1.1.1 Authorization handling in the IED

At delivery the default user is the SuperUser. No Log on is required to operate the IED until a user has been created with the User Management Tool.

Once a user is created and downloaded to the IED, that user can perform a Log on, introducing the password assigned in the tool.

If there is no user created, an attempt to log on will display a message box: “No user defined!”

If one user leaves the IED without logging off, then after the timeout (set in **Main menu/Settings/General Settings/HMI/Screen/Display Timeout**) elapses, the IED returns to Guest state, when only reading is possible. The display time out is set to 60 minutes at delivery.

If there are one or more users created with the User Management Tool and downloaded into the IED, then, when a user intentionally attempts a Log on or when the user attempts to perform an operation that is password protected, the Log on window will appear.

The cursor is focused on the User identity field, so upon pressing the “E” key, the user can change the user name, by browsing the list of users, with the “up” and “down” arrows. After choosing the right user name, the user must press the “E” key again. When it comes to password, upon pressing the “E” key, the following character will show up: “$”. The user must scroll for every letter in the password. After all the letters are introduced (passwords are case sensitive) choose OK and press the “E” key again.

If everything is alright at a voluntary Log on, the local HMI returns to the Authorization screen. If the Log on is OK, when required to change for example a password protected setting, the local HMI returns to the actual setting folder. If the Log on has failed, then the Log on window opens again, until either the user makes it right or presses “Cancel”.

4.2 Self supervision with internal event list

4.2.1 Introduction

Self supervision with internal event list function listens and reacts to internal system events, generated by the different built-in self-supervision elements. The internal events are saved in an internal event list.

4.2.2 Principle of operation

The self-supervision operates continuously and includes:

- Normal micro-processor watchdog function.
- Checking of digitized measuring signals.
- Other alarms, for example hardware and time synchronization.

The self-supervision function status can be monitored from the local HMI, from the Event Viewer in PCM600 or from a SMS/SCS system.

Under the Diagnostics menu in the local HMI the present information from the self-supervision function can be reviewed. The information can be found under **Main menu/Diagnostics/Internal events** or **Main menu/Diagnostics/IED status/General**. The information from the self-supervision function is also available in the Event Viewer in PCM600.

A self-supervision summary can be obtained by means of the potential free alarm contact (INTERNAL FAIL) located on the power supply module. The function of this output relay is an OR-function between the INT-FAIL signal see figure 25 and a couple of more severe faults that can occur in the IED, see figure 24

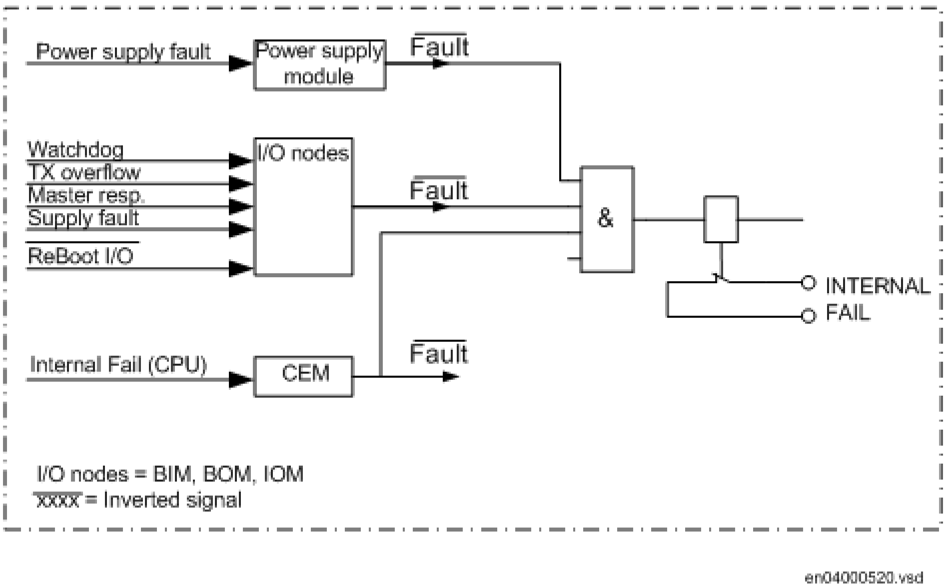


Figure 24: Hardware self-supervision, potential-free alarm contact

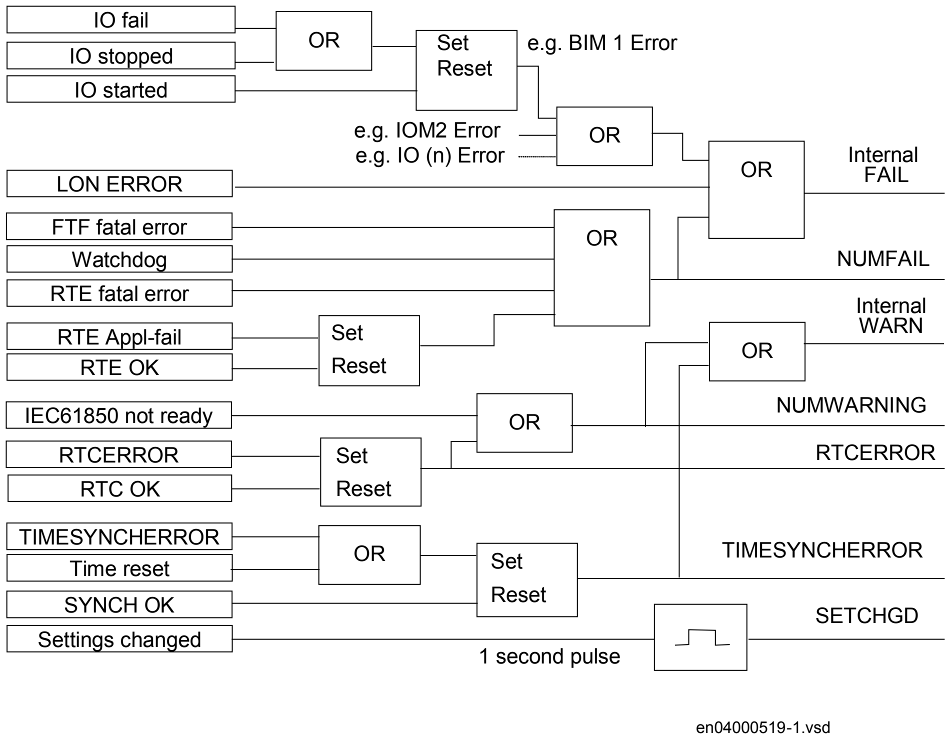


Figure 25: Software self-supervision, IES (IntErrorSign) function block

Some signals are available from the INTERRSIG function block. The signals from this function block are sent as events to the station level of the control system. The signals from the INTERRSIG function block can also be connected to binary outputs for signalization via output relays or they can be used as conditions for other functions if required/desired.

Individual error signals from I/O modules can be obtained from respective module in the Signal Matrix tool. Error signals from time synchronization can be obtained from the time synchronization block TIME.

4.2.2.1 Internal signals

Self supervision provides several status signals, that tells about the condition of the IED. As they provide information about the internal status of the IED, they are also called internal signals. The internal signals can be divided into two groups.

- Standard signals are always presented in the IED, see table 10.
- Hardware dependent internal signals are collected depending on the hardware configuration, see table 11.

Explanations of internal signals are listed in table 12.

Table 10: Self-supervision's standard internal signals

Name of signal	Description
FAIL	Internal Fail status
WARNING	Internal Warning status
NUMFAIL	CPU module Fail status
NUMWARNING	CPU module Warning status
RTCERROR	Real Time Clock status
TIMESYNCHERROR	Time Synchronization status
RTEERROR	Runtime Execution Error status
IEC61850ERROR	IEC 61850 Error status
WATCHDOG	SW Watchdog Error status
LMDERROR	LON/Mip Device Error status
APPERROR	Runtime Application Error status
SETCHGD	Settings changed
SETGRPCHGD	Setting groups changed
FTFERROR	Fault Tolerant Filesystem status

Table 11: Self-supervision's hardware dependent internal signals

Card	Name of signal	Description
PSM	PSM-Error	Power Supply Module Error status
ADOne	ADOne-Error	Analog In Module Error status
BIM	BIM-Error	Binary In Module Error status
BOM	BOM-Error	Binary Out Module Error status
IOM	IOM-Error	In/Out Module Error status
MIM	MIM-Error	Millampere Input Module Error status
LDCM	LDCM-Error	Line Differential Communication Error status

Table 12: Explanations of internal signals

Name of signal	Reasons for activation
FAIL	This signal will be active if one or more of the following internal signals are active; NUMFAIL, LMDERROR, WATCHDOG, APPERROR, RTEERROR, FTFERROR, or any of the HW dependent signals
WARNING	This signal will be active if one or more of the following internal signals are active; RTCERROR, IEC61850ERROR, TIMESYNCHERROR
NUMFAIL	This signal will be active if one or more of the following internal signals are active; WATCHDOG, APPERROR, RTEERROR, FTFERROR
NUMWARNING	This signal will be active if one or more of the following internal signals are active; RTCERROR, IEC61850ERROR
RTCERROR	This signal will be active when there is a hardware error with the real time clock.

Table continues on next page

Name of signal	Reasons for activation
TIMESYNCHERROR	This signal will be active when the source of the time synchronization is lost, or when the time system has to make a time reset.
RTEERROR	This signal will be active if the Runtime Engine failed to do some actions with the application threads. The actions can be loading of settings or parameters for components, changing of setting groups, loading or unloading of application threads.
IEC61850ERROR	This signal will be active if the IEC 61850 stack did not succeed in some actions like reading IEC 61850 configuration, startup, for example
WATCHDOG	This signal will be activated when the terminal has been under too heavy load for at least 5 minutes. The operating systems background task is used for the measurements.
LMDERROR	LON network interface, MIP/DPS, is in an unrecoverable error state.
APPERROR	This signal will be active if one or more of the application threads are not in the state that Runtime Engine expects. The states can be CREATED, INITIALIZED, RUNNING, for example
SETCHGD	This signal will generate an Internal Event to the Internal Event list if any settings are changed.
SETGRPCHGD	This signal will generate an Internal Event to the Internal Event list if any setting groups are changed.
FTFERROR	This signal will be active if both the working file and the backup file are corrupted and can not be recovered.

4.2.2.2 Run-time model

The analog signals to the A/D converter is internally distributed into two different converters, one with low amplification and one with high amplification, see figure 26.

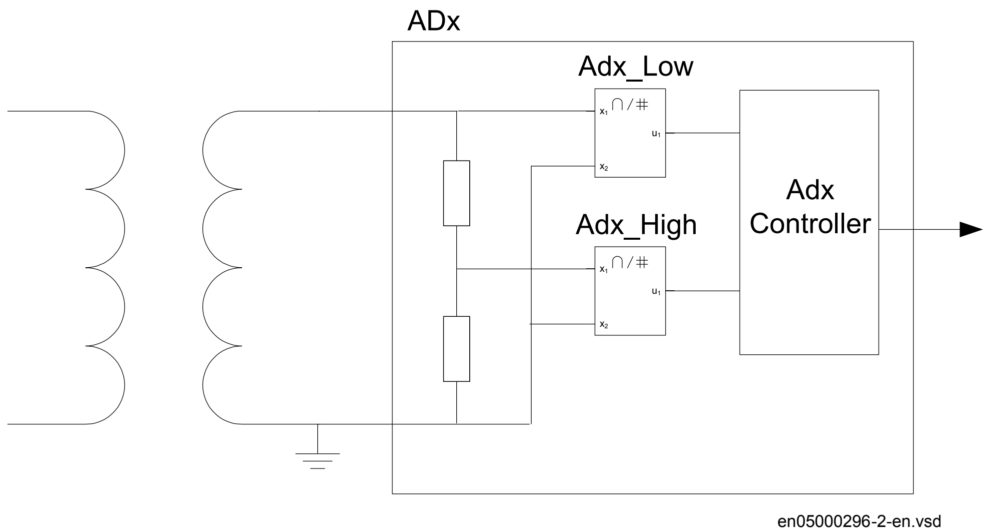


Figure 26: Simplified drawing of A/D converter for the IED.

The technique to split the analog input signal into two A/D converters with different amplification makes it possible to supervise the incoming signals under normal conditions where the signals from the two converters should be identical. An alarm is given if the signals are out of the boundaries. Another benefit is that it improves the dynamic performance of the A/D conversion.

The self-supervision of the A/D conversion is controlled by the ADx_Controller function. One of the tasks for the controller is to perform a validation of the input signals. This is done in a validation filter which has mainly two objects: First is the validation part that checks that the A/D conversion seems to work as expected. Secondly, the filter chooses which of the two signals that shall be sent to the CPU, that is the signal that has the most suitable level, the *ADx_LO* or the 16 times higher*ADx_HI*.

When the signal is within measurable limits on both channels, a direct comparison of the two channels can be performed. If the validation fails, the CPU will be informed and an alarm will be given.

The ADx_Controller also supervise other parts of the A/D converter.

4.2.3 Function block

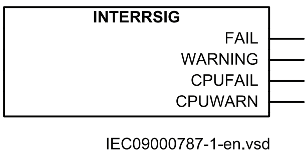


Figure 27: INTERRSIG function block

4.2.4 Output signals

Table 13: INTERRSIG Output signals

Name	Type	Description
FAIL	BOOLEAN	Internal fail
WARNING	BOOLEAN	Internal warning
CPUFAIL	BOOLEAN	CPU fail
CPUWARN	BOOLEAN	CPU warning

4.2.5 Setting parameters

The function does not have any parameters available in the local HMI or PCM600.

4.2.6 Technical data

Table 14: Self supervision with internal event list

Data	Value
Recording manner	Continuous, event controlled
List size	1000 events, first in-first out

4.3 Time synchronization

4.3.1 Introduction

The time synchronization source selector is used to select a common source of absolute time for the IED when it is a part of a protection system. This makes it possible to compare event- and disturbance data between all IEDs in a station automation system possible.

Micro SCADA OPC server should not be used as a time synchronization source.

4.3.2 Principle of operation

4.3.2.1 General concepts

Time definitions

The error of a clock is the difference between the actual time of the clock, and the time the clock is intended to have. The rate accuracy of a clock is normally called the clock accuracy and means how much the error increases, that is how much the clock gains or loses time. A disciplined (trained) clock knows its own faults and tries to compensate for them.

Design of the time system (clock synchronization)

The time system is based on a software clock, which can be adjusted from external time sources and a hardware clock. The protection and control modules will be timed from a hardware clock, which runs independently from the software clock. See figure 28.

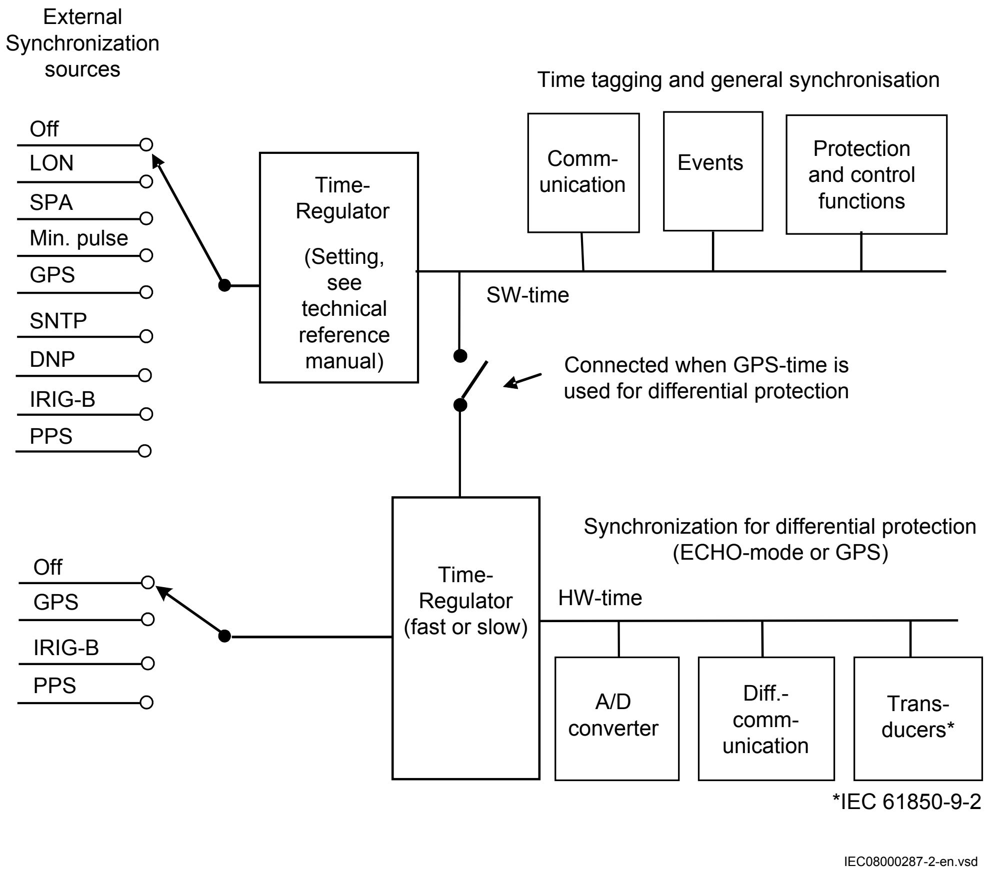


Figure 28: Design of time system (clock synchronization)

All time tagging is performed by the software clock. When for example a status signal is changed in the protection system with the function based on free running hardware clock, the event is time tagged by the software clock when it reaches the event recorder. Thus the hardware clock can run independently.

The echo mode for the differential protection is based on the hardware clock. Thus, there is no need to synchronize the hardware clock and the software clock.

The synchronization of the hardware clock and the software clock is necessary only when GPS or IRIG B 00X with optical fibre, IEEE 1344 is used for differential protection. The two clock systems are synchronized by a special clock synchronization unit with two modes, fast and slow. A special feature, an automatic fast clock time regulator is used. The automatic fast mode makes the synchronization time as short as possible during start-up or at interruptions/ disturbances in the GPS timing. The setting *fast* or *slow* is also available on the local HMI.

If a GPS clock is used for other 670 series IEDs than line differential RED670, the hardware and software clocks are not synchronized

Fast clock synchronization mode

At startup and after interruptions in the GPS or IRIG B time signal, the clock deviation between the GPS time and the internal differential time system can be substantial. A new startup is also required after for example maintenance of the auxiliary voltage system.

When the time difference is >16us, the differential function is blocked and the time regulator for the hardware clock is automatically using a fast mode to synchronize the clock systems. The time adjustment is made with an exponential function, i.e. big time adjustment steps in the beginning, then smaller steps until a time deviation between the GPS time and the differential time system of >16us has been reached. Then the differential function is enabled and the synchronization remains in fast mode or switches to slow mode, depending on the setting.

Slow clock synchronization mode

During normal service, a setting with slow synchronization mode is normally used, which prevents the hardware clock to make too big time steps, >16μs, emanating from the differential protection requirement of correct timing.

Synchronization principle

From a general point of view synchronization can be seen as a hierarchical structure. A function is synchronized from a higher level and provides synchronization to lower levels.

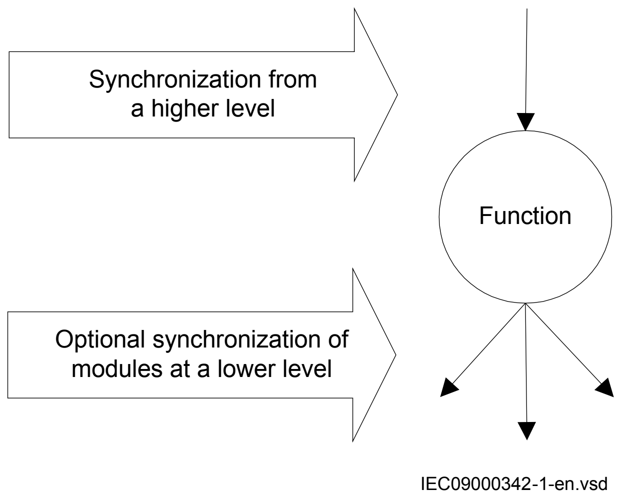


Figure 29: Synchronization principle

A function is said to be synchronized when it periodically receives synchronization messages from a higher level. As the level decreases, the accuracy of the synchronization decreases as well. A function can have several potential sources of synchronization, with different maximum errors, which give the function the possibility to choose the source with the best quality, and to adjust its internal clock after this source. The maximum error of a clock can be defined as:

- The maximum error of the last used synchronization message
- The time since the last used synchronization message
- The rate accuracy of the internal clock in the function.

4.3.2.2 Real-time clock (RTC) operation

The IED has a built-in real-time clock (RTC) with a resolution of one second. The clock has a built-in calendar that handles leap years through 2038.

Real-time clock at power off

During power off, the system time in the IED is kept by a capacitor-backed real-time clock that will provide 35 ppm accuracy for 5 days. This means that if the power is off, the time in the IED may drift with 3 seconds per day, during 5 days, and after this time the time will be lost completely.

Real-time clock at startup

Time synchronization startup procedure

The first message that contains the full time (as for instance LON, SNTP and GPS) gives an accurate time to the IED. After the initial setting of the clock, one of three things happens with each of the coming synchronization messages configured as “fine”:

- If the synchronization message, which is similar to the other messages, has an offset compared to the internal time in the IED, the message is used directly for synchronization, that is, for adjusting the internal clock to obtain zero offset at the next coming time message.
- If the synchronization message has an offset that is large compared to the other messages, a spike-filter in the IED removes this time-message.
- If the synchronization message has an offset that is large, and the following message also has a large offset, the spike filter does not act and the offset in the synchronization message is compared to a threshold that defaults to 100 milliseconds. If the offset is more than the threshold, the IED is brought into a safe state and the clock is set to the correct time. If the offset is lower than the threshold, the clock is adjusted with 1000 ppm until the offset is removed. With an adjustment of 1000 ppm, it takes 100 seconds or 1.7 minutes to remove an offset of 100 milliseconds.

Synchronization messages configured as coarse are only used for initial setting of the time. After this has been done, the messages are checked against the internal time and only an offset of more than 10 seconds resets the time.

Rate accuracy

In the IED, the rate accuracy at cold start is 100 ppm but if the IED is synchronized for a while, the rate accuracy is approximately 1 ppm if the surrounding temperature is constant. Normally, it takes 20 minutes to reach full accuracy.

Time-out on synchronization sources

All synchronization interfaces has a time-out and a configured interface must receive time-messages regularly in order not to give an error signal (TSYNCERR). Normally, the time-out is set so that one message can be lost without getting a TSYNCERR, but if more than one message is lost, a TSYNCERR is given.

4.3.2.3 Synchronization alternatives

Three main alternatives of external time synchronization are available. Either the synchronization message is applied via any of the communication ports of the IED as a telegram message including date and time or as a minute pulse, connected to a binary input, or via GPS. The minute pulse is used to fine tune already existing time in the IEDs.

Synchronization via SNTP

SNTP provides a ping-pong method of synchronization. A message is sent from an IED to an SNTP server, and the SNTP server returns the message after filling in a reception time and a transmission time. SNTP operates via the normal Ethernet network that connects IEDs together in an IEC 61850 network. For SNTP to operate properly, there must be an SNTP-server present, preferably in the same station. The SNTP synchronization provides an accuracy that gives 1 ms accuracy for binary inputs. The IED itself can be set as an SNTP-time server.

SNTP server requirements

The SNTP server to be used is connected to the local network, that is not more than 4-5 switches or routers away from the IED. The SNTP server is dedicated for its task, or at least equipped with a real-time operating system, that is not a PC with SNTP server software. The SNTP server should be stable, that is, either synchronized from a stable source like GPS, or local without synchronization. Using a local SNTP server without synchronization as primary or secondary server in a redundant configuration is not recommended.

Synchronization via Serial Communication Module (SLM)

On the serial buses (both LON and SPA) two types of synchronization messages are sent.

- Coarse message is sent every minute and comprises complete date and time, that is, year, month, day, hours, minutes, seconds and milliseconds.
- Fine message is sent every second and comprises only seconds and milliseconds.

IEC60870-5-103 is not used to synchronize the IED, but instead the offset between the local time in the IED and the time received from 103 is added to all times (in events and so on) sent via 103. In this way the IED acts as it is synchronized from various 103 sessions at the same time. Actually, there is a “local” time for each 103 session.

The SLM module is located on the AD conversion Module (ADM).

Synchronization via Built-in-GPS

The built in GPS clock modules receives and decodes time information from the global positioning system. The modules are located on the GPS time synchronization Module (GTM).

Synchronization via binary input

The IED accepts minute pulses to a binary input. These minute pulses can be generated from, for example station master clock. If the station master clock is not synchronized from a world wide source, time will be a relative time valid for the substation. Both positive and negative edge on the signal can be accepted. This signal is also considered as a fine time synchronization signal.

The minute pulse is connected to any channel on any Binary Input Module in the IED. The electrical characteristic is thereby the same as for any other binary input.

If the objective of synchronization is to achieve a relative time within the substation and if no station master clock with minute pulse output is available, a simple minute pulse generator can be designed and used for synchronization of the IEDs. The minute pulse generator can be created using the logical elements and timers available in the IED.

The definition of a minute pulse is that it occurs one minute after the last pulse. As only the flanks are detected, the flank of the minute pulse shall occur one minute after the last flank.

Binary minute pulses are checked with reference to frequency.

Pulse data:

- Period time (a) should be 60 seconds.
- Pulse length (b):
  - Minimum pulse length should be >50 ms.
  - Maximum pulse length is optional.
- Amplitude (c) - please refer to section "Binary input module (BIM)".

Deviations in the period time larger than 50 ms will cause TSYNCERR.

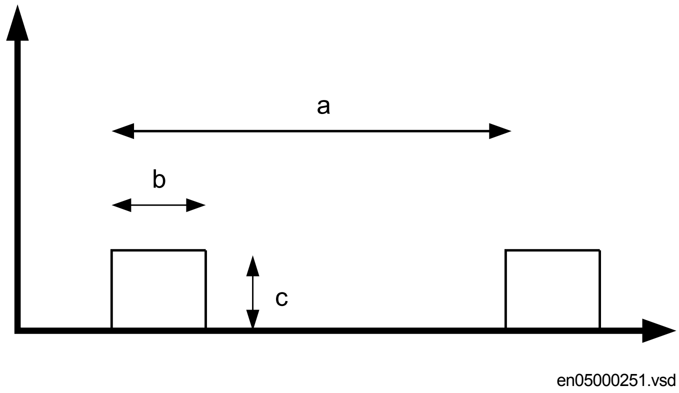


Figure 30: Binary minute pulses

The default time-out-time for a minute pulse is two minutes, and if no valid minute pulse is received within two minutes a SYNCERR will be given.

If contact bounces occurs, only the first pulse will be detected as a minute pulse. The next minute pulse will be registered first 60 s - 50 ms after the last contact bounce.

If the minute pulses are perfect, for example, it is exactly 60 seconds between the pulses, contact bounces might occur 49 ms after the actual minute pulse without effecting the system. If contact bounces occurs more than 50 ms, for example, it is less than 59950 ms between the two most adjacent positive (or negative) flanks, the minute pulse will not be accepted.

Binary synchronization example

An IED is configured to use only binary input, and a valid binary input is applied to a binary input card. The HMI is used to tell the IED the approximate time and the minute pulse is used to synchronize the IED thereafter. The definition of a minute pulse is that it occurs one minute after the previous minute pulse, so the first minute pulse is not used at all. The second minute pulse will probably be rejected due to the spike filter. The third pulse will give the IED a good time and will reset the time so that the fourth minute pulse will occur on a minute border. After the first three minutes, the time in the IED will be good if the coarse time is set properly via the HMI or the RTC backup still keeps the time since last up-time. If the minute pulse is removed for instance for an hour, the internal time will drift by maximum the error rate in the internal clock. If the minute pulse is returned, the first pulse automatically is rejected. The second pulse will possibly be rejected due to the spike filter. The third pulse will either synchronize the time, if the time offset is more than 100 ms, or adjust the time, if the time offset is small enough. If the time is set, the application will be brought to a safe state before the time is set. If the time is adjusted, the time will reach its destination within 1.7 minutes.

Synchronization via IRIG-B

The DNP3 communication can be the source for the course time synchronization, while the fine time synchronization needs a source with higher accuracy.

IRIG-B is a protocol used only for time synchronization. A clock can provide local time of the year in this format. The “B” in IRIG-B states that 100 bits per second are transmitted, and the message is sent every second. After IRIG-B there numbers stating if and how the signal is modulated and the information transmitted.

To receive IRIG-B there are two connectors in the IRIG-B module, one galvanic BNC connector and one optical ST connector. IRIG-B 12x messages can be supplied via the galvanic interface, and IRIG-B 00x messages can be supplied via either the galvanic interface or the optical interface, where x (in 00x or 12x) means a number in the range of 1-7.

“00” means that a base band is used, and the information can be fed into the IRIG-B module via the BNC contact or an optical fiber. “12” means that a 1 kHz modulation is used. In this case the information must go into the module via the BNC connector.

If the x in 00x or 12x is 4, 5, 6 or 7, the time message from IRIG-B contains information of the year. If x is 0, 1, 2 or 3, the information contains only the time within the year, and year information has to come from PCM600 or local HMI.

The IRIG-B module also takes care of IEEE1344 messages that are sent by IRIG-B clocks, as IRIG-B previously did not have any year information. IEEE1344 is compatible with IRIG-B and contains year information and information of the time-zone.

It is recommended to use IEEE 1344 for supplying time information to the IRIG-B module. In this case, send also the local time in the messages, as this local time plus the TZ Offset supplied in the message equals UTC at all times.

4.3.3 Function block

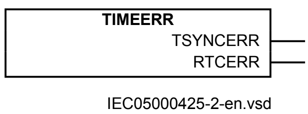


Figure 31: TIMEERR function block

4.3.4 Output signals

Table 15: TIMEERR Output signals

Name	Type	Description
TSYNCERR	BOOLEAN	Time synchronization error
RTCERR	BOOLEAN	Real time clock error

4.3.5 Setting parameters

Path in the local HMI is located under **Main menu/Setting/Time**

Path in PCM600 is located under **Main menu/Settings/Time/Synchronization**

Table 16: TIMESYNCHGEN Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
CoarseSyncSrc	Off SPA LON SNTP DNP	-	-	Off	Coarse time synchronization source
FineSyncSource	Off SPA LON BIN GPS GPS+SPA GPS+LON GPS+BIN SNTP GPS+SNTP IRIG-B GPS+IRIG-B PPS	-	-	Off	Fine time synchronization source
SyncMaster	Off SNTP-Server	-	-	Off	Activate IED as synchronization master
TimeAdjustRate	Slow Fast	-	-	Fast	Adjust rate for time synchronization
HWSyncSrc	Off GPS IRIG-B PPS	-	-	Off	Hardware time synchronization source
AppSynch	NoSynch Synch	-	-	NoSynch	Time synchronization mode for application
SyncAccLevel	Class T5 (1us) Class T4 (4us) Unspecified	-	-	Unspecified	Wanted time synchronization accuracy

Table 17: SYNCHBIN Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
ModulePosition	3 - 16	-	1	3	Hardware position of IO module for time synchronization
BinaryInput	1 - 16	-	1	1	Binary input number for time synchronization
BinDetection	PositiveEdge NegativeEdge	-	-	PositiveEdge	Positive or negative edge detection

Table 18: SYNCHSNTP Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
ServerIP-Add	0 - 18	IP Address	1	0.0.0.0	Server IP-address
RedServIP-Add	0 - 18	IP Address	1	0.0.0.0	Redundant server IP-address

Table 19: DSTBEGIN Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
MonthInYear	January February March April May June July August September October November December	-	-	March	Month in year when daylight time starts
DayInWeek	Sunday Monday Tuesday Wednesday Thursday Friday Saturday	-	-	Sunday	Day in week when daylight time starts
WeekInMonth	Last First Second Third Fourth	-	-	Last	Week in month when daylight time starts
UTCTimeOfDay	0 - 172800	s	1	3600	UTC Time of day in seconds when daylight time starts

Table 20: DSTEND Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
MonthInYear	January February March April May June July August September October November December	-	-	October	Month in year when daylight time ends
DayInWeek	Sunday Monday Tuesday Wednesday Thursday Friday Saturday	-	-	Sunday	Day in week when daylight time ends
WeekInMonth	Last First Second Third Fourth	-	-	Last	Week in month when daylight time ends
UTCTimeOfDay	0 - 172800	s	1	3600	UTC Time of day in seconds when daylight time ends

Table 21: TIMEZONE Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
NoHalfHourUTC	-24 - 24	-	1	0	Number of half-hours from UTC

Table 22: SYNCHIRIG-B Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
SynchType	BNC Opto	-	-	Opto	Type of synchronization
TimeDomain	LocalTime UTC	-	-	LocalTime	Time domain
Encoding	IRIG-B 1344 1344TZ	-	-	IRIG-B	Type of encoding
TimeZoneAs1344	MinusTZ PlusTZ	-	-	PlusTZ	Time zone as in 1344 standard

4.3.6 Technical data

Table 23: Time synchronization, time tagging

Function	Value
Time tagging resolution, events and sampled measurement values	1 ms
Time tagging error with synchronization once/min (minute pulse synchronization), events and sampled measurement values	± 1.0 ms typically
Time tagging error with SNTP synchronization, sampled measurement values	± 1.0 ms typically

4.4 Parameter setting groups

4.4.1 Introduction

Use the six sets of settings to optimize IED operation for different system conditions. By creating and switching between fine tuned setting sets, either from the local HMI or configurable binary inputs, results in a highly adaptable IED that can cope with a variety of system scenarios.

4.4.2 Principle of operation

Parameter setting groups ActiveGroup function has six functional inputs, each corresponding to one of the setting groups stored in the IED. Activation of any of these inputs changes the active setting group. Seven functional output signals are available for configuration purposes, so that up to date information on the active setting group is always available.

A setting group is selected by using the local HMI, from a front connected personal computer, remotely from the station control or station monitoring system or by activating the corresponding input to the ActiveGroup function block.

Each input of the function block can be configured to connect to any of the binary inputs in the IED. To do this PCM600 must be used.

The external control signals are used for activating a suitable setting group when adaptive functionality is necessary. Input signals that should activate setting groups must be either permanent or a pulse exceeding 400 ms.

More than one input may be activated at the same time. In such cases the lower order setting group has priority. This means that if for example both group four and group two are set to activate, group two will be the one activated.

Every time the active group is changed, the output signal SETCHGD is sending a pulse.

The parameter *MAXSETGR* defines the maximum number of setting groups in use to switch between.

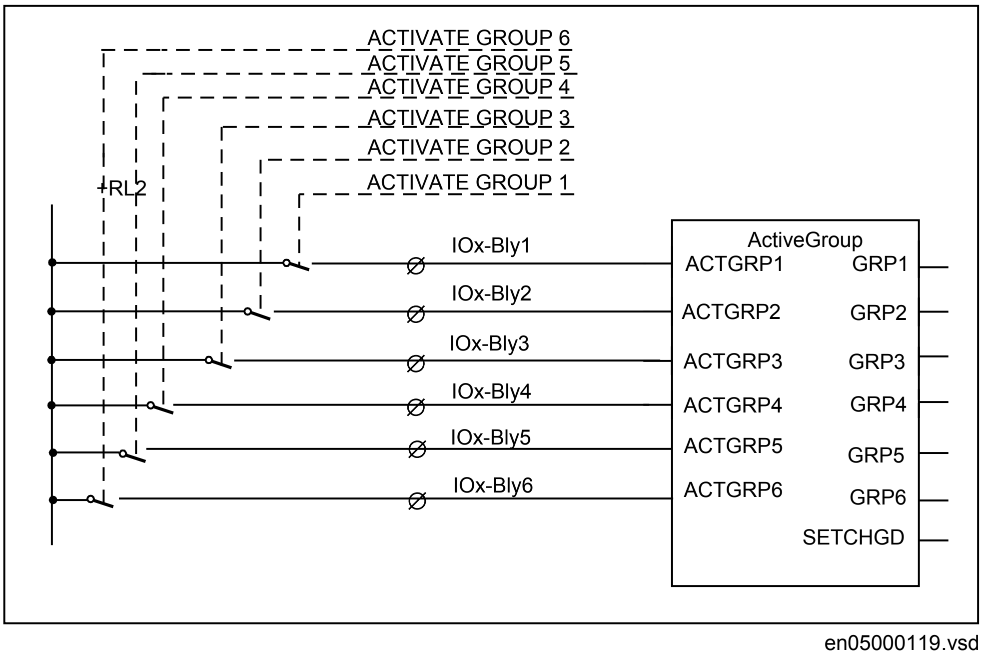


Figure 32: Connection of the function to external circuits

The above example also includes seven output signals, for confirmation of which group that is active.

SETGRPS function block has an input where the number of setting groups used is defined. Switching can only be done within that number of groups. The number of setting groups selected to be used will be filtered so only the setting groups used will be shown on the Parameter Setting Tool.

4.4.3 Function block

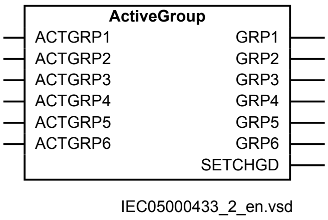


Figure 33: ActiveGroup function block

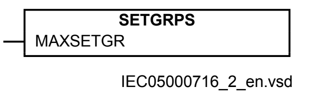


Figure 34: SETGRPS function block

4.4.4 Input and output signals

Table 24: ActiveGroup Input signals

Name	Type	Default	Description
ACTGRP1	BOOLEAN	0	Selects setting group 1 as active
ACTGRP2	BOOLEAN	0	Selects setting group 2 as active
ACTGRP3	BOOLEAN	0	Selects setting group 3 as active
ACTGRP4	BOOLEAN	0	Selects setting group 4 as active
ACTGRP5	BOOLEAN	0	Selects setting group 5 as active
ACTGRP6	BOOLEAN	0	Selects setting group 6 as active

Table 25: ActiveGroup Output signals

Name	Type	Description
GRP1	BOOLEAN	Setting group 1 is active
GRP2	BOOLEAN	Setting group 2 is active
GRP3	BOOLEAN	Setting group 3 is active
GRP4	BOOLEAN	Setting group 4 is active
GRP5	BOOLEAN	Setting group 5 is active
GRP6	BOOLEAN	Setting group 6 is active
SETCHGD	BOOLEAN	Pulse when setting changed

4.4.5 Setting parameters

Table 26: ActiveGroup Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
t	0.0 - 10.0	s	0.1	1.0	Pulse length of pulse when setting changed

Table 27: SETGRPS Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
ActiveSetGrp	SettingGroup1 SettingGroup2 SettingGroup3 SettingGroup4 SettingGroup5 SettingGroup6	-	-	SettingGroup1	ActiveSettingGroup
MAXSETGR	1 - 6	No	1	1	Max number of setting groups 1-6

4.5 ChangeLock function CHNGLCK

4.5.1 Introduction

Change lock function (CHNGLCK) is used to block further changes to the IED configuration and settings once the commissioning is complete. The purpose is to block inadvertent IED configuration changes beyond a certain point in time.

4.5.2 Principle of operation

The Change lock function (CHNGLCK) is configured using ACT.

The function, when activated, will still allow the following changes of the IED state that does not involve reconfiguring of the IED:

- Monitoring
- Reading events
- Resetting events
- Reading disturbance data
- Clear disturbances
- Reset LEDs
- Reset counters and other runtime component states
- Control operations
- Set system time
- Enter and exit from test mode
- Change of active setting group

The binary input signal LOCK controlling the function is defined in ACT or SMT:

Binary input	Function
1	Activated
0	Deactivated

4.5.3 Function block

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Figure 35: CHNGLCK function block

4.5.4 Input and output signals

Table 28: CHNGLCK Input signals

Name	Type	Default	Description
LOCK	BOOLEAN	0	Parameter change lock

4.5.5 Setting parameters

Table 29: CHNGLCK Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	LockHMI and Com LockHMI, EnableCom EnableHMI, LockCom	-	-	LockHMI and Com	Operation mode of change lock

4.6 Test mode functionality TEST

4.6.1 Introduction

When the Test mode functionality TESTMODE function is activated, protection functions in the IED are automatically blocked. It is then possible to unblock the protection functions individually from the local HMI or the Parameter Setting tool to perform required tests.

When leaving TESTMODE, all blockings are removed and the IED resumes normal operation. However, if during TESTMODE operation, power is removed and later restored, the IED will remain in TESTMODE with the same protection functions blocked or unblocked as before the power was removed. All testing will be done with actually set and configured values within the IED. No settings will be changed, thus mistakes are avoided.

4.6.2 Principle of operation

Put the IED into test mode to test functions in the IED. Set the IED in test mode by

- configuration, activating the input signal of the function block TESTMODE.
- setting *TestMode* to *On* in the local HMI, under **Main menu/TEST/IED test mode**.

While the IED is in test mode, the ACTIVE output of the function block TESTMODE is activated. The other outputs of the function block TESTMODE shows the generator of the “Test mode: On” state — input from configuration (OUTPUT output is activated) or setting from local HMI (SETTING output is activated).

While the IED is in test mode, the yellow START LED will flash and all functions are blocked. Any function can be unblocked individually regarding functionality and event signalling.

Most of the functions in the IED can individually be blocked by means of settings from the local HMI. To enable these blockings the IED must be set in test mode (output ACTIVE is activated), see example in figure 36. When leaving the test mode, that is entering normal mode, these blockings are disabled and everything is set to normal operation. All testing will be done with actually set and configured values within the IED. No settings will be changed, thus no mistakes are possible.

The blocked functions will still be blocked next time entering the test mode, if the blockings were not reset.

The blocking of a function concerns all output signals from the actual function, so no outputs will be activated.

When a binary input is used to set the IED in test mode and a parameter, that requires restart of the application, is changed, the IED will re-enter test mode and all functions will be blocked, also functions that were unblocked before the change. During the re-entering to test mode, all functions will be temporarily unblocked for a short time, which might lead to unwanted operations. This is only valid if the IED is put in TEST mode by a binary input, not by local HMI.

The TESTMODE function block might be used to automatically block functions when a test handle is inserted in a test switch. A contact in the test switch (RTXP24 contact 29-30) can supply a binary input which in turn is configured to the TESTMODE function block.

Each of the protection functions includes the blocking from the TESTMODE function block. A typical example from the undervoltage function is shown in figure 36.

The functions can also be blocked from sending events over IEC 61850 station bus to prevent filling station and SCADA databases with test events, for example during a maintenance test.

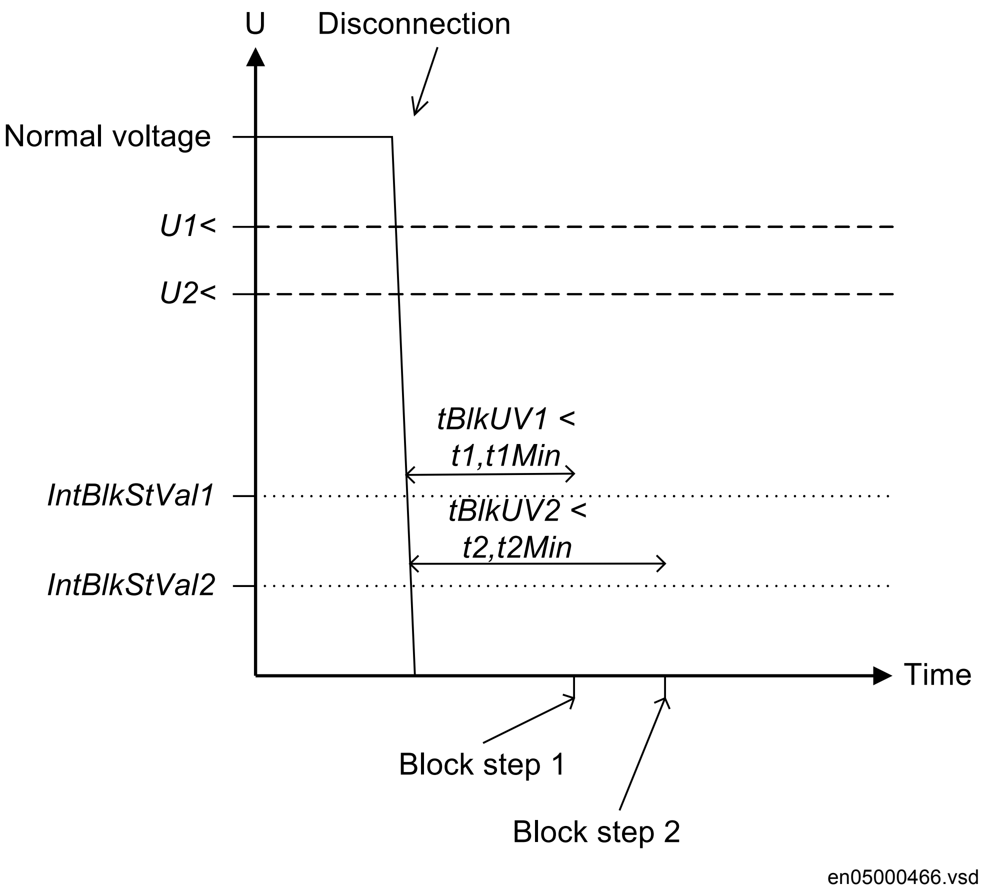

Figure 36: Example of blocking the time delayed undervoltage protection function.

4.6.3 Function block

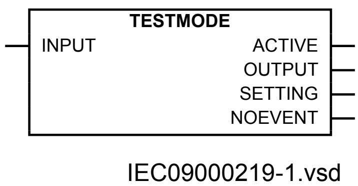

Figure 37: TESTMODE function block

4.6.4 Input and output signals

Table 30: TESTMODE Input signals

Name	Type	Default	Description
INPUT	BOOLEAN	0	Sets terminal in test mode when active

Table 31: TESTMODE Output signals

Name	Type	Description
ACTIVE	BOOLEAN	Terminal in test mode when active
OUTPUT	BOOLEAN	Test input is active
SETTING	BOOLEAN	Test mode setting is (On) or not (Off)
NOEVENT	BOOLEAN	Event disabled during testmode

4.6.5 Setting parameters

Table 32: TESTMODE Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
TestMode	Off On	-	-	Off	Test mode in operation (On) or not (Off)
EventDisable	Off On	-	-	Off	Event disable during testmode
CmdTestBit	Off On	-	-	Off	Command bit for test required or not during testmode

4.7 IED identifiers

4.7.1 Introduction

IED identifiers (TERMINALID) function allows the user to identify the individual IED in the system, not only in the substation, but in a whole region or a country.

Use only characters A-Z, a-z and 0-9 in station, object and unit names.

4.7.2 Setting parameters

Table 33: TERMINALID Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
StationName	0 - 18	-	1	Station name	Station name
StationNumber	0 - 99999	-	1	0	Station number
ObjectName	0 - 18	-	1	Object name	Object name
ObjectNumber	0 - 99999	-	1	0	Object number
UnitName	0 - 18	-	1	Unit name	Unit name
UnitNumber	0 - 99999	-	1	0	Unit number

4.8 Product information

4.8.1 Introduction

The Product identifiers function identifies the IED. The function has seven pre-set, settings that are unchangeable but nevertheless very important:

- IEDProdType
- ProductDef
- FirmwareVer
- SerialNo
- OrderingNo
- ProductionDate

The settings are visible on the local HMI , under **Main menu/Diagnostics/IED status/Product identifiers**

They are very helpful in case of support process (such as repair or maintenance).

4.8.2 Setting parameters

The function does not have any parameters available in the local HMI or PCM600.

4.8.3 Factory defined settings

The factory defined settings are very useful for identifying a specific version and very helpful in the case of maintenance, repair, interchanging IEDs between different Substation Automation Systems and upgrading. The factory made settings can not be changed by the customer. They can only be viewed. The settings are found in the local HMI under **Main menu/Diagnostics/IED status/Product identifiers**

The following identifiers are available:

- IEDProdType
  - Describes the type of the IED (like REL, REC or RET). Example: *REL670*
- ProductDef
  - Describes the release number, from the production. Example: *1.2.2.0*
- FirmwareVer
  - Describes the firmware version. Example: *1.4.51*
  - Firmware versions numbers are “running” independently from the release production numbers. For every release numbers (like *1.5.0.17*) there can be one or more firmware versions, depending on the small issues corrected in between releases.
- IEDMainFunType

  - Main function type code according to IEC 60870-5-103. Example: 128 (meaning line protection).
- SerialNo
- OrderingNo
- ProductionDate

4.9 Signal matrix for binary inputs SMBI

4.9.1 Introduction

The Signal matrix for binary inputs (SMBI) function is used within the Application Configuration Tool (ACT) in direct relation with the Signal Matrix Tool (SMT), see the application manual to get information about how binary inputs are brought in for one IED configuration.

4.9.2 Principle of operation

The Signal matrix for binary inputs (SMBI) function , see figure 38, receives its inputs from the real (hardware) binary inputs via the Signal Matrix Tool (SMT), and makes them available to the rest of the configuration via its outputs, BI1 to BI10. The inputs and outputs, as well as the whole block, can be given a user defined name. These names will be represented in SMT as information which signals shall be connected between physical IO and SMBI function. The input/output user defined name will also appear on the respective output/input signal.

4.9.3 Function block

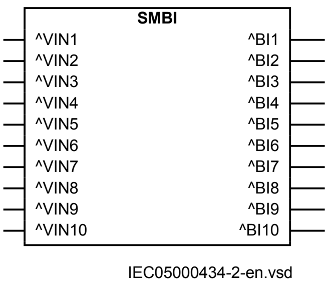

Figure 38: SMBI function block

4.9.4 Input and output signals

Table 34: SMBI Input signals

Name	Type	Default	Description
VIn1	BOOLEAN	0	SMT Connect input
VIn2	BOOLEAN	0	SMT Connect input
VIn3	BOOLEAN	0	SMT Connect input
VIn4	BOOLEAN	0	SMT Connect input
VIn5	BOOLEAN	0	SMT Connect input
VIn6	BOOLEAN	0	SMT Connect input
VIn7	BOOLEAN	0	SMT Connect input
VIn8	BOOLEAN	0	SMT Connect input
VIn9	BOOLEAN	0	SMT Connect input
VIn10	BOOLEAN	0	SMT Connect input

Table 35: SMBI Output signals

Name	Type	Description
BI1	BOOLEAN	Binary input 1
BI2	BOOLEAN	Binary input 2
BI3	BOOLEAN	Binary input 3
BI4	BOOLEAN	Binary input 4
BI5	BOOLEAN	Binary input 5
BI6	BOOLEAN	Binary input 6
BI7	BOOLEAN	Binary input 7
BI8	BOOLEAN	Binary input 8
BI9	BOOLEAN	Binary input 9
BI10	BOOLEAN	Binary input 10

4.10 Signal matrix for binary outputs SMBO

4.10.1 Introduction

The Signal matrix for binary outputs (SMBO) function is used within the Application Configuration Tool (ACT) in direct relation with the Signal Matrix Tool (SMT), see the application manual to get information about how binary inputs are sent from one IED configuration.

4.10.2 Principle of operation

The Signal matrix for binary outputs (SMBO) function , see figure 39, receives logical signal from the IED configuration, which is transferring to the real (hardware) outputs, via the Signal Matrix Tool (SMT). The inputs in SMBO are BO1 to BO10 and they, as well as the whole function block, can be tag-named. The name tags will appear in SMT as information which signals shall be connected between physical IO and the SMBO.

It is important that SMBO inputs are connected when SMBOs are connected to physical outputs through the Signal Matrix Tool. If SMBOs are connected (in SMT) but their inputs not, all the physical outputs will be set by default. This might cause malfunction of primary equipment and/or injury to personnel.

4.10.3 Function block

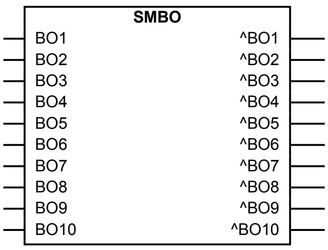

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Figure 39: SMBO function block

4.10.4 Input and output signals

Table 36: SMBO Input signals

Name	Type	Default	Description
BO1	BOOLEAN	1	Signal name for BO1 in Signal Matrix Tool
BO2	BOOLEAN	1	Signal name for BO2 in Signal Matrix Tool
BO3	BOOLEAN	1	Signal name for BO3 in Signal Matrix Tool
BO4	BOOLEAN	1	Signal name for BO4 in Signal Matrix Tool
BO5	BOOLEAN	1	Signal name for BO5 in Signal Matrix Tool
BO6	BOOLEAN	1	Signal name for BO6 in Signal Matrix Tool
BO7	BOOLEAN	1	Signal name for BO7 in Signal Matrix Tool
BO8	BOOLEAN	1	Signal name for BO8 in Signal Matrix Tool
BO9	BOOLEAN	1	Signal name for BO9 in Signal Matrix Tool
BO10	BOOLEAN	1	Signal name for BO10 in Signal Matrix Tool

4.11 Signal matrix for mA inputs SMMI

4.11.1 Introduction

The Signal matrix for mA inputs (SMMI) function is used within the Application Configuration Tool (ACT) in direct relation with the Signal Matrix Tool (SMT), see the application manual to get information about how milliamp (mA) inputs are brought in for one IED configuration.

4.11.2 Principle of operation

The Signal matrix for mA inputs (SMMI) function, see figure 40, receives its inputs from the real (hardware) mA inputs via the Signal Matrix Tool (SMT), and makes them available to the rest of the configuration via its analog outputs, named AI1 to AI6. The inputs, as well as the whole block, can be tag-named. These tags will be represented in SMT.

The outputs on SMMI are normally connected to the IEC61850 generic communication I/O functions (MVGGIO) function for further use of the mA signals.

4.11.3 Function block

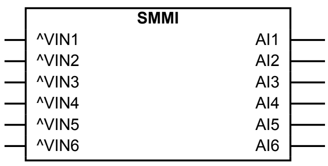

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Figure 40: SMMI function block

4.11.4 Input and output signals

Table 37: SMMI Input signals

Name	Type	Default	Description
VIn1	REAL	0	SMT connected milliampere input
VIn2	REAL	0	SMT connected milliampere input
VIn3	REAL	0	SMT connected milliampere input
VIn4	REAL	0	SMT connected milliampere input
VIn5	REAL	0	SMT connected milliampere input
VIn6	REAL	0	SMT connected milliampere input

Table 38: SMMI Output signals

Name	Type	Description
AI1	REAL	Analog milliampere input 1
AI2	REAL	Analog milliampere input 2
AI3	REAL	Analog milliampere input 3
AI4	REAL	Analog milliampere input 4
AI5	REAL	Analog milliampere input 5
AI6	REAL	Analog milliampere input 6

4.12 Signal matrix for analog inputs SMAI

4.12.1 Introduction

Signal matrix for analog inputs function SMAI (or the pre-processing function) is used within PCM600 in direct relation with the Signal Matrix tool or the Application Configuration tool. Signal Matrix tool represents the way analog inputs are brought in for one IED configuration.

4.12.2 Principle of operation

Every Signal matrix for analog inputs function (SMAI) can receive four analog signals (three phases and one neutral value), either voltage or current, see figure 42 and figure 43. SMAI outputs give information about every aspect of the 3ph analog signals acquired (phase angle, RMS value, frequency and frequency derivates etc. – 244 values in total). The BLOCK input will reset all outputs to 0.

The output signal AI1 to AI4 are direct output of the, in SMT, connected input to GRPxL1, GRPxL2, GRPxL3 and GRPxN, x=1-12. AIN is always the neutral current, calculated residual sum or the signal connected to GRPxN. Note that function block will always calculate the residual sum of current/voltage if the input is not connected in SMT. Applications with a few exceptions shall always be connected to AI3P.

4.12.3 Frequency values

The frequency functions includes a functionality based on level of positive sequence voltage, *IntBlockLevel*, to validate if the frequency measurement is valid or not. If positive sequence voltage is lower than *IntBlockLevel* the function is blocked. *IntBlockLevel*, is set in % of *UBase*/√3

If SMAI setting *ConnectionType* is *Ph-Ph* at least two of the inputs GRPxL1, GRPxL2 and GRPxL3 must be connected in order to calculate positive sequence voltage. If SMAI setting *ConnectionType* is *Ph-N*, all three inputs GRPxL1, GRPxL2 and GRPxL3 must be connected in order to calculate positive sequence voltage.

If only one phase-phase voltage is available and SMAI setting *ConnectionType* is *Ph-Ph* the user is advised to connect two (not three) of the inputs GRPxL1, GRPxL2 and GRPxL3 to the same voltage input as shown in figure 41 to make SMAI calculating a positive sequence voltage (that is input voltage/√3).

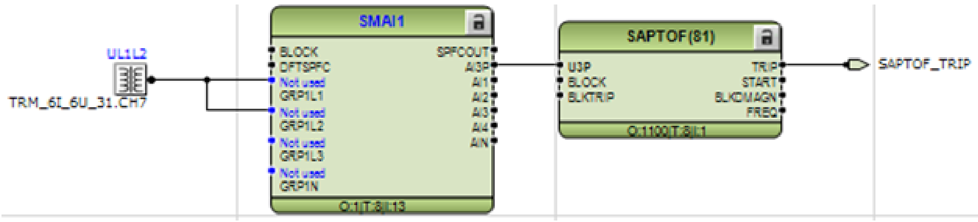

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Figure 41: Connection example

The above described scenario does not work if SMAI setting *ConnectionType* is *Ph-N*. If only one phase-earth voltage is available, the same type of connection can be used but the SMAI *ConnectionType* setting must still be *Ph-Ph* and this has to be accounted for when setting *IntBlockLevel*. If SMAI setting *ConnectionType* is *Ph-N* and the same voltage is connected to all three SMAI inputs, the positive sequence voltage will be zero and the frequency functions will not work properly.

The outputs from the above configured SMAI block shall only be used for Overfrequency protection (SAPTOF), Underfrequency protection (SAPTUF) and Rate-of-change frequency protection (SAPFRC) due to that all other information except frequency and positive sequence voltage might be wrongly calculated.

4.12.4 Function block

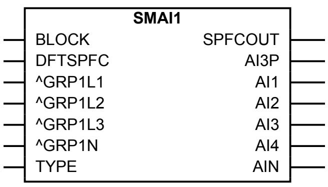

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Figure 42: SMAI1 function block

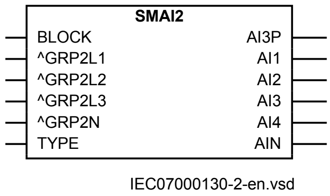

Figure 43: SMAI2 function block

4.12.5 Input and output signals

Table 39: SMAI1 Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block group 1
DFTSPFC	REAL	20.0	Number of samples per fundamental cycle used for DFT calculation
GRP1L1	STRING	-	Sample input to be used for group 1 phase L1 calculations
GRP1L2	STRING	-	Sample input to be used for group 1 phase L2 calculations
GRP1L3	STRING	-	Sample input to be used for group 1 phase L3 calculations
GRP1N	STRING	-	Sample input to be used for group 1 residual calculations

Table 40: SMAI1 Output signals

Name	Type	Description
SPFCOUT	REAL	Number of samples per fundamental cycle from internal DFT reference function
AI3P	GROUP SIGNAL	Group 1 analog input 3-phase group
AI1	GROUP SIGNAL	Group 1 analog input 1
AI2	GROUP SIGNAL	Group 1 analog input 2
AI3	GROUP SIGNAL	Group 1 analog input 3
AI4	GROUP SIGNAL	Group 1 analog input 4
AIN	GROUP SIGNAL	Group 1 analog input residual for disturbance recorder

Table 41: SMAI2 Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block group 2
GRP2L1	STRING	-	Sample input to be used for group 2 phase L1 calculations
GRP2L2	STRING	-	Sample input to be used for group 2 phase L2 calculations
GRP2L3	STRING	-	Sample input to be used for group 2 phase L3 calculations
GRP2N	STRING	-	Sample input to be used for group 2 residual calculations

Table 42: SMAI2 Output signals

Name	Type	Description
AI3P	GROUP SIGNAL	Group 2 analog input 3-phase group
AI1	GROUP SIGNAL	Group 2 analog input 1
AI2	GROUP SIGNAL	Group 2 analog input 2
AI3	GROUP SIGNAL	Group 2 analog input 3
AI4	GROUP SIGNAL	Group 2 analog input 4
AIN	GROUP SIGNAL	Group 2 analog input residual for disturbance recorder

4.12.6 Setting parameters

Settings *DFTRefExtOut* and *DFTReference* shall be set to default value *InternalDFTRef* if no VT inputs are available. Internal nominal frequency DFT reference is then the reference.

Table 43: SMAI1 Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
DFTRefExtOut	InternalDFTRef AdDFTRefCh1 AdDFTRefCh2 AdDFTRefCh3 AdDFTRefCh4 AdDFTRefCh5 AdDFTRefCh6 AdDFTRefCh7 AdDFTRefCh8 AdDFTRefCh9 AdDFTRefCh10 AdDFTRefCh11 AdDFTRefCh12 External DFT ref	-	-	InternalDFTRef	DFT reference for external output
DFTReference	InternalDFTRef AdDFTRefCh1 AdDFTRefCh2 AdDFTRefCh3 AdDFTRefCh4 AdDFTRefCh5 AdDFTRefCh6 AdDFTRefCh7 AdDFTRefCh8 AdDFTRefCh9 AdDFTRefCh10 AdDFTRefCh11 AdDFTRefCh12 External DFT ref	-	-	InternalDFTRef	DFT reference
ConnectionType	Ph-N Ph-Ph	-	-	Ph-N	Input connection type
TYPE	1 - 2	Ch	1	1	1=Voltage, 2=Current

Table 44: SMAI1 Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
Negation	Off NegateN Negate3Ph Negate3Ph+N	-	-	Off	Negation
MinValFreqMeas	5 - 200	%	1	10	Limit for frequency calculation in % of UBase
UBase	0.05 - 2000.00	kV	0.05	400.00	Base voltage

Table 45: SMAI2 Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
DFTReference	InternalDFTRef AdDFTRefCh1 AdDFTRefCh2 AdDFTRefCh3 AdDFTRefCh4 AdDFTRefCh5 AdDFTRefCh6 AdDFTRefCh7 AdDFTRefCh8 AdDFTRefCh9 AdDFTRefCh10 AdDFTRefCh11 AdDFTRefCh12 External DFT ref	-	-	InternalDFTRef	DFT reference
ConnectionType	Ph-N Ph-Ph	-	-	Ph-N	Input connection type
TYPE	1 - 2	Ch	1	1	1=Voltage, 2=Current

Table 46: SMAI2 Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
Negation	Off NegateN Negate3Ph Negate3Ph+N	-	-	Off	Negation
MinValFreqMeas	5 - 200	%	1	10	Limit for frequency calculation in % of UBase
UBase	0.05 - 2000.00	kV	0.05	400.00	Base voltage

4.13 Summation block 3 phase 3PHSUM

4.13.1 Introduction

Summation block 3 phase function 3PHSUM is used to get the sum of two sets of three-phase analog signals (of the same type) for those IED functions that might need it.

4.13.2 Principle of operation

Summation block 3 phase 3PHSUM receives the three-phase signals from Signal matrix for analog inputs function (SMAI). In the same way, the BLOCK input will reset all the outputs of the function to 0.

4.13.3 Function block

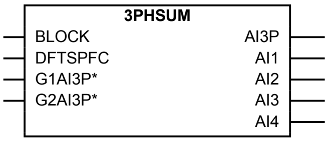

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Figure 44: 3PHSUM function block

4.13.4 Input and output signals

Table 47: 3PHSUM Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block
DFTSPFC	REAL	0	Number of samples per fundamental cycle used for DFT calculation
G1AI3P	GROUP SIGNAL	-	Group 1 analog input 3-phase group
G2AI3P	GROUP SIGNAL	-	Group 2 analog input 3-phase group

Table 48: 3PHSUM Output signals

Name	Type	Description
AI3P	GROUP SIGNAL	Group analog input 3-phase group
AI1	GROUP SIGNAL	Group 1 analog input
AI2	GROUP SIGNAL	Group 2 analog input
AI3	GROUP SIGNAL	Group 3 analog input
AI4	GROUP SIGNAL	Group 4 analog input

4.13.5 Setting parameters

Settings *DFTRefExtOut* and *DFTReference* shall be set to default value *InternalDFTRef* if no VT inputs are available.

Table 49: 3PHSUM Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
SummationType	Group1+Group2 Group1-Group2 Group2-Group1 -(Group1+Group2)	-	-	Group1+Group2	Summation type
DFTReference	InternalDFTRef AdDFTRefCh1 External DFT ref	-	-	InternalDFTRef	DFT reference

Table 50: 3PHSUM Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
FreqMeasMinVal	5 - 200	%	1	10	Amplitude limit for frequency calculation in % of Ubase
UBase	0.05 - 2000.00	kV	0.05	400.00	Base voltage

4.14 Authority status ATHSTAT

4.14.1 Introduction

Authority status (ATHSTAT) function is an indication function block for user log on activity.

4.14.2 Principle of operation

Authority status (ATHSTAT) function informs about two events related to the IED and the user authorization:

- the fact that at least one user has tried to log on wrongly into the IED and it was blocked (the output USRBLKED)
- the fact that at least one user is logged on (the output LOGGEDON)

Whenever one of the two events occurs, the corresponding output (USRBLKED or LOGGEDON) is activated. The output can for example, be connected on Event (EVENT) function block for LON/SPA.The signals are also available on IEC 61850 station bus.

4.14.3 Function block

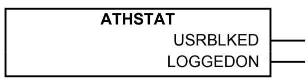

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Figure 45: ATHSTAT function block

4.14.4 Output signals

Table 51: ATHSTAT Output signals

Name	Type	Description
USRBLKED	BOOLEAN	At least one user is blocked by invalid password
LOGGEDON	BOOLEAN	At least one user is logged on

4.14.5 Setting parameters

The function does not have any parameters available in the local HMI or PCM600.

4.15 Denial of service DOS

4.15.1 Introduction

The Denial of service functions (DOSFRNT, DOSOEMAB and DOSOEMCD) are designed to limit overload on the IED produced by heavy Ethernet network traffic. The communication facilities must not be allowed to compromise the primary functionality of the device. All inbound network traffic will be quota controlled so that too heavy network loads can be controlled. Heavy network load might for instance be the result of malfunctioning equipment connected to the network.

4.15.2 Principle of operation

The Denial of service functions (DOSFRNT, DOSOEMAB and DOSOEMCD) measures the IED load from communication and, if necessary, limit it for not jeopardizing the IEDs control and protection functionality due to high CPU load. The function has the following outputs:

- LINKUP indicates the Ethernet link status
- WARNING indicates that communication (frame rate) is higher than normal
- ALARM indicates that the IED limits communication

4.15.3 Function blocks

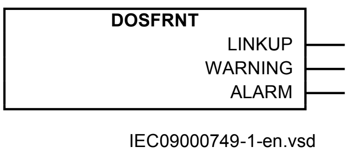

Figure 46: DOSFRNT function block

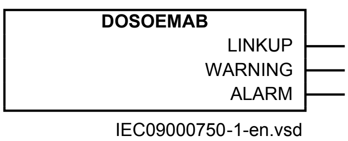

Figure 47: DOSOEMAB function block

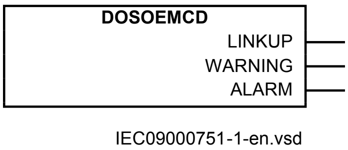

Figure 48: DOSOEMCD function block

4.15.4 Signals

Table 52: DOSFRNT Output signals

Name	Type	Description
LINKUP	BOOLEAN	Ethernet link status
WARNING	BOOLEAN	Frame rate is higher than normal state
ALARM	BOOLEAN	Frame rate is higher than throttle state

Table 53: DOSOEMAB Output signals

Name	Type	Description
LINKUP	BOOLEAN	Ethernet link status
WARNING	BOOLEAN	Frame rate is higher than normal state
ALARM	BOOLEAN	Frame rate is higher than throttle state

Table 54: DOSOEMCD Output signals

Name	Type	Description
LINKUP	BOOLEAN	Ethernet link status
WARNING	BOOLEAN	Frame rate is higher than normal state
ALARM	BOOLEAN	Frame rate is higher than throttle state

4.15.5 Settings

The function does not have any parameters available in the local HMI or PCM600.

Section 5 Differential protection

About this chapter

This chapter describes the measuring principles, functions and parameters used in differential protection.

5.1 Busbar differential protection

Busbar differential protection, 3-phase version

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Busbar differential protection, 2 zones, three phase/4 bays	BUTPTRC	3Id/I	87B
Busbar differential protection, 2 zones, three phase/4 or 8 bays	BTCZPDIF	3Id/I	87B
Busbar differential protection, 2 zones, three phase/4 or 8 bays	BTZNPDIF	3Id/I	87B
Busbar differential protection, 2 zones, three phase/4 or 8 bays	BTZNPDIF	3Id/I	87B
Busbar differential protection, 2 zones, three phase/4 or 8 bays	BZITGGIO	3Id/I	87B

Busbar differential protection, 1-phase version

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Busbar differential protection, 2 zones, single phase/12 or 24 bays	BUSPTRC	3Id/I	87B
Busbar differential protection, 2 zones, single phase/12 or 24 bays	BCZSPDIF	3Id/I	87B
Busbar differential protection, 2 zones, single phase/12 or 24 bays	BZNSPDIF	3Id/I	87B
Busbar differential protection, 2 zones, single phase/12 or 24 bays	BZNSPDIF	3Id/I	87B
Busbar differential protection, 2 zones, single phase/12 or 24 bays	BZISGGIO	3Id/I	87B

Status of primary switching object for Busbar protection zone selection

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Status of primary switching object for Busbar protection zone selection	SWSGGIO	-	-

5.1.1 Introduction

IED is designed for the selective, reliable and fast differential protection of busbars, T-connections and meshed corners. IED can be used for different switchgear layouts, including single and double busbar with or without transfer bus, double circuit breaker or one-and-half circuit breaker stations. The IED is applicable for the protection of medium voltage (MV), high voltage (HV) and extra high voltage (EHV) installations at a power system frequency of 50Hz or 60Hz.

The IED can detect all types of internal phase-to-phase and phase-to-earth faults in solidly earthed or low impedance earthed power systems, as well as all internal multi-phase faults in isolated or high-impedance earthed power systems.

5.1.1.1 Available versions

The following versions of the IED are available:

1. Three-phase version of the IED with two low-impedance differential protection zones and four three-phase CT inputs.
   - This version is available in 1/2 of 19” case. The version is intended for simpler applications such as T-connections, meshed corners and so on.
2. Three-phase version of the IED with two low-impedance differential protection zones and eight three-phase CT inputs.
   - This version is available in full 19” case. The version is intended for applications on smaller busbars, with up to two zones and eight CT inputs.
3. One-phase version of the IED with two low-impedance differential protection zones and twelve CT inputs.
   - This version is available in either 1/2 of 19” or full 19” case.
   - The IED in 1/2 of 19” case is intended for applications without need for dynamic Zone Selection. Typical examples are substations with single busbar with or without bus-section breaker, one-and-half breaker or double breaker arrangements. Three such IEDs offer cost effective solution for such simple substation arrangements with up to 12 CT inputs.
   - The IED in full 19” case is intended for applications in substation where dynamic Zone Selection or bigger number of binary inputs and outputs is needed. Such stations for example are double busbar station with or without transfer bus with up to 12 CT inputs.
   - This version can be optionally used with external auxiliary summation transformers.
4. One-phase version of the IED with two low-impedance differential protection zones and twenty-four CT inputs
   - This version is available in full 19” case. The IED is intended for busbar protection applications in big substation where dynamic Zone Selection, quite large number of binary inputs and outputs and many CT inputs are needed. The IED includes two differential zones and twenty-four CT inputs.
   - This version can be optionally used with external auxiliary summation transformers.

5.1.2 Principle of operation

Busbar differential protection detects internal faults within the station. In order to do that selectively it often incorporates more than one differential protection-measuring element. These differential protection-measuring elements are often called protection zones in relay protection literature. On the other hand, the protection function is quite specific, because typically all CTs in the station are connected to it. It is, therefore, of outmost importance that individually connected CT inputs are appropriately routed to the relevant protection zone. Sometimes these connections need to be dynamically changed in accordance with the actual connections within the station. Therefore, the busbar differential protection has two essential parts:

1. Differential Protection, which provide differential protection algorithm for each busbar section
2. Zone Selection, which provide dynamic linking between input CTs and individual protection zones as well as routing of zone trip signals to the individual bay CBs

It is also important to understand that all function blocks described in the next sections, except the Switch Status function block, are not independent from each other. Hidden connections are pre-made in the software in order to simplify the required engineering work in PCM600 for the end user.

5.1.3 Differential protection

This part of busbar protection consists of differential protection algorithm, sensitive differential protection algorithm, check zone algorithm, open CT algorithm and two supervision algorithms. It is presented to the end user as three function blocks:

1. Zone A
2. Zone B (functionality wise completely identical to the Zone A)
3. Check Zone

5.1.4 Differential Zone A or B BZNTPDIF, BZNSPDIF

The numerical, low-impedance differential protection function is designed for fast and selective protection for faults within protected zone. All connected CT inputs are provided with a restraint feature. The minimum pick-up value for the differential current is set to give a suitable sensitivity for all internal faults. For busbar protection applications typical setting value for the minimum differential operating current is from 50% to 150% of the biggest CT. This setting is made directly in primary amperes. The operating slope for the differential operating characteristic is fixed to 53% in the algorithm. The fast tripping time of the low-impedance differential protection function is especially advantages for power system networks with high fault levels or where fast fault clearance is required for power system stability. The advanced open CT detection algorithm detects instantly the open CT secondary circuits and prevents differential protection operation without any need for additional check zone.

Differential protection zones include a sensitive operational level. This sensitive operational level is designed to be able to detect internal busbar earth faults in low impedance earthed power systems (that is, power systems where the earth-fault current is limited to a certain level, typically between 300A and 2000A primary by a neutral point reactor or resistor). Alternatively, this sensitive level can be used when high sensitivity is required from busbar differential protection (that is, energizing of the bus via long line).

Overall operating characteristic of Busbar differential protection is shown in figure 49.

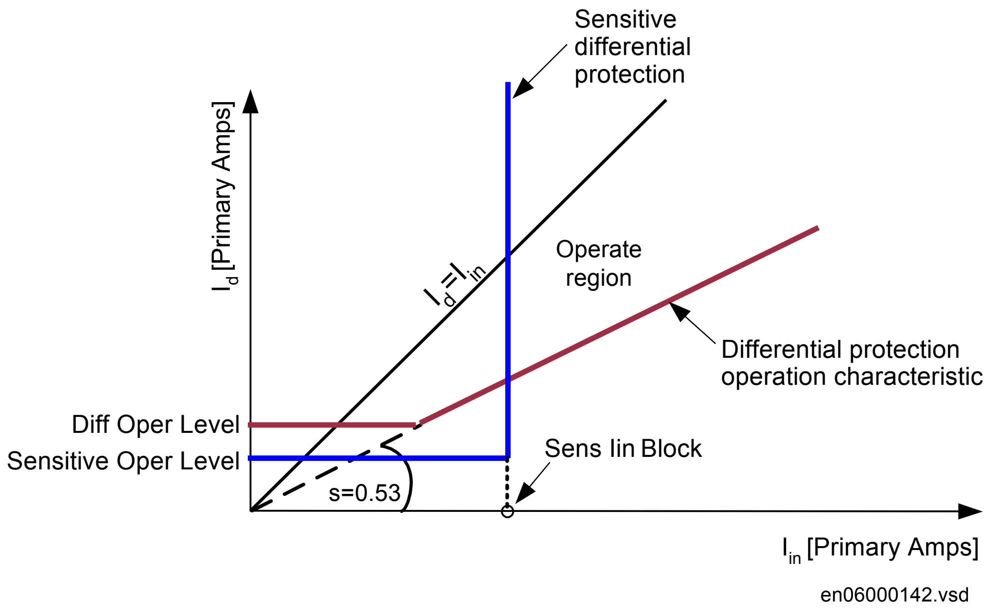

Figure 49: Operating characteristic

Where:

I_{in}	Iin represents the RMS value of the incoming current to the differential protection zone
I_d	Id represents the RMS value of the differential current of the differential protection zone
s = 0.53	the operating slope for the differential function is fixed to 0.53 in the algorithm and can not be changed by the user

5.1.4.1 Open CT detection

The innovative measuring algorithm provides stability for open or short-circuited main CT secondary circuits, which means that no separate check zone is actually necessary. Start current level for open CT detection can usually be set to detect the open circuit condition for the smallest CT. This built-in feature allows the protection terminal to be set very sensitive, even to a lower value than the maximum CT primary rating in the station. At detection of problems in CT secondary circuits, the differential protection can be instantly blocked and an alarm is given. Alternatively, the differential protection can be automatically desensitized in order to ensure busbar differential protection stability during normal through-load condition. When problems in CT secondary circuits have been found and associated error has been corrected a manual reset must be given to the IED. This can be done locally from the local HMI, or remotely via binary input or communication link.

However, it is to be noted that this feature can only be partly utilized when the summation principle is in use.

5.1.4.2 Differential protection supervision

Dual monitoring of differential protection status is available. The first monitoring feature operates after settable time delay when differential current is higher than the user settable level. This feature can be, for example, used to design automatic reset logic for previously described open CT detection feature. The second monitoring feature operates immediately when the busbar through-going current is bigger than the user settable level. Both of these monitoring features are phase segregated and they give out binary signals, which can be either used to trigger disturbance recorder or for alarming purposes.

5.1.4.3 Explanation of Zone function block

Detailed explanation of Zone function block inputs

- BLOCK, when this binary input has logical value one all trip commands from the zone are prevented
- BLKST, when this binary input has logical value one the differential protection within the zone is blocked (that is, can not operate)
- TRZONE, when this binary input has logical value one forced external trip will be given from the zone
- RSTTRIP, when this binary input has logical value one latched trip from the zone will be re-set back to zero. Whether zone trip is in Latched or SelfReset mode is defined by a parameter setting *DiffTripOut*
- RSTOCT, when this binary input has logical value one OCT latched signals and possible blocking will be re-set. It is to be noted that it is possible to do this only if the zone differential current has lower value then defined by a parameter *DiffOperLevel*
- ENSENS, when this binary input has logical value one the sensitive differential protection feature within the zone is allowed to operate in accordance with its settings (for example, connect here the start signal from open delta overvoltage relay in impedance grounded system)

Detailed explanation of Zone function block outputs

Fault condition/type	Check zone supervision	TRIP	TRIPLX	TREXTBAY	TREXTZ	TRSENS
I>DiffOperLevel	Off	Yes	Yes	-	-	-
BFP BU Trip	Off	Yes	Yes	Yes	-	-
TRZONE Input activated	Off	Yes	Yes	-	Yes	-
I>SensOperLevel + ENSENS activated	Off	Yes	Yes	-	-	Yes
I>DiffOperLevel without CheckZone operation	On	-	Yes	-	-	-
I>DiffOperLevel with CheckZone operation	On	Yes	Yes	-	-	-
BFP BU Trip	On	Yes	Yes	Yes	-	-
TRZONE Input activated	On	Yes	Yes	-	Yes	-
I>SensOperLevel + ENSENS activated	On	Yes	Yes	-	-	Yes

- TRIP, this binary output is used as general trip command from the zone. It is activated when either differential protection operates or sensitive differential protection operates or for any external trip signal (that is, either from the individual bays connected to the zone or via TRZONE input).
- TRIP_X, this binary output has logical value one whenever zone TRIP output signal is initiated (only available in 1Ph-version)
- TRIPL1, TRIPl2, TRIPL3, these binary outputs has logical value one whenever zone TRIP output signal is initiated (only available in 3Ph-version)
- TREXTBAY, this binary output has logical value one whenever zone TRIP output signal is initiated by operation of the external trip signal from one of the connected bays. In most cases this will in practice mean operation of back-up trip command from the breaker failure protection in that bay
- TREXTZ, this binary output has logical value one whenever zone TRIP output signal is initiated externally via input TRZONE
- TRSENS, this binary output has logical value one whenever zone TRIP output signal is initiated by operation of the sensitive differential protection algorithm (only available in 1Ph-version)
- TRSENSLx, this binary output has logical value one whenever zone TRIP output signal is initiated by operation of the sensitive differential protection algorithm in the corresponding phase (only available in 3Ph-version)
- OCT, this binary output is used as general Open CT detection signal from the zone. It is activated when either fast or slow OCT algorithm operates.

- SOCT, this binary output has logical value one whenever zone OCT output signal is initiated by operation of the slow OCT algorithm (only available in 1Ph-version)
- SOCTLx, this binary output has logical value one whenever zone OCT output signal is initiated by operation of the slow OCT algorithm in the corresponding phase (only available in 3Ph-version)
- FOCT, this binary output has logical value one whenever zone OCT output signal is initiated by operation of the fast OCT algorithm (only available in 1Ph-version)
- FOCTLx, this binary output has logical value one whenever zone OCT output signal is initiated by operation of the fast OCT algorithm in the corresponding phase (only available in 3Ph-version)
- ALDIFF, this binary output has logical value one whenever differential current supervision algorithm operates (only available in 1Ph-version)
- ALDIFFLx, this binary output has logical value one whenever differential current supervision algorithm operates in the corresponding phase (only available in 3Ph-version)
- ALIIN, this binary output has logical value one whenever incoming current supervision algorithm operates (only available in 1Ph-version)
- ALIINLx, this binary output has logical value one whenever incoming current supervision algorithm operates in the corresponding phase (only available in 3Ph-version)
- IIN_ZA, this output represents internally calculated RMS value of the incoming current. It can be connected to the disturbance recorder function in order to record it during external and internal faults (only available in 1Ph-version)
- IIN_ZALx, this output represents phase wise internally calculated RMS value of the incoming current. It can be connected to the disturbance recorder function in order to record it during external and internal faults (only available in 3Ph-version)
- IINRANGE, this output represents internally calculated RMS value of the incoming current. It can be connected to the measurement expander block for value reporting via IEC 61850 (only available in 1Ph-version)
- IINRNGLx, this output represents phase wise internally calculated RMS value of the incoming current. It can be connected to the measurement expander block for value reporting via IEC 61850 (only available in 3Ph-version)
- ID_ZA, this output represents internally calculated RMS value of the differential current. It can be connected to the disturbance recorder function in order to record it during external and internal faults (only available in 1Ph-version)
- ID_ZALx, this output represents phase wise internally calculated RMS value of the differential current. It can be connected to the disturbance recorder function in order to record it during external and internal faults (only available in 3Ph-version)
- IDRANGE, this output represents internally calculated RMS value of the differential current. It can be connected to the measurement expander block for value reporting via IEC 61850 (only available in 1Ph-version)

- IDRNGLx, this output represents phase wise internally calculated RMS value of the differential current. It can be connected to the measurement expander block for value reporting via IEC 61850 (only available in 3Ph-version)
- IDFRMS, this output represents internally calculated fundamental frequency RMS value of the differential current. It can be connected to the disturbance recorder function in order to record it during external and internal faults (only available in 1Ph-version)
- IDFRMSLx, this output represents phase wise internally calculated fundamental frequency RMS value of the differential current. It can be connected to the disturbance recorder function in order to record it during external and internal faults (only available in 3Ph-version)

Detailed explanation of Zone function block settings

- *Operation*: this setting determines whether the zone is in operation or out of operation. One of the following two alternatives shall be selected for every function block:
  1. *On*: when this mode is selected the zone is in operation
  2. *Off*: when this mode is selected the zone is out of operation
- *DiffOperLevel*: this setting determines the minimum start level for the differential feature. It shall be entered directly in primary amperes. Default value 1000A
- *DiffTripOut*: this setting determines how the trip output from the zone shall behave. One of the following two alternatives shall be selected for every function block:
  1. *SelfReset*: when this mode is selected the zone TRIP output will reset to logical value zero after the pre-set time determined by the setting parameter *tTripHold*.
  2. *Latched*: when this mode is selected the zone TRIP output will latched and it will require manual re-set command. This reset command can be given from local HMI or via communication link
- *tTripHold*: defines the drop-off time for the TRIP signal in the SelfReset mode of operation. Time delay can be set from 0.000s to 60.000s in step of 0.001s. Default value is 0.200s
- *CheckZoneSup*: this setting determines whether the busbar protection zone differential algorithm is supervised by the operation of the built-in Check Zone or not. One of the following two alternatives shall be selected for every function block:
  1. *On*: when this mode is selected the zone differential trip is supervised by the operation of the built-in Check Zone
  2. *Off*: when this mode is selected the zone differential trip is not supervised by the operation of the built-in Check Zone
- *SlowOCTOper*: this setting determines operation of the slow OCT algorithm. One of the following three alternatives shall be selected for every function block:

1. *Off*: when this mode is selected the slow OCT feature is completely disabled
2. *Block*: when this mode is selected the operation of the slow OCT feature completely blocks the operation of the differential protection. It shall be noted that this blocking is selective (that is, zone and phase wise)
3. *Supervise*: when this mode is selected the operation of the slow OCT feature only supervises the operation of the differential protection. As soon as differential current is bigger than the pre-set level determined by the setting parameter *OCTReleaseLev* the differential function will be again allowed to operate.

- *FastOCTOper*: this setting determines operation of the fast OCT algorithm. One of the following three alternatives shall be selected for every function block:
  1. *Off*: when this mode is selected the fast OCT feature is completely disabled
  2. *Block*: when this mode is selected the operation of the fast OCT feature completely blocks the operation of the differential protection. It shall be noted that this blocking is selective (that is, zone and phase wise)
  3. *Supervise*: when this mode is selected the operation of the fast OCT feature only supervises the operation of the differential protection. As soon as differential current is bigger than the pre-set level determined by the setting parameter *OCTReleaseLev* the differential function will be again allowed to operate
- *OCTOperLevel*: this setting determines the minimum start level for the slow and fast OCT feature. It shall be entered directly in primary amperes. Default value 200A.
- *tSlowOCT*: this delay on start timer is used in order to delay the action of the slow OCT algorithm. Time delay can be set from 0.00s to 6000.00s in step of 0.01s. Default value is 20.00s. Minimum setting should always be above 1 s
- *OCTReleaseLev*: this setting determines the differential current level above which the OCT feature will again allow the differential protection operation, when OCT feature is used in the *Supervise* mode of the operation. It is to be entered directly in primary amperes. Default value 2500A
- *IdAlarmLev*: this setting determines the differential current level above which the alarm is given after the pre-set time determined by the parameter setting *tIdAlarm*. It shall be entered directly in primary amperes. Default value 200A.
- *tIdAlarm*: this delay on start timer is used in order to delay the action of the differential alarm feature. Time delay can be set from 0.00s to 6000.00s in step of 0.01s. Default value is 30.00s
- *IinAlarmLev*: this setting determines the incoming current level (bus through-going current level) above which the alarm is given instantaneously. It is to be entered directly in primary amperes. Default value 3000A
- *SensDiffOper*: this setting determines operation of the sensitive differential algorithm. One of the following two alternatives is to be selected for every function block:

1. *On*: when this mode is selected the sensitive differential algorithm is in operation. Note that the input signal ENSENS must have logical value one in order to get operation from the sensitive differential algorithm
2. *Off*: when this mode is selected the sensitive differential algorithm is out of operation

- *SensOperLevel*: this setting determines the minimum start level for the sensitive differential algorithm. It shall be entered directly in primary amperes. Default value 200A.
- *SensIinBlock*: this setting determines the incoming current level (bus through-going current level) above which the sensitive differential algorithm is automatically blocked. It shall be entered directly in primary amperes. Default value 1000A
- *tSensDiff*: this delay on start timer is used in order to delay the action of the sensitive differential algorithm. Time delay can be set from 0.000s to 60.000s in step of 0.001s. Default value is 0.400s

5.1.4.4 Function block

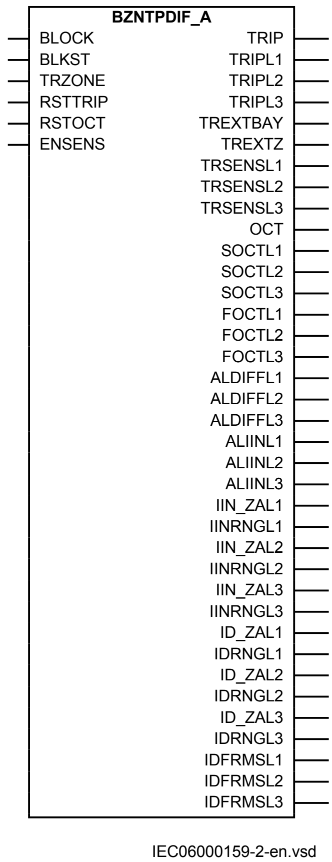

Figure 50: BZNTPDIF function block (Differential Zone A, 3ph). Also applicable for Differential Zone B, 3ph

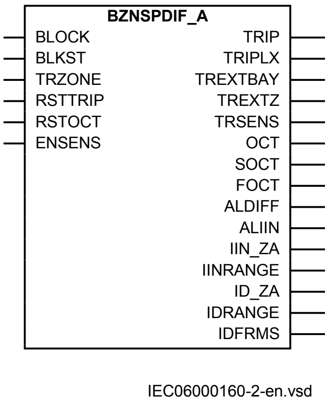

Figure 51: BZNSPDIF function block (Differential Zone A, 1ph). Also applicable for Differential Zone B, 1ph

5.1.4.5 Input and output signals

Table 55: BZNTPDIF_A Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block zone trip
BLKST	BOOLEAN	0	Block differential protection start
TRZONE	BOOLEAN	0	External zone trip
RSTTRIP	BOOLEAN	0	Reset latched zone trip
RSTOCT	BOOLEAN	0	Reset open CT alarm
ENSENS	BOOLEAN	0	Enable Sensitive Differential Protection

Table 56: BZNTPDIF_A Output signals

Name	Type	Description
TRIP	BOOLEAN	Zone A general trip
TRIPL1	BOOLEAN	Differential trip phase L1 Zone A
TRIPL2	BOOLEAN	Differential trip phase L2 Zone A
TRIPL3	BOOLEAN	Differential trip phase L3 Zone A
TREXTBAY	BOOLEAN	Zone A trip due to external trip from one of connected bays
TREXTZ	BOOLEAN	Zone A trip due to external input signal
TRSENSL1	BOOLEAN	Sensitive differential function trip phase L1 Zone A
TRSENSL2	BOOLEAN	Sensitive differential function trip phase L2 Zone A
TRSENSL3	BOOLEAN	Sensitive differential function trip phase L3 Zone A
OCT	BOOLEAN	General open CT alarm Zone A
SOCTL1	BOOLEAN	Open CT alarm from slow algorithm in phase L1 Zone A
Table continues on next page		

Name	Type	Description
SOCTL2	BOOLEAN	Open CT alarm from slow algorithm in phase L2 Zone A
SOCTL3	BOOLEAN	Open CT alarm from slow algorithm in phase L3 Zone A
FOCTL1	BOOLEAN	Open CT alarm from fast algorithm in phase L1 Zone A
FOCTL2	BOOLEAN	Open CT alarm from fast algorithm in phase L2 Zone A
FOCTL3	BOOLEAN	Open CT alarm from fast algorithm in phase L3 Zone A
ALDIFFL1	BOOLEAN	Differential current alarm in phase L1 Zone A
ALDIFFL2	BOOLEAN	Differential current alarm in phase L2 Zone A
ALDIFFL3	BOOLEAN	Differential current alarm in phase L3 Zone A
ALIINL1	BOOLEAN	Incoming current alarm in phase L1 Zone A
ALIINL2	BOOLEAN	Incoming current alarm in phase L2 Zone A
ALIINL3	BOOLEAN	Incoming current alarm in phase L3 Zone A
IIN_ZAL1	REAL	RMS incoming current L1, instantaneous value
IINRNGL1	INTEGER	RMS incoming current L1, range
IIN_ZAL2	REAL	RMS incoming current L2, instantaneous value
IINRNGL2	INTEGER	RMS incoming current L2, range
IIN_ZAL3	REAL	RMS incoming current L3, instantaneous value
IINRNGL3	INTEGER	RMS incoming current L3, range
ID_ZAL1	REAL	RMS differential current, instantaneous value
IDRNGL1	INTEGER	RMS differential current, range
ID_ZAL2	REAL	RMS differential current, instantaneous value
IDRNGL2	INTEGER	RMS differential current, range
ID_ZAL3	REAL	RMS differential current, instantaneous value
IDRNGL3	INTEGER	RMS differential current, range
IDFRMSL1	REAL	Fundamental Frequency Differential current Zone A
IDFRMSL2	REAL	Fundamental Frequency Differential current Zone A
IDFRMSL3	REAL	Fundamental Frequency Differential current Zone A

Table 57: BZNSPDIF_A Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block zone trip
BLKST	BOOLEAN	0	Block differential protection start
TRZONE	BOOLEAN	0	External zone trip
RSTTRIP	BOOLEAN	0	Reset latched zone trip
RSTOCT	BOOLEAN	0	Reset open CT alarm
ENSENS	BOOLEAN	0	Enable Sensitive Differential Protection

Table 58: BZNSPDIF_A Output signals

Name	Type	Description
TRIP	BOOLEAN	Zone A general trip
TRIPLX	BOOLEAN	Differential trip output Zone A
TREXTBAY	BOOLEAN	Zone A trip due to external trip from one of connected bays
TREXTZ	BOOLEAN	Zone A trip due to external input signal
TRSENS	BOOLEAN	Sensitive differential function trip Zone A
OCT	BOOLEAN	General open CT alarm Zone A
SOCT	BOOLEAN	Open CT alarm from slow algorithm Zone A
FOCT	BOOLEAN	Open CT alarm from fast algorithm Zone A
ALDIFF	BOOLEAN	Differential current alarm Zone A
ALIIN	BOOLEAN	Incoming current alarm Zone A
IIN_ZA	REAL	RMS incoming current, magnitude of instantaneous value
IINRANGE	INTEGER	RMS incoming current, range
ID_ZA	REAL	RMS differential current, magnitude of instantaneous value
IDRANGE	INTEGER	RMS differential current, range
IDFRMS	REAL	Fundamental Frequency Differential current Zone A

5.1.4.6 Setting parameters

All general settings for Busbar differential protection are only relevant for proper event reporting via IEC 61850-8-1. They are not important for proper operation of Busbar differential protection.

Note that all settings for busbar protection under relevant parameter setting group are directly related to proper operation of the Busbar differential protection.

Table 59: BZNTPDIF_A Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Differential protection operation
DiffOperLev	1 - 99999	A	1	1000	Differential protection operation level in primary amperes
DiffTripOut	SelfReset Latched	-	-	SelfReset	Differential protection trip output mode
tTripHold	0.000 - 60.000	s	0.001	0.200	Differential trip drop-off delay in SelfReset mode
CheckZoneSup	Off On	-	-	Off	Check zone supervises differential protection operation
SlowOCTOper	Off Block Supervise	-	-	Block	Operation of slow open CT alarm

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
FastOCTOper	Off Block Supervise	-	-	Block	Operation of fast open CT alarm
OCTOperLev	1 - 99999	A	1	200	Open CT operation level in primary amperes
tSlowOCT	0.00 - 6000.00	s	0.01	20.00	Time delay for slow open CT alarm
OCTReleaseLev	1 - 99999	A	1	2500	Id level above which OCT alarm releases in supervision mode
IdAlarmLev	1 - 99999	A	1	200	Differential current alarm level in primary amperes
tIdAlarm	0.00 - 6000.00	s	0.01	30.00	Time delay for Differential Current Alarm Level in sec.
IinAlarmLev	1 - 99999	A	1	3000	Incoming current alarm level in primary amperes
SensDiffOper	Off On	-	-	Off	Sensitive differential protection operation
SensOperLev	1 - 99999	A	1	200	Sensitive differential operation level in primary amperes
SensIinBlock	1 - 99999	A	1	1000	Iin level above which sensitive diff protection is blocked
tSensDiff	0.000 - 60.000	s	0.001	0.400	Time delay for sensitive differential function operation

Table 60: BZNTPDIF_A Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
IINL1 db	0 - 300	s,%,%s	1	10	Deadband value in % of range (in %s if integral is used)
IINL1 zeroDb	0 - 100000	-	1	500	Values less than this are forced to zero in 0,001% of range
IINL1 hhLim	0.000 - 10000000000.000	-	0.001	5000.000	High High limit
IINL1 hLim	0.000 - 10000000000.000	-	0.001	3000.000	High limit
IINL1 lLim	0.000 - 10000000000.000	-	0.001	100.000	Low limit
IINL1 llLim	0.000 - 10000000000.000	-	0.001	50.000	Low Low limit
IINL1 min	0.000 - 10000000000.000	-	0.001	25.000	Minimum value
IINL1 max	0.000 - 10000000000.000	-	0.001	6000.000	Maximum value
IINL1 dbType	Cyclic Dead band Int deadband	-	-	Dead band	Reporting type (0=cyclic, 1=db, 2=integral db)
IINL1 limHys	0.000 - 100.000	-	0.001	5.000	Hysteresis value in % of range and is common for all limits
IINL2 db	0 - 300	s,%,%s	1	10	Deadband value in % of range (in %s if integral is used)

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
IINL2 zeroDb	0 - 100000	-	1	500	Values less than this are forced to zero in 0,001% of range
IINL2 L2hhLim	0.000 - 10000000000.000	-	0.001	5000.000	High High limit
IINL2 hLim	0.000 - 10000000000.000	-	0.001	3000.000	High limit
IINL2 lLim	0.000 - 10000000000.000	-	0.001	100.000	Low limit
IINL2 llLim	0.000 - 10000000000.000	-	0.001	50.000	Low Low limit
IINL2 min	0.000 - 10000000000.000	-	0.001	25.000	Minimum value
IINL2 max	0.000 - 10000000000.000	-	0.001	6000.000	Maximum value
IINL2 dbType	Cyclic Dead band Int deadband	-	-	Dead band	Reporting type (0=cyclic, 1=db, 2=integral db)
IINL2 limHys	0.000 - 100.000	-	0.001	5.000	Hysteresis value in % of range and is common for all limits
IINL3 db	0 - 300	s,%,%s	1	10	Deadband value in % of range (in %s if integral is used)
IINL3 zeroDb	0 - 100000	-	1	500	Values less than this are forced to zero in 0,001% of range
IINL3 hhLim	0.000 - 10000000000.000	-	0.001	5000.000	High High limit
IINL3 hLim	0.000 - 10000000000.000	-	0.001	3000.000	High limit
IINL3 lLim	0.000 - 10000000000.000	-	0.001	100.00	Low limit
IINL3 llLim	0.000 - 10000000000.000	-	0.001	50.000	Low Low limit
IINL3 min	0.000 - 10000000000.000	-	0.001	25.000	Minimum value
IINL3 max	0.000 - 10000000000.000	-	0.001	6000.000	Maximum value
IINL3 dbType	Cyclic Dead band Int deadband	-	-	Dead band	Reporting type (0=cyclic, 1=db, 2=integral db)
IINL3 limHys	0.000 - 100.000	-	0.001	5.000	Hysteresis value in % of range and is common for all limits
IDL1 db	0 - 300	s,%,%s	1	10	Deadband value in % of range (in %s if integral is used)
IDL1 zeroDb	0 - 100000	-	1	500	Values less than this are forced to zero in 0,001% of range
IDL1 hhLim	0.000 - 10000000000.000	-	0.001	5000.000	High High limit
IDL1 hLim	0.000 - 10000000000.000	-	0.001	3000.000	High limit
IDL1 lLim	0.000 - 10000000000.000	-	0.001	100.000	Low limit

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
IDL1 llLim	0.000 - 10000000000.000	-	0.001	50.000	Low Low limit
IDL1 min	0.000 - 10000000000.000	-	0.001	25.000	Minimum value
IDL1 max	0.000 - 10000000000.000	-	0.001	6000.000	Maximum value
IDL1 dbType	Cyclic Dead band Int deadband	-	-	Dead band	Reporting type (0=cyclic, 1=db, 2=integral db)
IDL1 limHys	0.000 - 100.000	-	0.001	5.000	Hysteresis value in % of range and is common for all limits
IDL2 db	0 - 300	s,%,%s	1	10	Deadband value in % of range (in %s if integral is used)
IDL2 zeroDb	0 - 100000	-	1	500	Values less than this are forced to zero in 0,001% of range
IDL2 hhLim	0.000 - 10000000000.000	-	0.001	5000.000	High High limit
IDL2 hLim	0.000 - 10000000000.000	-	0.001	3000.000	High limit
IDL2 lLim	0.000 - 10000000000.000	-	0.001	100.000	Low limit
IDL2 llLim	0.000 - 10000000000.000	-	0.001	50.000	Low Low limit
IDL2 min	0.000 - 10000000000.000	-	0.001	25.000	Minimum value
IDL2 max	0.000 - 10000000000.000	-	0.001	6000.000	Maximum value
IDL2 dbType	Cyclic Dead band Int deadband	-	-	Dead band	Reporting type (0=cyclic, 1=db, 2=integral db)
IDL2 limHys	0.000 - 100.000	-	0.001	5.000	Hysteresis value in % of range and is common for all limits
IDL3 db	0 - 300	s,%,%s	1	10	Deadband value in % of range (in %s if integral is used)
IDL3 zeroDb	0 - 100000	-	1	500	Values less than this are forced to zero in 0,001% of range
IDL3 hhLim	0.000 - 10000000000.000	-	0.001	5000.000	High High limit
IDL3 hLim	0.000 - 10000000000.000	-	0.001	3000.000	High limit
IDL3 lLim	0.000 - 10000000000.000	-	0.001	100.000	Low limit
IDL3 llLim	0.000 - 10000000000.000	-	0.001	50.000	Low Low limit
IDL3 min	0.000 - 10000000000.000	-	0.001	25.000	Minimum value

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
IDL3 max	0.000 - 10000000000.000	-	0.001	6000.000	Maximum value
IDL3 dbType	Cyclic Dead band Int deadband	-	-	Dead band	Reporting type (0=cyclic, 1=db, 2=integral db)
IDL3 limHys	0.000 - 100.000	-	0.001	5.000	Hysteresis value in % of range and is common for all limits

Table 61: BZNSPDIF_A Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Differential protection operation
DiffOperLev	1 - 99999	A	1	1000	Differential protection operation level in primary amperes
DiffTripOut	SelfReset Latched	-	-	SelfReset	Differential protection trip output mode
tTripHold	0.000 - 60.000	s	0.001	0.200	Differential trip drop-off delay in SelfReset mode
CheckZoneSup	Off On	-	-	Off	Check zone supervises differential protection operation
SlowOCTOper	Off Block Supervise	-	-	Block	Operation of slow open CT alarm
FastOCTOper	Off Block Supervise	-	-	Block	Operation of fast open CT alarm
OCTOperLev	1 - 99999	A	1	200	Open CT operation level in primary amperes
tSlowOCT	0.00 - 6000.00	s	0.01	20.000	Time delay for slow open CT alarm
OCTReleaseLev	1 - 99999	A	1	2500	Id level above which OCT alarm releases in supervision mode
IdAlarmLev	1 - 99999	A	1	200	Differential current alarm level in primary amperes
tIdAlarm	0.00 - 6000.00	s	0.01	30.000	Time delay for Differential Current Alarm Level in sec.
IinAlarmLev	1 - 99999	A	1	3000	Incoming current alarm level in primary amperes
SensDiffOper	Off On	-	-	Off	Sensitive differential protection operation
SensOperLev	1 - 99999	A	1	200	Sensitive differential operation level in primary amperes
SensIinBlock	1 - 99999	A	1	1000	Iin level above which sensitive diff. protection is blocked
tSensDiff	0.000 - 60.000	s	0.001	0.400	Time delay for sensitive differential function operation

Table 62: BZNSPDIF_A Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
IIN db	0 - 300	s,%,%s	1	10	Deadband value in % of range (in %s if integral is used)
IIN zeroDb	0 - 100000	-	1	500	Values less than this are forced to zero in 0,001% of range
IIN hhLim	0.000 - 10000000000.000	-	0.001	5000.000	High High limit
IIN hLim	0.000 - 10000000000.000	-	0.001	3000.000	High limit
IIN lLim	0.000 - 10000000000.000	-	0.001	100.000	Low limit
IIN llLim	0.000 - 10000000000.000	-	0.001	50.000	Low Low limit
IIN min	0.000 - 10000000000.000	-	0.001	25.000	Minimum value
IIN max	0.000 - 10000000000.000	-	0.001	6000.000	Maximum value
IIN dbType	Cyclic Dead band Int deadband	-	-	Dead band	Reporting type (0=cyclic, 1=db, 2=integral db)
IIN limHys	0.000 - 100.000	-	0.001	5.000	Hysteresis value in % of range and is common for all limits
ID db	0 - 300	s,%,%s	1	10	Deadband value in % of range (in %s if integral is used)
ID zeroDb	0 - 100000	-	1	500	Values less than this are forced to zero in 0,001% of range
ID hhLim	0.000 - 10000000000.000	-	0.001	5000.000	High High limit
ID hLim	0.000 - 10000000000.000	-	0.001	3000.000	High limit
ID lLim	0.000 - 10000000000.000	-	0.001	100.000	Low limit
ID llLim	0.000 - 10000000000.000	-	0.001	50.000	Low Low limit
ID min	0.000 - 10000000000.000	-	0.001	25.000	Minimum value
ID max	0.000 - 10000000000.000	-	0.001	6000.000	Maximum value
ID dbType	Cyclic Dead band Int deadband	-	-	Dead band	Reporting type (0=cyclic, 1=db, 2=integral db)
ID limHys	0.000 - 100.000	-	0.001	5.000	Hysteresis value in % of range and is common for all limits

5.1.5 Calculation principles

5.1.5.1 General

The calculation of relevant quantities from the CT input values are performed by the IED and passed to the Busbar differential protection and open CT algorithm for further processing.

These calculations are completely phase-segregated. Therefore, they can be explained for one phase only. Calculations for other two phases are done in exactly the same way.

The prerequisites for correct calculations are:

- Sampling of all analog current inputs have to be done simultaneously
- Current samples have to be in primary amps
- All currents connected to the zone must be measured with same reference direction (that is, all towards the zone or all from the zone)

The instantaneous differential current is calculated as absolute value of the sum of all currents connected to the protection zone:

$$i_d = \left| \sum_{j=1}^{N} i_j \right|$$

(Equation 1)

Where:

i_d	instantaneous differential current (calculated from raw samples)
N	total number of bays connected to the protection zone
i_j	instantaneous current value (that is, latest sample value) for bay j

The sum of all latest current samples with positive value is made:

$$SP = \sum_{j=1}^{M} i_j$$

(Equation 2)

Where:

M	number of bays with positive value of the latest current sample (M<N)

as well as the absolute value of the sum of all latest negative current samples:

$$SN = \left| \sum_{j=M+1}^{N} i_j \right|$$

(Equation 3)

Now the instantaneous incoming and outgoing currents are calculated as follows:

$i_{in} = \max\{SP, SN\}$

$i_{out} = \min\{SP, SN\}$

All these quantities are calculated for every set of samples (that is, 20 times in one power system cycle in the IED). It is to be noted that all three quantities (that is, i_{in}, i_{out} & i_d) will be of a “DC” nature in time (that is, these quantities can only be positive). This means that the instantaneous incoming current during normal load condition looks like as the output of the full wave rectifier. Note that i_{in} is always bigger than or equal to i_{out}.

Figure 52 shows the comparison between above calculated quantities and REB103 (or RADSS) design:

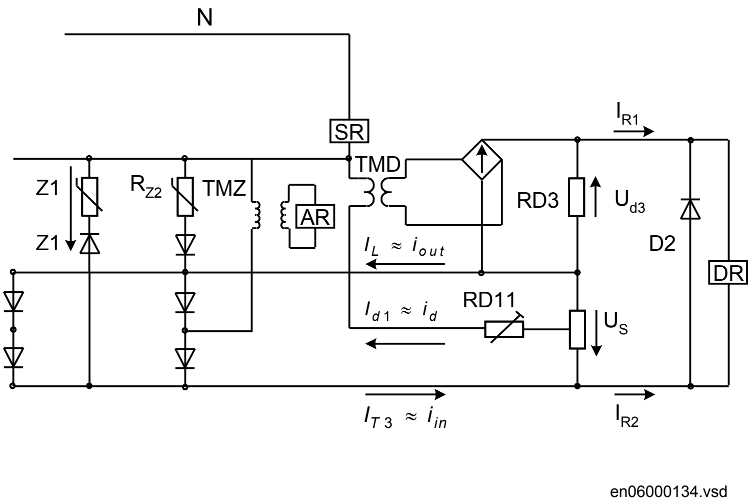

Figure 52: Comparison between i_{in}, i_{out} and i_d quantities inside REB670 and REB103 (or RADSS) analog design

Where:

i_{out}	instantaneous outgoing current from the zone of protection (calculated from raw samples)
i_d	instantaneous differential current (calculated from raw samples)
i_{in}	instantaneous incoming current into the zone of protection (calculated from raw samples)

This means that any differential protection zone in the IED can be represented as shown in figure 53, regardless the number of the connected feeders.

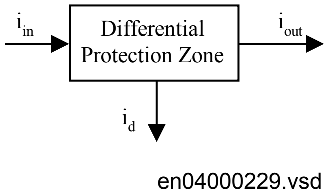

Figure 53: Differential zone representation

The instantaneous quantities are constantly changing in time, therefore, RMS values of the incoming, outgoing and differential currents (that is, Iin, Iout and Id respectively) are used in the algorithm. These quantities are calculated over last power system cycle (that is, 20ms long, moving window for 50Hz system). The only requirement for this type of calculation is that the last twenty samples of the instantaneous quantity must be stored in the IED internal memory. The calculated values of Iin and Id are available as service values on local HMI.

When all six values (that is, i_{in}, i_{out}, i_d, Iin, Iout and Id) are calculated, they are passed further to the general differential protection function and open CT algorithm for further processing to the differential and open CT algorithms.

CT saturation

Differential relays do not measure directly the primary currents in the high voltage conductors, but the secondary currents of magnetic core current transformers, which are installed in all high-voltage bays. Because the current transformer is a non-linear measuring device, under high current conditions in the primary CT circuit, the secondary CT current can be drastically different from the original primary current. This is caused by CT saturation, a phenomenon that is well known to protection engineers. This phenomenon is especially relevant for bus differential protection applications, because it has the tendency to cause unwanted operation of the differential relay.

Another difficulty is the large number of main CTs (that is, up to 24x3 for REB670 single phase and up to 8x3 CTs for REB670 three phase version) which can be connected to the differential IED. If the CT saturation has to be checked and preventive measures taken for every HV CT connected to the protection zone on one-by-one basis, the differential relay algorithm would be slow and quite complex. Therefore, only the properties of incoming, outgoing and differential currents are used in order to cope with CT saturation of any main CT connected to the IED as shown in figure 54.

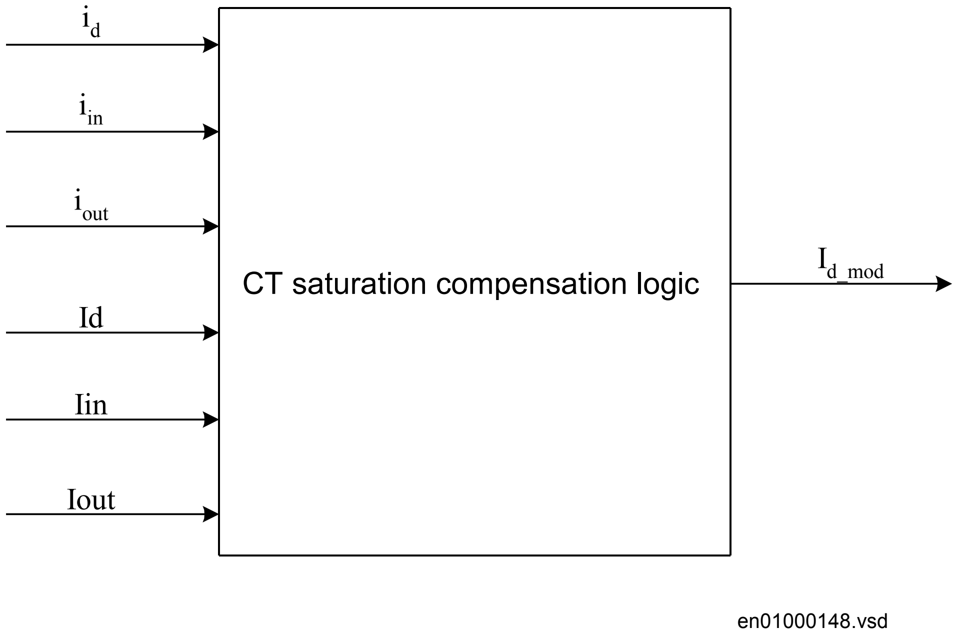

Figure 54: CT saturation compensation logic inside REB670 terminal

This CT saturation compensation logic effectively suppresses the false differential current by looking into properties of the six input quantities. Output of the logic is modified RMS value of the differential current Id_mod, which has quite small value during external faults followed by CT saturation or full Id value in case of an internal fault.

This logic incorporate a memory feature as well in order to cope with full CT remanence in the faulty overhead line bay in case of a high speed autoreclosing onto permanent fault.

By this approach a new, patented differential algorithm has been formed, which is completely stable for all external faults and operates very fast in case of an internal fault. All problems caused by the non-linearity of the CTs are solved in an innovative numerical way on the basic principles described above.

Tripping criteria

To provide reliable but fast differential protection, a multiple tripping criterion is implemented in the general differential protection function.

The main tripping criteria can be listed as follows:

- Minimum differential current level (Id >*DiffOperLev*)
- RMS tripping criteria (Id_mod >0.53 * Iin)
- Instantaneous tripping criteria based only on properties of iin, iout and id
- No pick-up of the Block binary input

- No operation of open CT algorithm
- Sensitive differential current level (Id>*SensOperLev*) which can be enable or disable.
- Check zone differential operation can also supervise the trip output signal. This feature can be enable or disabled.

These tripping conditions are then arranged in an AND gate in order to provide final trip signal to the binary output contacts of the terminal.

The trip from differential zone can be either latched or self rest in accordance with end user settings. Figure 55 shows the simplified internal trip logic for the busbar protection.

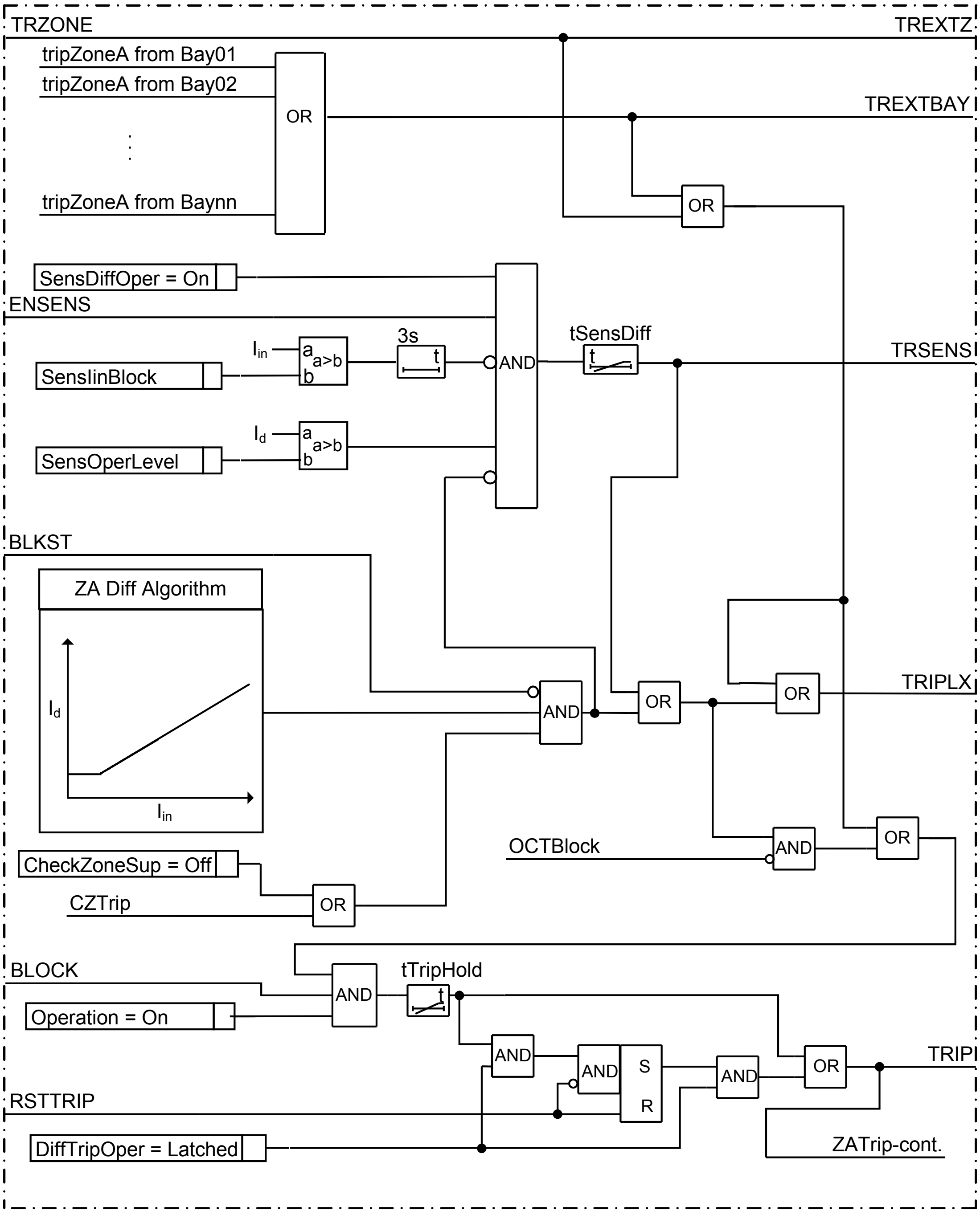

Figure 55: Simplified Zone internal trip logic for one phase

Dual monitoring of differential protection status is available. The first monitoring feature operates after settable time delay when differential current is higher than the user settable level. This feature can for example be used to design automatic reset logic for previously described open CT detection feature. The second monitoring feature operates immediately when the busbar through-going current is bigger than the user settable level. Both of these monitoring features are phase segregated and they give out binary signals, which can be either used to trigger disturbance recorder or for alarming purposes.

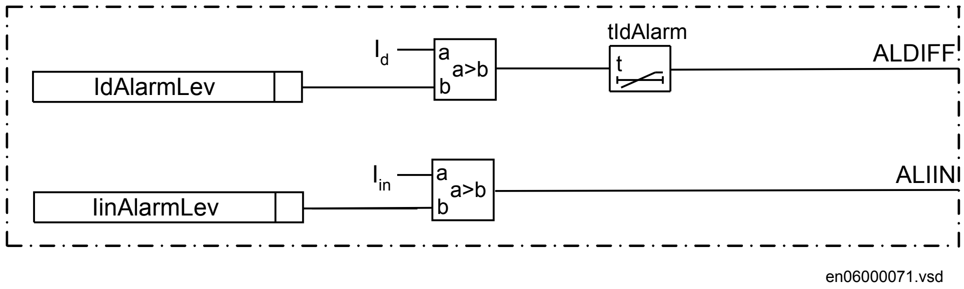

Figure 56: Simplified logic for Zone supervision features

5.1.5.2 Open CT detection

The three input quantities into the open CT detection algorithm are:

- Id = RMS value of the differential current
- Iin = RMS value of the incoming current
- Iout = RMS value of the outgoing current

It is to be noted that the open CT detection algorithm does not know the number of connected CT inputs into the IED.

The open CT detection algorithm is completely phase-segregated. Therefore, it is explained for one phase only.

Fast operating open CT detection logic instantly detects the moment when a healthy CT secondary circuit carrying the load current is accidently opened (that is, current interrupted to the differential relay). The logic is based on the perception that the total busbar through-load current is the same before and after that CT is open circuited.

In order to prevent false operation of this logic in case of a fault or disturbance in the power system, the total through-load current must not have big changes three seconds before the open CT condition is detected.

When one CT secondary circuit is open circuited during normal through-load condition one measuring point is lost and, therefore, the following should hold true:

- values of Iin and Iout were equal one cycle before
- value of Iin remains constant (that is, unchanged)
- value of Iout drops for more than pre-set value of *OCTOperLev*
- value of Id rises for more than pre-set value of *OCTOperLev*
- value of the sum Iout + Id is equal to value of Iin one cycle before

When all above conditions are simultaneously detected open CT condition is declared, the trip output of the affected phase is blocked and alarm output is set

It is to be noted that this logic can only detect an instant of time when an already connected CT with the secondary load current is open circuited. This logic do not detect, for example, the situation when a new bay is connected to the differential zone, but its CT secondary circuits are short circuited or open circuited.

Slow operating open CT detection logic will detect most abnormalities in the CT secondary circuits or in the Zone Selection logic, but with the time delay determined by setting parameter *tSlowOCT*. The logic is based on the perception that the values of Iin and Iout shall be equal during normal through-load situation.

This logic will operate when:

- there was not any big through-load current change during last five seconds
- value of Iin is much bigger than value of Iout (0.9·Iin > Iout)
- Id > *OCTOperLevel*

When these conditions are fulfilled for longer than time defined by the *tSlowOCT* parameter, the open CT condition is declared.

Note that the setting of *tSlowOCT* should always be longer than 1 s.

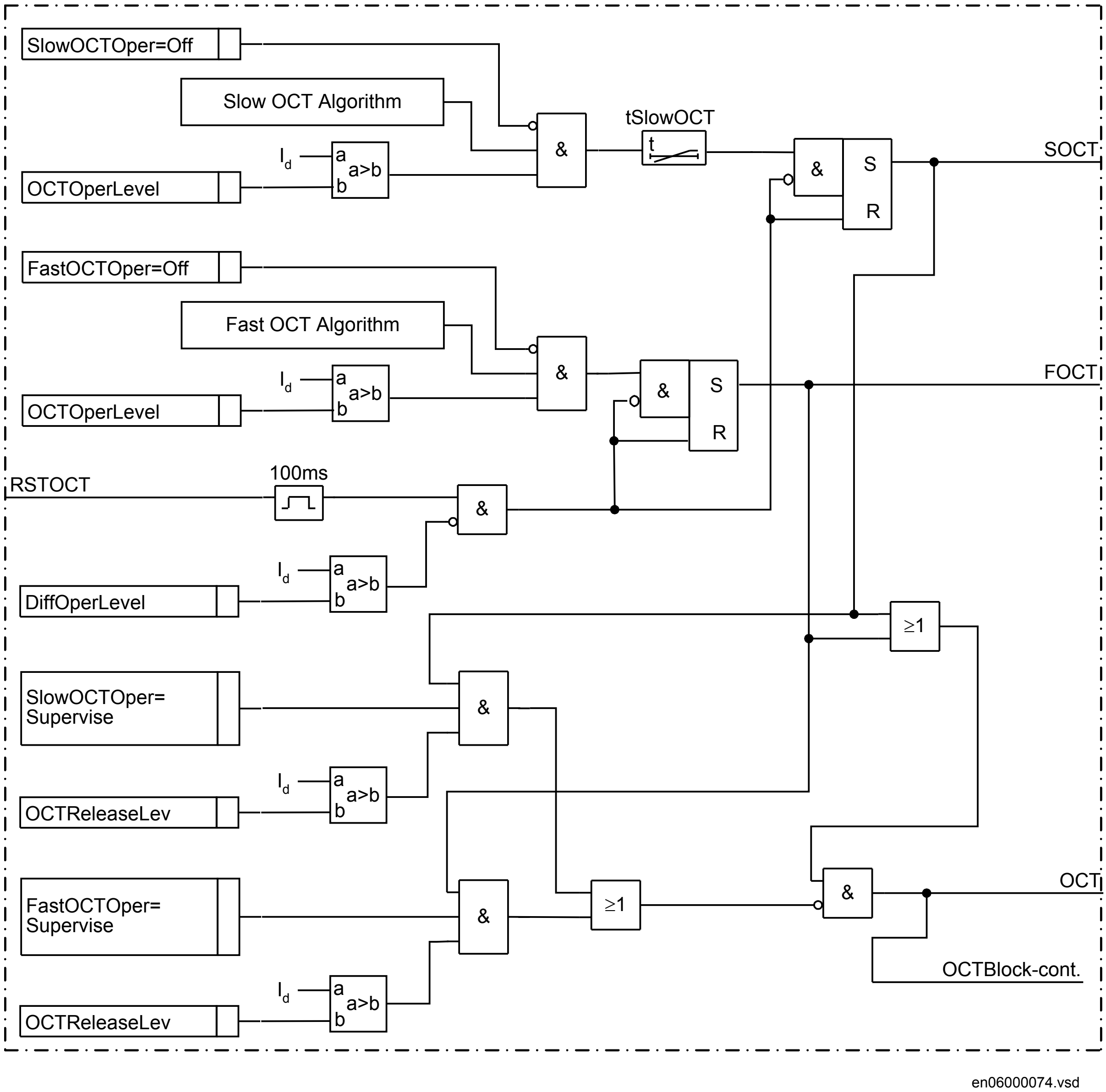

Figure 57: Simplified internal logic for fast and slow OCT features

5.1.6 Check zone BCZTPDIF, BCZSPDIF

5.1.6.1 Introduction

For busbar protection in double busbar stations when dynamic zone selection is needed, it is sometimes required to include the overall differential zone (that is, check zone). Hence, the built-in, overall check zone is available in the IED. Because the built-in check zone current measurement is not dependent on the disconnector status, this feature ensures stability of Busbar differential protection even for completely wrong status indication from the busbar disconnectors. It is to be noted that the overall check zone, only supervise the usual differential protection operation. The external trip commands, breaker failure backup-trip commands and sensitive differential protection operation are not supervised by the overall check zone.

The overall check zone has simple current operating algorithm, which ensures check zone operation for all internal faults regardless the fault current distribution. To achieve this, the outgoing current from the overall check zone is used as restraint quantity. If required, the check zone operation can be activated externally by a binary signal.

Operating characteristic of the check zone is shown in figure 58.

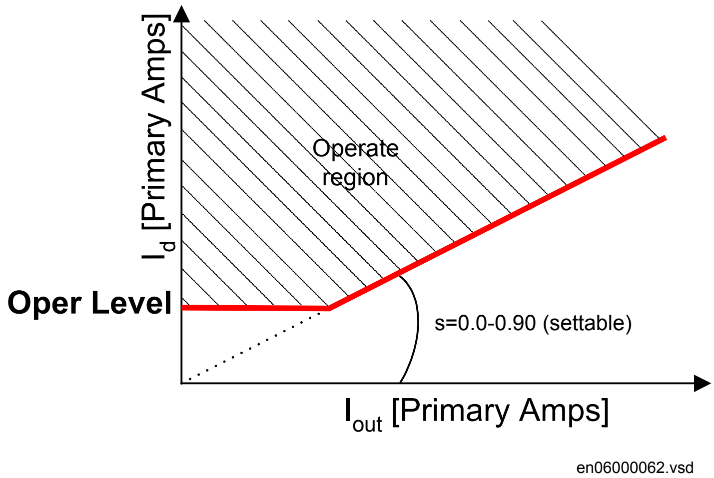

Figure 58: Check zone operating characteristic

5.1.6.2 Explanation of Check zone function block

Detailed explanation of Check Zone function block inputs

When EXTTRIP binary input has logical value one, operation of the check zone is forced (that is, TRIP output signal set to one). Therefore, this signal can be used to connect other release criteria (for example, start signal from external undervoltage IED) .

Detailed explanation of Check Zone function block outputs

- TRIP, this binary output is used as general trip command from the check zone. It is activated when either differential protection in check zone operates or when external signal EXTTRIP is set one.
- TR_x, this binary output has logical value one whenever check zone TRIP output signal is initiated by operation of the differential protection in the corresponding phase (only available in 3Ph-version)

Detailed explanation of Check Zone function block settings

- *Operation*, this setting determines whether check zone is in operation or out of operation. One of the following two alternatives is selected for every function block:
  1. *On*, when this mode is selected the check zone is enabled
  2. *Off*, when this mode is selected the check zone is out of operation
- *OperLevel*, this setting determines the minimum start level for the check zone. It shall be entered directly in primary amperes. Default value 1000A.
- *Slope*, this setting determines the slope of the check zone operating characteristic. It can be set from 0.00 to 0.90 in step of 0.01. Default value 0.15.

Check zone uses simple differential algorithm. Outgoing current is used for restraining in order to insure check zone operation for all internal faults.

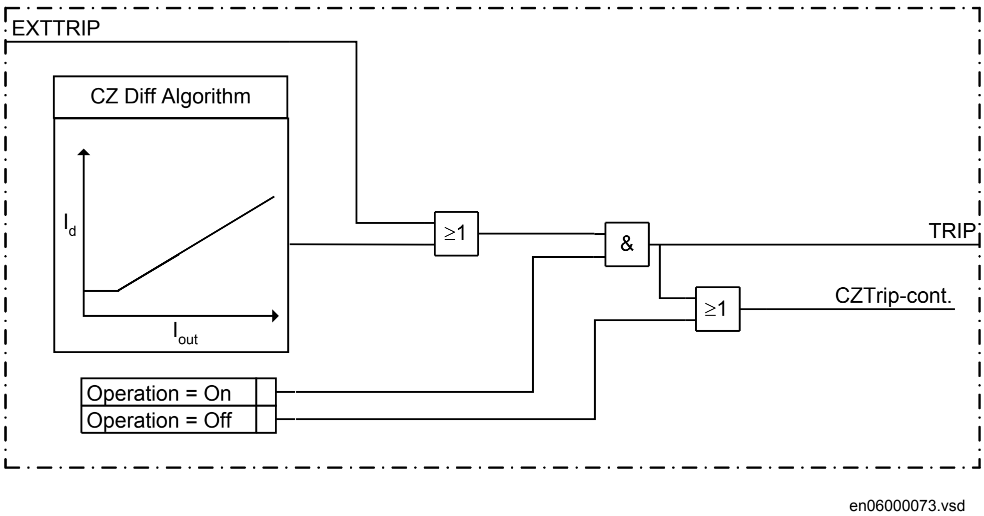

Figure 59: Simplified Check zone internal logic

5.1.6.3 Function block

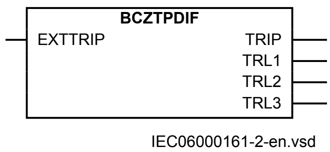

Figure 60: BCZTPDIF function block (Check zone, 3ph)

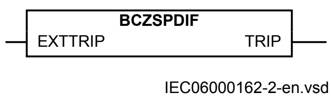

Figure 61: BCZSPDIF function block (Check zone, 1ph)

5.1.6.4 Input and output signals

Table 63: BCZTPDIF Input signals

Name	Type	Default	Description
EXTTRIP	BOOLEAN	0	External check zone trip

Table 64: BCZTPDIF Output signals

Name	Type	Description
TRIP	BOOLEAN	Check zone general trip
TRL1	BOOLEAN	Check zone trip phase L1
TRL2	BOOLEAN	Check zone trip phase L2
TRL3	BOOLEAN	Check zone trip phase L3

Table 65: BCZSPDIF Input signals

Name	Type	Default	Description
EXTTRIP	BOOLEAN	0	External check zone trip

Table 66: BCZSPDIF Output signals

Name	Type	Description
TRIP	BOOLEAN	Check zone general trip

5.1.6.5 Setting parameters

Table 67: BCZTPDIF Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Check zone operation
OperLevel	1 - 99999	A	1	1000	Check zone operation level in primary amperes
Slope	0.00 - 0.90	-	0.01	0.15	Check zone slope

Table 68: BCZSPDIF Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Check zone operation
OperLevel	0 - 99999	A	1	1000	Check zone operation level in primary amperes
Slope	0.00 - 0.90	-	0.01	0.15	Check zone slope

5.1.7 Zone selection

Typically CT secondary circuits from every bay in the station are connected to the busbar protection. The built-in software feature called “Zone Selection” gives a simple but efficient control over the connected CTs to busbar protection IED in order to provide fully operational differential protection scheme for multi-zone applications on both small and large buses.

Flexible, software based dynamic Zone Selection enables easy and fast adaptation to the most common substation arrangements such as single busbar with or without transfer bus, double busbar with or without transfer bus, one-and-a-half breakerbreaker-and-a-half stations, double busbar-double breaker stations, ring busbars and so on. The software based dynamic Zone Selections ensures:

1. Dynamic linking of measured CT currents to the appropriate differential protection zone as required by substation topology
2. Efficient merging of the two differential zones when required by substation topology (that is, zone interconnection)
3. Selective operation of busbar differential protection to ensure tripping only of circuit breakers connected to the faulty zone
4. Correct marshaling of backup-trip commands from internally integrated or external circuit breaker failure protections to all surrounding circuit breakers
5. Easy incorporation of bus-section and/or bus-coupler bays (that is, tie-breakers) with one or two sets of CTs into the protection scheme
6. Disconnector and/or circuit breaker status supervision

Zone Selection logic accompanied by optionally available end-fault and/or circuit breaker failure protections ensure minimum possible tripping time and selectivity for faults within the blind spot or the end zone between main CT and affiliated circuit breaker. Therefore, the IED offers best possible coverage for such faults in feeder and bus-section/bus-coupler bays.

The Zone Selection functionality consists of the following function blocks:

- Switch Status, for monitoring of disconnector/circuit breaker status
- Bay, which provide all necessary interface for one primary bay to/from busbar protection
- Zone Interconnection, which offer facility to effectively merge two zones when required

5.1.8 Switch status monitoring SWSGGIO

5.1.8.1 Introduction

For stations with complex primary layout (that is, double busbar single breaker station with or without transfer bus) the information about busbar disconnector position in every bay is crucial information for busbar protection. The positions of these disconnectors then actually determine which CT input (that is, bay) is connected to which differential protection zone. For some more advanced features like end-fault or blind-spot protection the actual status of the circuit breaker in some or even all bays can be vital information for busbar protection as well. The switch function block is used to take the status of two auxiliary contacts from the primary device, evaluate them and then to deliver the device primary contact position to the rest of the zone selection logic.

For such applications typically two auxiliary contacts (that is, normally open and normally closed auxiliary contacts) from each relevant primary switching object shall be connected to the IED. Then the status for every individual primary switching object will be determined. The dedicated function block for each primary switching object is available in order to determine the status of the object primary contacts. By a parameter setting one of the following two logical schemes can be selected for each primary object individually by the end user:

- If not open then closed (that is, as in RADSS schemes)
- Open or closed only when clearly indicated by aux contact status (that is, as in INX schemes)

Table 69 gives quick overview about both schemes.

Note that the first scheme only requires fast breaking normally closed auxiliary contact (that is, b contact) for proper operation. The timing of normally open auxiliary contact is not critical because it is only used for supervision of the primary object status. The second scheme in addition requires properly timed-adjusted, early-making normally open auxiliary contact (that is, early making a contact) for proper operation.

Regardless which scheme is used the time-delayed disconnector/circuit breaker status supervision alarm is available (that is, 00 or 11 auxiliary contact status). How two integrated differential protection zones behave when disconnector alarm appears is freely configurable by the end user.

It is possible by a parameter setting to override the primary object status as either permanently open or permanently closed. This feature can be useful during testing, installation and commissioning of the busbar protection scheme. At the same time, separate alarm is given to indicate that the actual object status is overwritten by a setting parameter.

It is to be noted that it is as well possible to use only normally closed auxiliary contacts for Zone Selection logic. In that case the Switch function blocks are not used.

Table 69: Treatment of primary object auxiliary contact status

Primary equipment		Status in busbar protection		Alarm facility	
Normally Open auxiliary contact status (that is, “closed” or “a” contact)	Normally Closed auxiliary contact status (that is, “open” or “b” contact)	when “Scheme 1 RADSS” is selected	when “Scheme 2 INX” is selected	Alarm after settable time delay	Information visible on local HMI
open	open	closed	Last position saved	yes	intermediate_00
open	closed	open	open	no	open
closed	open	closed	closed	no	closed
closed	closed	closed	closed	yes	badState_11

5.1.8.2 Explanation of Switch status monitoring function block

Inputs

- DISABLE, when this binary input has logical value zero function works in accordance with the selected scheme (see setting *OperMode*). When this binary input has logical value one, OPEN and CLOSED outputs from the function are unconditionally set to logical value zero. All other outputs work as usual.
- NO, to this binary input normally open (that is, ”closed” or “a” contact) of the primary switching object shall be connected
- NC, to this binary input normally closed (that is, ”OPEN” or “b” contact) of the primary switching object shall be connected.

Outputs

- CLOSED, this binary output has logical value one when the internal logic determines that the primary object is closed (for more information about available logical schemes, refer to table 69)
- OPEN, this binary output has logical value one when the internal logic determines that the primary object is open (for more info about available logical schemes, refer to table 69)
- ALARM, this binary output has logical value one when pre-set timer set under setting *tAlarm* expires and the auxiliary contacts still have illegal status (that is, 00 or 11)
- FORCED, this binary output has logical value zero when the object status is forced via parameter setting *OperMode*

Settings

- *SwitchName*, this setting is only a string with user definable free, descriptive text to designate particular primary switching object in the station in order to make easier identification of the relevant primary object in the

SwitchgearStatus matrix on the local HMI. The string can be up to thirteen characters long.

- *OperMode*, this setting determines the operating logic used within the function block. One of the following five alternatives shall be selected for every function block
  1. *Off*, when this mode is selected the entire function block is switched off (that is, de-activated)
  2. *Scheme1_RADSS*, when this mode is selected the internal logic behaves as described in table 69/row 3. Note that this logical scheme has the minimal requirements regarding the auxiliary contacts timing. It is recommended scheme to be used, especially to determine the circuit breaker status
  3. *Scheme2_INX*, when this mode is selected the internal logic behaves as described in table 69/row 4. Note that this logical scheme has increased requirements regarding the auxiliary contacts timing, especially for normally open (that is, a contact), as explained intable 69.
  4. *ForceOpen*, when this mode is selected the internal logic consider the primary object as open regardless the status of the auxiliary contacts. However, note that ALARM output will still work as usual and that FORCED binary output will be unconditionally set to one
  5. *ForceClosed*, when this mode is selected the internal logic consider the primary object as closed regardless the actual status of the auxiliary contacts. However, note that ALARM output will still work as usual and that FORCED binary output will be unconditionally set to one
- *tAlarm*, this delay on start timer is used in order to give an alarm output when illegal status of auxiliary input contacts (that is, 00 or 11) is given to the function. Timer can be set from 0.00s to 6000.00s in step of 0.01s. Default value is 15.00s.

5.1.8.3 Function block

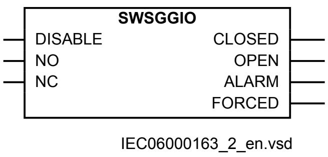

Figure 62: SWSGGIO function block

5.1.8.4 Input and output signals

Table 70: SWSGGIO Input signals

Name	Type	Default	Description
DISABLE	BOOLEAN	0	OPEN & CLOSED outputs are both set unconditionally to zero
NO	BOOLEAN	0	Connect normally open auxiliary contact (a contact) here
NC	BOOLEAN	0	Connect normally closed auxiliary contact (b contact) here

Table 71: SWSGGIO Output signals

Name	Type	Description
CLOSED	BOOLEAN	Indicates that primary object is closed
OPEN	BOOLEAN	Indicates that primary object is open
ALARM	BOOLEAN	Delayed alarm for abnormal aux. contact status, 00 or 11
FORCED	BOOLEAN	Primary object status forced to open or closed by setting

5.1.8.5 Setting parameters

Table 72: SWSGGIO Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
OperMode	Off Scheme1_RADSS Scheme2_INX ForceOpen ForceClosed	-	-	Off	Switch operating mode (Scheme 1, Scheme 2 or forced)
tAlarm	0.00 - 6000.00	s	0.01	15.00	Alarm time delay for abnormal aux. contact status

Table 73: SWSGGIO Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
SwitchName	0 - 13	-	1	Switch#	User defined name for switch

5.1.9 Bay BUTPTRC, BUSPTRC

5.1.9.1 Introduction

Each CT input is allocated to one dedicated bay function block. This function block is used to provide complete user interface for all signals from and towards this bay. It is also used to influence bay measured current.

In order to guarantee proper operation of the IED, the first instance of Bay function block must always be used in the configuration.

It is possible by a parameter setting *CTConnection* to connect or disconnect the CT input to the bay function block. Once the CT input is connected to the bay function block this associated current input can be included to or excluded from the two internally available differential functions in software. This can be done by a parameter setting for simple station layouts (that is, one-and-a-half breaker stations) or alternatively via dedicated logical scheme (that is, double busbar stations). For each bay the end user have to select one of the following five alternatives:

- Permanently connect this bay current to zone A (that is, ZA)
- Permanently connect this bay current to zone B (that is, ZB)
- Permanently connect this bay current to zone A and inverted bay current to ZB (that is, ZA and ZB)
- Connect this bay current to ZA or ZB depending on the logical status of the two input binary signals available on this bay function block. These two input signals will include measured current to the respective zone when their logical value is one (that is, *CntrlIncludes*). This option is used together with above described Switch function blocks in order to provide complete Zone Selection logic
- Connect the bay current to ZA or ZB depending on the logical status of the two input binary signals available on this bay function block. These two signals will include measured current to the respective zone when their logical value is zero (that is, *CntrlExcludes*). This option is typically used when only normally closed auxiliary contacts from the busbar disconnector are available to the Zone Selection logic

At the same time, an additional feature for instantaneous or time delayed disconnection or even inversion of the connected bay current via separate logical signals is also available. This feature is provided in order to facilitate for bus-section or bus-coupler CT disconnection for tie-breakers with a CT only on one side of the circuit breaker. This ensures correct and fast fault clearance of faults between the CT and the circuit breaker within these bays. The same feature can be individually used in any feeder bay to optimize Busbar differential protection performance, when feeder circuit breaker is open. Thus, the end-fault protection for faults between circuit breaker and the CT is available. However, to use this feature circuit breaker auxiliary contacts and closing command to the circuit breaker shall be wired to the binary inputs of the IED. Therefore, he IED offers best possible coverage for these special faults between CT and circuit breaker in feeder and bus-section/bus-coupler bays.

Within the Bay function block it is decided by a parameter setting how this bay should behave during zone interconnection (that is, load transfer). For each bay individually one of the following three options can be selected:

- Bay current is forced out from both zones during zone interconnection (used for bus-coupler bays)
- Bay current is unconditionally forced into both zones during zone interconnection (used in special applications)
- Bay current is connected to both zones during zone interconnection if the bay was previously connected to one of the two zones (typically used for feeder bays)

The third option ensures that the feeder, which is out of service, is not connected to any of the two zones during zone interconnection.

Within the Bay function block it is decided by a parameter setting whether this bay should be connected to the check zone or not. In this way the end user has simple control over the bays, which shall be connected to the overall check zone.

By appropriate configuration logic it is possible to take any bay (that is, CT input) out of service. This can be done from the local HMI or externally via binary signal. In that case all internal current measuring functions (that is, differential protection, sensitive differential protection, check zone, breaker failure protection and overcurrent protection) are disabled. At the same time, any trip command to this bay circuit breaker can be inhibited.

Via two dedicated binary input signals it is possible to:

- Trip only the bay circuit breaker (used for integrated OC protection tripping)
- Trip the whole differential zone to which this bay is presently connected (used for backup-trip command from either integrated or external bay circuit breaker failure protection)

Finally dedicated trip binary output from the Bay function block is available in order to provide common trip signal to the bay circuit breaker from busbar differential protection, breaker failure protection, backup overcurrent protection and so on.

In this way the interface to the user is kept as simple as possible and IED engineering work is quite straight forward.

5.1.9.2 Explanation of Bay function block

Inputs

- I3PB1, 3ph CT input; applicable for 3-phase version of the terminal
- ISI1, 1ph CT input; applicable for 1-phase version of the terminal
- BLKTR, when this binary input has logical value one all trip commands from the bay function block are prevented including busbar protection, breaker failure and external trip commands
- CTRLZA, this binary input is used to control the bay CT connection to the differential zone A. Note that the status of this binary input is considered ONLY if the value of setting parameter *ZoneSel* is either

    - *CtrlIncludes* when logical value one of this input will include current to zone A, or
    - *CtrlExcludes* when logical value zero of this input will include current to zone A
- CTRLZB, this binary input is used to control the bay CT connection to the differential zone B. Note that the status of this binary input is considered ONLY if the value of setting parameter *ZoneSel* is either
    - *CtrlIncludes* when logical value one of this input will include current to zone B, or
    - *CtrlExcludes* when logical value zero of this input will include current to zone B
- ZEROCUR, when this binary input has logical value one the bay CT current is unconditionally forced to zero (that is, internally multiplied with zero) after the internal delay on start timer has expired. The time delay is determined by setting parameter *tZeroCurrent*. Note that the zero current value will be given to all differential zones, including the check zone, to which this bay is currently connected
- INVCUR, when this binary input has logical value one the bay CT current will be inverted (that is, internally multiplied with –1) after the internal delay on start timer has expired. The time delay is determined by setting parameter *tInvertCurrent*. Note that the inverted current value will be given to all differential zones, including the check zone, to which this bay is currently connected. However, it shall be noted that the INVCUR input has lower priority than the ZEROCUR input. This means that, when both of them simultaneously have logical value one, and both timers have expired, the bay CT current will be forced to zero.
- TRZONE, when this binary input has logical value one the trip signal will be sent to the differential zone to which this bay is currently connected. As a consequence all bays connected to that zone will receive the trip signal. To this input the breaker failure protection backup trip command for this bay is typically connected. This will insure that all breakers connected to the same zone with the failed breaker will be tripped. Note that this tripping is not supervised by the Check Zone operation, in application where Check Zone is enabled.
- TRBAY, when this binary input has logical value one the output TRIP signal from the same function block will be activated. In this way only the bay circuit breaker is tripped. No any other breaker in the station will receive this trip command. This input is used to give backup overcurrent trip command to the bay CB.

Outputs

- TRIP, this binary output shall be used as dedicated three-phase trip command to the bay circuit breaker. It will be activated when the differential zone, to which this bay is currently connected, operates for internal fault, or in case of breaker failure in some other bay connected to the same zone (see description for input TRZONE). It operates when external trip signal is given to this bay (see description for input TRBAY).

- CONNZA, this binary output has logical value one whenever this bay CT is connected to zone A
- CONNZB, this binary output has logical value one whenever this bay CT is connected to zone B
- CONNBAY, this is not a binary output. It has integer value between 1 and 9 and is used in order to display actual “BayConnections” information on the local HMI.

Settings

- *BAYnn*, this setting is only a string with user definable free, descriptive text to designate particular primary bay in the station in order to make easier bay identification on the BayConnections matrix on the local HMI. The string can be up to thirteen characters long.
- *CTConnection*, this setting determines how the hardware CT input is connected to bay function block in software. One of the following three alternatives shall be selected for every function block:
    1. *NotConnected*, when this mode is selected the hardware CT input is disconnected from the bay function block in software. This setting shall be used for spare CT inputs in the IED or for a CT inputs where only for example, breaker failure protection is required (that is, for middle breaker in one and half breaker configuration)
    2. *Connected*, when this mode is selected the hardware CT input is connected to the bay function block in software. This is normal setting for a CT input which is used for busbar protection
    3. *Conn Inverted*, when this mode is selected the hardware CT input is connected to the bay function block in software, but the CT current is inverted (that is, multiplied with –1). This is used only in special applications.
- *ZoneSel*, this setting determines how the bay CT input connection to the differential zones is controlled within the IED internal logic. One of the five alternatives listed below shall be selected for every function block. *CtrlIncludes* and *CtrlExcludes* are typically used for feeder bays in double busbar-single breaker stations where dynamic connections between CT and differential zones are required. It shall be noted that when one of the last two modes are selected and in the same time the operation of the Zone Interconnection function block is set to "On" the zone interconnection (that is, merging between ZA & ZB) will be automatically started as soon as the bay is connected to both zones simultaneously (that is, zone interconnection on a feeder bay).
    1. *FixedToZA*, when this mode is selected the bay CT input is always connected to the differential zone A. This is for example used for simple busbar configurations where dynamic connections between CTs and

differential zones are not required (that is, single zone, double bus-double breaker or one and a half breaker stations)
2. *FixedToZB*, when this mode is selected the bay CT input is always connected to the differential zone B. This is for example used for simple busbar configurations where dynamic connections between CTs and differential zones are not required (that is, double bus-double breaker or one and a half breaker stations)
3. *FixedToZA&-ZB*, when this mode is selected the bay CT input is always connected to the differential zone A and its inverted value to the differential zone B. This is for example used for bus-tie bays with just one set of main CT. In this way the same current is easily given to both differential zones. It shall be noted that the CT staring shall be set with respect to zone A.
4. *CtrlIncludes*, when this mode is selected the bay CT input will be: **connected to zone A** when binary input CTRLZA into the function block have logical value one **connected to zone B** when binary input CTRLZB into the function block have logical value one
5. *CtrlExcludes*, when this mode is selected the bay CT input will be: **connected to zone A** when binary input CTRLZA into the function block have logical value zero **connected to zone B** when binary input CTRLZB into the function block have logical value zero

- *ZoneSwitching*, this setting determines how the bay CT shall behave when zone interconnection is active (that is, merging between ZA & ZB). One of the following three alternatives shall be selected for every function block:
  1. *ForceOut*, when this mode is selected the bay CT input is unconditionally disconnected from both differential zones when zone interconnection feature is active. This setting is typically used for bus-coupler bay in double busbar stations.
  2. *ForceIn*, when this mode is selected the bay CT input is unconditionally connected to both differential zones when zone interconnection feature is active.
  3. *Conditionally*, when this mode is selected the bay CT input is connected to both differential zones when zone interconnection feature is active if it was previously connected to at least one of them. This setting is typically used for feeder bays in double busbar-single breaker stations, and for all spare/future bays.
- *CheckZoneSel*, this setting determines the bay CT input connection towards the check zone. One of the following two alternatives shall be selected for every function block:
  1. *NotConnected*, when this mode is selected the bay CT input is not connected to the overall check zone. This setting is typically used for bus-coupler bay in double busbar-single breaker stations.
  2. *Connected*, when this mode is selected the bay CT input is connected to the overall check zone. This setting is typically used for feeder bays in double busbar-single breaker stations.

- *tTripPulse*, this pulse timer is used in order to guaranty minimum trip pulse duration from the bay function block. Pulse time can be set from 0.000s to 60.000s in step of 0.001s. Default value is 0.200s.
- *tZeroCurrent*, this delay on start timer is used in order to unconditionally force bay current to zero when ZEROCUR input into the function block has logical value one. Time delay can be set from 0.000s to 60.000s in step of 0.001s. Default value is 0.200s.
- *tInvertCurrent*, this delay on start timer is used in order to invert bay current when INVCUR input into the function block has logical value one. Time delay can be set from 0.000s to 60.000s in step of 0.001s. Default value is 0.200s.

5.1.9.3 Bay operation principles

In order to have properly balanced differential function for the station busbar disconnector switching arrangements, it is important to properly configure the zone selection data for every connected current transformer. Due to this configuration parameter, the IED allows an effective application for stations where the zone selection (that is, CT switching) is required. This is possible due to the software facility to have full and easy control over all CT inputs connected to the terminal. The philosophy is to allow every CT input to be individually controlled by a setting parameter.

The setting parameters for the differential protection function (DFB) are set via the local HMI or PCM600. See the technical reference manual for setting parameters and path in local HMI.

Description of bay connection

The setting parameter for bay connection called *ZoneSel* can be individually set for every CT. *ZoneSel* can be set to only one of the following five alternatives:

- *FixedToZA*, the CTx will be fixed to zone A.
- *FixedToZB*, the CTx will be fixed to zone B.
- *FixedToZA&-ZB*, the CTx is included to zone A and invert included to zone B.
- *CtrlIncludes*, the CTx will be included to zone A/zone B when the input signal CTRLZA/CTRLZB is TRUE.
- *CtrlExcludes*, the CTx will be included to zone A/zone B when the input signal CTRLZA/CTRLZB is FALSE (see figure 63).

When the last two options are used the CT input can be dynamically included or excluded from the differential zone by simply controlling the dedicated inputs of the Bay function block.

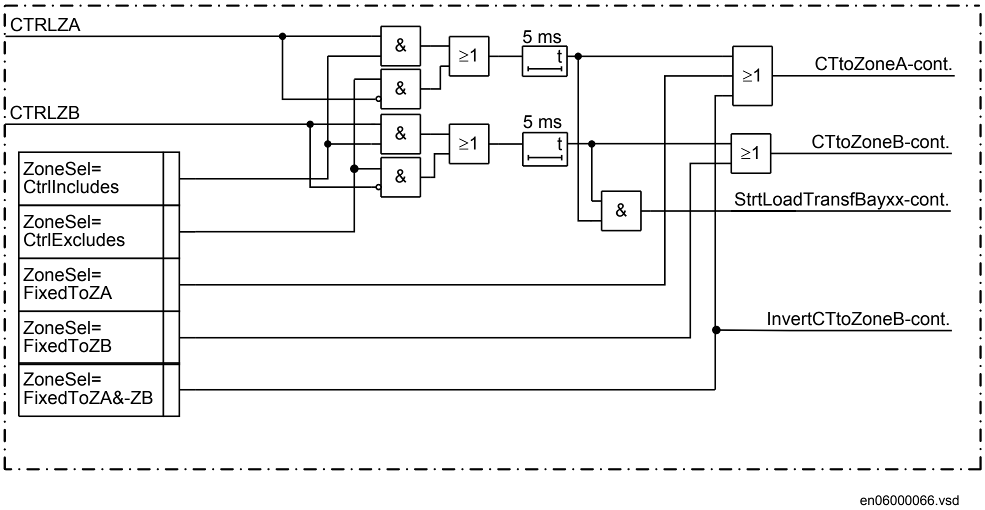

Figure 63: Zone selection logic

Description of invert current and forcing current to zero

This logic is intended for binary input signals that give possibility to force current to zero or invert the current. Two settable delays on timer *tZeroCurrent* and *tInvertCurrent* are also implemented making sure that the right decision is taken, see figure 64.

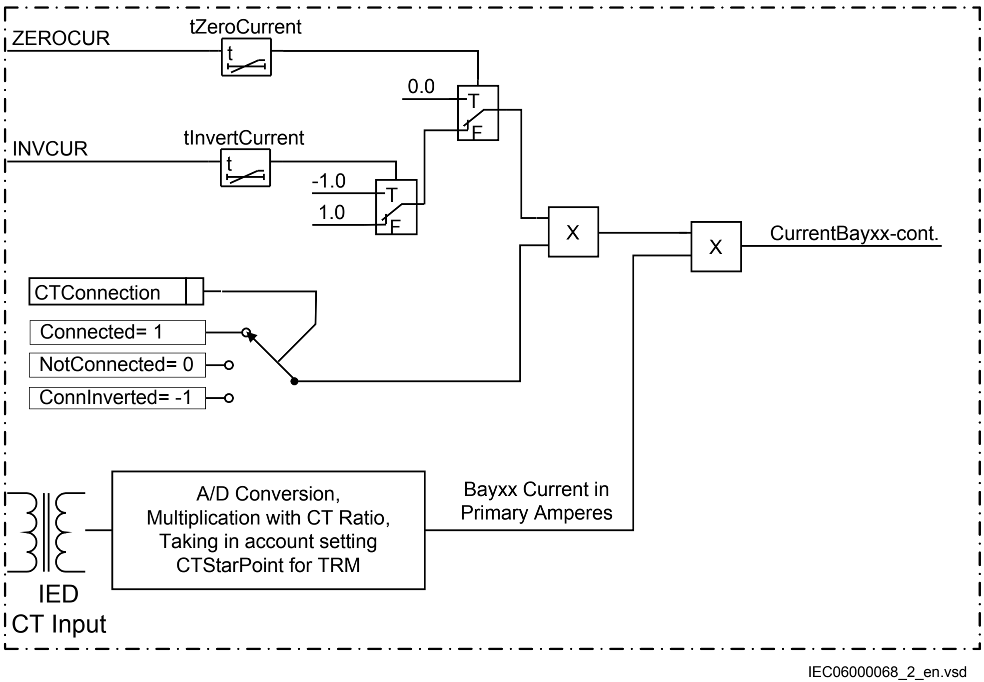

Figure 64: Overall CT status

Description of Zone interconnection and Check zone selection influence on Zone selection

Figure 65 shows influence of zone interconnection feature and check zone selection on overall zone selection logic. At the same time influence on TRZONE binary input is shown.

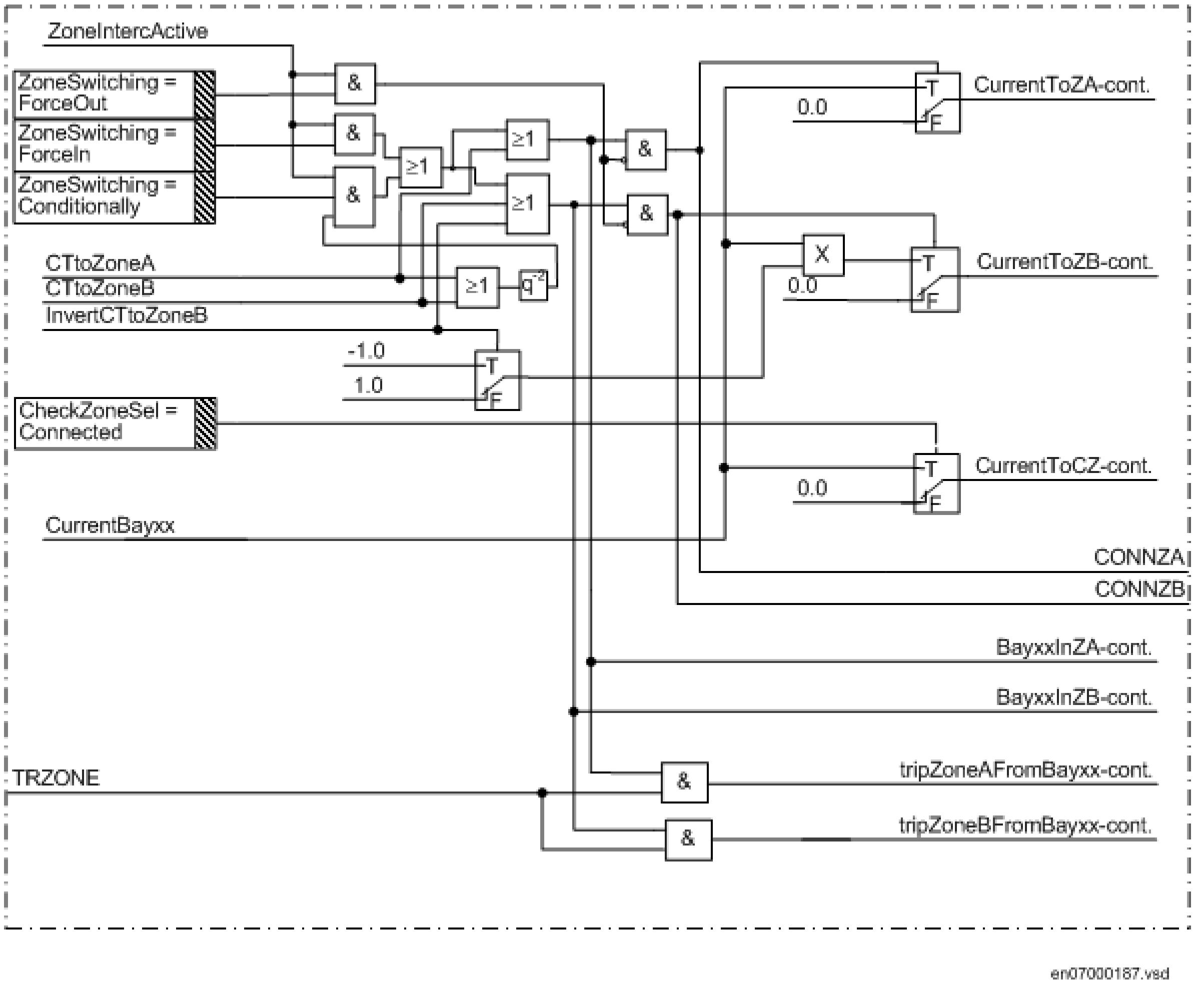

Figure 65: Check zone selection and zone interconnection operation influence on zone selection.

Bay trip logic

If there is an internal fault, differential function will operate, that is, a tripZoneA/ TripZoneB will be given to all bays. All the bays that are connected to that zone will be tripped if they are not blocked by input BLKTR.

A pulse timer *tTripPulse* will ensure the minimal duration of the trip signal.

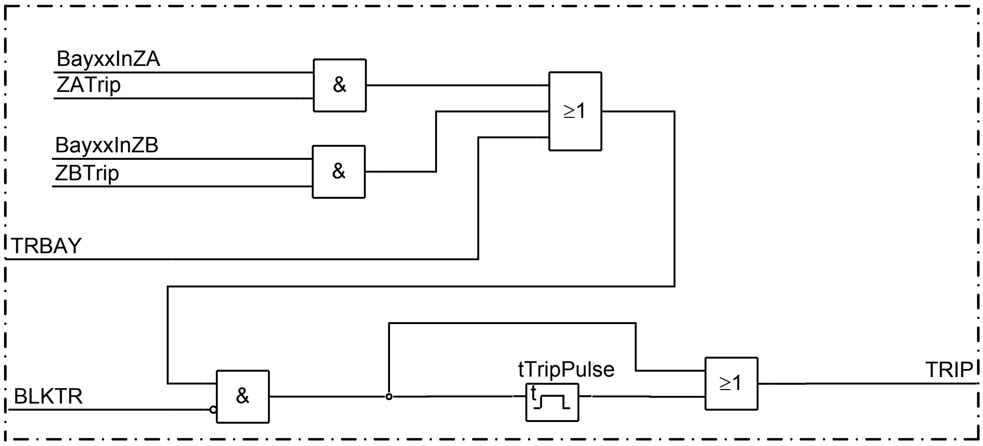

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Figure 66: Bay trip logic

5.1.9.4 Function block

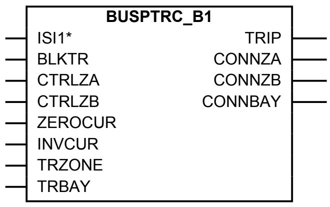

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Figure 67: BUSPTRC function block (Bay, 1ph), example for BUSPTRC1 to BUSPTRC21

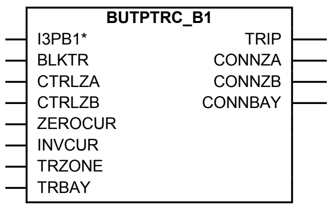

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Figure 68: BUTPTRC function block (Bay, 3ph), example for BUTPTRC1 to BUTPTRC8

5.1.9.5 Input and output signals

Table 74: BUTPTRC_B1 Input signals

Name	Type	Default	Description
I3PB1	GROUP SIGNAL	-	Group signal for current input
BLKTR	BOOLEAN	0	Block bay trip
CTRLZA	BOOLEAN	0	Logical signal which controls bay connection to zone A
CTRLZB	BOOLEAN	0	Logical signal which controls bay connection to zone B
ZEROCUR	BOOLEAN	0	Force bay current to zero
INVCUR	BOOLEAN	0	Invert bay current
TRZONE	BOOLEAN	0	Trip zone to which bay is connected
TRBAY	BOOLEAN	0	External bay trip

Table 75: BUTPTRC_B1 Output signals

Name	Type	Description
TRIP	BOOLEAN	Common trip signal for the bay
CONNZA	BOOLEAN	Bay is connected to zone A
CONNZB	BOOLEAN	Bay is connected to zone B
CONNBAY	INTEGER	Status of bay to zones connections

Table 76: BUSPTRC_B1 Input signals

Name	Type	Default	Description
ISI1	GROUP SIGNAL	-	Group signal for current input
BLKTR	BOOLEAN	0	Block bay trip
CTRLZA	BOOLEAN	0	Logical signal which controls bay connection to zone A
CTRLZB	BOOLEAN	0	Logical signal which controls bay connection to zone B
ZEROCUR	BOOLEAN	0	Force bay current to zero
INVCUR	BOOLEAN	0	Invert bay current
TRZONE	BOOLEAN	0	Trip zone to which bay is connected
TRBAY	BOOLEAN	0	External bay trip

Table 77: BUSPTRC_B1 Output signals

Name	Type	Description
TRIP	BOOLEAN	Common trip signal for the bay
CONNZA	BOOLEAN	Bay is connected to zone A
CONNZB	BOOLEAN	Bay is connected to zone B
CONNBAY	INTEGER	Status of bay to zones connections

5.1.9.6 Setting parameters

Table 78: BUTPTRC_B1 Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
CTConnection	Conn Inverted NotConnected Connected	-	-	Connected	Hardware CT input connection to the bay function block
ZoneSel	FixedToZA FixedToZB FixedToZA&-ZB CtrlIncludes CtrlExcludes	-	-	CtrlIncludes	How bay/CT is controlled toward the zones
ZoneSwitching	ForceOut ForceIn Conditionally	-	-	ForceIn	Bay/CT status during zone switching
CheckZoneSel	NotConnected Connected	-	-	NotConnected	Bay/CT status for the check zone
tTripPulse	0.000 - 60.000	s	0.001	0.200	Bay trip pulse duration if zone trips in SelfReset mode
tZeroCurrent	0.000 - 60.000	s	0.001	0.200	Time delay to force current to zero via binary signal
tInvertCurrent	0.000 - 60.000	s	0.001	0.200	Time delay to invert current via binary signal

Table 79: BUTPTRC_B1 Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
BAY01	0 - 13	-	1	BayName01	User defined name for bay

Table 80: BUSPTRC_B1 Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
CTConnection	Conn Inverted NotConnected Connected	-	-	Connected	Hardware CT input connection to the bay function block
ZoneSel	FixedToZA FixedToZB FixedToZA&-ZB CtrlIncludes CtrlExcludes	-	-	CtrlIncludes	How bay/CT is controlled toward the zones
ZoneSwitching	ForceOut ForceIn Conditionally	-	-	ForceIn	Bay/CT status during zone switching
CheckZoneSel	NotConnected Connected	-	-	NotConnected	Bay/CT status for the check zone
tTripPulse	0.000 - 60.000	s	0.001	0.200	Bay trip pulse duration if zone trips in SelfReset mode
tZeroCurrent	0.000 - 60.000	s	0.001	0.200	Time delay to force current to zero via binary signal
tInvertCurrent	0.000 - 60.000	s	0.001	0.200	Time delay to invert current via binary signal

Table 81: BUSPTRC_B1 Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
BAY01	0 - 13	-	1	BayName01	User defined name for bay

5.1.10 Zone interconnection (Load transfer) BZITGGIO, BZISGGIO

5.1.10.1 Introduction

When this feature is activated the two integrated differential protection zones are merged into one common, overall differential zone. This feature is required in double busbar stations when in any of the feeder bays both busbar disconnectors are closed at the same time (that is, load transfer). As explained in above section Bay each CT input will then behave in the pre-set way in order to ensure proper current balancing during this special condition. This feature can be started automatically (when Zone Selection logic determines that both busbar disconnectors in one feeder bay are closed at the same time) or externally via dedicated binary signal. If this feature is active for longer time than the pre-set vale the alarm signal is given.

5.1.10.2 Explanation of Zone interconnection (Load transfer) function block

Inputs

- EXTSTART, when this binary input has logical value one the zone interconnection feature will be activated if it is enabled by the setting parameter *Operation*
- SUMB1B2, this binary input is used for quite special feature which enables the user to internally sum Bay 01 and Bay 02 currents while the zone interconnection is active
- SUMB3B4, this binary input is used for quite special feature which enables the user to internally sum Bay 03 and Bay 04 currents while the zone interconnection is active
- SUMB5B6, this binary input is used for quite special feature which enables the user to internally sum Bay 05 and Bay 06 currents while the zone interconnection is active. It shall be noted that this input is only available in 1-phase version of REB670.

Outputs

- ACTIVE, this binary output has logical value one while zone interconnection feature is active in the IED
- ALARM, this binary output has logical value one, if the zone interconnection feature is active longer than the time set under setting parameter *tAlarm*

Settings

- *Operation*, this setting is used to switch On/Off zone interconnection feature.
- *tAlarm*, this delay on start timer is used in order to give an alarm output when zone interconnection feature is active for too long time. Timer can be set from 0.00s to 6000.00s in step of 0.01s. Default value is 300.00s.

5.1.10.3 Description of Zone interconnection operation

Zone interconnection can be activated by external signal or by internal logic inside the IED, when a bay is connected to both zones, it means that zone interconnection can be activated by any particular bay. When the binary output signal ACTIVE is activated, each CT will individually be include or exclude to the both zones depending on status of *ZoneSwitching* setting.

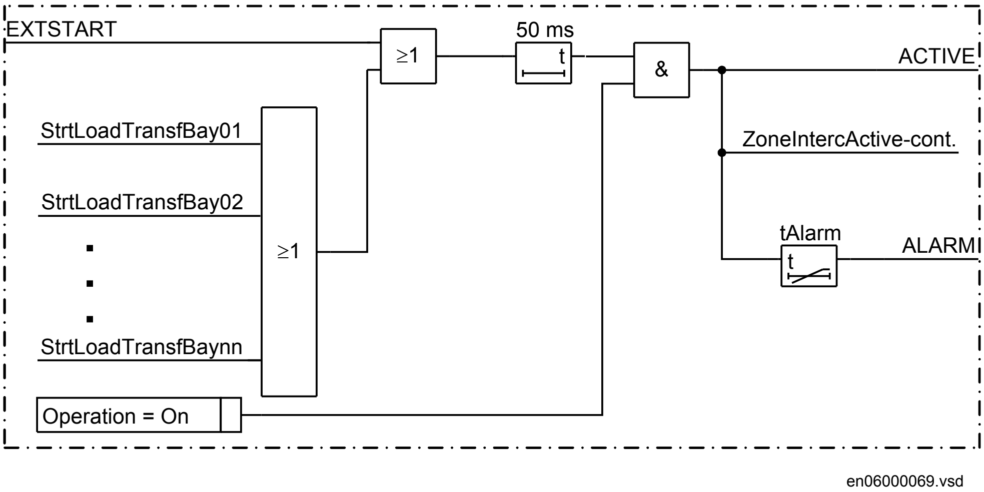


Figure 69: Zone interconnection logic

ZoneSwitching can be set to only one of the following three alternatives:

- ForceOut, the particular bay will be excluded during the zone interconnection.
- ForceIn, the particular bay will be included during the zone interconnection.
- Conditionally, the particular bay will be included if it was in operation two ms before, otherwise the bay will be excluded during the zone interconnection.

5.1.10.4 Function block

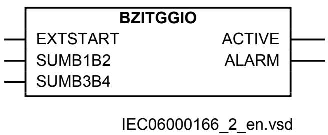


Figure 70: BZITGGIO function block (Zone interconnection, 3ph)

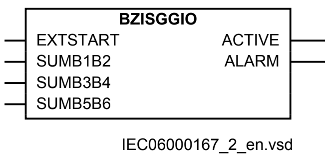


Figure 71: BZISGGIO function block (Zone interconnection, 1ph)

5.1.10.5 Input and output signals

Table 82: BZITGGIO Input signals

Name	Type	Default	Description
EXTSTART	BOOLEAN	0	External Load Transfer/Zone Interconnection start
SUMB1B2	BOOLEAN	0	Sum Bay1 and Bay2 currents during load transfer
SUMB3B4	BOOLEAN	0	Sum Bay3 and Bay4 currents during load transfer

Table 83: BZITGGIO Output signals

Name	Type	Description
ACTIVE	BOOLEAN	Load Transfer/Zone Interconnection active
ALARM	BOOLEAN	Too long load transfer alarm

Table 84: BZISGGIO Input signals

Name	Type	Default	Description
EXTSTART	BOOLEAN	0	External Load Transfer/Zone Interconnection start
SUMB1B2	BOOLEAN	0	Sum Bay1 and Bay2 currents during load transfer
SUMB3B4	BOOLEAN	0	Sum Bay3 and Bay4 currents during load transfer
SUMB5B6	BOOLEAN	0	Sum Bay5 and Bay6 currents during load transfer

Table 85: BZISGGIO Output signals

Name	Type	Description
ACTIVE	BOOLEAN	Load Transfer/Zone Interconnection active
ALARM	BOOLEAN	Too long load transfer alarm

5.1.10.6 Setting parameters

Table 86: BZITGGIO Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Load Transfer/Zone Interconnection operation
tAlarm	0.00 - 6000.00	s	0.01	300.00	Time delayed alarm for too long Load Transfer/Zone Intercon

Table 87: BZISGGIO Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Load Transfer/Zone Interconnection operation
tAlarm	0.00 - 6000.00	s	0.01	300.00	Time delayed alarm for too long Load Transfer/Zone Intercon.

5.1.11 Technical data

Table 88: technical data

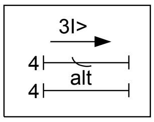
Function	Range or value	Accuracy
Operating characteristic	S=0.53 fixed	± 2.0% of I_r for I < I_r ± 2.0% of I for I > I_r
Reset ratio	> 95%	-
Differential current operating level	(1-100000) A	± 2.0% of I_r for I < I_r ± 2.0% of I for I > I_r
Sensitive differential operation level	(1-100000) A	± 2.0% of I_r for I < I_r ± 2.0% of I for I < I_r
Check zone operation level	(0-100000) A	± 2.0% of I_r for I < I_r ± 2.0% of I for I > I_r
Check zone slope	(0.0-0.9)	-
Timers	(0.000-60.000) s	± 0.5% ± 10 ms
Timers	(0.00-6000.00) s	± 0.5% ± 10 ms
Operate time Reset time Critical impulse time	19 ms typically at 0 to 2 x I_d 12 ms typically at 0 to 10 x I_d 21 ms typically at 2 to 0 x I_d 29 ms typically at 10 to 0 x I_d 8 ms typically at 0 to 2 x I_d	- - -

Section 6 Current protection

About this chapter

This chapter describes current protection functions. These include functions like Instantaneous phase overcurrent protection, Four step phase overcurrent protection, Pole discordance protection and Residual overcurrent protection.

6.1 Four step phase overcurrent protection OC4PTOC

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Four step phase overcurrent protection	OC4PTOC		51/67

6.1.1 Introduction

The four step phase overcurrent protection function OC4PTOC has an inverse or definite time delay independent for step 1 and 4 separately. Step 2 and 3 are always definite time delayed.

All IEC and ANSI inverse time characteristics are available together with an optional user defined time characteristic.

The directional function is voltage polarized with memory. The function can be set to be directional or non-directional independently for each of the steps.

A 2nd harmonic blocking can be set individually for each step.

6.1.2 Principle of operation

The Four step overcurrent protection function OC4PTOC is divided into four different sub-functions, one for each step. For each step *x* , where x is step 1, 2, 3 and 4, an operation mode is set by *DirModex*: *Off*/*Non-directional*/*Forward*/*Reverse*.

The protection design can be decomposed in four parts:

- The direction element
- The harmonic Restraint Blocking function
- The four step over current function
- The mode selection

If VT inputs are not available or not connected, setting parameter *DirModex* shall be left to default value, *Non-directional*.

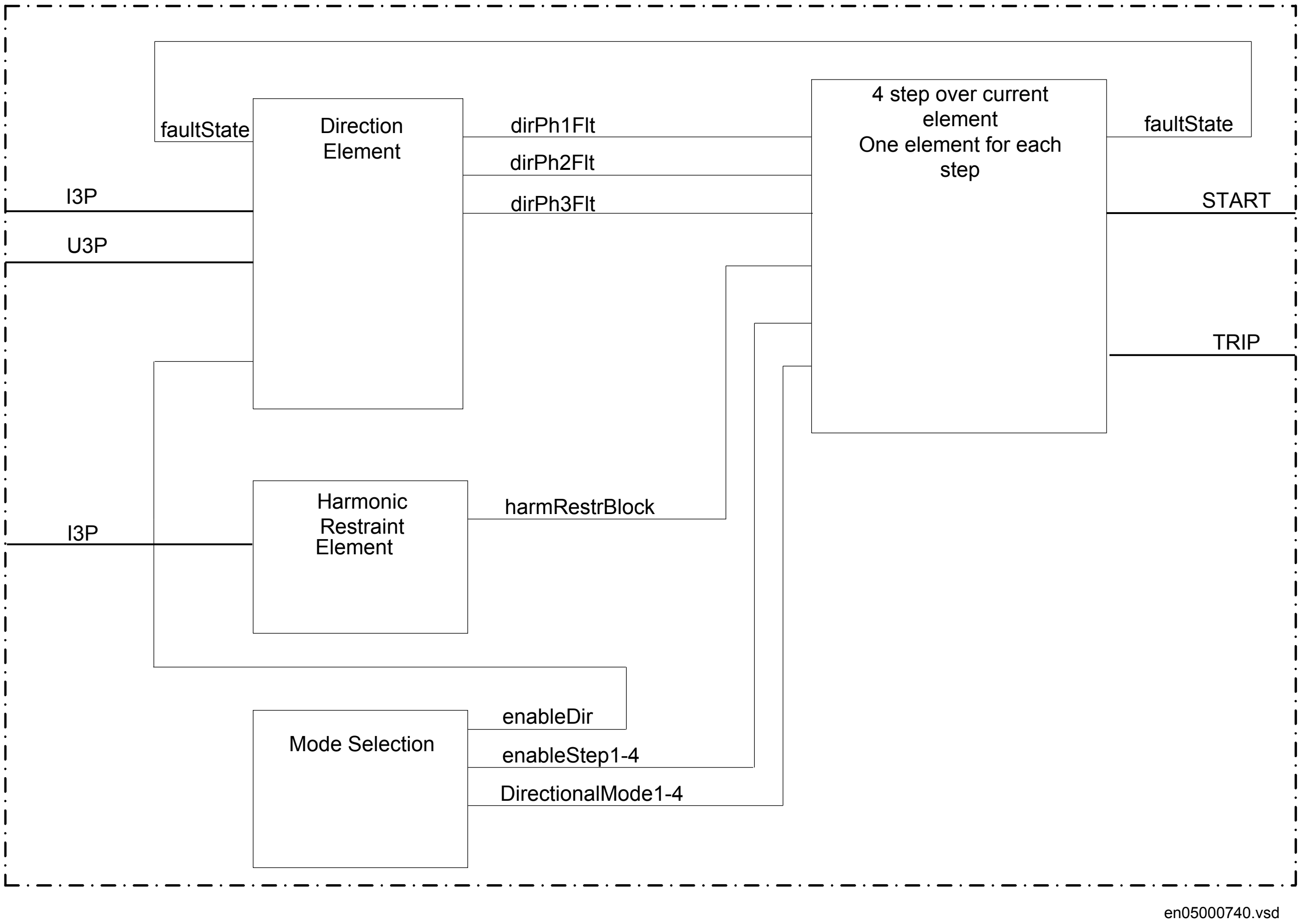


Figure 72: Functional overview of OC4PTOC

A common setting for all steps, *StartPhSel*, is used to specify the number of phase currents to be high to enable operation. The settings can be chosen: *1 out of 3*, *2 out of 3* or *3 out of 3*.

The sampled analogue phase currents are processed in a pre-processing function block. Using a parameter setting *MeasType* within the general settings for the four step phase overcurrent protection function OC4PTOC, it is possible to select the type of the measurement used for all overcurrent stages. It is possible to select either discrete Fourier filter (DFT) or true RMS filter (RMS).

If DFT option is selected then only the RMS value of the fundamental frequency components of each phase current is derived. Influence of DC current component and higher harmonic current components are almost completely suppressed. If RMS option is selected then the true RMS values is used. The true RMS value in addition to the fundamental frequency component includes the contribution from the current DC component as well as from higher current harmonic. The selected current values are fed to OC4PTOC.

In a comparator, for each phase current, the DFT or RMS values are compared to the set operation current value of the function *(I1>, I2>, I3> or I4>)*. If a phase current is larger than the set operation current, outputs START, STx, STL1, STL2 and STL3 are, without delay, activated. Output signals STL1, STL2 and STL3 are common for all steps. This means that the lowest set step will initiate the activation. The START signal is common for all three phases and all steps. It shall be noted that the selection of measured value (DFT or RMS) do not influence the operation of directional part of OC4PTOC.

Service value for individually measured phase currents are also available on the local HMI for OC4PTOC function, which simplifies testing, commissioning and in service operational checking of the function.

A harmonic restrain of the function can be chosen. A set 2nd harmonic current in relation to the fundamental current is used. The 2nd harmonic current is taken from the pre-processing of the phase currents and the relation is compared to a set restrain current level.

The function can be directional. The direction of the fault current is given as current angle in relation to the voltage angle. The fault current and fault voltage for the directional function is dependent of the fault type. To enable directional measurement at close in faults, causing low measured voltage, the polarization voltage is a combination of the apparent voltage (85%) and a memory voltage (15%). The following combinations are used.

Phase-phase short circuit:

$$U_{refL1L2} = U_{L1} - U_{L2} \quad I_{dirL1L2} = I_{L1} - I_{L2}$$

(Equation 4)

$$U_{refL2L3} = U_{L2} - U_{L3} \quad I_{dirL2L3} = I_{L2} - I_{L3}$$

(Equation 5)

$$U_{refL3L1} = U_{L3} - U_{L1} \quad I_{dirL3L1} = I_{L3} - I_{L1}$$

(Equation 6)

Phase-earth short circuit:

Table continues on next page

$$U_{refL1} = U_{L1} \quad I_{dirL1} = I_{L1}$$

(Equation 7)

$$U_{refL2} = U_{L2} \quad I_{dirL2} = I_{L2}$$

(Equation 8)

$$U_{refL3} = U_{L3} \quad I_{dirL3} = I_{L3}$$

(Equation 9)

The polarizing voltage is available as long as the positive-sequence voltage exceeds 4% of the set base voltage *UBase*. So the directional element can use it for all unsymmetrical faults including close-in faults.

For close-in three-phase faults, the $U1_{L1M}$ memory voltage, based on the same positive sequence voltage, ensures correct directional discrimination.

The memory voltage is used for 100 ms or until the positive sequence voltage is restored.

After 100 ms, the following occurs:

- If the current is still above the set value of the minimum operating current (between 10 and 30% of the set terminal rated current *IBase*), the condition seals in.
  - If the fault has caused tripping, the trip endures.
  - If the fault was detected in the reverse direction, the measuring element in the reverse direction remains in operation.
- If the current decreases below the minimum operating value, the memory resets until the positive sequence voltage exceeds 10% of its rated value.

The directional setting is given as a characteristic angle *AngleRCA* for the function and an angle window *AngleROA*.

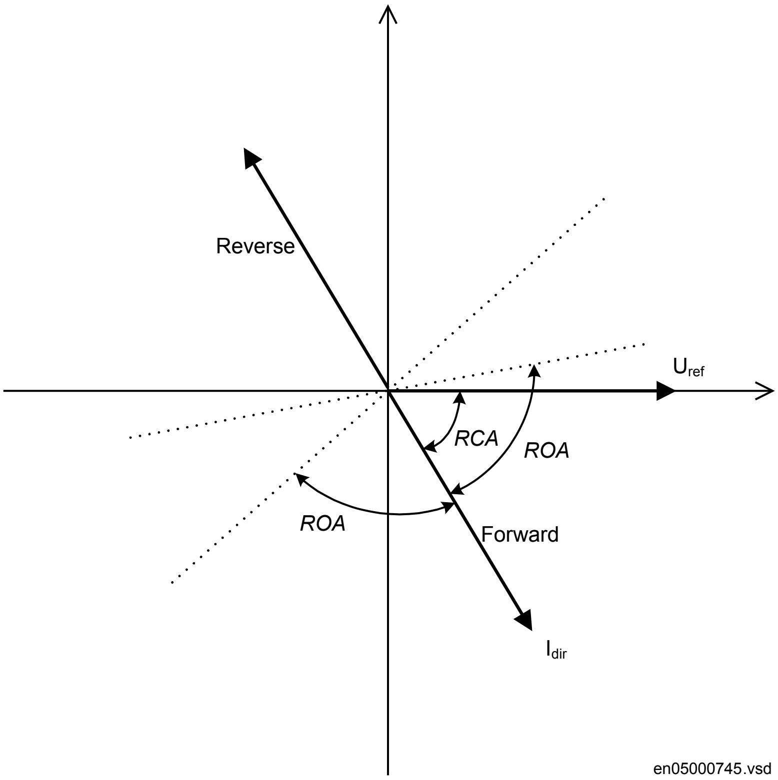


Figure 73: Directional characteristic of the phase overcurrent protection

The default value of *AngleRCA* is –65°. The parameters *AngleROA* gives the angle sector from *AngleRCA* for directional borders.

A minimum current for directional phase start current signal can be set: *IminOpPhSel*.

If no blockings are given the start signals will start the timers of the step. The time characteristic for each step can be chosen as definite time delay or inverse time characteristic. A wide range of standardized inverse time characteristics is available. It is also possible to create a tailor made time characteristic. The possibilities for inverse time characteristics are described in section "Inverse characteristics".

All four steps in OC4PTOC can be blocked from the binary input BLOCK. The binary input BLKSTx (x=1, 2, 3 or 4) blocks the operation of respective step.

Different types of reset time can be selected as described in section "Inverse characteristics".

There is also a possibility to activate a preset change (*IxMult* x= 1, 2, 3 or 4) of the set operation current via a binary input (enable multiplier). In some applications the operation value needs to be changed, for example due to changed network switching state. The function can be blocked from the binary input BLOCK. The start signals from the function can be blocked from the binary input BLKST. The trip signals from the function can be blocked from the binary input BLKTR.

6.1.3 Function block

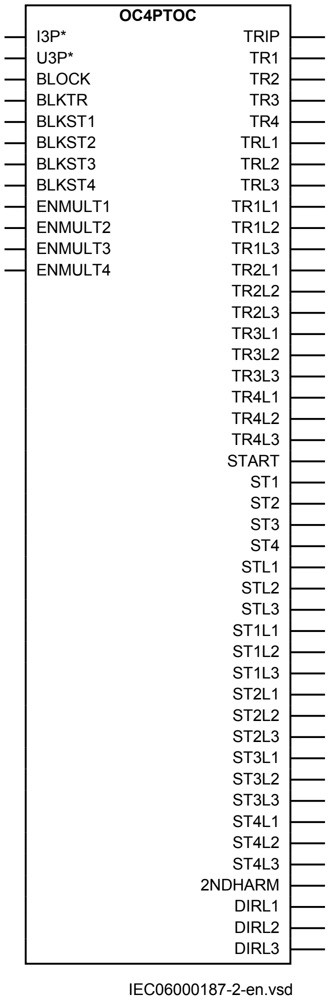


Figure 74: OC4PTOC function block

6.1.4 Input and output signals

Table 89: OC4PTOC Input signals

Name	Type	Default	Description
I3P	GROUP SIGNAL	-	Group signal for current input
U3P	GROUP SIGNAL	-	Group signal for voltage input
BLOCK	BOOLEAN	0	Block of function
BLKTR	BOOLEAN	0	Block of trip
BLKST1	BOOLEAN	0	Block of Step1
BLKST2	BOOLEAN	0	Block of Step2

Table continues on next page

Name	Type	Default	Description
BLKST3	BOOLEAN	0	Block of Step3
BLKST4	BOOLEAN	0	Block of Step4
ENMULT1	BOOLEAN	0	When activated, the current multiplier is in use for step1
ENMULT2	BOOLEAN	0	When activated, the current multiplier is in use for step2
ENMULT3	BOOLEAN	0	When activated, the current multiplier is in use for step3
ENMULT4	BOOLEAN	0	When activated, the current multiplier is in use for step4

Table 90: OC4PTOC Output signals

Name	Type	Description
TRIP	BOOLEAN	Trip
TR1	BOOLEAN	Common trip signal from step1
TR2	BOOLEAN	Common trip signal from step2
TR3	BOOLEAN	Common trip signal from step3
TR4	BOOLEAN	Common trip signal from step4
TRL1	BOOLEAN	Trip signal from phase L1
TRL2	BOOLEAN	Trip signal from phase L2
TRL3	BOOLEAN	Trip signal from phase L3
TR1L1	BOOLEAN	Trip signal from step1 phase L1
TR1L2	BOOLEAN	Trip signal from step1 phase L2
TR1L3	BOOLEAN	Trip signal from step1 phase L3
TR2L1	BOOLEAN	Trip signal from step2 phase L1
TR2L2	BOOLEAN	Trip signal from step2 phase L2
TR2L3	BOOLEAN	Trip signal from step2 phase L3
TR3L1	BOOLEAN	Trip signal from step3 phase L1
TR3L2	BOOLEAN	Trip signal from step3 phase L2
TR3L3	BOOLEAN	Trip signal from step3 phase L3
TR4L1	BOOLEAN	Trip signal from step4 phase L1
TR4L2	BOOLEAN	Trip signal from step4 phase L2
TR4L3	BOOLEAN	Trip signal from step4 phase L3
START	BOOLEAN	General start signal
ST1	BOOLEAN	Common start signal from step1
ST2	BOOLEAN	Common start signal from step2
ST3	BOOLEAN	Common start signal from step3
ST4	BOOLEAN	Common start signal from step4
STL1	BOOLEAN	Start signal from phase L1
STL2	BOOLEAN	Start signal from phase L2

Table continues on next page

Name	Type	Description
STL3	BOOLEAN	Start signal from phase L3
ST1L1	BOOLEAN	Start signal from step1 phase L1
ST1L2	BOOLEAN	Start signal from step1 phase L2
ST1L3	BOOLEAN	Start signal from step1 phase L3
ST2L1	BOOLEAN	Start signal from step2 phase L1
ST2L2	BOOLEAN	Start signal from step2 phase L2
ST2L3	BOOLEAN	Start signal from step2 phase L3
ST3L1	BOOLEAN	Start signal from step3 phase L1
ST3L2	BOOLEAN	Start signal from step3 phase L2
ST3L3	BOOLEAN	Start signal from step3 phase L3
ST4L1	BOOLEAN	Start signal from step4 phase L1
ST4L2	BOOLEAN	Start signal from step4 phase L2
ST4L3	BOOLEAN	Start signal from step4 phase L3
2NDHARM	BOOLEAN	Block from second harmonic detection
DIRL1	INTEGER	Direction for phase1
DIRL2	INTEGER	Direction for phase2
DIRL3	INTEGER	Direction for phase3

6.1.5 Setting parameters

Table 91: OC4PTOC Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
IBase	1 - 99999	A	1	3000	Base current
UBase	0.05 - 2000.00	kV	0.05	400.00	Base voltage
AngleRCA	40 - 65	Deg	1	55	Relay characteristic angle (RCA)
AngleROA	40 - 89	Deg	1	80	Relay operation angle (ROA)
StartPhSel	1 out of 3 2 out of 3 3 out of 3	-	-	1 out of 3	Number of phases required for op (1 of 3, 2 of 3, 3 of 3)
DirMode1	Off Non-directional Forward Reverse	-	-	Non-directional	Directional mode of step 1 (off, nodir, forward, reverse)

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
Characterist1	ANSI Ext. inv. ANSI Very inv. ANSI Norm. inv. ANSI Mod. inv. ANSI Def. Time L.T.E. inv. L.T.V. inv. L.T. inv. IEC Norm. inv. IEC Very inv. IEC inv. IEC Ext. inv. IEC S.T. inv. IEC L.T. inv. IEC Def. Time Reserved Programmable RI type RD type	-	-	ANSI Def. Time	Selection of time delay curve type for step 1
I1>	1 - 2500	%IB	1	1000	Phase current operate level for step1 in % of IBase
t1	0.000 - 60.000	s	0.001	0.000	Definitive time delay of step 1
k1	0.05 - 999.00	-	0.01	0.05	Time multiplier for the inverse time delay for step 1
IMin1	1 - 10000	%IB	1	100	Minimum operate current for step1 in % of IBase
t1Min	0.000 - 60.000	s	0.001	0.000	Minimum operate time for inverse curves for step 1
I1Mult	1.0 - 10.0	-	0.1	2.0	Multiplier for current operate level for step 1
DirMode2	Off Non-directional Forward Reverse	-	-	Non-directional	Directional mode of step 2 (off, nodir, forward, reverse)
Characterist2	ANSI Ext. inv. ANSI Very inv. ANSI Norm. inv. ANSI Mod. inv. ANSI Def. Time L.T.E. inv. L.T.V. inv. L.T. inv. IEC Norm. inv. IEC Very inv. IEC inv. IEC Ext. inv. IEC S.T. inv. IEC L.T. inv. IEC Def. Time Reserved Programmable RI type RD type	-	-	ANSI Def. Time	Selection of time delay curve type for step 2
I2>	1 - 2500	%IB	1	500	Phase current operate level for step2 in % of IBase
t2	0.000 - 60.000	s	0.001	0.400	Definitive time delay of step 2

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
k2	0.05 - 999.00	-	0.01	0.05	Time multiplier for the inverse time delay for step 2
IMin2	1 - 10000	%IB	1	50	Minimum operate current for step2 in % of IBase
t2Min	0.000 - 60.000	s	0.001	0.000	Minimum operate time for inverse curves for step 2
I2Mult	1.0 - 10.0	-	0.1	2.0	Multiplier for current operate level for step 2
DirMode3	Off Non-directional Forward Reverse	-	-	Non-directional	Directional mode of step 3 (off, nodir, forward, reverse)
Characterist3	ANSI Ext. inv. ANSI Very inv. ANSI Norm. inv. ANSI Mod. inv. ANSI Def. Time L.T.E. inv. L.T.V. inv. L.T. inv. IEC Norm. inv. IEC Very inv. IEC inv. IEC Ext. inv. IEC S.T. inv. IEC L.T. inv. IEC Def. Time Reserved Programmable RI type RD type	-	-	ANSI Def. Time	Selection of time delay curve type for step 3
I3>	1 - 2500	%IB	1	250	Phase current operate level for step3 in % of IBase
t3	0.000 - 60.000	s	0.001	0.800	Definitive time delay of step 3
k3	0.05 - 999.00	-	0.01	0.05	Time multiplier for the inverse time delay for step 3
IMin3	1 - 10000	%IB	1	33	Minimum operate current for step3 in % of IBase
t3Min	0.000 - 60.000	s	0.001	0.000	Minimum operate time for inverse curves for step 3
I3Mult	1.0 - 10.0	-	0.1	2.0	Multiplier for current operate level for step 3
DirMode4	Off Non-directional Forward Reverse	-	-	Non-directional	Directional mode of step 4 (off, nodir, forward, reverse)

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
Characterist4	ANSI Ext. inv. ANSI Very inv. ANSI Norm. inv. ANSI Def. Time L.T.E. inv. L.T.V. inv. L.T. inv. IEC Norm. inv. IEC Very inv. IEC inv. IEC Ext. inv. IEC S.T. inv. IEC L.T. inv. IEC Def. Time Reserved Programmable RI type RD type	-	-	ANSI Def. Time	Selection of time delay curve type for step 4
I4>	1 - 2500	%IB	1	175	Phase current operate level for step4 in % of IBase
t4	0.000 - 60.000	s	0.001	2.000	Definitive time delay of step 4
k4	0.05 - 999.00	-	0.01	0.05	Time multiplier for the inverse time delay for step 4
IMin4	1 - 10000	%IB	1	17	Minimum operate current for step4 in % of IBase
t4Min	0.000 - 60.000	s	0.001	0.000	Minimum operate time for inverse curves for step 4
I4Mult	1.0 - 10.0	-	0.1	2.0	Multiplier for current operate level for step 4

Table 92: OC4PTOC Group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
IMinOpPhSel	1 - 100	%IB	1	7	Minimum current for phase selection in % of IBase
2ndHarmStab	5 - 100	%IB	1	20	Operate level of 2nd harm restrain op in % of Fundamental
ResetTypeCrv1	Instantaneous IEC Reset ANSI reset	-	-	Instantaneous	Selection of reset curve type for step 1
tReset1	0.000 - 60.000	s	0.001	0.020	Reset time delay used in IEC Definite Time curve step 1
tPCrv1	0.005 - 3.000	-	0.001	1.000	Parameter P for customer programmable curve for step 1
tACrv1	0.005 - 200.000	-	0.001	13.500	Parameter A for customer programmable curve for step 1
tBCrv1	0.00 - 20.00	-	0.01	0.00	Parameter B for customer programmable curve for step 1
tCCrv1	0.1 - 10.0	-	0.1	1.0	Parameter C for customer programmable curve for step 1
tPRCrv1	0.005 - 3.000	-	0.001	0.500	Parameter PR for customer programmable curve for step 1

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
tTRCrv1	0.005 - 100.000	-	0.001	13.500	Parameter TR for customer programmable curve for step 1
tCRCrv1	0.1 - 10.0	-	0.1	1.0	Parameter CR for customer programmable curve for step 1
HarmRestrain1	Off On	-	-	Off	Enable block of step 1 from harmonic restrain
ResetTypeCrv2	Instantaneous IEC Reset ANSI reset	-	-	Instantaneous	Selection of reset curve type for step 2
tReset2	0.000 - 60.000	s	0.001	0.020	Reset time delay used in IEC Definite Time curve step 2
tPCrv2	0.005 - 3.000	-	0.001	1.000	Parameter P for customer programmable curve for step 2
tACrv2	0.005 - 200.000	-	0.001	13.500	Parameter A for customer programmable curve for step 2
tBCrv2	0.00 - 20.00	-	0.01	0.00	Parameter B for customer programmable curve for step 2
tCCrv2	0.1 - 10.0	-	0.1	1.0	Parameter C for customer programmable curve for step 2
tPRCrv2	0.005 - 3.000	-	0.001	0.500	Parameter PR for customer programmable curve for step 2
tTRCrv2	0.005 - 100.000	-	0.001	13.500	Parameter TR for customer programmable curve for step 2
tCRCrv2	0.1 - 10.0	-	0.1	1.0	Parameter CR for customer programmable curve for step 2
HarmRestrain2	Off On	-	-	Off	Enable block of step 2 from harmonic restrain
ResetTypeCrv3	Instantaneous IEC Reset ANSI reset	-	-	Instantaneous	Selection of reset curve type for step 3
tReset3	0.000 - 60.000	s	0.001	0.020	Reset time delay used in IEC Definite Time curve step 3
tPCrv3	0.005 - 3.000	-	0.001	1.000	Parameter P for customer programmable curve for step 3
tACrv3	0.005 - 200.000	-	0.001	13.500	Parameter A for customer programmable curve for step 3
tBCrv3	0.00 - 20.00	-	0.01	0.00	Parameter B for customer programmable curve for step 3
tCCrv3	0.1 - 10.0	-	0.1	1.0	Parameter C for customer programmable curve for step 3
tPRCrv3	0.005 - 3.000	-	0.001	0.500	Parameter PR for customer programmable curve for step 3
tTRCrv3	0.005 - 100.000	-	0.001	13.500	Parameter TR for customer programmable curve for step 3
tCRCrv3	0.1 - 10.0	-	0.1	1.0	Parameter CR for customer programmable curve for step 3
HarmRestrain3	Off On	-	-	Off	Enable block of step3 from harmonic restrain

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
ResetTypeCrv4	Instantaneous IEC Reset ANSI reset	-	-	Instantaneous	Selection of reset curve type for step 4
tReset4	0.000 - 60.000	s	0.001	0.020	Reset time delay used in IEC Definite Time curve step 4
tPCrv4	0.005 - 3.000	-	0.001	1.000	Parameter P for customer programmable curve for step 4
tACrv4	0.005 - 200.000	-	0.001	13.500	Parameter A for customer programmable curve for step 4
tBCrv4	0.00 - 20.00	-	0.01	0.00	Parameter B for customer programmable curve for step 4
tCCrv4	0.1 - 10.0	-	0.1	1.0	Parameter C for customer programmable curve for step 4
tPRCrv4	0.005 - 3.000	-	0.001	0.500	Parameter PR for customer programmable curve for step 4
tTRCrv4	0.005 - 100.000	-	0.001	13.500	Parameter TR for customer programmable curve for step 4
tCRCrv4	0.1 - 10.0	-	0.1	1.0	Parameter CR for customer programmable curve for step 4
HarmRestrain4	Off On	-	-	Off	Enable block of step 4 from harmonic restrain

Table 93: OC4PTOC Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
MeasType	DFT RMS	-	-	DFT	Selection between DFT and RMS measurement

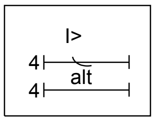
6.1.6 Technical data

Table 94: OC4PTOC technical data

Function	Setting range	Accuracy
Operate current	(1-2500)% of *IBase*	± 1.0% of I_r at $I \leq I_r$ ± 1.0% of I at $I > I_r$
Reset ratio	> 95%	-
Min. operating current	(1-100)% of *IBase*	± 1.0% of I_r at $I \leq I_r$ ±1.0% of I at $I > I_r$
Maximum forward angle	(40.0–70.0) degrees	± 2.0 degrees
Minimum forward angle	(75.0–90.0) degrees	± 2.0 degrees
2nd harmonic blocking	(5–100)% of fundamental	± 2.0% of I_r
Independent time delay	(0.000-60.000) s	± 0.5% ±10 ms
Minimum operate time	(0.000-60.000) s	± 0.5% ±10 ms
Inverse characteristics, see table 483, table 484 and table 485	19 curve types	See table 483, table 484 and table 485
Table continues on next page		

Function	Setting range	Accuracy
Operate time, start function	25 ms typically at 0 to 2 x I_{set}	-
Reset time, start function	25 ms typically at 2 to 0 x I_{set}	-
Critical impulse time	10 ms typically at 0 to 2 x I_{set}	-
Impulse margin time	15 ms typically	-

6.2 Four step single phase overcurrent protection PH4SPTOC

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Four step single phase overcurrent protection	PH4SPTOC		51

6.2.1 Introduction

Four step single phase overcurrent protection (PH4SPTOC)has an inverse or definite time delay independent for each step separately.

All IEC and ANSI time delayed characteristics are available together with an optional user defined time characteristic.

The function is normally used as end fault protection to clear faults between current transformer and circuit breaker.

6.2.2 Principle of operation

The function is divided into four different sub-functions, one for each step.

The function consists of two major parts:

- The harmonic Restraint Blocking function
- Four step overcurrent protection (PH4SPTOC)

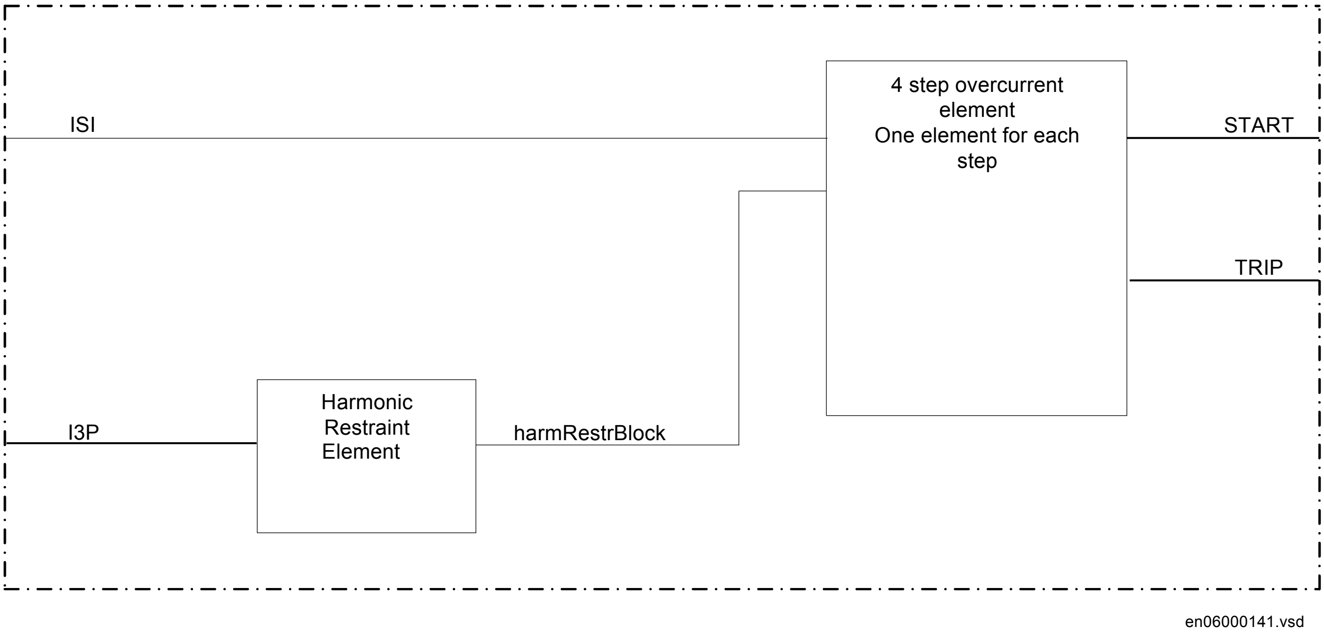


Figure 75: Functional overview of PH4SPTOC

The sampled analogue phase currents are pre-processed in a discrete Fourier filter (DFT) block. The RMS value of the phase current is derived. The phase current value is fed to the PH4SPTOC function. In a comparator the RMS value is compared to the set operation current value of the function (*I1>, I2>, I3> or I4>*). If the phase current is larger than the set operation current a signal from the comparator is set to true. This signal will, without delay, activate the output signal Start for this step and a common Start signal.

A harmonic restrain of the function can be chosen. A set 2^{nd} harmonic current in relation to the fundamental current is used. The 2^{nd} harmonic current is taken from the pre-processing of the phase current and compared to a set restrain current level.

If no blockings are given the start signals will start the timers of the step. The time characteristic for each step can be chosen as definite time delay or some type of inverse time characteristic. A wide range of standardized inverse time characteristics is available. It is also possible to create a tailor made time characteristic. The possibilities for inverse time characteristics are described in chapter "Inverse time characteristics".

Different types of reset time can be selected as described in chapter "Inverse time characteristics".

There is also a possibility to activate a preset change (*IxMult*, x= 1, 2, 3 or 4) of the set operation current via a binary input (enable multiplier). In some applications the operation value needs to be changed, for example due to changed network switching state. The function can be blocked from the binary input BLOCK. The start signals from the function can be blocked from the binary input BLKST. The trip signals from the function can be blocked from the binary input BLKTR.

6.2.3 Function block

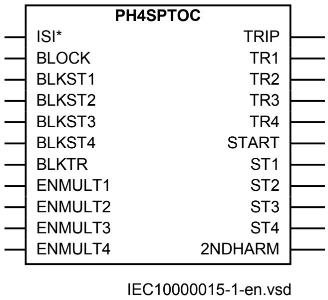


Figure 76: PH4SPTOC function block

6.2.4 Input and output signals

Table 95: PH4SPTOC Input signals

Name	Type	Default	Description
ISI	GROUP SIGNAL	-	Group signal for current input
BLOCK	BOOLEAN	0	Block of function
BLKST1	BOOLEAN	0	Block of Step1
BLKST2	BOOLEAN	0	Block of Step2
BLKST3	BOOLEAN	0	Block of Step3
BLKST4	BOOLEAN	0	Block of Step4
BLKTR	BOOLEAN	0	Block of trip
ENMULT1	BOOLEAN	0	When activated, the current multiplier is in use for step1
ENMULT2	BOOLEAN	0	When activated, the current multiplier is in use for step2
ENMULT3	BOOLEAN	0	When activated, the current multiplier is in use for step3
ENMULT4	BOOLEAN	0	When activated, the current multiplier is in use for step4

Table 96: PH4SPTOC Output signals

Name	Type	Description
TRIP	BOOLEAN	Trip
TR1	BOOLEAN	Common trip signal from step1
TR2	BOOLEAN	Common trip signal from step2
TR3	BOOLEAN	Common trip signal from step3
TR4	BOOLEAN	Common trip signal from step4
START	BOOLEAN	General start signal
Table continues on next page		

Name	Type	Description
ST1	BOOLEAN	Common start signal from step1
ST2	BOOLEAN	Common start signal from step2
ST3	BOOLEAN	Common start signal from step3
ST4	BOOLEAN	Common start signal from step4
2NDHARM	BOOLEAN	Block from second harmonic detection

6.2.5 Setting parameters

Table 97: PH4SPTOC Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
IBase	1 - 99999	A	1	3000	Base setting for current values in A
OpStep1	Off On	-	-	On	Operation over current step 1 Off / On
Characterist1	ANSI Ext. inv. ANSI Very inv. ANSI Norm. inv. ANSI Mod. inv. ANSI Def. Time L.T.E. inv. L.T.V. inv. IEC Norm. inv. IEC Very inv. IEC inv. IEC Ext. inv. IEC L.T. inv. IEC Def. Time Reserved Programmable RI type RD type	-	-	ANSI Def. Time	Selection of time delay curve type for step 1
I1>	1 - 2500	%IB	1	1000	Operate phase current level for step1 in % of IBase
t1	0.000 - 60.000	s	0.001	0.000	Independent (defenitive) time delay of step 1
k1	0.05 - 999.00	-	0.01	0.05	Time multiplier for the dependent time delay for step 1
I1Mult	1.0 - 10.0	-	0.1	2.0	Multiplier for operate current level for step 1
t1Min	0.000 - 60.000	s	0.001	0.000	Minimum operate time for IEC IDMT curves for step 1
OpStep2	Off On	-	-	On	Operation over current step 2 Off / On

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
Characterist2	ANSI Ext. inv. ANSI Very inv. IEC Reset ANSI Norm. inv. ANSI Mod. inv. ANSI Def. Time L.T.E. inv. L.T.V. inv. L.T. inv. IEC Norm. inv. IEC Very inv. IEC inv. IEC Ext. inv. IEC L.T. inv. IEC Def. Time Reserved Programmable RI type RD type	-	-	ANSI Def. Time	Selection of time delay curve type for step 2
I2>	1 - 2500	%IB	1	500	Operate phase current level for step2 in %of IBase
t2	0.000 - 60.000	s	0.001	0.400	Independent (defenitive) time delay of step 2
k2	0.05 - 999.00	-	0.01	0.05	Time multiplier for the dependent time delay for step 2
I2Mult	1.0 - 10.0	-	0.1	2.0	Multiplier for scaling the current setting value for step 2
t2Min	0.000 - 60.000	s	0.001	0.000	Minimum operate time for IEC IDMT curves for step 2
OpStep3	Off On	-	-	On	Operation over current step 3 Off / On
Characterist3	ANSI Ext. inv. ReportEvents ANSI Very inv. ANSI Norm. inv. ANSI Mod. inv. ANSI Def. Time L.T.E. inv. L.T.V. inv. L.T. inv. IEC Norm. inv. IEC Very inv. IEC inv. IEC Ext. inv. IEC S.T. inv. IEC L.T. inv. IEC Def. Time Programmable RI type RD type	-	-	ANSI Def. Time	Selection of time delay curve type for step 3
I3>	1 - 2500	%IB	1	250	Operate phase current level for step3 in %of Ibase
t3	0.000 - 60.000	s	0.001	0.800	Independent (definitive) time delay for step 3
k3	0.05 - 999.00	-	0.01	0.05	Time multiplier for the dependent time delay for step 3

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
I3Mult	1.0 - 10.0	-	0.1	2.0	Multiplier for scaling the current setting value for step 3
t3Min	0.000 - 60.000	s	0.001	0.000	Minimum operate time for IEC IDMT curves for step 3
OpStep4	Off On	-	-	On	Operation over current step 4 Off / On
Characterist4	ANSI Ext. inv. ANSI Very inv. ANSI Norm. inv. ANSI Mod. inv. ANSI Def. Time L.T.E. inv. L.T.V. inv. L.T. inv. IEC Norm. inv. IEC Very inv. IEC inv. IEC Ext. inv. IEC S.T. inv. IEC L.T. inv. IEC Def. Time Reserved Programmable RI type RD type	-	-	ANSI Def. Time	Selection of time delay curve type for step 4
I4>	1 - 2500	%IB	1	175	Operate phase current level for step4 in % of IBase
t4	0.000 - 60.000	s	0.001	2.000	Independent (definitive) time delay of step4
k4	0.05 - 999.00	-	0.01	0.05	Time multiplier for the dependent time delay for step 4
I4Mult	1.0 - 10.0	-	0.1	2.0	Multiplier for scaling the current setting value for step 4
t4Min	0.000 - 60.000	s	0.001	0.000	Minimum operate time for IEC IDMT curves for step 4

Table 98: PH4SPTOC Group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
2ndHarmStab	5 - 100	%IB	1	20	Operate level of 2nd harm restrain op in % of Fundamental
ResetTypeCrv1	Instantaneous IEC Reset ANSI reset	-	-	Instantaneous	Selection of reset curve type for step
tReset1	0.000 - 60.000	s	0.001	0.020	Reset time delay used in IEC Definite Time curve step 1
tPCrv1	0.005 - 3.000	-	0.001	1.000	Parameter P for customer programmable curve for step 1
tACrv1	0.005 - 200.000	-	0.001	13.500	Parameter A for customer programmable curve for step 1
tBCrv1	0.00 - 20.00	-	0.01	0.00	Parameter B for customer programmable curve for step 1

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
tCCrv1	0.1 - 10.0	-	0.1	1.0	Parameter C for customer programmable curve for step 1
tPRCrv1	0.005 - 3.000	-	0.001	0.500	Parameter PR for customer programmable curve for step 1
tTRCrv1	0.005 - 100.000	-	0.001	13.500	Parameter TR for customer programmable curve for step 1
tCRCrv1	0.1 - 10.0	-	0.1	1.0	Parameter CR for customer programmable curve for step 1
HarmRestrain1	Disabled Enabled	-	-	Enabled	Enable block of step 1 from harmonic restrain
ResetTypeCrv2	Instantaneous IEC Reset ANSI reset	-	-	Instantaneous	Selection of reset curve type for step 2
tReset2	0.000 - 60.000	s	0.001	0.020	Reset time delay used in IEC Definite Time curve step 2
tPCrv2	0.005 - 3.000	-	0.001	1.000	Parameter P for customer programmable curve for step 2
tACrv2	0.005 - 200.000	-	0.001	13.500	Parameter A for customer programmable curve for step 2
tBCrv2	0.00 - 20.00	-	0.01	0.00	Parameter B for customer programmable curve for step 2
tCCrv2	0.1 - 10.0	-	0.1	1.0	Parameter C for customer programmable curve for step 2
tPRCrv2	0.005 - 3.000	-	0.001	0.500	Parameter PR for customer programmable curve for step 2
tTRCrv2	0.005 - 100.000	-	0.001	13.500	Parameter TR for customer programmable curve for step 2
tCRCrv2	0.1 - 10.0	-	0.1	1.0	Parameter CR for customer programmable curve for step 2
HarmRestrain2	Disabled Enabled	-	-	Enabled	Enable block of step 2 from harmonic restrain
ResetTypeCrv3	Instantaneous IEC Reset ANSI reset	-	-	Instantaneous	Selection of reset curve type for step 3
tReset3	0.000 - 60.000	s	0.001	0.020	Reset time delay used in IEC Definite Time curve step 3
tPCrv3	0.005 - 3.000	-	0.001	1.000	Parameter P for customer programmable curve for step 3
tACrv3	0.005 - 200.000	-	0.001	13.500	Parameter A for customer programmable curve for step 3
tBCrv3	0.00 - 20.00	-	0.01	0.00	Parameter B for customer programmable curve for step 3
tCCrv3	0.1 - 10.0	-	0.1	1.0	Parameter C for customer programmable curve for step 3
tPRCrv3	0.005 - 3.000	-	0.001	0.500	Parameter PR for customer programmable curve for step 3
tTRCrv3	0.005 - 100.000	-	0.001	13.500	Parameter TR for customer programmable curve for step 3
tCRCrv3	0.1 - 10.0	-	0.1	1.0	Parameter CR for customer programmable curve for step 3

Table continues on next page

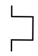
Name	Values (Range)	Unit	Step	Default	Description
HarmRestrain3	Disabled Enabled	-	-	Enabled	Enable block of step3 from harmonic restrain
ResetTypeCrv4	Instantaneous IEC Reset ANSI reset	-	-	Instantaneous	Selection of reset curve type for step 4
tReset4	0.000 - 60.000	s	0.001	0.020	Reset time delay used in IEC Definite Time curve step 4
tPCrv4	0.005 - 3.000	-	0.001	1.000	Parameter P for customer programmable curve for step 4
tACrv4	0.005 - 200.000	-	0.001	13.500	Parameter A for customer programmable curve for step 4
tBCrv4	0.00 - 20.00	-	0.01	0.00	Parameter B for customer programmable curve for step 4
tCCrv4	0.1 - 10.0	-	0.1	1.0	Parameter C for customer programmable curve for step 4
tPRCrv4	0.005 - 3.000	-	0.001	0.500	Parameter PR for customer programmable curve for step 4
tTRCrv4	0.005 - 100.000	-	0.001	13.500	Parameter TR for customer programmable curve for step 4
tCRCrv4	0.1 - 10.0	-	0.1	1.0	Parameter CR for customer programmable curve for step 4
HarmRestrain4	Disabled Enabled	-	-	Enabled	Enable block of Step 4 from harmonic restrain

6.2.6 Technical data

Table 99: PH4SPTOC technical data

Function	Setting range	Accuracy
Operate current	(1-2500)% of I_{base}	$\pm$ 1.0% of I_r at $I \leq I_r$ $\pm$ 1.0% of I at $I > I_r$
Reset ratio	> 95%	-
Second harmonic blocking	(5–100)% of fundamental	$\pm$ 2.0% of I_r
Independent time delay	(0.000-60.000) s	$\pm$ 0.5% $\pm$ 10 ms
Minimum operate time	(0.000-60.000) s	$\pm$ 0.5% $\pm$ 10 ms
Inverse characteristics, see table 483 and table 484	19 curve types	See table 483 and table 484
Operate time, start function	25 ms typically at 0 to 2 x I_{set}	-
Reset time, start function	25 ms typically at 2 to 0 x I_{set}	-
Critical impulse time	10 ms typically at 0 to 2 x I_{set}	-
Impulse margin time	15 ms typically	-

6.3 Thermal overload protection, two time constants TRPTTR

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Thermal overload protection, two time constants	TRPTTR		49

6.3.1 Introduction

If a power transformer or generator reaches very high temperatures the equipment might be damaged. The insulation within the transformer/generator will have forced ageing. As a consequence of this the risk of internal phase-to-phase or phase-to-earth faults will increase. High temperature will degrade the quality of the transformer/generator insulation.

The thermal overload protection estimates the internal heat content of the transformer/generator (temperature) continuously. This estimation is made by using a thermal model of the transformer/generator with two time constants, which is based on current measurement.

Two warning levels are available. This enables actions in the power system to be done before dangerous temperatures are reached. If the temperature continues to increase to the trip value, the protection initiates a trip of the protected transformer/generator.

6.3.2 Principle of operation

The sampled analogue phase currents are pre-processed and for each phase current the true RMS value of each phase current is derived. These phase current values are fed to the Thermal overload protection, two time constants (TRPTTR).

From the largest of the three phase currents a relative final temperature (heat content) is calculated according to the expression:

$$\Theta_{final} = \left(\frac{I}{I_{ref}} \right)^2$$

(Equation 10)

where:

I	is the largest phase current
I_{ref}	is a given reference current

If this calculated relative temperature is larger than the relative temperature level corresponding to the set operate (trip) current a start output signal START is activated.

The actual temperature at the actual execution cycle is calculated as:

If $\Theta_{final} > \Theta_n$

(Equation 11)

$$\Theta_n = \Theta_{n-1} + \left(\Theta_{final} - \Theta_{n-1} \right) \cdot \left(1 - e^{-\frac{\Delta t}{\tau}} \right)$$

(Equation 12)

If $\Theta_{final} < \Theta_n$

(Equation 13)

$$\Theta_n = \Theta_{final} - \left(\Theta_{final} - \Theta_{n-1} \right) \cdot e^{-\frac{\Delta t}{\tau}}$$

(Equation 14)

where:

Θ_n	is the calculated present temperature
Θ_{n-1}	is the calculated temperature at the previous time step
Θ_{final}	is the calculated final (steady state) temperature with the actual current
Δt	is the time step between calculation of the actual and final temperature
τ	is the set thermal time constant Tau1 or Tau2 for the protected transformer

The calculated transformer relative temperature can be monitored as it is exported from the function as a real figure HEATCONT.

When the transformer temperature reaches any of the set alarm levels *Alarm1* or *Alarm2* the corresponding output signals ALARM1 or ALARM2 are activated. When the temperature of the object reaches the set trip level which corresponds to continuous current equal to *ITrip* the output signal TRIP is activated.

There is also a calculation of the present time to operation with the present current. This calculation is only performed if the final temperature is calculated to be above the operation temperature:

$$t_{operate} = -\tau \cdot \ln\left(\frac{\Theta_{final} - \Theta_{operate}}{\Theta_{final} - \Theta_{n}}\right)$$

(Equation 15)

The calculated time to trip can be monitored as it is exported from the function as a real figure TTRIP.

After a trip, caused by the thermal overload protection, there can be a lockout to reconnect the tripped circuit. The output lockout signal LOCKOUT is activated when the temperature of the object is above the set lockout release temperature setting *ResLo*.

The time to lockout release is calculated, That is, a calculation of the cooling time to a set value.

$$t_{lockout\_release} = -\tau \cdot \ln\left(\frac{\Theta_{final} - \Theta_{lockout\_release}}{\Theta_{final} - \Theta_{n}}\right)$$

(Equation 16)

In the above equation, the final temperature is calculated according to equation 10. Since the transformer normally is disconnected, the current I is zero and thereby the Θ_{final} is also zero. The calculated component temperature can be monitored as it is exported from the function as a real figure, TRESLO.

When the current is so high that it has given a start signal START, the estimated time to trip is continuously calculated and given as analogue output TTRIP. If this calculated time get less than the setting time Warning, set in minutes, the output WARNING is activated.

In case of trip a pulse with a set duration *tPulse* is activated.

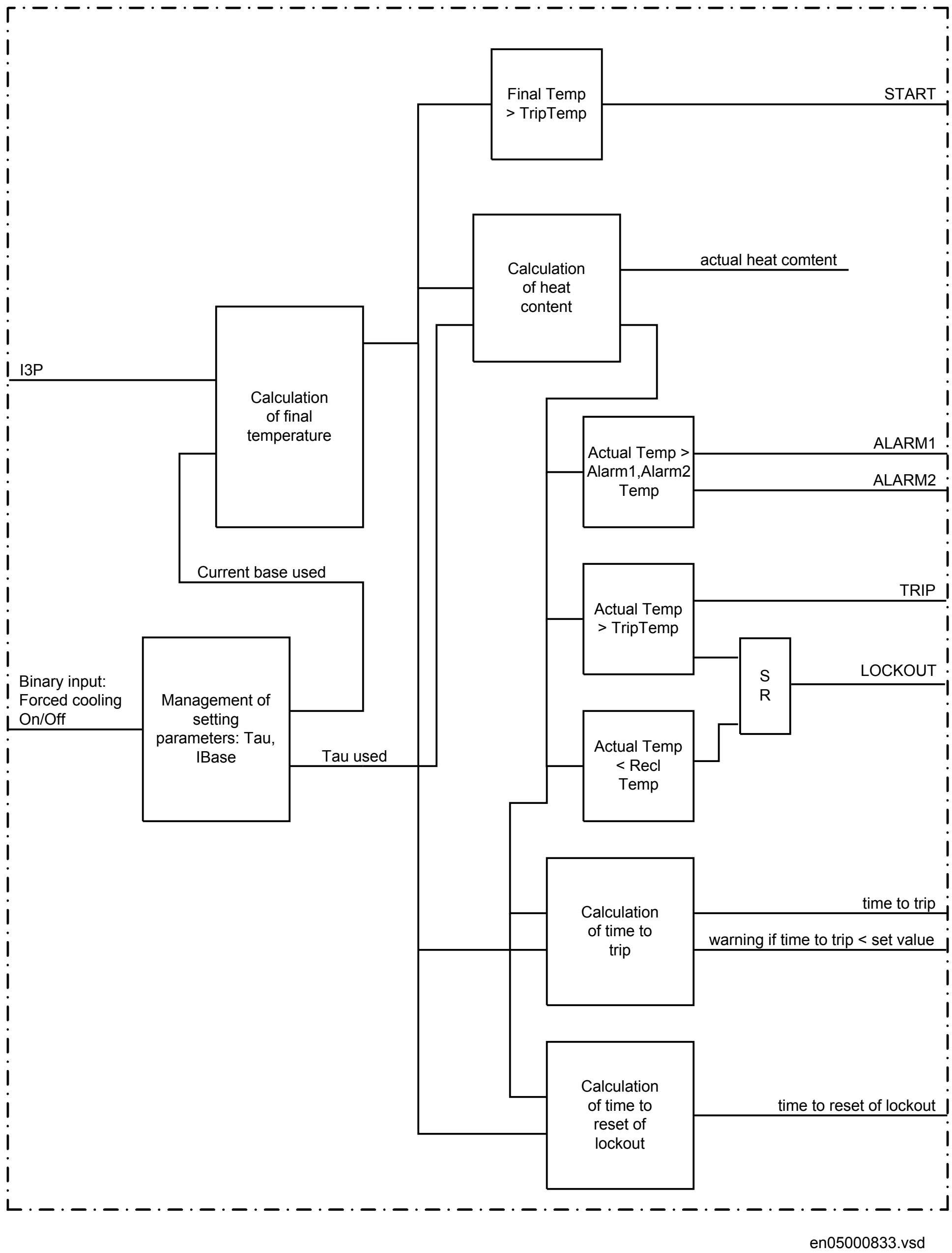


Figure 77: Functional overview of TRPTTR

6.3.3 Function block

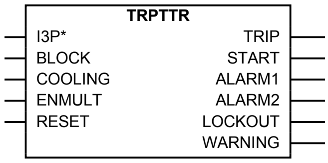


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Figure 78: TRPTTR function block

6.3.4 Input and output signals

Table 100: TRPTTR Input signals

Name	Type	Default	Description
I3P	GROUP SIGNAL	-	Group signal for current input
BLOCK	BOOLEAN	0	Block of function
COOLING	BOOLEAN	0	Cooling input Off / On. Changes Ib setting and time constant
ENMULT	BOOLEAN	0	Enable Multiplier for currentReference setting
RESET	BOOLEAN	0	Reset of function

Table 101: TRPTTR Output signals

Name	Type	Description
TRIP	BOOLEAN	Trip Signal
START	BOOLEAN	Start signal
ALARM1	BOOLEAN	First level alarm signal
ALARM2	BOOLEAN	Second level alarm signal
LOCKOUT	BOOLEAN	Lockout signal
WARNING	BOOLEAN	Warning signal: Trip within set warning time

6.3.5 Setting parameters

Table 102: TRPTTR Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
IBase	1 - 99999	A	1	3000	Base current in A
IRef	10.0 - 1000.0	%IB	1.0	100.0	Reference current in % of IBASE
IRefMult	0.01 - 10.00	-	0.01	1.00	Multiplication Factor for reference current
Table continues on next page					

Name	Values (Range)	Unit	Step	Default	Description
IBase1	30.0 - 250.0	%IB	1.0	100.0	Base current,IBase1 without Cooling inpout in % of IBASE
IBase2	30.0 - 250.0	%IB	1.0	100.0	Base Current,IBase2, with Cooling input ON in % of IBASE
Tau1	1.0 - 500.0	Min	1.0	60.0	Time constant without cooling input in min, with IBase1
Tau2	1.0 - 500.0	Min	1.0	60.0	Time constant with cooling input in min, with IBase2
IHighTau1	30.0 - 250.0	%IB1	1.0	100.0	Current Sett, in % of IBase1 for rescaling TC1 by TC1-IHIGH
Tau1High	5 - 2000	%tC1	1	100	Multiplier in % to TC1 when current is > IHIGH-TC1
ILowTau1	30.0 - 250.0	%IB1	1.0	100.0	Current Set, in % of IBase1 for rescaling TC1 by TC1-ILOW
Tau1Low	5 - 2000	%tC1	1	100	Multiplier in % to TC1 when current is < ILOW-TC1
IHighTau2	30.0 - 250.0	%IB2	1.0	100.0	Current Set, in % of IBase2 for rescaling TC2 by TC2-IHIGH
Tau2High	5 - 2000	%tC2	1	100	Multiplier in % to TC2 when current is >IHIGH-TC2
ILowTau2	30.0 - 250.0	%IB2	1.0	100.0	Current Set, in % of IBase2 for rescaling TC2 by TC2-ILOW
Tau2Low	5 - 2000	%tC2	1	100	Multiplier in % to TC2 when current is < ILOW-TC2
ITrip	50.0 - 250.0	%IBx	1.0	110.0	Steady state operate current level in % of IBasex
Alarm1	50.0 - 99.0	%Itr	1.0	80.0	First alarm level in % of heat content trip value
Alarm2	50.0 - 99.0	%Itr	1.0	90.0	Second alarm level in % of heat content trip value
ResLo	10.0 - 95.0	%Itr	1.0	60.0	Lockout reset level in % of heat content trip value
ThetaInit	0.0 - 95.0	%	1.0	50.0	Initial Heat content, in % of heat content trip value
Warning	1.0 - 500.0	Min	0.1	30.0	Time setting, below which warning would be set (in min)
tPulse	0.01 - 0.30	s	0.01	0.10	Length of the pulse for trip signal (in msec).

6.3.6 Technical data

Table 103: TRPTTR technical data

Function	Range or value	Accuracy
Base current 1 and 2	(30–250)% of *IBase*	± 1.0% of I_r
Operate time: $$t = \tau \cdot \ln\left(\frac{I^2 - I_p{}^2}{I^2 - I_b{}^2}\right)$$ (Equation 17) $I = I_{measured}$	I_p = load current before overload occurs Time constant τ = (1–500) minutes	IEC 60255–8, class 5 + 200 ms
Alarm level 1 and 2	(50–99)% of heat content trip value	± 2.0% of heat content trip
Operate current	(50–250)% of *IBase*	± 1.0% of I_r
Reset level temperature	(10–95)% of heat content trip	± 2.0% of heat content trip

6.4 Breaker failure protection CCRBRF

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Breaker failure protection	CCRBRF	*3I>BF*	50BF

6.4.1 Introduction

Breaker failure protection (CCRBRF) ensures fast back-up tripping of surrounding breakers in case the own breaker fails to open. CCRBRF can be current based, contact based, or an adaptive combination of these two conditions.

Current check with extremely short reset time is used as check criterion to achieve high security against unnecessary operation.

Contact check criteria can be used where the fault current through the breaker is small.

CCRBRF can be single- or three-phase initiated to allow use with single phase tripping applications. For the three-phase version of CCRBRF the current criteria can be set to operate only if two out of four for example, two phases or one phase plus the residual current start. This gives a higher security to the back-up trip command.

CCRBRF function can be programmed to give a single- or three-phase re-trip of the own breaker to avoid unnecessary tripping of surrounding breakers at an incorrect initiation due to mistakes during testing.

6.4.2 Principle of operation

Breaker failure protection CCRBRF is initiated from protection trip command, either from protection functions within the IED or from external protection devices.

The start signal can be phase selective or general (for all three phases). Phase selective start signals enable single pole re-trip function. This means that a second attempt to open the breaker is done. The re-trip attempt can be made after a set time delay. For transmission lines single pole trip and autoreclosing is often used. The re-trip function can be phase selective if it is initiated from phase selective line protection. The re-trip function can be done with or without current check. With the current check the re-trip is only performed if the current through the circuit breaker is larger than the operate current level.

The start signal can be an internal or external protection trip signal. This signal will start the back-up trip timer. If the opening of the breaker is successful this is detected by the function, by detection of either low current through RMS evaluation and a special adapted current algorithm or by open contact indication. The special algorithm enables a very fast detection of successful breaker opening, that is, fast resetting of the current measurement. If the current and/or contact detection has not detected breaker opening before the back-up timer has run its time a back-up trip is initiated.

Further the following possibilities are available:

- The minimum length of the re-trip pulse, the back-up trip pulse and the back-up trip pulse 2 are settable. The re-trip pulse, the back-up trip pulse and the back-up trip pulse 2 will however sustain as long as there is an indication of closed breaker.
- In the current detection it is possible to use three different options: *1 out of 3* where it is sufficient to detect failure to open (high current) in one pole, *1 out of 4* where it is sufficient to detect failure to open (high current) in one pole or high residual current and *2 out of 4* where at least two current (phase current and/or residual current) shall be high for breaker failure detection.
- The current detection level for the residual current can be set different from the setting of phase current detection.
- It is possible to have different back-up time delays for single-phase faults and for multi-phase faults.
- The back-up trip can be made without current check. It is possible to have this option activated for small load currents only.
- It is possible to have instantaneous back-up trip function if a signal is high if the circuit breaker is insufficient to clear faults, for example at low gas pressure.

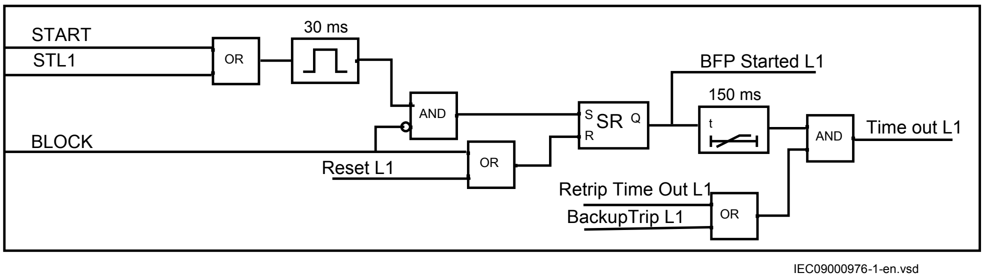

Figure 79: Simplified logic scheme of the CCRBRF starting logic

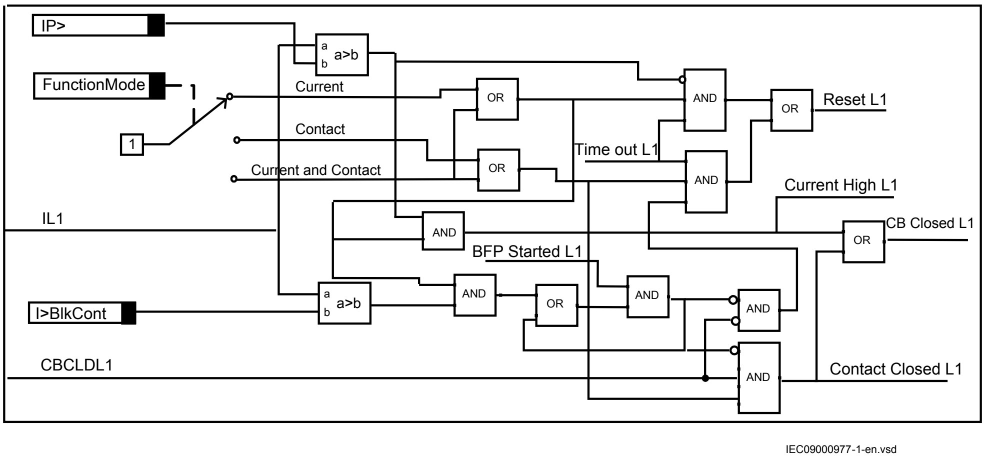

Figure 80: Simplified logic scheme of the CCRBRF, CB position evaluation

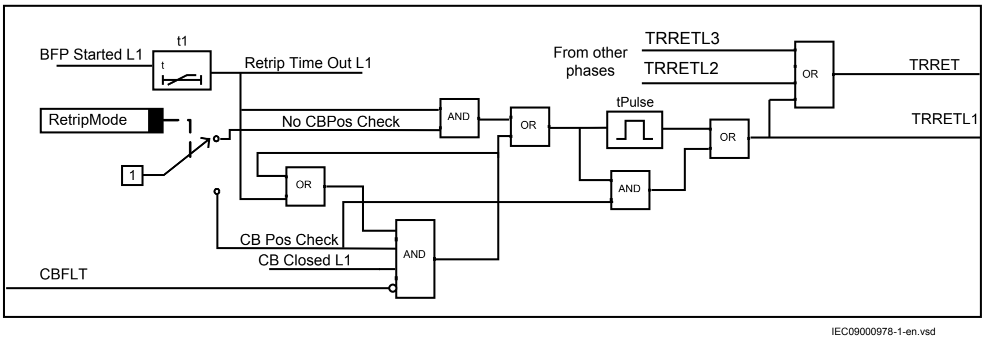

Figure 81: Simplified logic scheme of the retrip logic function

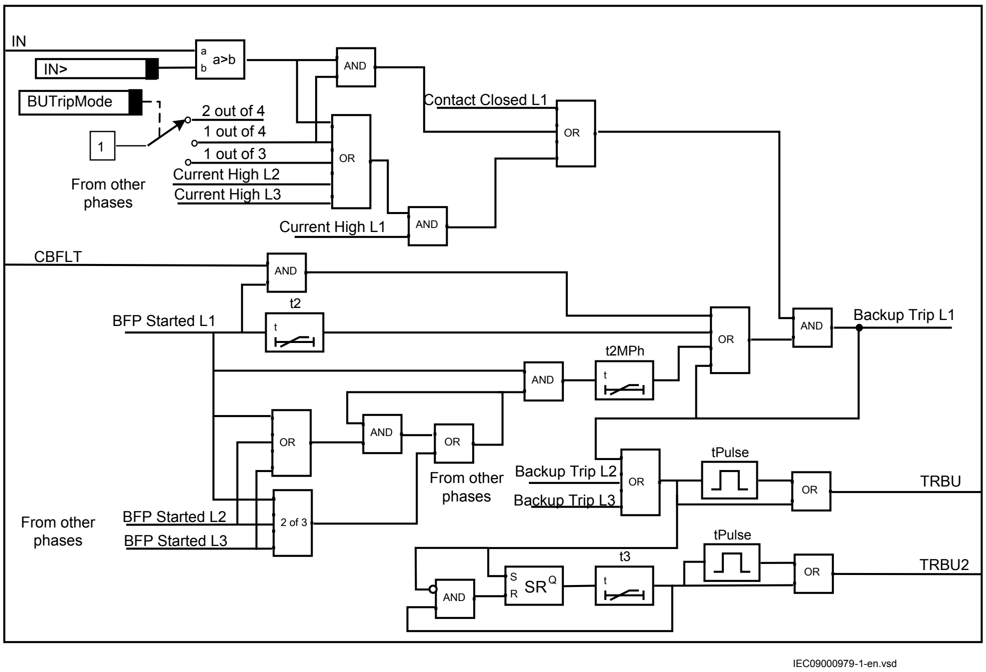

Figure 82: Simplified logic scheme of the back-up trip logic function

Internal logical signals Current High L1, Current High L2, Current High L3 have logical value 1 when current in respective phase has magnitude larger than setting parameter *IP>*.

6.4.3 Function block

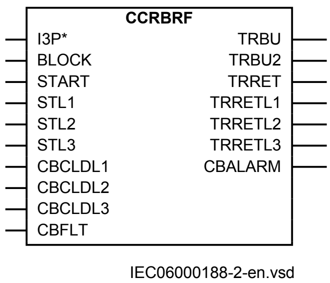

Figure 83: CCRBRF function block

6.4.4 Input and output signals

Table 104: CCRBRF Input signals

Name	Type	Default	Description
I3P	GROUP SIGNAL	-	Three phase group signal for current inputs
BLOCK	BOOLEAN	0	Block of function
START	BOOLEAN	0	Three phase start of breaker failure protection function
STL1	BOOLEAN	0	Start signal of phase L1
STL2	BOOLEAN	0	Start signal of phase L2
STL3	BOOLEAN	0	Start signal of phase L3
CBCLDL1	BOOLEAN	1	Circuit breaker closed in phase L1
CBCLDL2	BOOLEAN	1	Circuit breaker closed in phase L2
CBCLDL3	BOOLEAN	1	Circuit breaker closed in phase L3
CBFLT	BOOLEAN	0	CB faulty, unable to trip. Back-up trip instantaneously

Table 105: CCRBRF Output signals

Name	Type	Description
TRBU	BOOLEAN	Back-up trip by breaker failure protection function
TRBU2	BOOLEAN	Second back-up trip by breaker failure protection function
TRRET	BOOLEAN	Retrip by breaker failure protection function
TRRETL1	BOOLEAN	Retrip by breaker failure protection function phase L1
TRRETL2	BOOLEAN	Retrip by breaker failure protection function phase L2
TRRETL3	BOOLEAN	Retrip by breaker failure protection function phase L3
CBALARM	BOOLEAN	Alarm for faulty circuit breaker

6.4.5 Setting parameters

Table 106: CCRBRF Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
IBase	1 - 99999	A	1	3000	Base current
FunctionMode	Current Contact Current&Contact	-	-	Current	Detection principle for back-up trip

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
BuTripMode	2 out of 4 1 out of 3 1 out of 4	-	-	1 out of 3	Back-up trip mode
RetripMode	Retrip Off CB Pos Check No CBPos Check	-	-	Retrip Off	Operation mode of re-trip logic
IP>	5 - 200	%IB	1	10	Operate phase current level in % of IBase
IN>	2 - 200	%IB	1	10	Operate residual current level in % of IBase
t1	0.000 - 60.000	s	0.001	0.000	Time delay of re-trip
t2	0.000 - 60.000	s	0.001	0.150	Time delay of back-up trip
t2MPh	0.000 - 60.000	s	0.001	0.150	Time delay of back-up trip at multi-phase start
tPulse	0.000 - 60.000	s	0.001	0.200	Trip pulse duration

Table 107: CCRBRF Group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
I>BlkCont	5 - 200	%IB	1	20	Current for blocking of CB contact operation in % of IBase
t3	0.000 - 60.000	s	0.001	0.030	Additional time delay to t2 for a second back-up trip
tCBAlarm	0.000 - 60.000	s	0.001	5.000	Time delay for CB faulty signal

6.4.6 Technical data

Table 108: CCRBRF technical data

Function	Range or value	Accuracy
Operate phase current	(5-200)% of *IBase*	± 1.0% of I_r at $I \leq I_r$ ± 1.0% of I at $I > I_r$
Reset ratio, phase current	> 95%	-
Operate residual current	(2-200)% of *IBase*	± 1.0% of I_r at $I \leq I_r$ ± 1.0% of I at $I > I_r$
Reset ratio, residual current	> 95%	-
Phase current level for blocking of contact function	(5-200)% of *IBase*	± 1.0% of I_r at $I \leq I_r$ ± 1.0% of I at $I > I_r$
Reset ratio	> 95%	-
Timers	(0.000-60.000) s	± 0.5% ±10 ms
Operate time for current detection	10 ms typically	-
Reset time for current detection	15 ms maximum	-

6.5 Breaker failure protection, single phase version CCSRBRF

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Breaker failure protection, single phase version	CCSRBRF	I>BF	50BF

6.5.1 Introduction

Breaker failure protection, single phase version (CCSRBRF) function ensures fast back-up tripping of surrounding breakers.

A current check with extremely short reset time is used as check criteria to achieve a high security against unnecessary operation.

CCSRBRF can be programmed to give a re-trip of the own breaker to avoid unnecessary tripping of surrounding breakers at an incorrect starting due to mistakes during testing.

6.5.2 Principle of operation

Breaker failure protection, single phase version CCSRBRF is initiated from protection trip command, either from protection functions within the protection IED or from external protection devices.

The start signal enables the re-trip function. This means that a second attempt to open the breaker is done. The re-trip attempt can be made after a set time delay. The re-trip function can be done with or without current check. With the current check the re-trip is only performed if the current through the circuit breaker is larger than the operate current level.

The start signal can be an internal or external protection trip signal. If this start signal gets high at the same time as current is detected through the circuit breaker, the back-up trip timer is started. If the opening of the breaker is successful this is detected by the function, both by detection of low RMS current and by a special adapted algorithm. The special algorithm enables a very fast detection of successful breaker opening, that is, fast resetting of the current measurement. If the current detection has not detected breaker opening before the set back-up time has elapsed, a back-up trip is initiated. There is also a possibility to have a second back-up trip output activated a settable time after the first back-up trip.

Further the following possibilities are available:

- The minimum length of the re-trip pulse, the back-up trip pulse and the back-up trip pulse 2 are settable. The re-trip pulse, the back-up trip pulse and the back-up trip pulse 2 will however sustain as long as there is an indication of closed breaker.
- The back-up trip can be made without current check. It is possible to have this option activated for small load currents only.
- It is possible to have instantaneous back-up trip function if a signal (CBFLT) is high due to that circuit breaker is unable to clear faults, for example at low gas pressure.

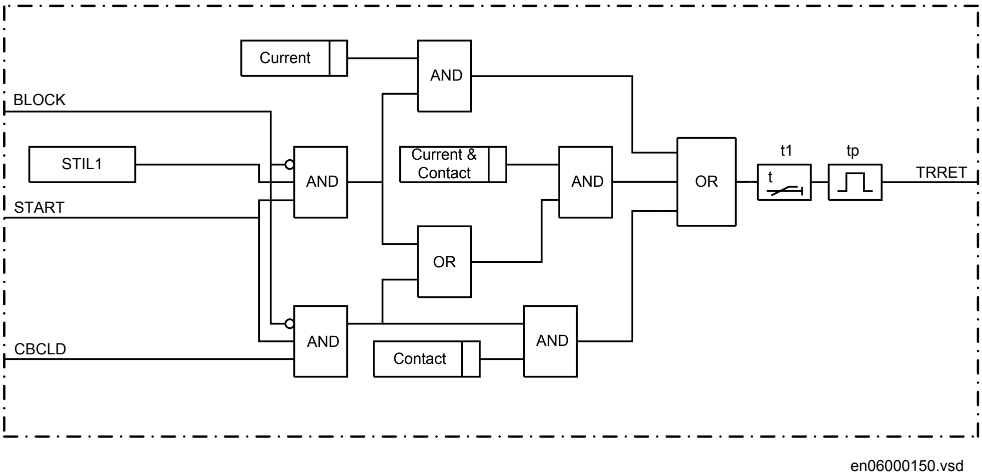

Figure 84: Simplified logic diagram of the retrip function

Internal logical signal STIL1 has logical value 1 when current in that phase has magnitude larger than setting parameter *IP>*.

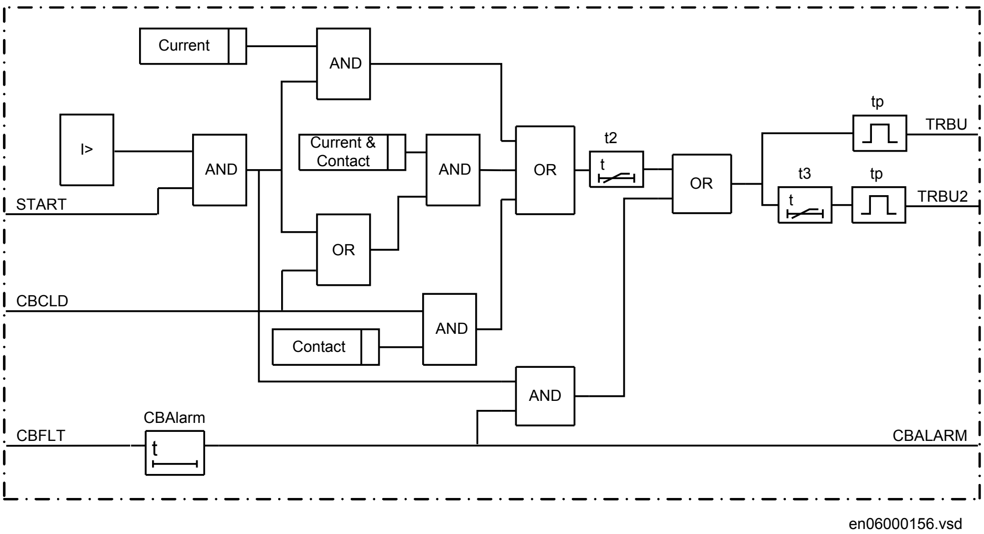

Figure 85: Simplified logic diagram of the back-up trip function

6.5.3 Function block

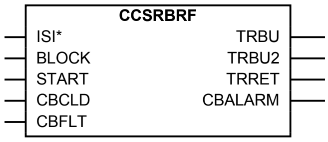

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Figure 86: CCSRBRF function block

6.5.4 Input and output signals

Table 109: CCSRBRF Input signals

Name	Type	Default	Description
ISI	GROUP SIGNAL	-	Single phase group signal for current input
BLOCK	BOOLEAN	0	Block of function
START	BOOLEAN	0	Start of breaker failure protection
CBCLD	BOOLEAN	0	Circuit breaker closed
CBFLT	BOOLEAN	0	CB faulty, unable to trip. Back-up trip instantaneously

Table 110: CCSRBRF Output signals

Name	Type	Description
TRBU	BOOLEAN	Back-up trip by breaker failure protection
TRBU2	BOOLEAN	Second back-up trip by breaker failure protection
TRRET	BOOLEAN	Retrip by breaker failure protection
CBALARM	BOOLEAN	Alarm for faulty circuit breaker

6.5.5 Setting parameters

Table 111: CCSRBRF Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
IBase	1 - 99999	A	1	3000	Base setting for current level settings
FunctionMode	Current Contact Current&Contact	-	-	Current	Detection for trip Current/Contact/ Current&Contact
RetripMode	Retrip Off I> Check No I> Check	-	-	Retrip Off	Operation mode of re-trip logic: OFF /I> check/ No I> check
IP>	5 - 200	%IB	1	10	Operate level in % of IBase

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
I>BlkCont	5 - 200	%IB	1	20	Current for blocking of CB contact operation in % of IBase
t1	0.000 - 60.000	s	0.001	0.000	Delay for re-trip
t2	0.000 - 60.000	s	0.001	0.150	Delay of back-up trip
t3	0.000 - 60.000	s	0.001	0.030	Additional delay to t2 for a second back-up trip
tCBAlarm	0.000 - 60.000	s	0.001	5.000	Delay for CB faulty signal
tPulse	0.000 - 60.000	s	0.001	0.200	Trip pulse duration

6.5.6 Technical data

Table 112: CCSRBRF technical data

Function	Range or value	Accuracy
Operate phase current	(5-200)% of *IBase*	± 1.0% of I_r at $I \leq I_r$ ± 1.0% of I at $I > I_r$
Reset ratio, phase current	> 95%	-
Phase current level for blocking of contact function	(5-200)% of *IBase*	± 1.0% of I_r at $I \leq I_r$ ± 1.0% of I at $I > I_r$
Reset ratio	> 95%	-
Timers	(0.000-60.000) s	± 0.5% ± 10 ms
Operate time for current detection	10 ms typically	-
Reset time for current detection	15 ms maximum	-

6.6 Directional underpower protection GUPPDUP

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Directional underpower protection	GUPPDUP	P < →	37

6.6.1 Introduction

The task of a generator in a power plant is to convert mechanical energy available as a torque on a rotating shaft to electric energy.

Sometimes, the mechanical power from a prime mover may decrease so much that it does not cover bearing losses and ventilation losses. Then, the synchronous generator becomes a synchronous motor and starts to take electric power from the rest of the power system. This operating state, where individual synchronous machines operate as motors, implies no risk for the machine itself. If the generator under consideration is very large and if it consumes lots of electric power, it may be desirable to disconnect it to ease the task for the rest of the power system.

Often, the motoring condition may imply that the turbine is in a very dangerous state. The task of the reverse power protection is to protect the turbine and not to protect the generator itself.

Figure 87 illustrates the low forward power and reverse power protection with underpower and overpower functions respectively. The underpower IED gives a higher margin and should provide better dependability. On the other hand, the risk for unwanted operation immediately after synchronization may be higher. One should set the underpower IED to trip if the active power from the generator is less than about 2%. One should set the overpower IED to trip if the power flow from the network to the generator is higher than 1% depending on the type of turbine.

When IED with a metering class input CTs is used pickup can be set to more sensitive value (e.g.0,5% or even to 0,2%).

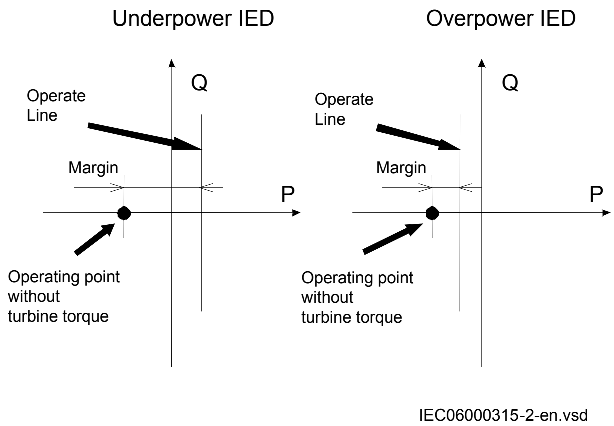


Figure 87: Protection with underpower IED and overpower IED

6.6.2 Principle of operation

A simplified scheme showing the principle of the power protection function is shown in figure 88. The function has two stages with individual settings.

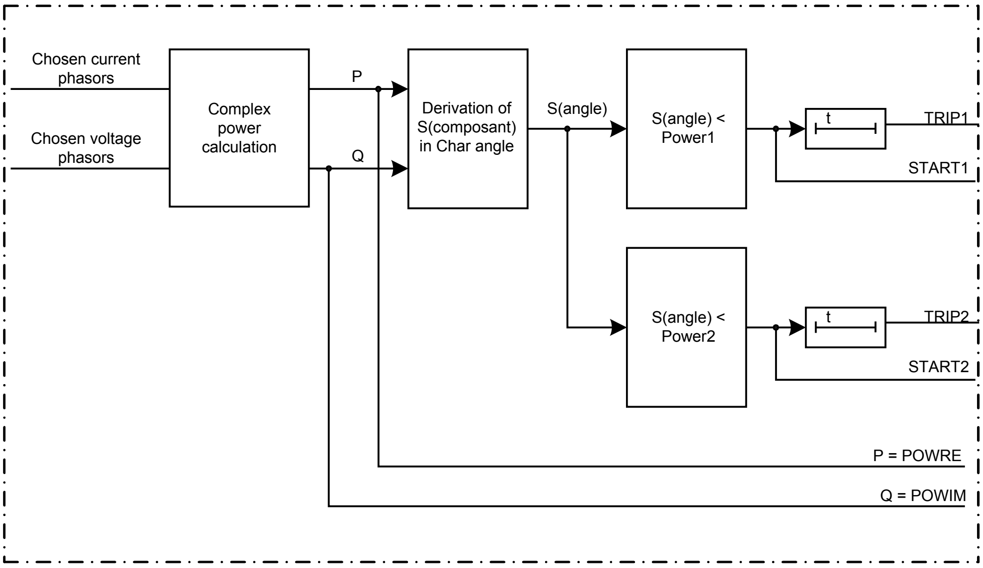


Figure 88: Simplified logic diagram of the power protection function

The function will use voltage and current phasors calculated in the pre-processing blocks. The apparent complex power is calculated according to chosen formula as shown in table 113.

Table 113: Complex power calculation

Set value: *Mode*	Formula used for complex power calculation
L1, L2, L3	$\overline{S} = \overline{U}_{L1} \cdot \overline{I}_{L1}^{*} + \overline{U}_{L2} \cdot \overline{I}_{L2}^{*} + \overline{U}_{L3} \cdot \overline{I}_{L3}^{*}$ (Equation 18)
Arone	$\overline{S} = \overline{U}_{L1L2} \cdot \overline{I}_{L1}^{*} - \overline{U}_{L2L3} \cdot \overline{I}_{L3}^{*}$ (Equation 19)
PosSeq	$\overline{S} = 3 \cdot \overline{U}_{PosSeq} \cdot \overline{I}_{PosSeq}^{*}$ (Equation 20)
L1L2	$\overline{S} = \overline{U}_{L1L2} \cdot (\overline{I}_{L1}^{*} - \overline{I}_{L2}^{*})$ (Equation 21)
L2L3	$\overline{S} = \overline{U}_{L2L3} \cdot (\overline{I}_{L2}^{*} - \overline{I}_{L3}^{*})$ (Equation 22)
L3L1	$\overline{S} = \overline{U}_{L3L1} \cdot (\overline{I}_{L3}^{*} - \overline{I}_{L1}^{*})$ (Equation 23)

Table continues on next page

Set value: *Mode*	Formula used for complex power calculation
L1	$\bar{S} = 3 \cdot \bar{U}_{L1} \cdot \bar{I}_{L1}^{*}$ (Equation 24)
L2	$\bar{S} = 3 \cdot \bar{U}_{L2} \cdot \bar{I}_{L2}^{*}$ (Equation 25)
L3	$\bar{S} = 3 \cdot \bar{U}_{L3} \cdot \bar{I}_{L3}^{*}$ (Equation 26)

The active and reactive power is available from the function and can be used for monitoring and fault recording.

The component of the complex power S = P + jQ in the direction *Angle1(2)* is calculated. If this angle is 0° the active power component P is calculated. If this angle is 90° the reactive power component Q is calculated.

The calculated power component is compared to the power pick up setting *Power1(2)*. For directional underpower protection, a start signal START1(2) is activated if the calculated power component is smaller than the pick up value. For directional overpower protection, a start signal START1(2) is activated if the calculated power component is larger than the pick up value. After a set time delay *TripDelay1(2)* a trip TRIP1(2) signal is activated if the start signal is still active. At activation of any of the two stages a common signal START will be activated. At trip from any of the two stages also a common signal TRIP will be activated.

To avoid instability there is a settable hysteresis in the power function. The absolute hysteresis of the stage1(2) is *Hysteresis1(2)* = abs *(Power1(2)* + drop-power1(2)). For generator low forward power protection the power setting is very low, normally down to 0.02 p.u. of rated generator power. The hysteresis should therefore be set to a smaller value. The drop-power value of stage1 can be calculated with *the Power1(2), Hysteresis1(2)*: drop-power1(2) = *Power1(2)* + *Hysteresis1(2)*

For small power1 values the hysteresis1 may not be too big, because the drop-power1(2) would be too small. In such cases, the hysteresis1 greater than (0.5 · *Power1(2)*) is corrected to the minimal value.

If the measured power drops under the drop-power1(2) value, the function will reset after a set time *DropDelay1(2)*. The reset means that the start signal will drop out and that the timer of the stage will reset.

6.6.2.1 Low pass filtering

In order to minimize the influence of the noise signal on the measurement it is possible to introduce the recursive, low pass filtering of the measured values for S (P, Q). This will make slower measurement response to the step changes in the measured quantity. Filtering is performed in accordance with the following recursive formula:

$$S = k \cdot S_{Old} + (1 - k) \cdot S_{Calculated}$$

(Equation 27)

Where

S	is a new measured value to be used for the protection function
S_{old}	is the measured value given from the function in previous execution cycle
SCalculated	is the new calculated value in the present execution cycle
k	is settable parameter by the end user which influence the filter properties

Default value for parameter *k* is *0.00*. With this value the new calculated value is immediately given out without any filtering (that is without any additional delay). When *k* is set to value bigger than 0, the filtering is enabled. A typical value for *k=0.92* in case of slow operating functions.

6.6.2.2 Calibration of analog inputs

Measured currents and voltages used in the Power function can be calibrated to get class 0.5 measuring accuracy. This is achieved by amplitude and angle compensation at 5, 30 and 100% of rated current and voltage. The compensation below 5% and above 100% is constant and linear in between, see example in figure 89.

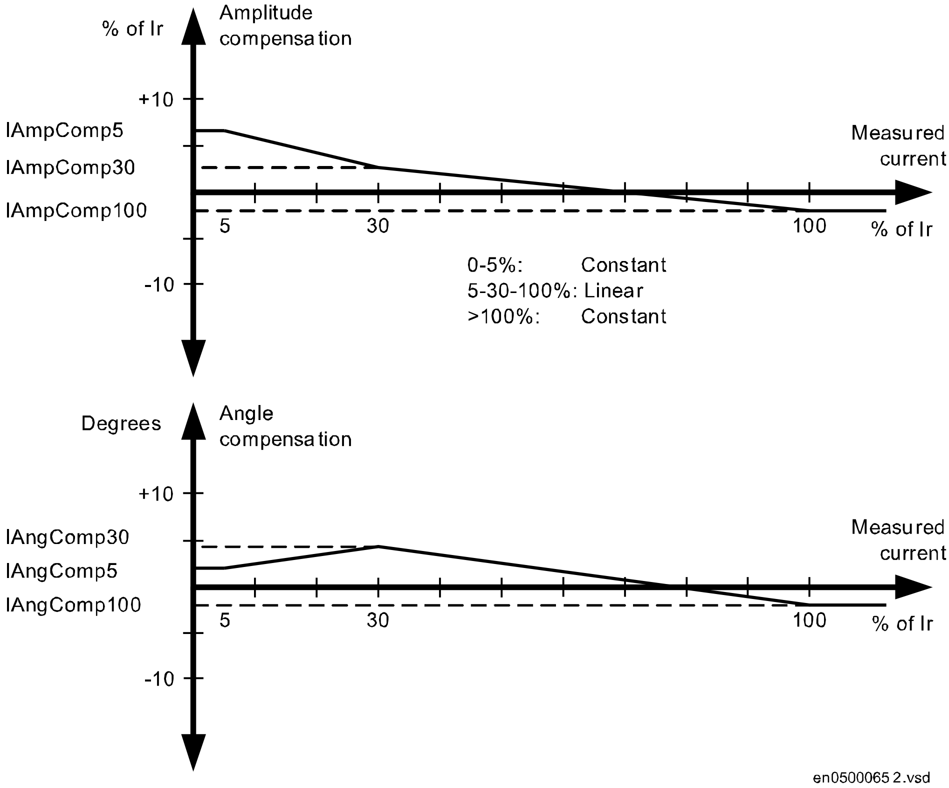


Figure 89: Calibration curves

The first current and voltage phase in the group signals will be used as reference and the amplitude and angle compensation will be used for related input signals.

Analog outputs (Monitored data) from the function can be used for service values or in the disturbance report. The active power is provided as MW value: P, or in percent of base power: PPERCENT. The reactive power is provided as Mvar value: Q, or in percent of base power: QPERCENT.

6.6.3 Function block

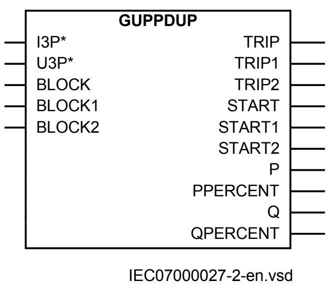


Figure 90: GUPPDUP function block

6.6.4 Input and output signals

Table 114: GUPPDUP Input signals

Name	Type	Default	Description
I3P	GROUP SIGNAL	-	Current group connection
U3P	GROUP SIGNAL	-	Voltage group connection
BLOCK	BOOLEAN	0	Block of function
BLOCK1	BOOLEAN	0	Block of stage 1
BLOCK2	BOOLEAN	0	Block of stage 2

Table 115: GUPPDUP Output signals

Name	Type	Description
TRIP	BOOLEAN	Common trip signal
TRIP1	BOOLEAN	Trip of stage 1
TRIP2	BOOLEAN	Trip of stage 2
START	BOOLEAN	Common start
START1	BOOLEAN	Start of stage 1
START2	BOOLEAN	Start of stage 2
P	REAL	Active Power in MW
PPERCENT	REAL	Active power in % of SBASE
Q	REAL	Reactive power in Mvar
QPERCENT	REAL	Reactive power in % of SBASE

6.6.5 Setting parameters

Table 116: GUPPDUP Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
OpMode1	Off UnderPower	-	-	UnderPower	Operation mode 1
Power1	0.0 - 500.0	%SB	0.1	1.0	Power setting for stage 1 in % of Sbase
Angle1	-180.0 - 180.0	Deg	0.1	0.0	Angle for stage 1
TripDelay1	0.010 - 6000.000	s	0.001	1.000	Trip delay for stage 1
DropDelay1	0.010 - 6000.000	s	0.001	0.060	Drop delay for stage 1
OpMode2	Off UnderPower	-	-	UnderPower	Operation mode 2
Power2	0.0 - 500.0	%SB	0.1	1.0	Power setting for stage 2 in % of Sbase
Angle2	-180.0 - 180.0	Deg	0.1	0.0	Angle for stage 2
TripDelay2	0.010 - 6000.000	s	0.001	1.000	Trip delay for stage 2
DropDelay2	0.010 - 6000.000	s	0.001	0.060	Drop delay for stage 2

Table 117: GUPPDUP Group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
k	0.000 - 0.999	-	0.001	0.000	Low pass filter coefficient for power measurement, P and Q
Hysteresis1	0.2 - 5.0	pu	0.1	0.5	Absolute hysteresis of stage 1 in % Sbase
Hysteresis2	0.2 - 5.0	pu	0.1	0.5	Absolute hysteresis of stage 2 in % Sbase
IAmpComp5	-10.000 - 10.000	%	0.001	0.000	Amplitude factor to calibrate current at 5% of Ir
IAmpComp30	-10.000 - 10.000	%	0.001	0.000	Amplitude factor to calibrate current at 30% of Ir
IAmpComp100	-10.000 - 10.000	%	0.001	0.000	Amplitude factor to calibrate current at 100% of Ir
UAmpComp5	-10.000 - 10.000	%	0.001	0.000	Amplitude factor to calibrate voltage at 5% of Ur
UAmpComp30	-10.000 - 10.000	%	0.001	0.000	Amplitude factor to calibrate voltage at 30% of Ur
UAmpComp100	-10.000 - 10.000	%	0.001	0.000	Amplitude factor to calibrate voltage at 100% of Ur
IAngComp5	-10.000 - 10.000	Deg	0.001	0.000	Angle calibration for current at 5% of Ir
IAngComp30	-10.000 - 10.000	Deg	0.001	0.000	Angle calibration for current at 30% of Ir
IAngComp100	-10.000 - 10.000	Deg	0.001	0.000	Angle calibration for current at 100% of Ir

Table 118: GUPPDUP Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
IBase	1 - 99999	A	1	3000	Base setting for current level
UBase	0.05 - 2000.00	kV	0.05	400.00	Base setting for voltage level
Mode	L1, L2, L3 Arone Pos Seq L1L2 L2L3 L3L1 L1 L2 L3	-	-	Pos Seq	Selection of measured current and voltage

6.6.6 Technical data

Table 119: GUPPDUP technical data

Function	Range or value	Accuracy
Power level	(0.0–500.0)% of *SBase* At low setting: (0.5-2.0)% of *SBase* (2.0-10)% of *SBase*	± 1.0% of S_r at S < S_r ± 1.0% of S at S > S_r < ± 50% of set value < ± 20% of set value
Characteristic angle	(-180.0–180.0) degrees	2 degrees
Timers	(0.00-6000.00) s	± 0.5% ± 10 ms

6.7 Directional overpower protection GOPPDOP

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Directional overpower protection	GOPPDOP	P > →	32

6.7.1 Introduction

The task of a generator in a power plant is to convert mechanical energy available as a torque on a rotating shaft to electric energy.

Sometimes, the mechanical power from a prime mover may decrease so much that it does not cover bearing losses and ventilation losses. Then, the synchronous generator becomes a synchronous motor and starts to take electric power from the rest of the power system. This operating state, where individual synchronous machines operate as motors, implies no risk for the machine itself. If the generator under consideration is very large and if it consumes lots of electric power, it may be desirable to disconnect it to ease the task for the rest of the power system.

Often, the motoring condition may imply that the turbine is in a very dangerous state. The task of the reverse power protection is to protect the turbine and not to protect the generator itself.

Figure 91 illustrates the low forward power and reverse power protection with underpower and overpower functions respectively. The underpower IED gives a higher margin and should provide better dependability. On the other hand, the risk for unwanted operation immediately after synchronization may be higher. One should set the underpower IED to trip if the active power from the generator is less than about 2%. One should set the overpower IED to trip if the power flow from the network to the generator is higher than 1%.

When IED with a metering class input CTs is used pickup can be set to more sensitive value (e.g.0,5% or even to 0,2%).

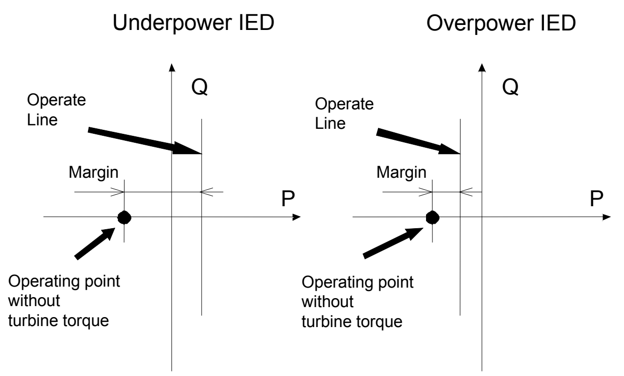


Figure 91: Reverse power protection with underpower IED and overpower IED

6.7.2 Principle of operation

A simplified scheme showing the principle of the power protection function is shown in figure 92. The function has two stages with individual settings.

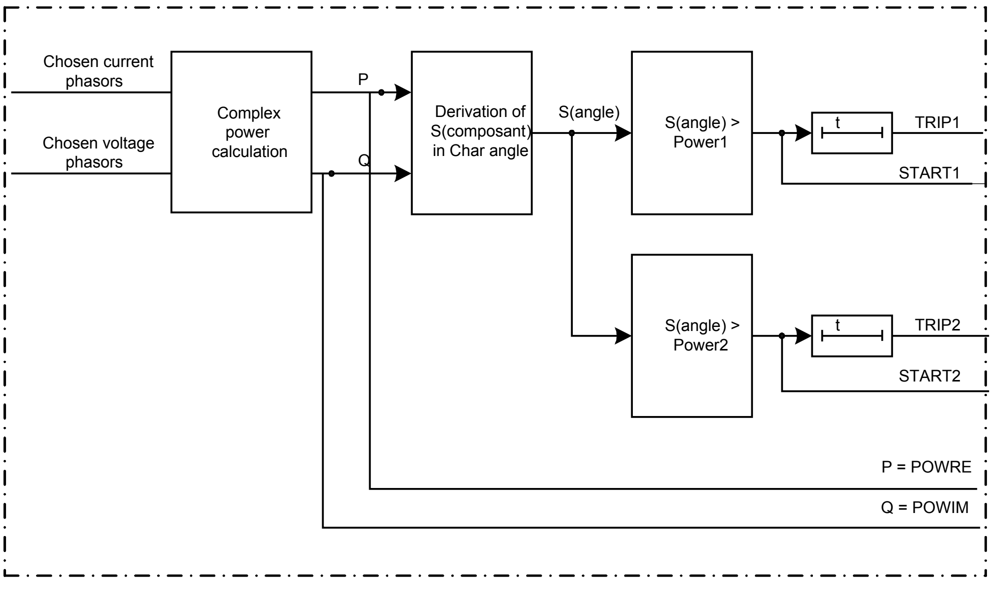


Figure 92: Simplified logic diagram of the power protection function

The function will use voltage and current phasors calculated in the pre-processing blocks. The apparent complex power is calculated according to chosen formula as shown in table 120.

Table 120: Complex power calculation

Set value: *Mode*	Formula used for complex power calculation
L1, L2, L3	$\bar{S} = \bar{U}_{L1} \cdot \bar{I}_{L1}^{*} + \bar{U}_{L2} \cdot \bar{I}_{L2}^{*} + \bar{U}_{L3} \cdot \bar{I}_{L3}^{*}$ (Equation 28)
Arone	$\bar{S} = \bar{U}_{L1L2} \cdot \bar{I}_{L1}^{*} - \bar{U}_{L2L3} \cdot \bar{I}_{L3}^{*}$ (Equation 29)
PosSeq	$\bar{S} = 3 \cdot \bar{U}_{PosSeq} \cdot \bar{I}_{PosSeq}^{*}$ (Equation 30)
L1L2	$\bar{S} = \bar{U}_{L1L2} \cdot (\bar{I}_{L1}^{*} - \bar{I}_{L2}^{*})$ (Equation 31)
L2L3	$\bar{S} = \bar{U}_{L2L3} \cdot (\bar{I}_{L2}^{*} - \bar{I}_{L3}^{*})$ (Equation 32)
L3L1	$\bar{S} = \bar{U}_{L3L1} \cdot (\bar{I}_{L3}^{*} - \bar{I}_{L1}^{*})$ (Equation 33)
L1	$\bar{S} = 3 \cdot \bar{U}_{L1} \cdot \bar{I}_{L1}^{*}$ (Equation 34)
L2	$\bar{S} = 3 \cdot \bar{U}_{L2} \cdot \bar{I}_{L2}^{*}$ (Equation 35)
L3	$\bar{S} = 3 \cdot \bar{U}_{L3} \cdot \bar{I}_{L3}^{*}$ (Equation 36)

The active and reactive power is available from the function and can be used for monitoring and fault recording.

The component of the complex power S = P + jQ in the direction *Angle1(2)* is calculated. If this angle is 0° the active power component P is calculated. If this angle is 90° the reactive power component Q is calculated.

The calculated power component is compared to the power pick up setting *Power1(2)*. A start signal START1(2) is activated if the calculated power component is larger than the pick up value. After a set time delay *TripDelay1(2)* a trip TRIP1(2) signal is activated if the start signal is still active. At activation of any of the two stages a common signal START will be activated. At trip from any of the two stages also a common signal TRIP will be activated.

To avoid instability there is a settable hysteresis in the power function. The absolute hysteresis of the stage1(2) is *Hysteresis1(2)* = abs *(Power1(2)* – drop-power1(2)). For generator reverse power protection the power setting is very low, normally down to 0.02 p.u. of rated generator power. The hysteresis should therefore be set to a smaller value. The drop-power value of stage1 can be calculated with the *Power1(2)*, *Hysteresis1(2)*: drop-power1(2) = *Power1(2) – Hysteresis1(2)*

For small power1 values the hysteresis1 may not be too big, because the drop-power1(2) would be too small. In such cases, the hysteresis1 greater than (0.5 · *Power1(2)*) is corrected to the minimal value.

If the measured power drops under the drop-power1(2) value the function will reset after a set time *DropDelay1(2)*. The reset means that the start signal will drop out ant that the timer of the stage will reset.

6.7.2.1 Low pass filtering

In order to minimize the influence of the noise signal on the measurement it is possible to introduce the recursive, low pass filtering of the measured values for S (P, Q). This will make slower measurement response to the step changes in the measured quantity. Filtering is performed in accordance with the following recursive formula:

$$S = k \cdot S_{Old} + (1 - k) \cdot S_{Calculated}$$

(Equation 37)

Where

S	is a new measured value to be used for the protection function
S_{old}	is the measured value given from the function in previous execution cycle
$S_{Calculated}$	is the new calculated value in the present execution cycle
k	is settable parameter by the end user which influence the filter properties

Default value for parameter *k* is *0.00*. With this value the new calculated value is immediately given out without any filtering (that is, without any additional delay). When *k* is set to value bigger than 0, the filtering is enabled. A typical value for *k = 0.92* in case of slow operating functions.

6.7.2.2 Calibration of analog inputs

Measured currents and voltages used in the Power function can be calibrated to get class 0.5 measuring accuracy. This is achieved by amplitude and angle compensation at 5, 30 and 100% of rated current and voltage. The compensation below 5% and above 100% is constant and linear in between, see example in figure 93.

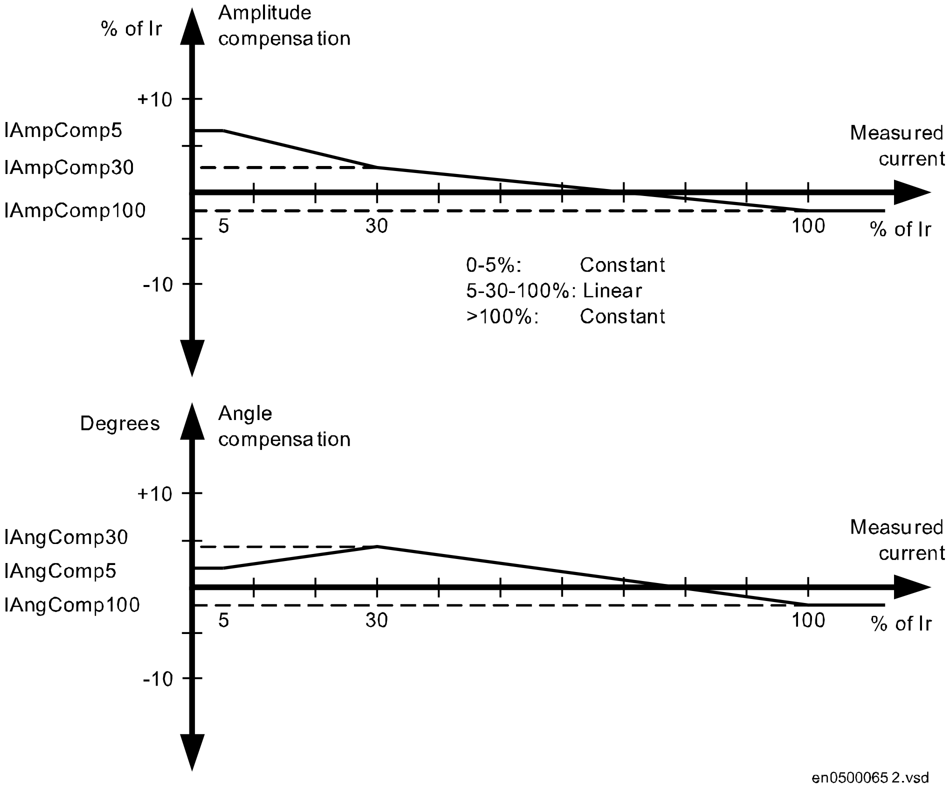


Figure 93: Calibration curves

The first current and voltage phase in the group signals will be used as reference and the amplitude and angle compensation will be used for related input signals.

Analog outputs from the function can be used for service values or in the disturbance report. The active power is provided as MW value: P, or in percent of base power: PPERCENT. The reactive power is provided as Mvar value: Q, or in percent of base power: QPERCENT.

6.7.3 Function block

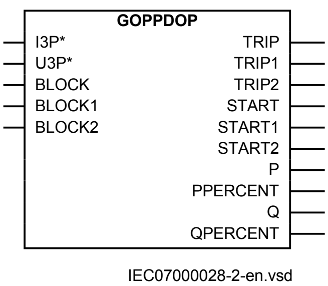


Figure 94: GOPPDOP function block

6.7.4 Input and output signals

Table 121: GOPPDOP Input signals

Name	Type	Default	Description
I3P	GROUP SIGNAL	-	Current group connection
U3P	GROUP SIGNAL	-	Voltage group connection
BLOCK	BOOLEAN	0	Block of function
BLOCK1	BOOLEAN	0	Block of stage 1
BLOCK2	BOOLEAN	0	Block of stage 2

Table 122: GOPPDOP Output signals

Name	Type	Description
TRIP	BOOLEAN	Common trip signal
TRIP1	BOOLEAN	Trip of stage 1
TRIP2	BOOLEAN	Trip of stage 2
START	BOOLEAN	Common start
START1	BOOLEAN	Start of stage 1
START2	BOOLEAN	Start of stage 2
P	REAL	Active Power in MW
PPERCENT	REAL	Active power in % of SBASE
Q	REAL	Reactive power in Mvar
QPERCENT	REAL	Reactive power in % of SBASE

6.7.5 Setting parameters

Table 123: GOPPDOP Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
OpMode1	Off OverPower	-	-	OverPower	Operation mode 1
Power1	0.0 - 500.0	%SB	0.1	120.0	Power setting for stage 1 in % of Sbase
Angle1	-180.0 - 180.0	Deg	0.1	0.0	Angle for stage 1
TripDelay1	0.010 - 6000.000	s	0.001	1.000	Trip delay for stage 1
DropDelay1	0.010 - 6000.000	s	0.001	0.060	Drop delay for stage 1
OpMode2	Off OverPower	-	-	OverPower	Operation mode 2
Power2	0.0 - 500.0	%SB	0.1	120.0	Power setting for stage 2 in % of Sbase
Angle2	-180.0 - 180.0	Deg	0.1	0.0	Angle for stage 2
TripDelay2	0.010 - 6000.000	s	0.001	1.000	Trip delay for stage 2
DropDelay2	0.010 - 6000.000	s	0.001	0.060	Drop delay for stage 2

Table 124: GOPPDOP Group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
k	0.000 - 0.999	-	0.001	0.000	Low pass filter coefficient for power measurement, P and Q
Hysteresis1	0.2 - 5.0	pu	0.1	0.5	Absolute hysteresis of stage 1 in % of Sbase
Hysteresis2	0.2 - 5.0	pu	0.1	0.5	Absolute hysteresis of stage 2 in % of Sbase
IAmpComp5	-10.000 - 10.000	%	0.001	0.000	Amplitude factor to calibrate current at 5% of Ir
IAmpComp30	-10.000 - 10.000	%	0.001	0.000	Amplitude factor to calibrate current at 30% of Ir
IAmpComp100	-10.000 - 10.000	%	0.001	0.000	Amplitude factor to calibrate current at 100% of Ir
UAmpComp5	-10.000 - 10.000	%	0.001	0.000	Amplitude factor to calibrate voltage at 5% of Ur
UAmpComp30	-10.000 - 10.000	%	0.001	0.000	Amplitude factor to calibrate voltage at 30% of Ur
UAmpComp100	-10.000 - 10.000	%	0.001	0.000	Amplitude factor to calibrate voltage at 100% of Ur
IAngComp5	-10.000 - 10.000	Deg	0.001	0.000	Angle calibration for current at 5% of Ir
IAngComp30	-10.000 - 10.000	Deg	0.001	0.000	Angle calibration for current at 30% of Ir
IAngComp100	-10.000 - 10.000	Deg	0.001	0.000	Angle calibration for current at 100% of Ir

Table 125: GOPPDOP Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
IBase	1 - 99999	A	1	3000	Base setting for current level
UBase	0.05 - 2000.00	kV	0.05	400.00	Base setting for voltage level
Mode	L1, L2, L3 Arone Pos Seq L1L2 L2L3 L3L1 L1 L2 L3	-	-	Pos Seq	Selection of measured current and voltage

6.7.6 Technical data

Table 126: GOPPDOP technical data

Function	Range or value	Accuracy
Power level	(0.0–500.0)% of S_{base} At low setting: (0.5-2.0)% of S_{base} (2.0-10)% of S_{base}	± 1.0% of S_r at $S < S_r$ ± 1.0% of S at $S > S_r$ < ± 50% of set value < ± 20% of set value
Characteristic angle	(-180.0–180.0) degrees	2 degrees
Timers	(0.00-6000.00) s	± 0.5% ± 10 ms

6.8 Capacitor bank protection CBPGAPC

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Capacitor bank protection	CBPGAPC	-	-

6.8.1 Introduction

Shunt Capacitor Banks (SCB) are used in a power system to provide reactive power compensation and power factor correction. They are as well used as integral parts of Static Var Compensators (SVC) or Harmonic Filters installations. Capacitor bank protection (CBPGAPC) function is specially designed to provide protection and supervision features for SCBs.

6.8.2 Principle of operation

Capacitor bank protection (CBPGAPC) function measures the SCB three-phase current. CBPGAPC function has the following built-in features:

- Overcurrent stage
- Undercurrent stage
- Reconnection inhibit
- Harmonic overload
- Reactive power overload

6.8.2.1 Measured quantities

Three-phase input current from the SCB is connected via the preprocessing block to CBPGAPC function. From this preprocessing block CBPGAPC function obtains the following quantities for every phase:

- Current sample values with sampling rate of 1 kHz in 50 Hz power system and 1.2 kHz in 60 Hz power system (that is, 20 samples in fundamental power system cycle). These samples correspond to the instantaneous current waveform of the protected SCB and in further text will be marked with symbol "$i_{\sim}$"
- Equivalent RMS current value based on Peak Current measurement. This value is obtained as maximum absolute current sample value over last power system cycle divided by √2 and in further text will be marked with symbol "$I_{peakRMS}$"
- Equivalent true RMS current value based on the following formula:

$$I_{TRMS} = \sqrt{\frac{\sum_{m=1}^{N} i_{\sim m}^{2}}{\mathrm{N}}}$$

(Equation 38)

where N is used number of samples in one power system cycle (that is, 20) and $i_{\sim m}$ are last N samples of the current waveform. In further text this equivalent true rms current quantity will be marked with symbol I_{TRMS}.

Note that the measured $I_{peakRMS}$ value is available as a service value in primary amperes for every phase from the function.

From the measured SCB currents, voltage value across every SCB phase is calculated. This is done by continuous integration of the measured current waveform by using the following principal equation:

$$u(t) = \frac{1}{C} \cdot \int i(t) \cdot \partial t$$

(Equation 39)

Where:

u(t)	is voltage waveform across capacitor
i(t)	is capacitor current waveform
C	is capacitance in Farads

By using this integration procedure and subsequent filtering the following quantities for every phase are calculated within the function:

- Voltage sample values with rate of 1 kHz in 50 Hz power system and 1.2 kHz in 60 Hz power system (that is, 20 samples in fundamental power system cycle). These samples correspond to the instantaneous voltage waveform across the protected SCB and in further text will be marked with symbol $u_{\sim}$

- Equivalent rms voltage value based on Peak Voltage measurement. This value is obtained as maximum absolute voltage sample value over last power system cycle divided by √2 and in further text will be marked with symbol $U_{peakRMS}$
- Equivalent true RMS voltage value based on the following formula:

$$U_{TRMS} = \sqrt{\frac{\sum_{m=1}^{N} u_{\sim m}^{2}}{N}}$$

(Equation 40)

Where:

N	is used number of samples in one power system cycle (for example, 20)
$u_{\sim m}$	are last N samples of the voltage waveform

In further text this equivalent true RMS voltage quantity will be marked with symbol U_{TRMS}

Some additional filtering of the calculated voltage quantities is additionally performed within the function in order to avoid equivalent RMS voltage values overshooting during capacitor switching.

In order to avoid dependence of the current integration on exact value of the protected capacitor bank capacitance the whole integration process is done in per unit system. In order to convert measured current in primary amperes into per unit value the base current for the protected capacitor bank shall be known. This value is set as parameter *IBase* and it represents the rated SCB current in primary amperes at fundamental frequency. This value is calculated for a three-phase SCB as follows:

$$IBase = \frac{1000 \cdot Q\left[MVAr\right]}{\sqrt{3} \cdot U\left[kV\right]}$$

(Equation 41)

Where:

IBase	is base current for the function in primary amperes
Q[MVAr]	is shunt capacitor bank MVAr rating
U[kV]	is shunt capacitor bank rated phase-to-phase voltage in kV

Once the base current is known the internal voltage calculations can be performed. Note that the calculated $U_{peakRMS}$ value is available as a service value in percent for every phase from the function.

Generated reactive power (Q) by the capacitor bank is calculated within the function for every phase as given by the following equation:

$$Q = U_{TRMS} \cdot I_{TRMS}$$

(Equation 42)

Where:

Q	is generated reactive power in per-unit
U_{TRMS}	is capacitor equivalent true RMS voltage in per-unit
I_{TRMS}	is capacitor equivalent true RMS current in per-unit

Additional filtering of the calculated Q quantity is performed within the function in order to avoid overshooting during capacitor switching. Note that the calculated Q value is available as a service value in percent for every phase from the function.

Simplified logic diagram about used analog quantities within one phase of the capacitor bank protection function are shown in figure 95.

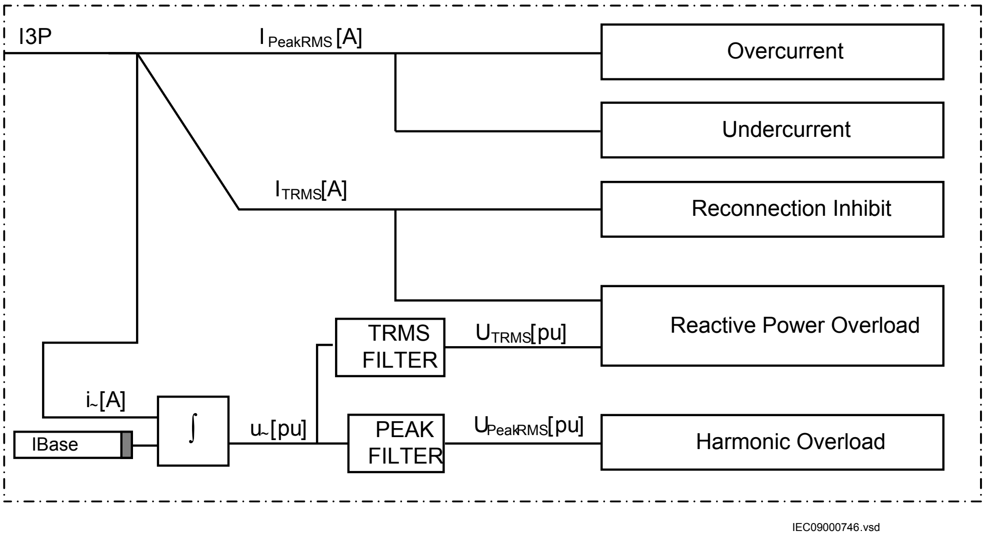


Figure 95: Simplified logic diagram about used analog quantities within one phase

6.8.2.2 Reconnection inhibit feature

This feature determines that capacitor banks are disconnected from the power system and is used to prevent reconnection of a charged capacitor bank to a live network. The I_{RMS} values of the three phase currents are compared with the

IRecnInhibit< parameter in order to determine when the capacitor bank is energized or disconnected. The simplified logic diagram is shown in fig 96.

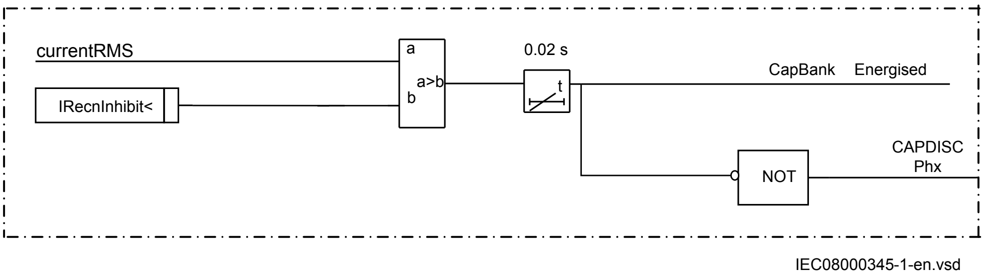


Figure 96: Capacitor bank energization check for one phase. Similar for all three phases

When SCB is disconnected in all three phases, the reconnection inhibit signal will be given. This signal will be active until the preset time elapsed and is used to inhibit the reconnection of charged capacitor bank to live network. The internal logic diagram for the inhibit feature is shown in figure 97.

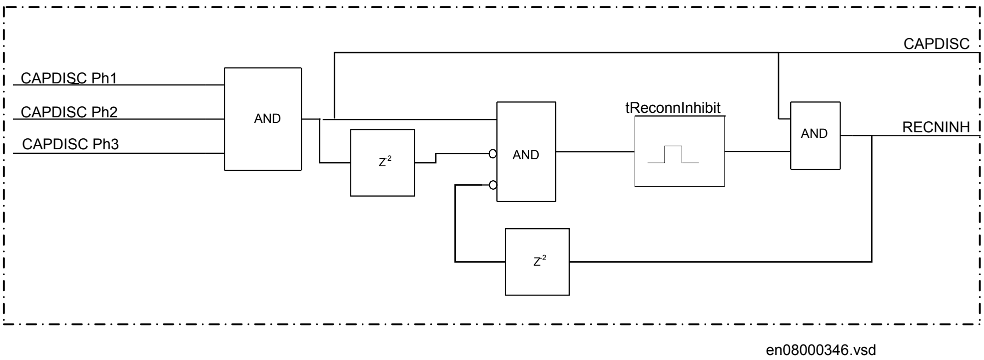


Figure 97: Capacitor bank reconnection inhibit

6.8.2.3 Overcurrent feature

The overcurrent protection feature protects the capacitor bank from excessive current conditions. The sub function takes the current peakRMS value from the preprocessing block in the IED as input. The peakRMS value of the current is compared with the setting of parameter *IOC>*. Whenever the peakRMS value of the current crosses the set level the function sends a START signal as output. The signal is passed through the definite timer for giving the TRIP signal. Each phase will have its own START and TRIP signals for overcurrent. The internal logic for the overcurrent feature is shown in fig 98.

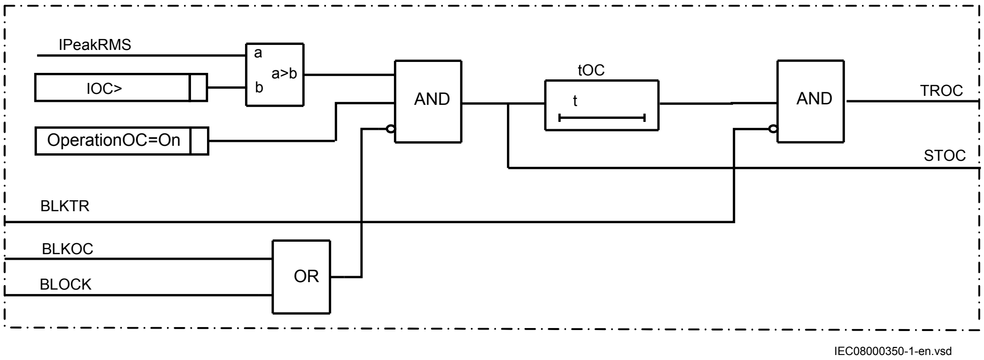


Figure 98: Capacitor bank overcurrent protection

6.8.2.4 Undercurrent feature

Undercurrent protection feature is used to disconnect the capacitor bank from the rest of the power system when the voltage at the capacitor bank terminals is too low for too long period of time. This sub function uses the current peakRMS value from the preprocessing block in the IED as input. The peakRMS value of the current is compared to the set value of the parameter *IUC<*. Whenever the peakRMS value of the current falls below the set undercurrent level, the function will send a START signal as output. The function can be blocked when the current falls below the cut off level. The capacitor bank disconnected signals are used for this blocking. This feature will help to prevent trip operation when the capacitor bank is disconnected from the power system. The TRIP output signal is delayed by a definite timer. Each phase will have its own START and TRIP signals for undercurrent. The internal logic for the undercurrent feature is shown in fig 99.

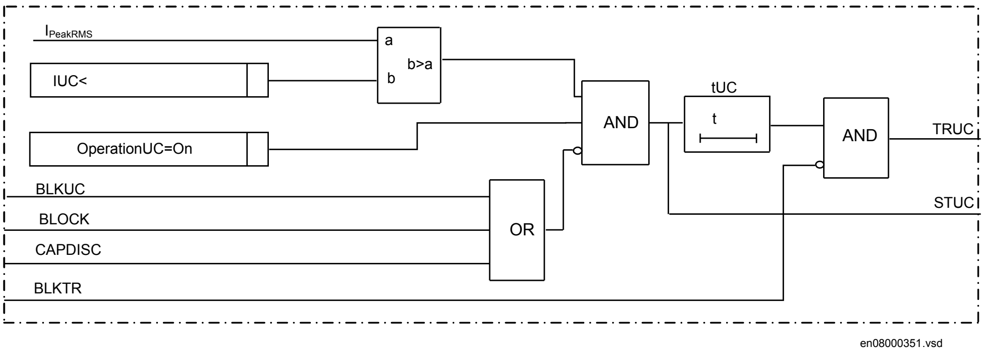


Figure 99: Capacitor bank undercurrent protection

6.8.2.5 Capacitor harmonic overload feature

Harmonic overload protection feature will protect the capacitor from over load conditions caused by harmonics. The sub-function protects the capacitor in two stages, first stage is Inverse time delay (IDMT) based and a second stage is based on Definite Time (DT) delay.

IDMT curve has adjustable k factor and inverse time characteristic is shown in figure 100, where k = 1. The IDMT curve starts only when the equivalent RMS voltage value is higher than set value of parameter *HOLIDMTU>* and stays active until the value falls below the reset value.

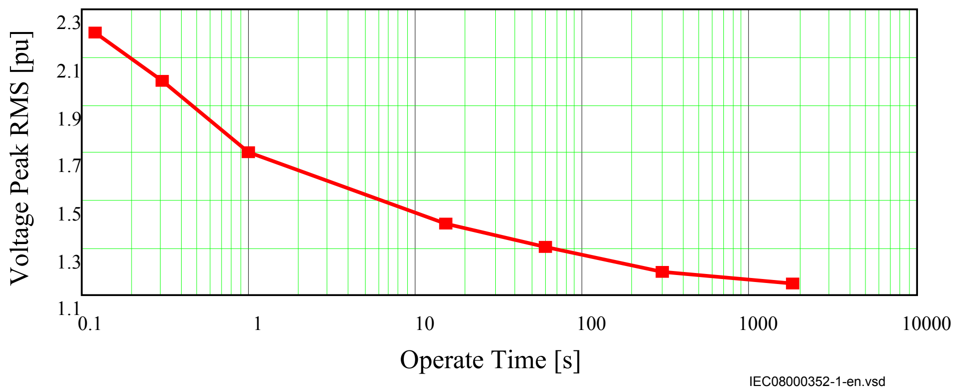


Figure 100: IDMT curve for harmonic overload (kHOLIDMT=1.0)

Main seven operating points for this IDMT curve are defined by IEC/ANSI standards and they are shown in above figure and summarized in the following table:

Table 127: Main operating points for IDMT curve

$U_{peakRMS}$ [pu]	1.15	1.2	1.3	1.4	1.7	2.0	2.2
Time [s]	1800	300	60	15	1.0	0.3	0.12

Note the following regarding this IDMT curve:

1. When parameter *kHOLIDMT* has different value from 1.0 operating time is proportionally changed (for example, when *kHOLIDMT* =0.9 operating times will be 90% of the values shown in above figure 100 and table 127)
2. Between the seven main points in table 127, the operate time is calculate by using linear interpolation in the logarithmic scale
3. Integration process is used to calculate the operate time for varying voltage condition
4. By setting parameter *tMinHOLIDMT =0.1*s standard requirements for minimum operating time of 100ms for harmonic overload IDMT curve can be fluffed
5. By setting parameter *tMaxHOLIDMT =2000*s operation for small harmonics overload condition when $U_{peakRMS}$ is in-between 1.1pu and 1.2pu is assured

Harmonic overload definite time curve has settings facilities for independent pickup and time delay. It can be used as separate tripping stage or as an alarm stage.

Both of these two harmonic overload stages are active during capacitor bank energizing and are capable to properly measure and operate up to and including 9th harmonic.

The internal logic for harmonic overload feature is shown in figure 101:

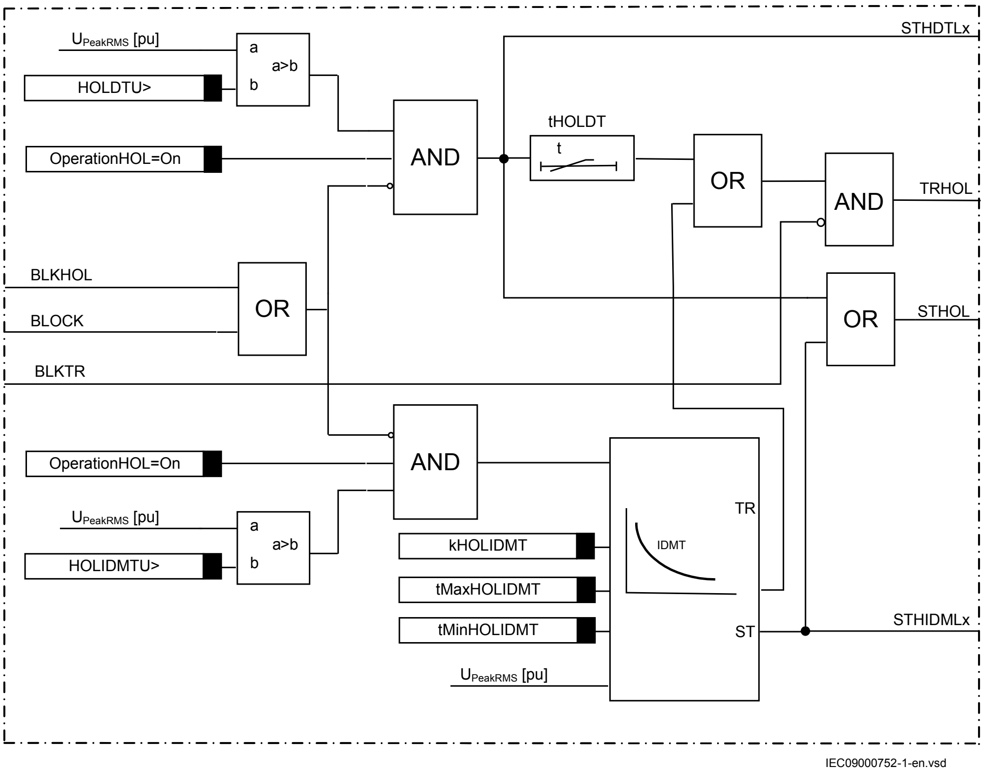


Figure 101: Simplified logic diagram for harmonic overload

6.8.2.6 Capacitor reactive power overload feature

Reactive power overload protection feature will protect the capacitor bank from reactive power overload conditions.

The sub-function will use the reactive power values as input. The reactive power input values are calculated from the true RMS value of voltage and current. The reactive power value is compared with the *QOL>* setting. When the reactive power value exceeds the *QOL>* setting the STQOL signal will be activated. The start signal is delayed by the definite timer before activating the TRQOL signal. The internal logic diagram for this feature is shown in figure 102.

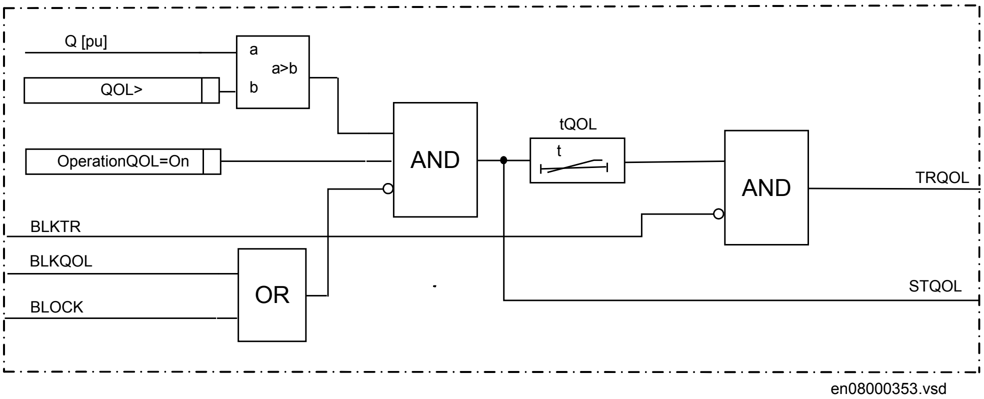


Figure 102: Capacitor bank reactive power overload protection

6.8.3 Function block

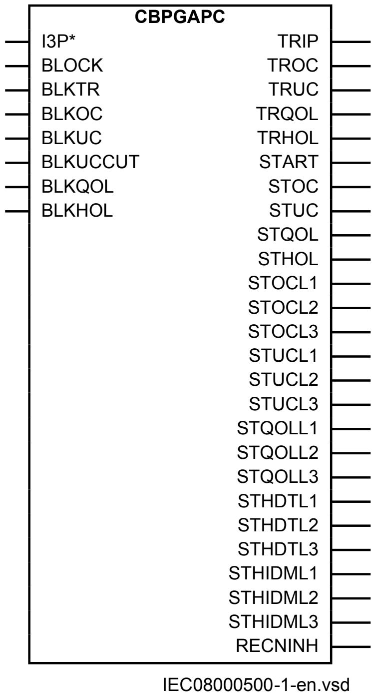


Figure 103: CBPGAPC function block

6.8.4 Input and output signals

Table 128: CBPGAPC Input signals

Name	Type	Default	Description
I3P	GROUP SIGNAL	-	Three Phase Current Input
BLOCK	BOOLEAN	0	Block the complete function
BLKTR	BOOLEAN	0	Block all operate output signals
BLKOC	BOOLEAN	0	Block over current functionality
BLKUC	BOOLEAN	0	Block under current functionality
BLKUCCUT	BOOLEAN	0	Block the under current functionality in cap cut off cond
BLKQOL	BOOLEAN	0	Block reactive power over load functionality
BLKHOL	BOOLEAN	0	Block harmonic over load functionality

Table 129: CBPGAPC Output signals

Name	Type	Description
TRIP	BOOLEAN	General trip signal
TROC	BOOLEAN	Trip signal for over current
TRUC	BOOLEAN	Trip signal for under current
TRQOL	BOOLEAN	Trip signal for reactive power over load
TRHOL	BOOLEAN	Trip signal for harmonic over load
START	BOOLEAN	General start signal
STOC	BOOLEAN	Start signals for over current
STUC	BOOLEAN	Start signal for under current
STQOL	BOOLEAN	Start signal for reactive power over load
STHOL	BOOLEAN	Start signal for harmonic over load
STOCL1	BOOLEAN	Start signal for over current of phase L1
STOCL2	BOOLEAN	Start signal for over current of phase L2
STOCL3	BOOLEAN	Start signal for over current of phase L3
STUCL1	BOOLEAN	Start signal for under current of phase L1
STUCL2	BOOLEAN	Start signal for under current of phase L2
STUCL3	BOOLEAN	Start signal for under current of phase L3
STQOLL1	BOOLEAN	Start signal for reactive power over load of phase L1
STQOLL2	BOOLEAN	Start signal for reactive power over load of phase L2
STQOLL3	BOOLEAN	Start signal for reactive power over load of phase L3
STHDTL1	BOOLEAN	Start signal for harmonic over load DT stage of phase L1
STHDTL2	BOOLEAN	Start signal for harmonic over load DT stage of phase L2

Table continues on next page

Name	Type	Description
STHDTL3	BOOLEAN	Start signal for harmonic over load DT stage of phase L3
STHIDML1	BOOLEAN	Start signal for harmonic over load IDMT stage of phase L1
STHIDML2	BOOLEAN	Start signal for harmonic over load IDMT stage of phase L2
STHIDML3	BOOLEAN	Start signal for harmonic over load IDMT stage of phase L3
RECNINH	BOOLEAN	Capacitor bank reconnection inhibit signal

6.8.5 Setting parameters

Table 130: CBPGAPC Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off/On
IBase	1 - 99999	A	1	3000	Rated capacitor bank current
OperationRecIn	Off On	-	-	On	Operation reconnection inhibit Off/On
IRecnInhibit<	4 - 1000	%IB	1	10	Cap bank cut off current level for inhibit in % of IBase
tReconnInhibit	1.00 - 6000.00	s	0.01	300.00	Time delay for reconnected inhibit signal
OperationOC	Off On	-	-	On	Operation over current Off/On
IOC>	0 - 900	%IB	1	135	Start level for over current operation, % of IBase
tOC	0.00 - 6000.00	s	0.01	30.00	Time delay for over current operation
OperationUC	Off On	-	-	Off	Operation under current Off/On
IUC<	5 - 100	%IB	1	70	Start level for under current operation, % of IBase
tUC	0.00 - 6000.00	s	0.01	5.00	Time delay for under current operation
OperationQOL	Off On	-	-	On	Operation reactive power over load Off/On
QOL>	5 - 900	%	1	130	Start level for reactive power over load in %
tQOL	1.00 - 6000.00	s	0.01	60.00	Time delay for reactive power overload operation
OperationHOL	Off On	-	-	On	Operation harmonic over load Off/On
HOLDTU>	5 - 500	%	1	200	Start value of voltage for harmOvLoad for DT stage in %
tHOLDT	0.00 - 6000.00	s	0.01	10.00	Time delay for minimum operation for harmonic overload
HOLIDMTU>	80 - 200	%	1	110	Start value of voltage for harmOvLoad in IDMT stage in %

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
kHOLIDMT	0.50 - 1.50	-	0.01	1.00	Time multiplier for harmonic overload IDMT curve
tMaxHOLIDMT	0.05 - 6000.00	s	0.01	2000.00	Maximum trip delay for harmonic overload
tMinHOLIDMT	0.05 - 60.00	s	0.01	0.10	Minimum trip delay for harmonic overload

6.8.6 Technical data

Table 131: CBPGAPC technical data

Function	Range or value	Accuracy
Operate value, overcurrent	(0-900)% of IBase	± 1.0% of I_r at $I < I_r$ ± 1.0% of I at $I > I_r$
Reset ratio, overcurrent	>95%	-
Operate time, start	10 ms typically	-
Reset time, start	30 ms typically	-
Critical impulse time, overcurrent protection start	2 ms typically at 0.5 to.2xIset 1 ms typically at 0.5 to 10xIset	-
Impulse margin time, overcurrent protection start	15 ms typically	
Operate value, undercurrent	(5-100)% of IBase	± 1.0% of I_r at $I < I_r$ ± 1.0% of I at $I > I_r$
Reset ratio, undercurrent	<105%	-
Operate value, reconnection inhibit function	(4-1000)% of IBase	± 1.0% of I_r at $I < I_r$ ± 1.0% of I at $I > I_r$
Operate value, reactive power overload function	(5-900)%	± 1.0% of Sr at $S < S_r$ ± 1.0% of S at $S > S_r$
Operate value, voltage protection function for harmonic overload (Definite time)	(5-500)%	± 0.5% of U_r at $U<U_r$ ± 0.5% of U at $U>U_r$
Operate value, voltage protection function for harmonic overload (Inverse time)	(80-200)%	± 0.5% of U_r at $U<U_r$ ± 0.5% of U at $U>U_r$
Inverse time characteristic	According to IEC60871-1 (2005) and IEEE/ANSI C37.99 (2000)	Class 10 + 50 ms
Maximum trip delay, harmonic overload IDMT	(0.05-6000.00) s	± 0.5% ± 10 ms
Minimum trip delay, harmonic overload IDMT	(0.05-60.00) s	± 0.5% ± 10 ms
Timers	(0.00-6000.00) s	± 0.5% ± 10 ms

Section 7 Voltage protection

About this chapter

This chapter describes voltage related protection functions. The way the functions work, their setting parameters, function blocks, input and output signals and technical data are included for each function.

7.1 Two step undervoltage protection UV2PTUV

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Two step undervoltage protection	UV2PTUV	*3U*<	27

7.1.1 Introduction

Undervoltages can occur in the power system during faults or abnormal conditions. Two step undervoltage protection (UV2PTUV) function can be used to open circuit breakers to prepare for system restoration at power outages or as long-time delayed back-up to primary protection.

UV2PTUV has two voltage steps, each with inverse or definite time delay.

7.1.2 Principle of operation

Two-step undervoltage protection (UV2PTUV) is used to detect low power system voltage. UV2PTUV has two voltage measuring steps with separate time delays. If one, two or three phase voltages decrease below the set value, a corresponding START signal is generated. UV2PTUV can be set to START/TRIP based on *1 out of 3*, *2 out of 3* or *3 out of 3* of the measured voltages, being below the set point. If the voltage remains below the set value for a time period corresponding to the chosen time delay, the corresponding trip signal is issued. To avoid an unwanted trip due to disconnection of the related high voltage equipment, a voltage controlled blocking of the function is available, that is, if the voltage is lower than the set blocking level the function is blocked and no START or TRIP signal is generated. The time delay characteristic is individually chosen for each step and can be either definite time delay or inverse time delay.

UV2PTUV can be set to measure phase-to-earth fundamental value, phase-to-phase fundamental value, phase-to-earth true RMS value or phase-to-phase true RMS value. The choice of the measuring is done by the parameter *ConnType*. The voltage related settings are made in percent of base voltage which is set in kV phase-to-phase voltage. This means operation for phase-to-earth voltage under:

$$U < (\%) \cdot UBase(kV) \Big/ \sqrt{3}$$

(Equation 43)

and operation for phase-to-phase voltage under:

$$\mathrm{U} < (\%) \cdot \mathrm{UBase(kV)}$$

(Equation 44)

7.1.2.1 Measurement principle

Depending on the set *ConnType* value, UV2PTUV measures phase-to-earth or phase-to-phase voltages and compare against set values, *U1<* and *U2<*. The parameters *OpMode1* and *OpMode2* influence the requirements to activate the START outputs. Either *1 out of 3*, *2 out of 3*, or *3 out of 3* measured voltages have to be lower than the corresponding set point to issue the corresponding START signal.

To avoid oscillations of the output START signal, a hysteresis has been included.

7.1.2.2 Time delay

The time delay for the two steps can be either definite time delay (DT) or inverse time delay (IDMT). For the inverse time delay three different modes are available:

- inverse curve A
- inverse curve B
- customer programmable inverse curve

The type A curve is described as:

$$t = \frac{k}{\left(\frac{U< - U}{U<} \right)}$$

(Equation 45)

The type B curve is described as:

$$t = \frac{k \cdot 480}{\left(32 \cdot \frac{U< - U}{U<} - 0.5\right)^{2.0}} + 0.055$$

(Equation 46)

The customer programmable curve can be created as:

$$t = \left[\frac{k \cdot A}{\left(B \cdot \frac{U< - U}{U<} - C\right)^{p}} \right] + D$$

(Equation 47)

When the denominator in the expression is equal to zero the time delay will be infinity. There will be an undesired discontinuity. Therefore a tuning parameter *CrvSatn* is set to compensate for this phenomenon. In the voltage interval *U<* down to *U<* · (1.0 – *CrvSatn*/100) the used voltage will be: *U<* · (1.0 – *CrvSatn*/100). If the programmable curve is used this parameter must be calculated so that:

$$B \cdot \frac{CrvSatn}{100} - C > 0$$

(Equation 48)

The lowest voltage is always used for the inverse time delay integration. The details of the different inverse time characteristics are shown in section 20.3 "Inverse characteristics".

Trip signal issuing requires that the undervoltage condition continues for at least the user set time delay. This time delay is set by the parameter *t1* and *t2* for definite time mode (DT) and by some special voltage level dependent time curves for the inverse time mode (IDMT). If the start condition, with respect to the measured voltage ceases during the delay time, and is not fulfilled again within a user defined reset time (*tReset1* and *tReset2* for the definite time and *tIReset1* and *tIReset2*pickup for the inverse time) the corresponding start output is reset. Here it should be noted that after leaving the hysteresis area, the start condition must be fulfilled again and it is not sufficient for the signal to only return back to the hysteresis area. Note that for the undervoltage function the IDMT reset time is constant and does not depend on the voltage fluctuations during the drop-off period. However, there are three ways to reset the timer, either the timer is reset instantaneously, or the timer value is frozen during the reset time, or the timer value is linearly decreased during the reset time. See figure 104 and figure 105.

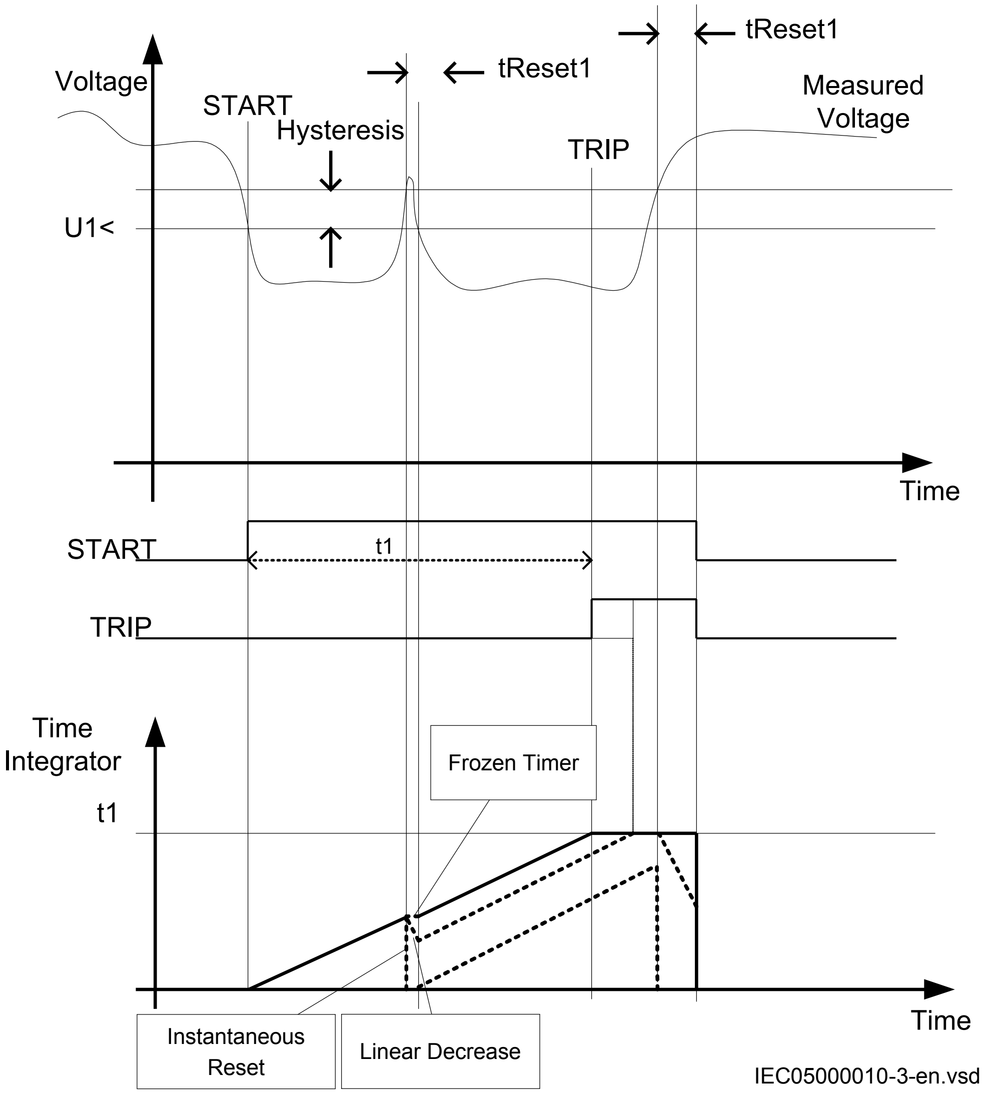


Figure 104: Voltage profile not causing a reset of the start signal for step 1, and inverse time delay

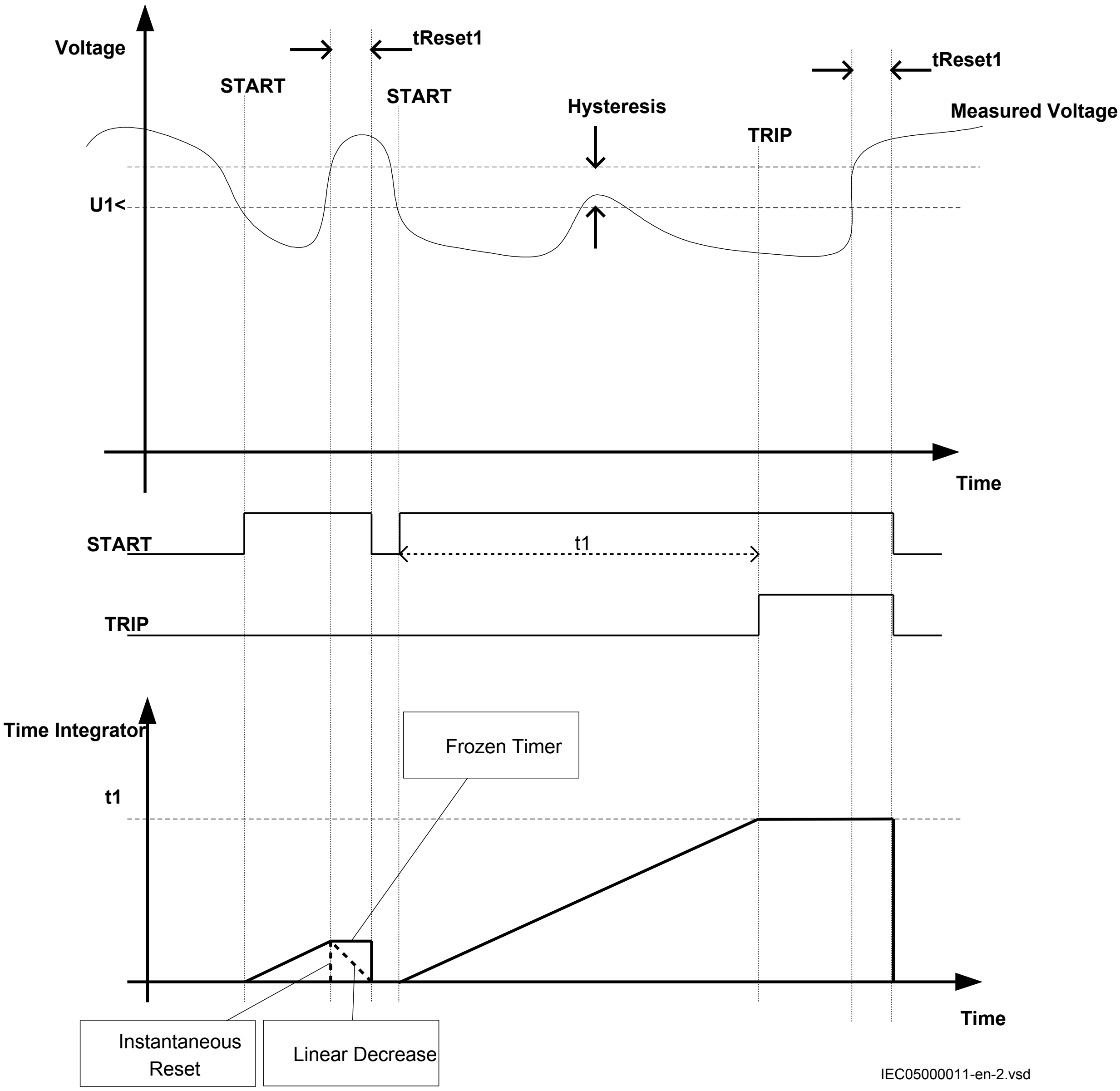


Figure 105: Voltage profile causing a reset of the start signal for step 1, and inverse time delay

Definite timer delay

When definite time delay is selected the function will operate as shown in figure 106. Detailed information about individual stage reset/operation behavior is shown in figure 107 and figure 108 receptively. Note that by setting *tResetn* = *0.0s* instantaneous reset of the definite time delayed stage is ensured.

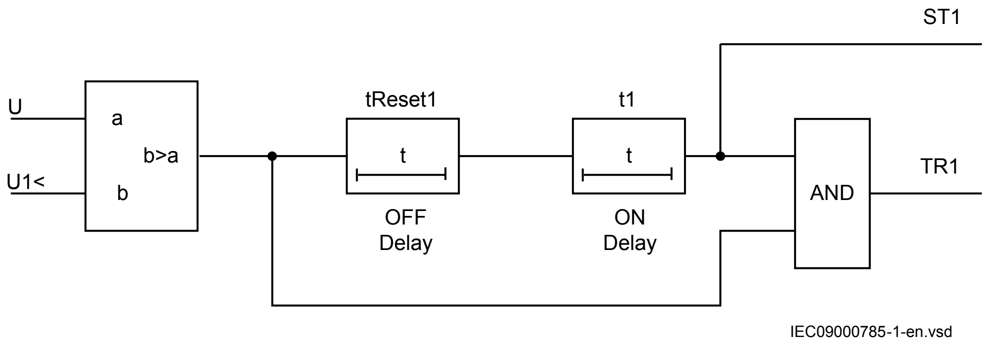


Figure 106: Detailed logic diagram for step 1, DT operation

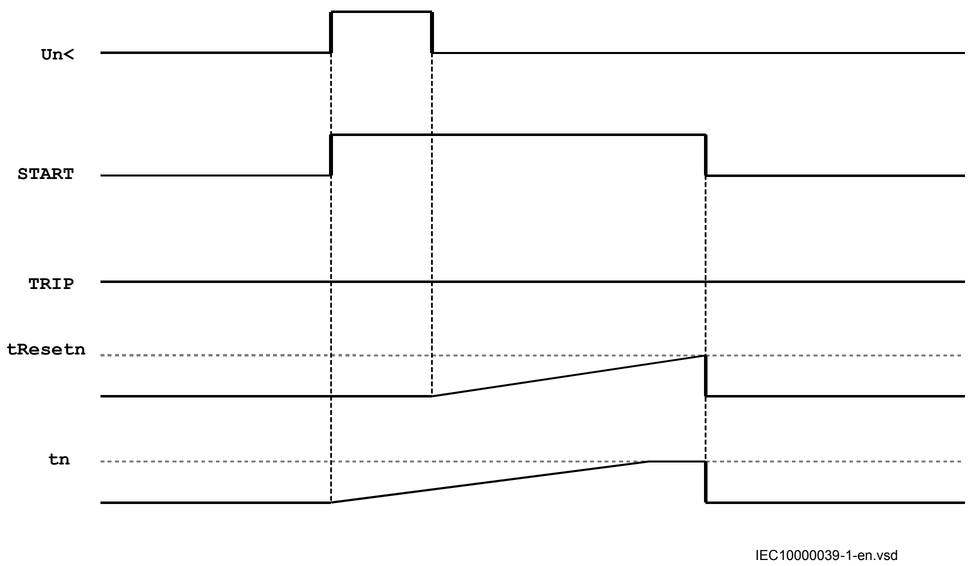


Figure 107: Example for Definite Time Delay stage rest

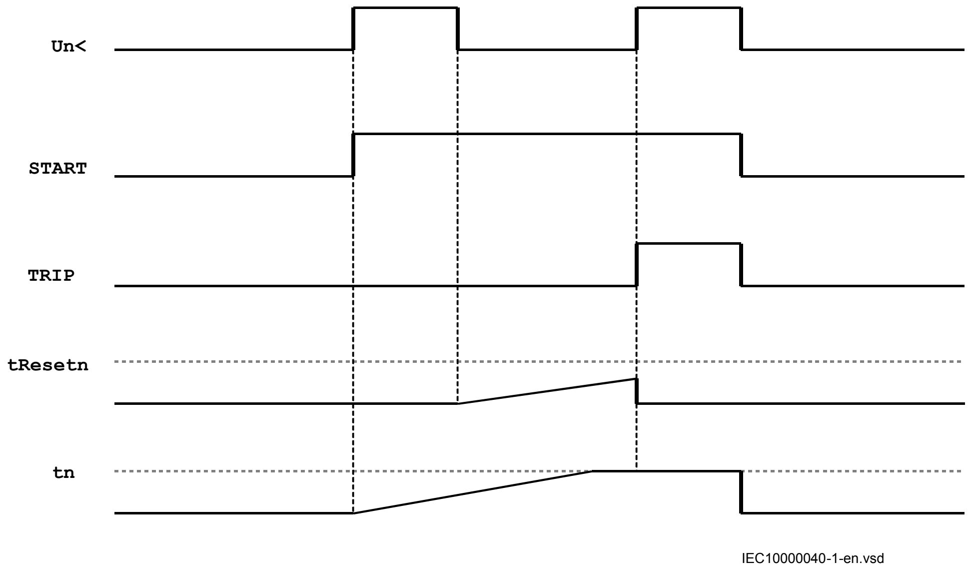


Figure 108: Example for Definite Time Delay stage operation

7.1.2.3 Blocking

It is possible to block Two step undervoltage protection UV2PTUV partially or completely, by binary input signals or by parameter settings, where:

BLOCK:	blocks all outputs
BLKTR1:	blocks all trip outputs of step 1
BLKST1:	blocks all start and trip outputs related to step 1
BLKTR2:	blocks all trip outputs of step 2
BLKST2:	blocks all start and trip outputs related to step 2

If the measured voltage level decreases below the setting of *IntBlkStVal1*, either the trip output of step 1, or both the trip and the START outputs of step 1, are blocked. The characteristic of the blocking is set by the *IntBlkSel1* parameter. This internal blocking can also be set to *Off* resulting in no voltage based blocking. Corresponding settings and functionality are valid also for step 2.

In case of disconnection of the high voltage component the measured voltage will get very low. The event will START both the under voltage function and the blocking function, as seen in figure 109. The delay of the blocking function must be set less than the time delay of under voltage function.

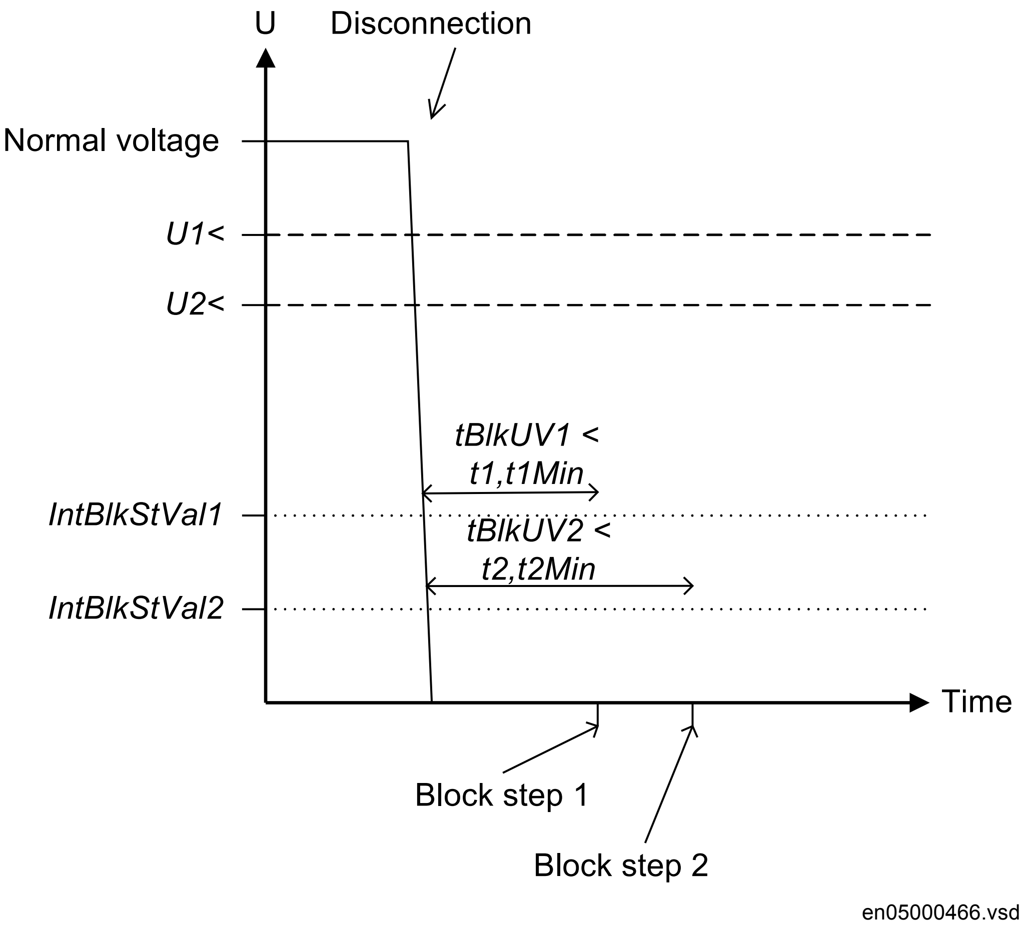


Figure 109: Blocking function

7.1.2.4 Design

The voltage measuring elements continuously measure the three phase-to-neutral voltages or the three phase-to-phase voltages. Recursive fourier filters, true RMS filters or input voltage signals are used. The voltages are individually compared to the set value, and the lowest voltage is used for the inverse time characteristic integration. A special logic is included to achieve the *1 out of 3*, *2 out of 3* and *3 out of 3* criteria to fulfill the START condition. The design of Two step undervoltage protection UV2PTUV is schematically shown in figure 110.

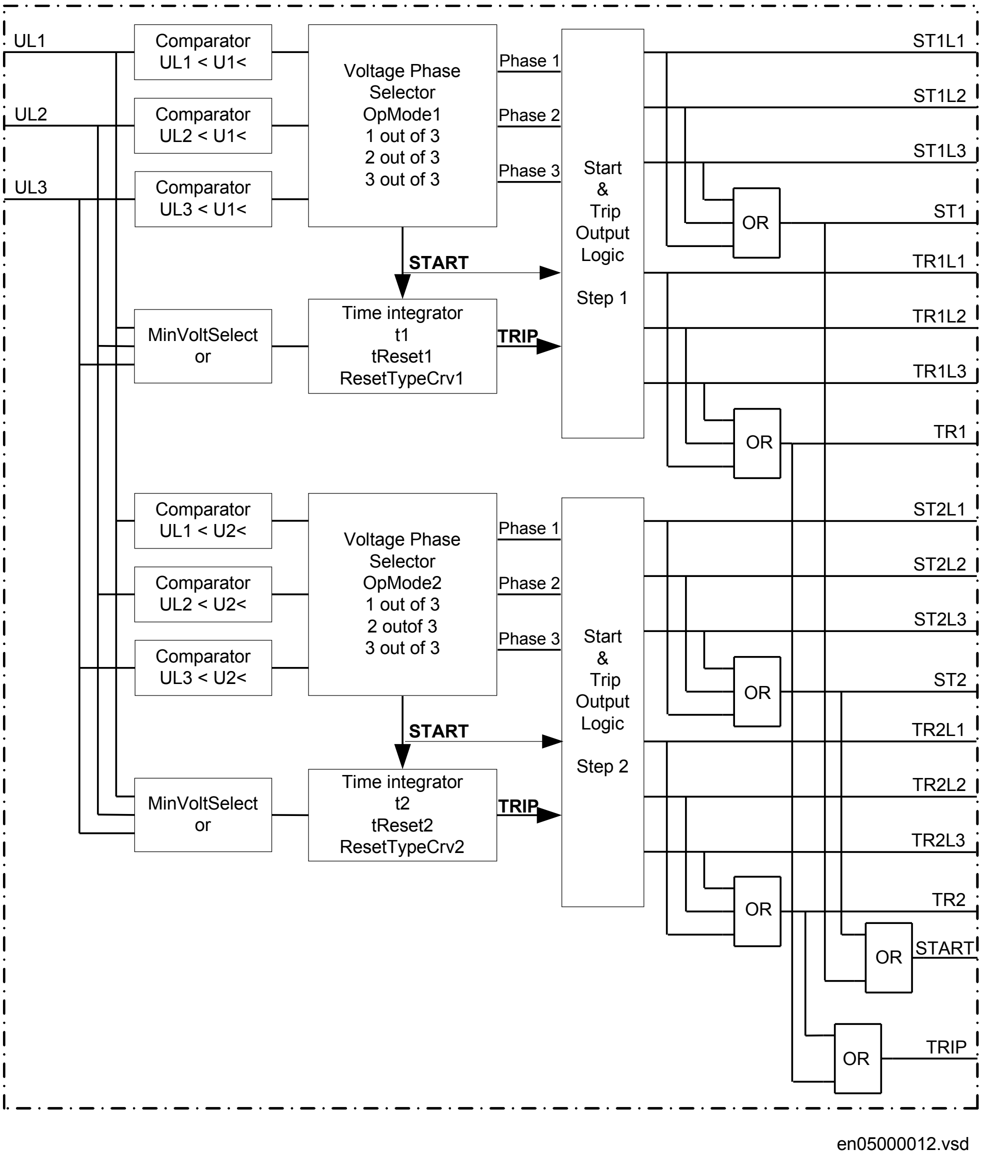


Figure 110: Schematic design of Two step undervoltage protection UV2PTUV

7.1.3 Function block

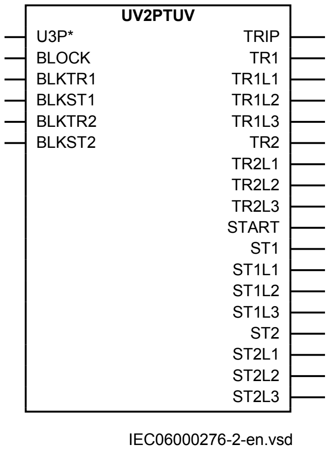


Figure 111: UV2PTUV function block

7.1.4 Input and output signals

Table 132: UV2PTUV Input signals

Name	Type	Default	Description
U3P	GROUP SIGNAL	-	Three phase voltages
BLOCK	BOOLEAN	0	Block of function
BLKTR1	BOOLEAN	0	Block of operate signal, step 1
BLKST1	BOOLEAN	0	Block of step 1
BLKTR2	BOOLEAN	0	Block of operate signal, step 2
BLKST2	BOOLEAN	0	Block of step 2

Table 133: UV2PTUV Output signals

Name	Type	Description
TRIP	BOOLEAN	Trip
TR1	BOOLEAN	Common trip signal from step1
TR1L1	BOOLEAN	Trip signal from step1 phase L1
TR1L2	BOOLEAN	Trip signal from step1 phase L2
TR1L3	BOOLEAN	Trip signal from step1 phase L3
TR2	BOOLEAN	Common trip signal from step2
TR2L1	BOOLEAN	Trip signal from step2 phase L1
TR2L2	BOOLEAN	Trip signal from step2 phase L2
TR2L3	BOOLEAN	Trip signal from step2 phase L3
START	BOOLEAN	General start signal

Table continues on next page

Name	Type	Description
ST1	BOOLEAN	Common start signal from step1
ST1L1	BOOLEAN	Start signal from step1 phase L1
ST1L2	BOOLEAN	Start signal from step1 phase L2
ST1L3	BOOLEAN	Start signal from step1 phase L3
ST2	BOOLEAN	Common start signal from step2
ST2L1	BOOLEAN	Start signal from step2 phase L1
ST2L2	BOOLEAN	Start signal from step2 phase L2
ST2L3	BOOLEAN	Start signal from step2 phase L3

7.1.5 Setting parameters

Table 134: UV2PTUV Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
UBase	0.05 - 2000.00	kV	0.05	400.00	Base voltage
OperationStep1	Off On	-	-	On	Enable execution of step 1
Characterist1	Definite time Inverse curve A Inverse curve B Prog. inv. curve	-	-	Definite time	Selection of time delay curve type for step 1
OpMode1	1 out of 3 2 out of 3 3 out of 3	-	-	1 out of 3	Number of phases required for op (1 of 3, 2 of 3, 3 of 3) from step 1
U1<	1 - 100	%UB	1	70	Voltage setting/start val (DT & IDMT) in % of UBase, step 1
t1	0.00 - 6000.00	s	0.01	5.00	Definitive time delay of step 1
t1Min	0.000 - 60.000	s	0.001	5.000	Minimum operate time for inverse curves for step 1
k1	0.05 - 1.10	-	0.01	0.05	Time multiplier for the inverse time delay for step 1
IntBlkSel1	Off Block of trip Block all	-	-	Off	Internal (low level) blocking mode, step 1
IntBlkStVal1	1 - 100	%UB	1	20	Voltage setting for internal blocking in % of UBase, step 1
tBlkUV1	0.000 - 60.000	s	0.001	0.000	Time delay of internal (low level) blocking for step 1
HystAbs1	0.0 - 100.0	%UB	0.1	0.5	Absolute hysteresis in % of UBase, step 1
OperationStep2	Off On	-	-	On	Enable execution of step 2
Characterist2	Definite time Inverse curve A Inverse curve B Prog. inv. curve	-	-	Definite time	Selection of time delay curve type for step 2
Table continues on next page					

Name	Values (Range)	Unit	Step	Default	Description
OpMode2	1 out of 3 2 out of 3 3 out of 3	-	-	1 out of 3	Number of phases required for op (1 of 3, 2 of 3, 3 of 3) from step 2
U2<	1 - 100	%UB	1	50	Voltage setting/start val (DT & IDMT) in % of UBase, step 2
t2	0.000 - 60.000	s	0.001	5.000	Definitive time delay of step 2
t2Min	0.000 - 60.000	s	0.001	5.000	Minimum operate time for inverse curves for step 2
k2	0.05 - 1.10	-	0.01	0.05	Time multiplier for the inverse time delay for step 2
IntBlkSel2	Off Block of trip Block all	-	-	Off	Internal (low level) blocking mode, step 2
IntBlkStVal2	1 - 100	%UB	1	20	Voltage setting for internal blocking in % of UBase, step 2
tBlkUV2	0.000 - 60.000	s	0.001	0.000	Time delay of internal (low level) blocking for step 2
HystAbs2	0.0 - 100.0	%UB	0.1	0.5	Absolute hysteresis in % of UBase, step 2

Table 135: UV2PTUV Group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
tReset1	0.000 - 60.000	s	0.001	0.025	Reset time delay used in IEC Definite Time curve step 1
ResetTypeCrv1	Instantaneous Frozen timer Linearly decreased	-	-	Instantaneous	Selection of used IDMT reset curve type for step 1
tIReset1	0.000 - 60.000	s	0.001	0.025	Time delay in IDMT reset (s), step 1
ACrv1	0.005 - 200.000	-	0.001	1.000	Parameter A for customer programmable curve for step 1
BCrv1	0.50 - 100.00	-	0.01	1.00	Parameter B for customer programmable curve for step 1
CCrv1	0.0 - 1.0	-	0.1	0.0	Parameter C for customer programmable curve for step 1
DCrv1	0.000 - 60.000	-	0.001	0.000	Parameter D for customer programmable curve for step 1
PCrv1	0.000 - 3.000	-	0.001	1.000	Parameter P for customer programmable curve for step 1
CrvSat1	0 - 100	%	1	0	Tuning param for prog. under voltage IDMT curve, step 1
tReset2	0.000 - 60.000	s	0.001	0.025	Reset time delay used in IEC Definite Time curve step 2
ResetTypeCrv2	Instantaneous Frozen timer Linearly decreased	-	-	Instantaneous	Selection of used IDMT reset curve type for step 2
tIReset2	0.000 - 60.000	s	0.001	0.025	Time delay in IDMT reset (s), step 2
ACrv2	0.005 - 200.000	-	0.001	1.000	Parameter A for customer programmable curve for step 2

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
BCrv2	0.50 - 100.00	-	0.01	1.00	Parameter B for customer programmable curve for step 2
CCrv2	0.0 - 1.0	-	0.1	0.0	Parameter C for customer programmable curve for step 2
DCrv2	0.000 - 60.000	-	0.001	0.000	Parameter D for customer programmable curve for step 2
PCrv2	0.000 - 3.000	-	0.001	1.000	Parameter P for customer programmable curve for step 2
CrvSat2	0 - 100	%	1	0	Tuning param for prog. under voltage IDMT curve, step 2

Table 136: UV2PTUV Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
ConnType	PhN DFT PhPh RMS PhN RMS PhPh DFT	-	-	PhN DFT	Group selector for connection type

7.1.6 Technical data

Table 137: UV2PTUV technical data

Function	Range or value	Accuracy
Operate voltage, low and high step	(1–100)% of *UBase*	± 0.5% of U_r
Absolute hysteresis	(0–100)% of *UBase*	± 0.5% of U_r
Internal blocking level, low and high step	(1–100)% of *UBase*	± 0.5% of U_r
Inverse time characteristics for low and high step, see table 487	-	See table 487
Definite time delays	(0.000-60.000) s	± 0.5% ±10 ms
Minimum operate time, inverse characteristics	(0.000–60.000) s	± 0.5% ± 10 ms
Operate time, start function	25 ms typically at 2 to 0 x U_{set}	-
Reset time, start function	25 ms typically at 0 to 2 x U_{set}	-
Critical impulse time	10 ms typically at 1.2 to 0.8 x U_{set}	-
Impulse margin time	15 ms typically	-

7.2 Two step overvoltage protection OV2PTOV

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Two step overvoltage protection	OV2PTOV	3U>	59

7.2.1 Introduction

Overvoltages may occur in the power system during abnormal conditions such as sudden power loss, tap changer regulating failures, open line ends on long lines etc.

Two step overvoltage protection (OV2PTOV) function can be used to detect open line ends, normally then combined with a directional reactive over-power function to supervise the system voltage. When triggered, the function will cause an alarm, switch in reactors, or switch out capacitor banks.

OV2PTOV has two voltage steps, each of them with inverse or definite time delayed.

OV2PTOV has an extremely high reset ratio to allow settings close to system service voltage.

7.2.2 Principle of operation

Two step overvoltage protection OV2PTOV is used to detect high power system voltage. OV2PTOV has two steps with separate time delays. If one-, two- or three-phase voltages increase above the set value, a corresponding START signal is issued. OV2PTOV can be set to START/TRIP, based on *1 out of 3*, *2 out of 3* or *3 out of 3* of the measured voltages, being above the set point. If the voltage remains above the set value for a time period corresponding to the chosen time delay, the corresponding trip signal is issued.

The time delay characteristic is individually chosen for the two steps and can be either, definite time delay or inverse time delay.

The voltage related settings are made in percent of the global set base voltage, which is set in kV, phase-to-phase.

OV2PTOV can be set to measure phase-to-earth fundamental value, phase-to-phase fundamental value, phase-to-earth RMS value or phase-to-phase RMS value. The choice of measuring is done by the parameter *ConnType*.

The setting of the analog inputs are given as primary phase-to-earth or phase-to-phase voltage. OV2PTOV will operate if the voltage gets higher than the set percentage of the set base voltage *UBase*. This means operation for phase-to-earth voltage over:

$$U > (\%) \cdot UBase(kV) \Big/ \sqrt{3}$$

(Equation 49)

and operation for phase for phase voltage over:

$$\mathrm{U > (\%) \cdot UBase(kV)}$$

(Equation 50)

7.2.2.1 Measurement principle

All the three voltages are measured continuously, and compared with the set values, *U1>* and *U2>*. The parameters *OpMode1* and *OpMode2* influence the requirements to activate the START outputs. Either *1 out of 3*, *2 out of 3* or *3 out of 3* measured voltages have to be higher than the corresponding set point to issue the corresponding START signal.

To avoid oscillations of the output START signal, a hysteresis has been included.

7.2.2.2 Time delay

The time delay for the two steps can be either definite time delay (DT) or inverse time delay (IDMT). For the inverse time delay four different modes are available:

- inverse curve A
- inverse curve B
- inverse curve C
- customer programmable inverse curve

The type A curve is described as:

$$t = \frac{k}{\left(\frac{U - U>}{U>}\right)}$$

(Equation 51)

The type B curve is described as:

$$t = \frac{k \cdot 480}{\left(32 \cdot \frac{U - U>}{U>} - 0.5\right)^{2.0}} - 0.035$$

(Equation 52)

The type C curve is described as:

$$t = \frac{k \cdot 480}{\left(32 \cdot \frac{U - U>}{U>} - 0.5\right)^{3.0}} + 0.035$$

(Equation 53)

The customer programmable curve can be created as:

$$t = \frac{k \cdot A}{\left(B \cdot \frac{U - U>}{U>} - C\right)^{p}} + D$$

(Equation 54)

When the denominator in the expression is equal to zero the time delay will be infinity. There will be an undesired discontinuity. Therefore, a tuning parameter *CrvSatn* is set to compensate for this phenomenon. In the voltage interval U< down to U< · (1.0 – *CrvSatn*/100) the used voltage will be: U< · (1.0 – *CrvSatn*/100). If the programmable curve is used this parameter must be calculated so that:

$$B \cdot \frac{CrvSatn}{100} - C > 0$$

(Equation 55)

The highest phase (or phase-to-phase) voltage is always used for the inverse time delay integration, see figure 112. The details of the different inverse time characteristics are shown in section "Inverse characteristics"

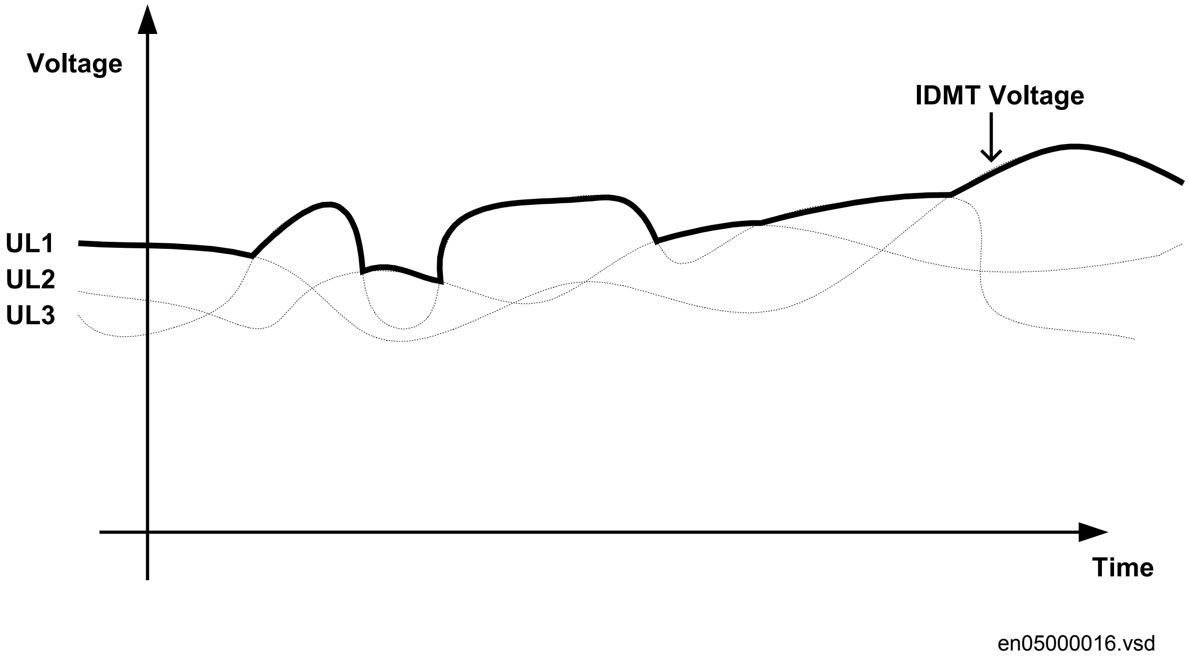


Figure 112: Voltage used for the inverse time characteristic integration

Trip signal issuing requires that the overvoltage condition continues for at least the user set time delay. This time delay is set by the parameter *t1* and *t2* for definite time mode (DT) and by selected voltage level dependent time curves for the inverse time mode (IDMT). If the START condition, with respect to the measured voltage ceases during the delay time, and is not fulfilled again within a user defined reset time (*tReset1* and *tReset2* for the definite time and *tIReset1* and *tIReset2* for the inverse time) the corresponding START output is reset, after that the defined reset time has elapsed. Here it should be noted that after leaving the hysteresis area, the START condition must be fulfilled again and it is not sufficient for the signal to only return back to the hysteresis area. The hysteresis value for each step is settable *(HystAbs2)* to allow an high and accurate reset of the function. It should be noted that for Two step overvoltage protection OV2PTOV the IDMT reset time is constant and does not depend on the voltage fluctuations during the drop-off period. However, there are three ways to reset the timer, either the timer is reset instantaneously, or the timer value is frozen during the reset time, or the timer value is linearly decreased during the reset time..

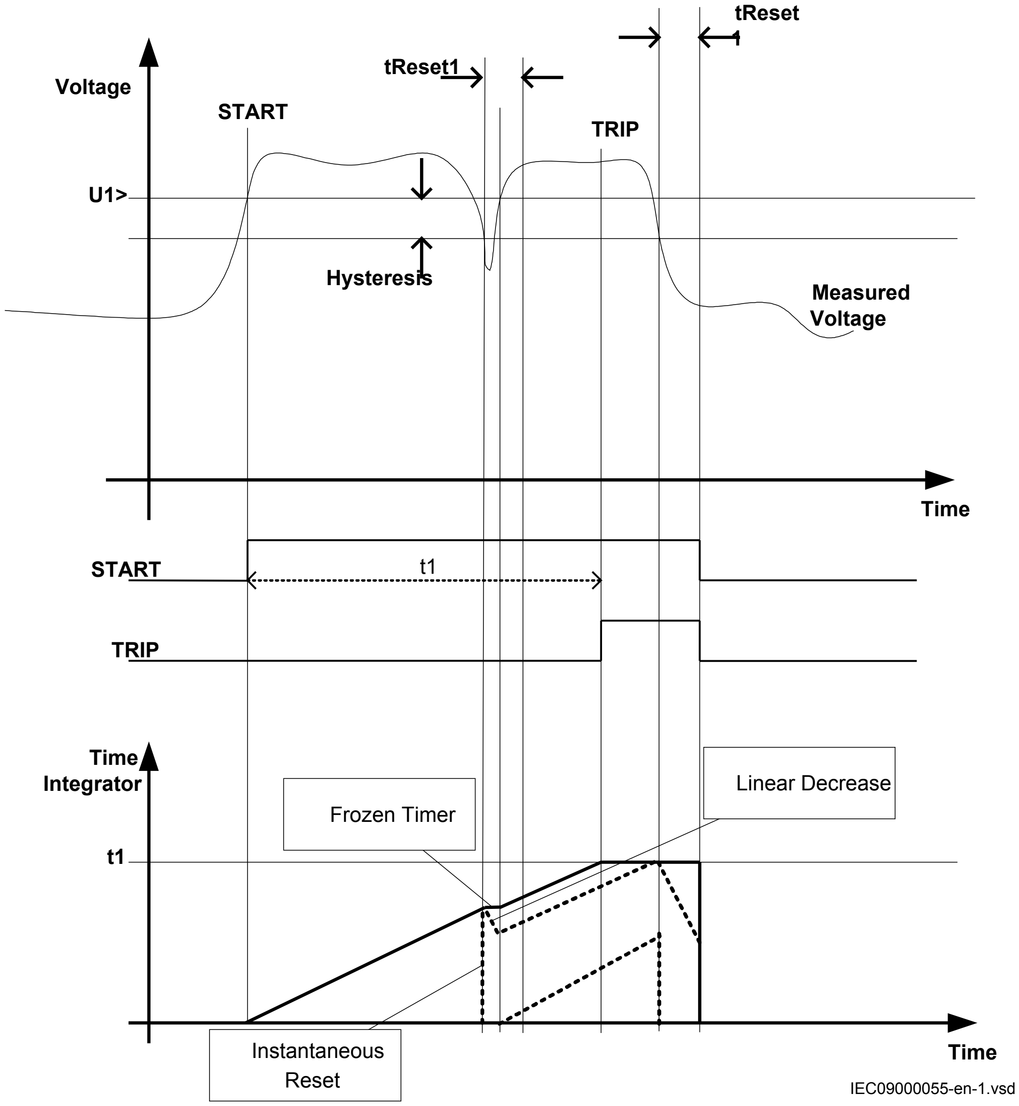


Figure 113: Voltage profile not causing a reset of the START signal for step 1, and inverse time delay

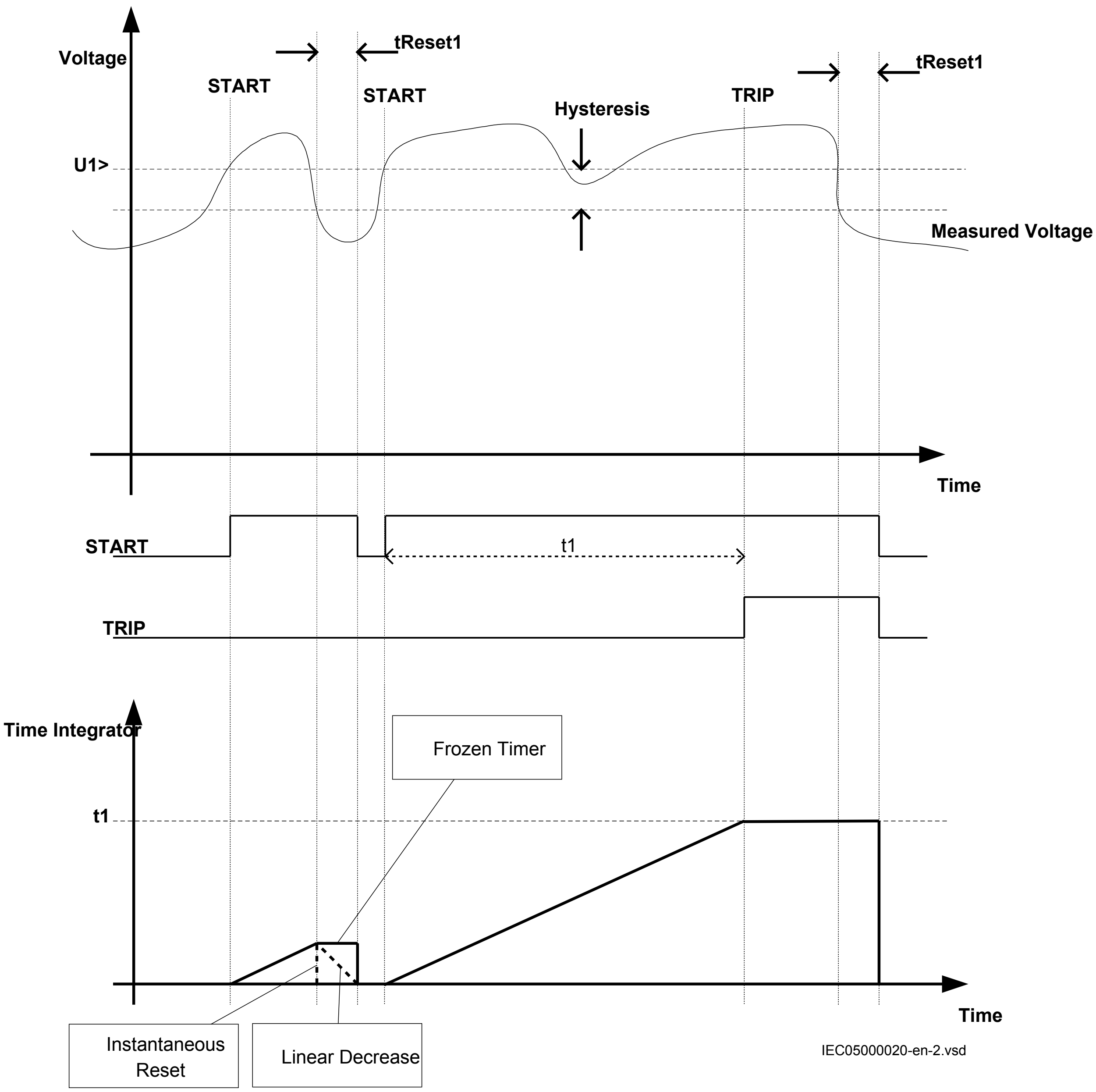


Figure 114: Voltage profile causing a reset of the START signal for step 1, and inverse time delay

Definite time delay

When definite time delay is selected the function will operate as shown in figure 115. Detailed information about individual stage reset/operation behavior is shown in figure 107 and figure 108 receptively. Note that by setting *tResetn = 0.0s* instantaneous reset of the definite time delayed stage is ensured

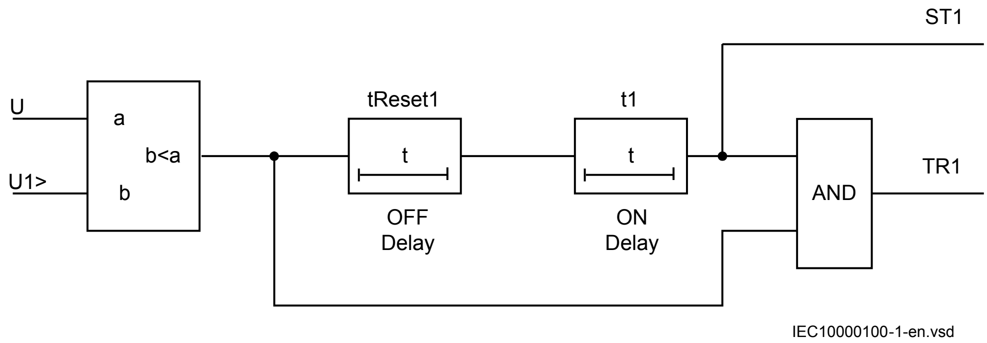


Figure 115: Detailed logic diagram for step 1, DT operation

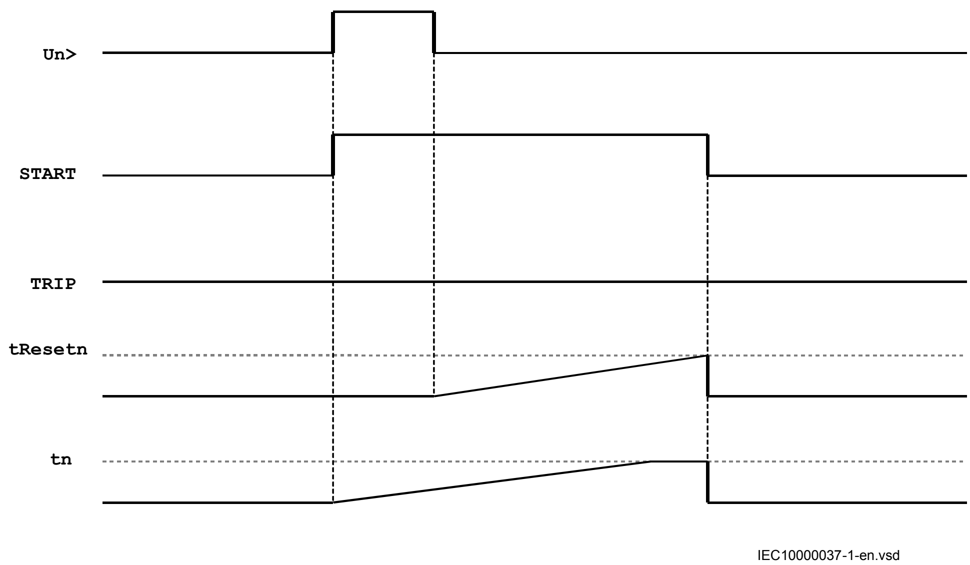


Figure 116: Example for Definite Time Delay stage rest

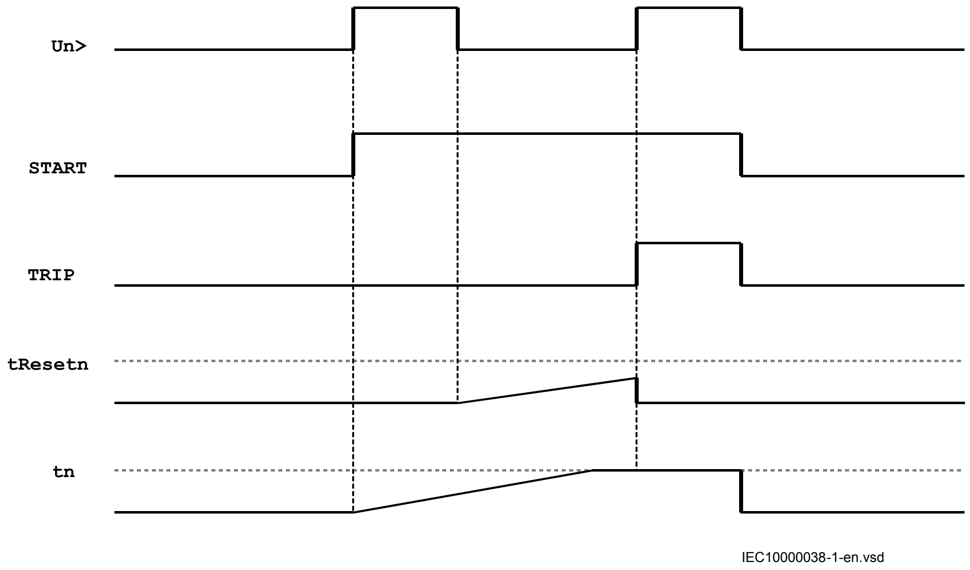


Figure 117: Example for Definite Time Delay stage operation

7.2.2.3 Blocking

It is possible to block Two step overvoltage protection OV2PTOV partially or completely, by binary input signals where:

BLOCK:	blocks all outputs
BLKTR1:	blocks all trip outputs of step 1
BLKST1:	blocks all start and trip outputs related to step 1
BLKTR2:	blocks all trip outputs of step 2
BLKST2:	blocks all start and trip outputs related to step 2

7.2.2.4 Design

The voltage measuring elements continuously measure the three phase-to-earth voltages or the three phase-to-phase voltages. Recursive Fourier filters filter the input voltage signals. The phase voltages are individually compared to the set value, and the highest voltage is used for the inverse time characteristic integration. A special logic is included to achieve the *1 out of 3*, *2 out of 3* or *3 out of 3* criteria to fulfill the START condition. The design of Two step overvoltage protection (OV2PTOV) is schematically described in figure 118.

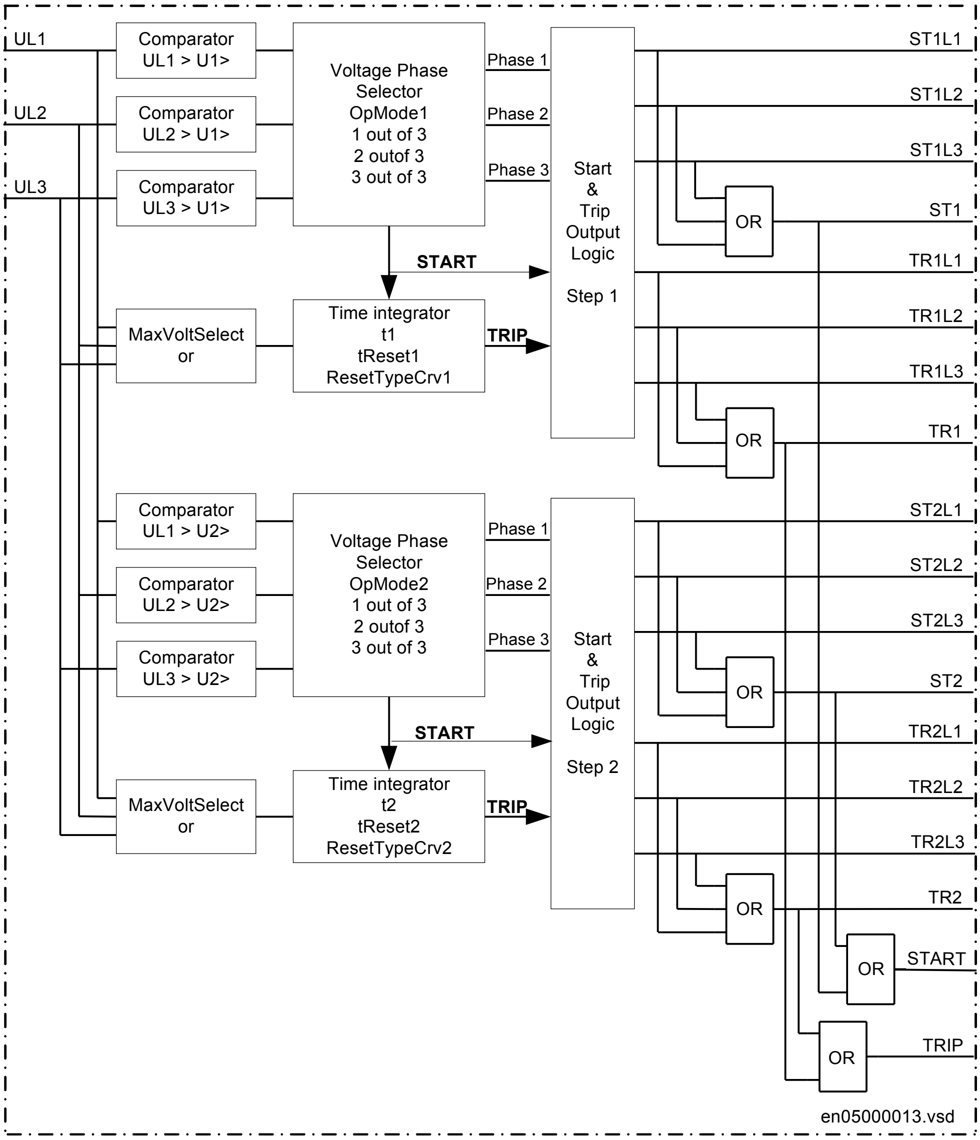


Figure 118: Schematic design of Two step overvoltage protection OV2PTOV

7.2.3 Function block

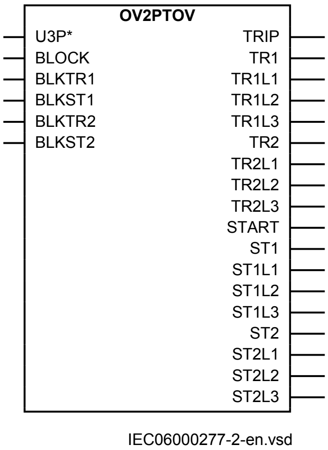


Figure 119: OV2PTOV function block

7.2.4 Input and output signals

Table 138: OV2PTOV Input signals

Name	Type	Default	Description
U3P	GROUP SIGNAL	-	Group signal for three phase voltage input
BLOCK	BOOLEAN	0	Block of function
BLKTR1	BOOLEAN	0	Block of operate signal, step 1
BLKST1	BOOLEAN	0	Block of step 1
BLKTR2	BOOLEAN	0	Block of operate signal, step 2
BLKST2	BOOLEAN	0	Block of step 2

Table 139: OV2PTOV Output signals

Name	Type	Description
TRIP	BOOLEAN	Trip
TR1	BOOLEAN	Common trip signal from step1
TR1L1	BOOLEAN	Trip signal from step1 phase L1
TR1L2	BOOLEAN	Trip signal from step1 phase L2
TR1L3	BOOLEAN	Trip signal from step1 phase L3
TR2	BOOLEAN	Common trip signal from step2
TR2L1	BOOLEAN	Trip signal from step2 phase L1
TR2L2	BOOLEAN	Trip signal from step2 phase L2
TR2L3	BOOLEAN	Trip signal from step2 phase L3
START	BOOLEAN	General start signal

Table continues on next page

Name	Type	Description
ST1	BOOLEAN	Common start signal from step1
ST1L1	BOOLEAN	Start signal from step1 phase L1
ST1L2	BOOLEAN	Start signal from step1 phase L2
ST1L3	BOOLEAN	Start signal from step1 phase L3
ST2	BOOLEAN	Common start signal from step2
ST2L1	BOOLEAN	Start signal from step2 phase L1
ST2L2	BOOLEAN	Start signal from step2 phase L2
ST2L3	BOOLEAN	Start signal from step2 phase L3

7.2.5 Setting parameters

Table 140: OV2PTOV Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
UBase	0.05 - 2000.00	kV	0.05	400.00	Base voltage
OperationStep1	Off On	-	-	On	Enable execution of step 1
Characterist1	Definite time Inverse curve A Inverse curve B Inverse curve C Prog. inv. curve	-	-	Definite time	Selection of time delay curve type for step 1
OpMode1	1 out of 3 2 out of 3 3 out of 3	-	-	1 out of 3	Number of phases required for op (1 of 3, 2 of 3, 3 of 3) from step 1
U1>	1 - 200	%UB	1	120	Voltage setting/start val (DT & IDMT) in % of UBase, step 1
t1	0.00 - 6000.00	s	0.01	5.00	Definitive time delay of step 1
t1Min	0.000 - 60.000	s	0.001	5.000	Minimum operate time for inverse curves for step 1
k1	0.05 - 1.10	-	0.01	0.05	Time multiplier for the inverse time delay for step 1
HystAbs1	0.0 - 100.0	%UB	0.1	0.5	Absolute hysteresis in % of UBase, step 1
OperationStep2	Off On	-	-	On	Enable execution of step 2
Characterist2	Definite time Inverse curve A Inverse curve B Inverse curve C Prog. inv. curve	-	-	Definite time	Selection of time delay curve type for step 2
OpMode2	1 out of 3 2 out of 3 3 out of 3	-	-	1 out of 3	Number of phases required for op (1 of 3, 2 of 3, 3 of 3) from step 2
U2>	1 - 200	%UB	1	150	Voltage setting/start val (DT & IDMT) in % of UBase, step 2

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
t2	0.000 - 60.000	s	0.001	5.000	Definitive time delay of step 2
t2Min	0.000 - 60.000	s	0.001	5.000	Minimum operate time for inverse curves for step 2
k2	0.05 - 1.10	-	0.01	0.05	Time multiplier for the inverse time delay for step 2
HystAbs2	0.0 - 100.0	%UB	0.1	0.5	Absolute hysteresis in % of UBase, step 2

Table 141: OV2PTOV Group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
tReset1	0.000 - 60.000	s	0.001	0.025	Reset time delay used in IEC Definite Time curve step 1
ResetTypeCrv1	Instantaneous Frozen timer Linearly decreased	-	-	Instantaneous	Selection of used IDMT reset curve type for step 1
tIReset1	0.000 - 60.000	s	0.001	0.025	Time delay in IDMT reset (s), step 1
ACrv1	0.005 - 200.000	-	0.001	1.000	Parameter A for customer programmable curve for step 1
BCrv1	0.50 - 100.00	-	0.01	1.00	Parameter B for customer programmable curve for step 1
CCrv1	0.0 - 1.0	-	0.1	0.0	Parameter C for customer programmable curve for step 1
DCrv1	0.000 - 60.000	-	0.001	0.000	Parameter D for customer programmable curve for step 1
PCrv1	0.000 - 3.000	-	0.001	1.000	Parameter P for customer programmable curve for step 1
CrvSat1	0 - 100	%	1	0	Tuning param for prog. over voltage IDMT curve, step 1
tReset2	0.000 - 60.000	s	0.001	0.025	Reset time delay used in IEC Definite Time curve step 2
ResetTypeCrv2	Instantaneous Frozen timer Linearly decreased	-	-	Instantaneous	Selection of used IDMT reset curve type for step 2
tIReset2	0.000 - 60.000	s	0.001	0.025	Time delay in IDMT reset (s), step 2
ACrv2	0.005 - 200.000	-	0.001	1.000	Parameter A for customer programmable curve for step 2
BCrv2	0.50 - 100.00	-	0.01	1.00	Parameter B for customer programmable curve for step 2
CCrv2	0.0 - 1.0	-	0.1	0.0	Parameter C for customer programmable curve for step 2
DCrv2	0.000 - 60.000	-	0.001	0.000	Parameter D for customer programmable curve for step 2
PCrv2	0.000 - 3.000	-	0.001	1.000	Parameter P for customer programmable curve for step 2
CrvSat2	0 - 100	%	1	0	Tuning param for prog. over voltage IDMT curve, step 2

Table 142: OV2PTOV Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
ConnType	PhN DFT PhPh DFT PhN RMS PhPh RMS	-	-	PhN DFT	Group selector for connection type

7.2.6 Technical data

Table 143: OV2PTOV technical data

Function	Range or value	Accuracy
Operate voltage, low and high step	(1-200)% of *UBase*	± 0.5% of U_r at $U < U_r$ ± 0.5% of U at $U > U_r$
Absolute hysteresis	(0–100)% of *UBase*	± 0.5% of U_r at $U < U_r$ ± 0.5% of U at $U > U_r$
Inverse time characteristics for low and high step, see table 486	-	See table 486
Definite time delays	(0.000-60.000) s	± 0.5% ± 10 ms
Minimum operate time, Inverse characteristics	(0.000-60.000) s	± 0.5% ± 10 ms
Operate time, start function	25 ms typically at 0 to 2 x U_{set}	-
Reset time, start function	25 ms typically at 2 to 0 x U_{set}	-
Critical impulse time	10 ms typically at 0 to 2 x U_{set}	-
Impulse margin time	15 ms typically	-

7.3 Two step residual overvoltage protection ROV2PTOV

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Two step residual overvoltage protection	ROV2PTOV	3U0	59N

7.3.1 Introduction

Residual voltages may occur in the power system during earth faults.

Two step residual overvoltage protection ROV2PTOV function calculates the residual voltage from the three-phase voltage input transformers or measures it from a single voltage input transformer fed from an open delta or neutral point voltage transformer.

ROV2PTOV has two voltage steps, each with inverse or definite time delay.

Reset delay ensures operation for intermittent earth faults.

7.3.2 Principle of operation

Two step residual overvoltage protection ROV2PTOV is used to detect high single-phase voltage, such as high residual voltage, also called $3U_0$. The residual voltage can be measured directly from a voltage transformer in the neutral of a power transformer or from a three-phase voltage transformer, where the secondary windings are connected in an open delta. Another possibility is to measure the three-phase voltages and internally in the IED calculate the corresponding residual voltage and connect this calculated residual voltage to ROV2PTOV. ROV2PTOV has two steps with separate time delays. If the single-phase (residual) voltage remains above the set value for a time period corresponding to the chosen time delay, the corresponding TRIP signal is issued.

The time delay characteristic is individually chosen for the two steps and can be either, definite time delay or inverse time delay.

The voltage related settings are made in percent of the base voltage, which is set in kV, phase-phase.

7.3.2.1 Measurement principle

The residual voltage is measured continuously, and compared with the set values, *U1>* and *U2>*.

To avoid oscillations of the output START signal, a hysteresis has been included.

7.3.2.2 Time delay

The time delay for the two steps can be either definite time delay (DT) or inverse time delay (IDMT). For the inverse time delay four different modes are available:

- inverse curve A
- inverse curve B
- inverse curve C
- customer programmable inverse curve

The type A curve is described as:

$$t = \frac{k}{\left(\frac{U - U>}{U>}\right)}$$

(Equation 56)

The type B curve is described as:

$$t = \frac{k \cdot 480}{\left(32 \cdot \frac{U - U>}{U>} - 0.5\right)^{2.0}} - 0.035$$

(Equation 57)

The type C curve is described as:

$$t = \frac{k \cdot 480}{\left(32 \cdot \frac{U - U>}{U>} - 0.5\right)^{3.0}} + 0.035$$

(Equation 58)

The customer programmable curve can be created as:

$$t = \frac{k \cdot A}{\left(B \cdot \frac{U - U>}{U>} - C\right)^{p}} + D$$

(Equation 59)

When the denominator in the expression is equal to zero the time delay will be infinity. There will be an undesired discontinuity. Therefore a tuning parameter *CrvSatn* is set to compensate for this phenomenon. In the voltage interval *U>* up to *U>* · (1.0 + *CrvSatn*/100) the used voltage will be: *U>* · (1.0 + *CrvSatn*/100). If the programmable curve is used this parameter must be calculated so that:

$$B \cdot \frac{CrvSatn}{100} - C > 0$$

(Equation 60)

The details of the different inverse time characteristics are shown in section "Inverse characteristics".

TRIP signal issuing requires that the residual overvoltage condition continues for at least the user set time delay. This time delay is set by the parameter *t1* and *t2* for definite time mode (DT) and by some special voltage level dependent time curves for the inverse time mode (IDMT).

If the START condition, with respect to the measured voltage ceases during the delay time, and is not fulfilled again within a user defined reset time (*tReset1* and *tReset2* for the definite time and *tIReset1* and *tIReset2* for the inverse time) the corresponding START output is reset, after that the defined reset time has elapsed.

Here it should be noted that after leaving the hysteresis area, the START condition must be fulfilled again and it is not sufficient for the signal to only return back to the hysteresis area. Also notice that for the overvoltage function IDMT reset time is constant and does not depend on the voltage fluctuations during the drop-off period. However, there are three ways to reset the timer, either the timer is reset instantaneously, or the timer value is frozen during the reset time, or the timer value is linearly decreased during the reset time. See figure 113 and figure 114.

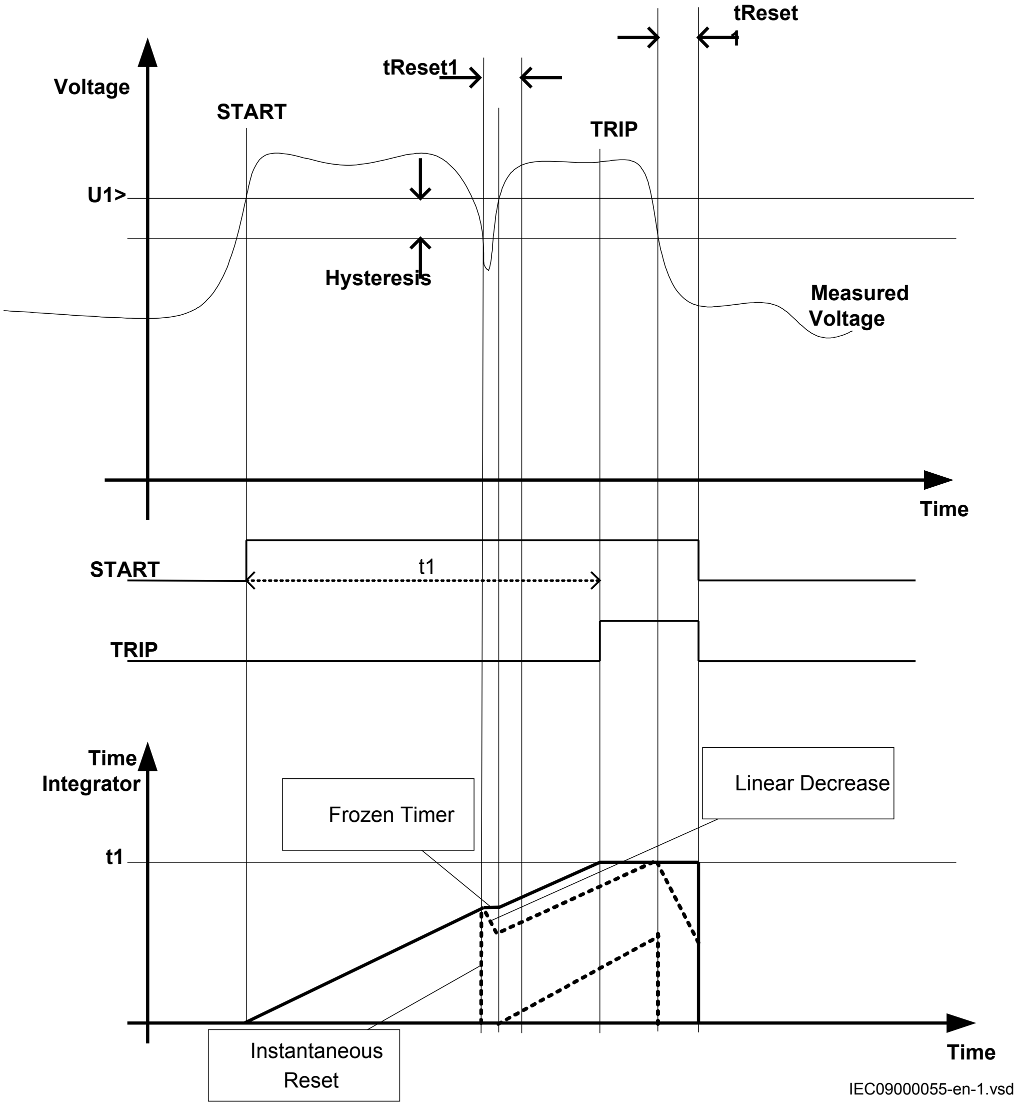


Figure 120: Voltage profile not causing a reset of the START signal for step 1, and inverse time delay

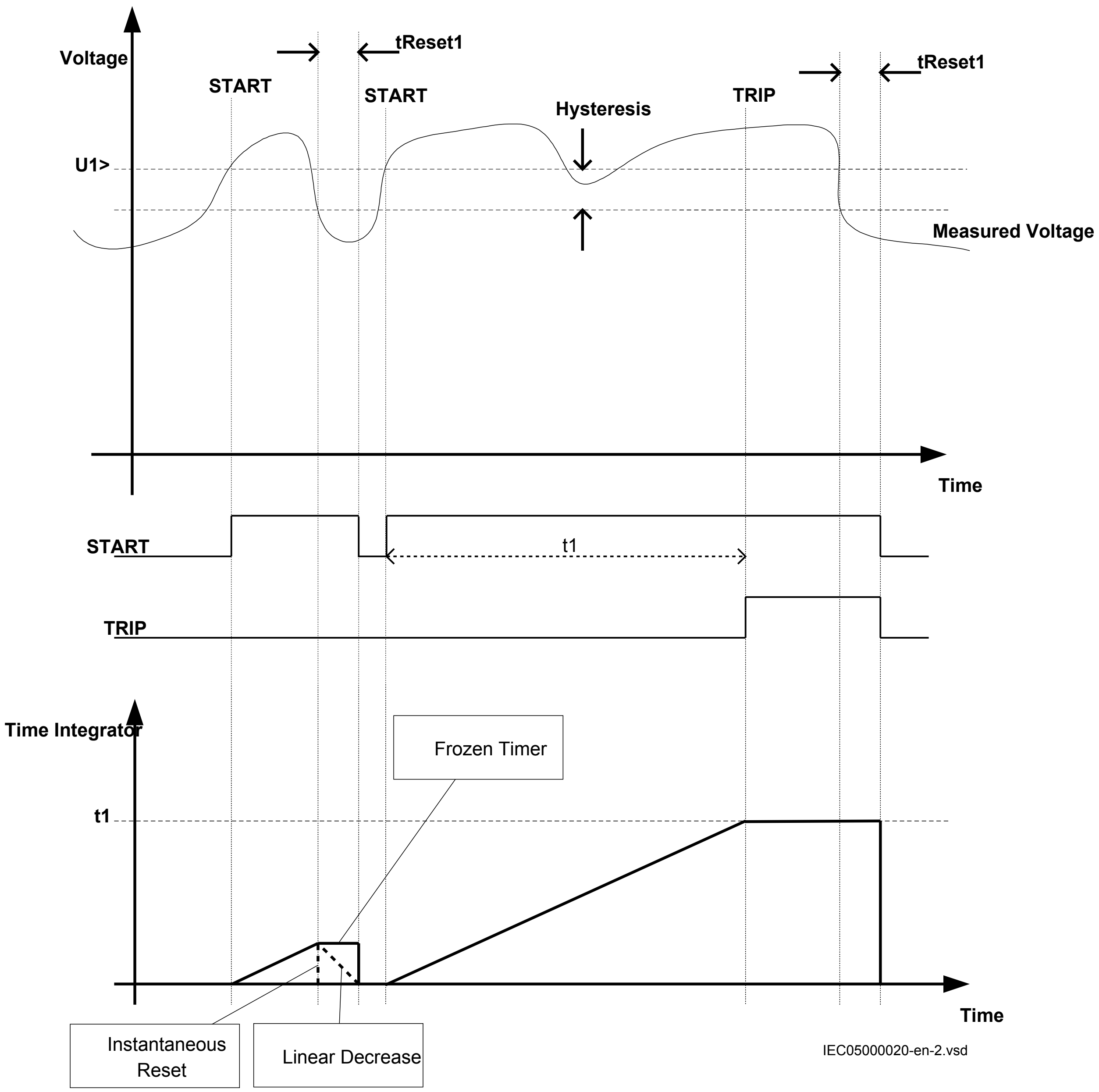


Figure 121: Voltage profile causing a reset of the START signal for step 1, and inverse time delay

Definite timer delay

When definite time delay is selected the function will operate as shown in figure 122. Detailed information about individual stage reset/operation behavior is shown in figure 107 and figure 108 receptively. Note that by setting *tResetn = 0.0s* instantaneous reset of the definite time delayed stage is ensured

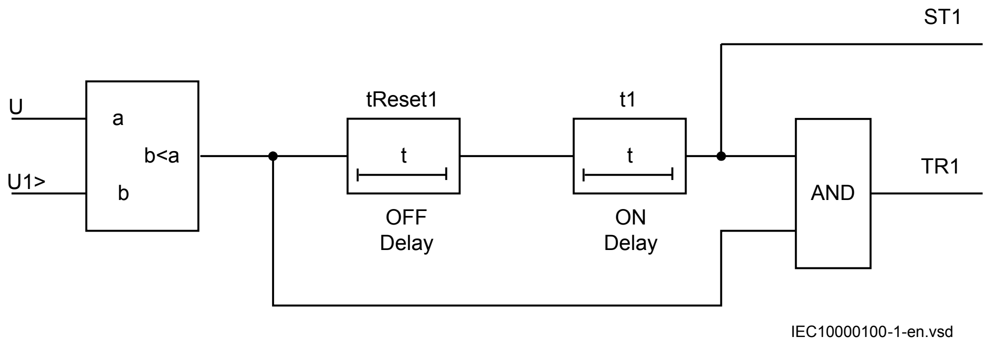


Figure 122: Detailed logic diagram for step 1, DT operation

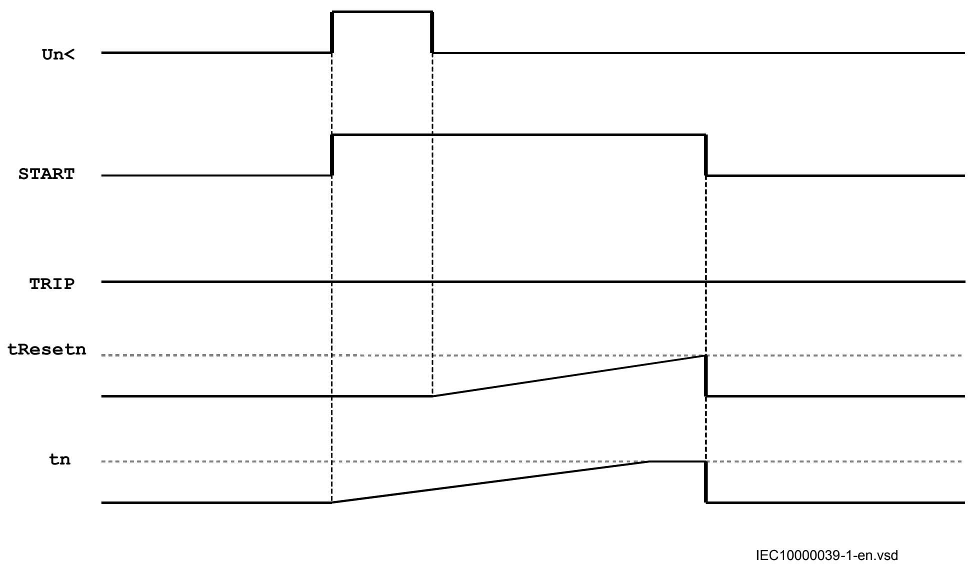


Figure 123: Example for Definite Time Delay stage rest

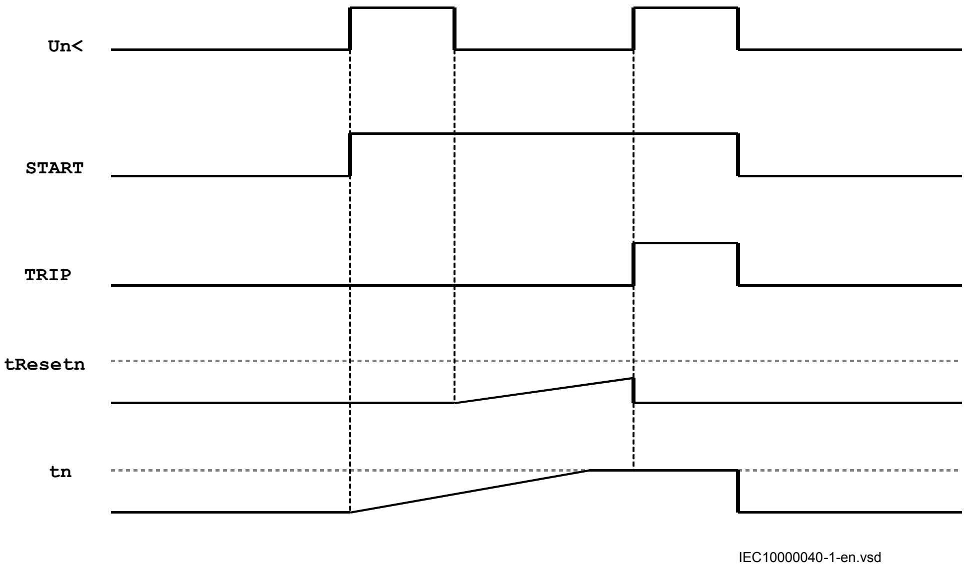


Figure 124: Example for Definite Time Delay stage operation

7.3.2.3 Blocking

It is possible to block Two step residual overvoltage protection ROV2PTOV partially or completely, by binary input signals where:

BLOCK:	blocks all outputs
BLKTR1:	blocks all trip outputs of step 1
BLKST1:	blocks all start and trip outputs related to step 1
BLKTR2:	blocks all trip outputs of step 2
BLKST2:	blocks all START and trip inputs related to step 2

7.3.2.4 Design

The voltage measuring elements continuously measure the residual voltage. Recursive Fourier filters filter the input voltage signal. The single input voltage is compared to the set value, and is also used for the inverse time characteristic integration. The design of Two step residual overvoltage protection (ROV2PTOV) is schematically described in figure 125.

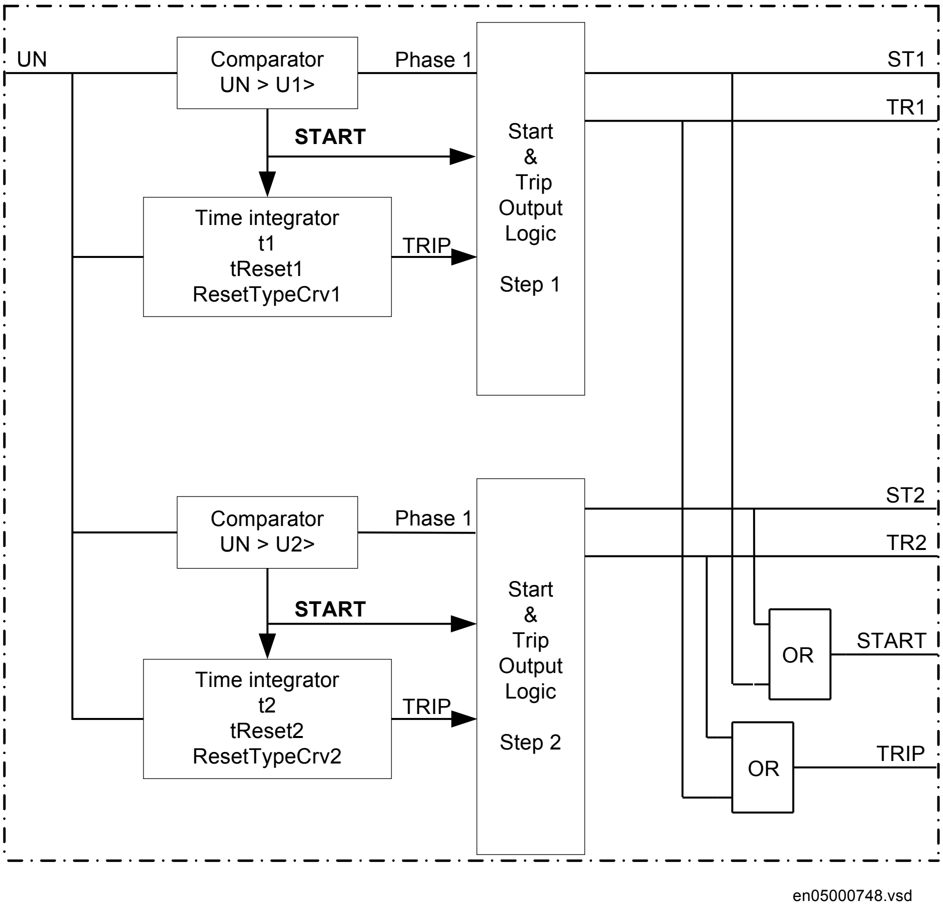


Figure 125: Schematic design of Two step residual overvoltage protection ROV2PTOV

7.3.3 Function block

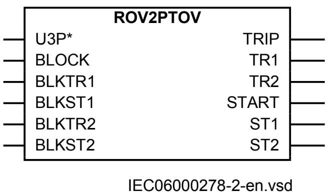


Figure 126: ROV2PTOV function block

7.3.4 Input and output signals

Table 144: ROV2PTOV Input signals

Name	Type	Default	Description
U3P	GROUP SIGNAL	-	Three phase voltages
BLOCK	BOOLEAN	0	Block of function
BLKTR1	BOOLEAN	0	Block of operate signal, step 1
BLKST1	BOOLEAN	0	Block of step 1
BLKTR2	BOOLEAN	0	Block of operate signal, step 2
BLKST2	BOOLEAN	0	Block of step 2

Table 145: ROV2PTOV Output signals

Name	Type	Description
TRIP	BOOLEAN	Trip
TR1	BOOLEAN	Common trip signal from step1
TR2	BOOLEAN	Common trip signal from step2
START	BOOLEAN	General start signal
ST1	BOOLEAN	Common start signal from step1
ST2	BOOLEAN	Common start signal from step2

7.3.5 Setting parameters

Table 146: ROV2PTOV Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
UBase	0.05 - 2000.00	kV	0.05	400.00	Base voltage
OperationStep1	Off On	-	-	On	Enable execution of step 1
Characterist1	Definite time Inverse curve A Inverse curve B Inverse curve C Prog. inv. curve	-	-	Definite time	Selection of time delay curve type for step 1
U1>	1 - 200	%UB	1	30	Voltage setting/start val (DT & IDMT), step 1 in % of UBase
t1	0.00 - 6000.00	s	0.01	5.00	Definitive time delay of step 1
t1Min	0.000 - 60.000	s	0.001	5.000	Minimum operate time for inverse curves for step 1
k1	0.05 - 1.10	-	0.01	0.05	Time multiplier for the inverse time delay for step 1
HystAbs1	0.0 - 100.0	%UB	0.1	0.5	Absolute hysteresis in % of UBase, step 1

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
OperationStep2	Off On	-	-	On	Enable execution of step 2
Characterist2	Definite time Inverse curve A Inverse curve B Inverse curve C Prog. inv. curve	-	-	Definite time	Selection of time delay curve type for step 2
U2>	1 - 100	%UB	1	45	Voltage setting/start val (DT & IDMT), step 2 in % of UBase
t2	0.000 - 60.000	s	0.001	5.000	Definitive time delay of step 2
t2Min	0.000 - 60.000	s	0.001	5.000	Minimum operate time for inverse curves for step 2
k2	0.05 - 1.10	-	0.01	0.05	Time multiplier for the inverse time delay for step 2
HystAbs2	0.0 - 100.0	%UB	0.1	0.5	Absolute hysteresis in % of UBase, step 2

Table 147: ROV2PTOV Group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
tReset1	0.000 - 60.000	s	0.001	0.025	Reset time delay used in IEC Definite Time curve step 1
ResetTypeCrv1	Instantaneous Frozen timer Linearly decreased	-	-	Instantaneous	Selection of used IDMT reset curve type for step 1
tIReset1	0.000 - 60.000	s	0.001	0.025	Time delay in IDMT reset (s), step 1
ACrv1	0.005 - 200.000	-	0.001	1.000	Parameter A for customer programmable curve for step 1
BCrv1	0.50 - 100.00	-	0.01	1.00	Parameter B for customer programmable curve for step 1
CCrv1	0.0 - 1.0	-	0.1	0.0	Parameter C for customer programmable curve for step 1
DCrv1	0.000 - 60.000	-	0.001	0.000	Parameter D for customer programmable curve for step 1
PCrv1	0.000 - 3.000	-	0.001	1.000	Parameter P for customer programmable curve for step 1
CrvSat1	0 - 100	%	1	0	Tuning param for prog. over voltage IDMT curve, step 1
tReset2	0.000 - 60.000	s	0.001	0.025	Time delay in DT reset (s), step 2
ResetTypeCrv2	Instantaneous Frozen timer Linearly decreased	-	-	Instantaneous	Selection of used IDMT reset curve type for step 2
tIReset2	0.000 - 60.000	s	0.001	0.025	Time delay in IDMT reset (s), step 2
ACrv2	0.005 - 200.000	-	0.001	1.000	Parameter A for customer programmable curve for step 2
BCrv2	0.50 - 100.00	-	0.01	1.00	Parameter B for customer programmable curve for step 2
CCrv2	0.0 - 1.0	-	0.1	0.0	Parameter C for customer programmable curve for step 2

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
DCrv2	0.000 - 60.000	-	0.001	0.000	Parameter D for customer programmable curve for step 2
PCrv2	0.000 - 3.000	-	0.001	1.000	Parameter P for customer programmable curve for step 2
CrvSat2	0 - 100	%	1	0	Tuning param for prog. over voltage IDMT curve, step 2

7.3.6 Technical data

Table 148: ROV2PTOV technical data

Function	Range or value	Accuracy
Operate voltage, low and high step	(1-200)% of *UBase*	± 0.5% of U_r at U < U_r ± 1.0% of U at U > U_r
Absolute hysteresis	(0–100)% of *UBase*	± 0.5% of U_r at U < U_r ± 1.0% of U at U > U_r
Inverse time characteristics for low and high step, see table 488	-	See table 488
Definite time setting	(0.000–60.000) s	± 0.5% ± 10 ms
Minimum operate time	(0.000-60.000) s	± 0.5% ± 10 ms
Operate time, start function	25 ms typically at 0 to 2 x U_{set}	-
Reset time, start function	25 ms typically at 2 to 0 x U_{set}	-
Critical impulse time	10 ms typically at 0 to 2 x U_{set}	-
Impulse margin time	15 ms typically	-

7.4 Voltage differential protection VDCPTOV

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Voltage differential protection	VDCPTOV	-	60

7.4.1 Introduction

A voltage differential monitoring function is available. It compares the voltages from two three phase sets of voltage transformers and has one sensitive alarm step and one trip step.

7.4.2 Principle of operation

The Voltage differential protection function VDCPTOV (60) is based on comparison of the amplitudes of the two voltages connected in each phase. Possible differences between the ratios of the two Voltage/Capacitive voltage transformers can be compensated for with a ratio correction factors *RFLx*. The voltage difference is evaluated and if it exceeds the alarm level *UDAlarm* or trip level *UDATrip* signals for alarm (ALARM output) or trip (TRIP output) is given after definite time delay *tAlarm* respectively *tTrip*. The two three phase voltage supplies are also supervised with undervoltage settings *U1Low* and *U2Low*. The outputs for loss of voltage U1LOW resp U2LOW will be activated. The U1 voltage is supervised for loss of individual phases whereas the U2 voltage is supervised for loss of all three phases.

Loss of all U1or all U2 voltages will block the differential measurement. This blocking can be switched off with setting *BlkDiffAtULow = No*.

VDCPTOV function can be blocked from an external condition with the binary BLOCK input. It can for example, be activated from Fuse failure supervision function SDDRFUF.

To allow easy commissioning the measured differential voltage is available as service value. This allows simple setting of the ratio correction factor to achieve full balance in normal service.

The principle logic diagram is shown in figure 127.

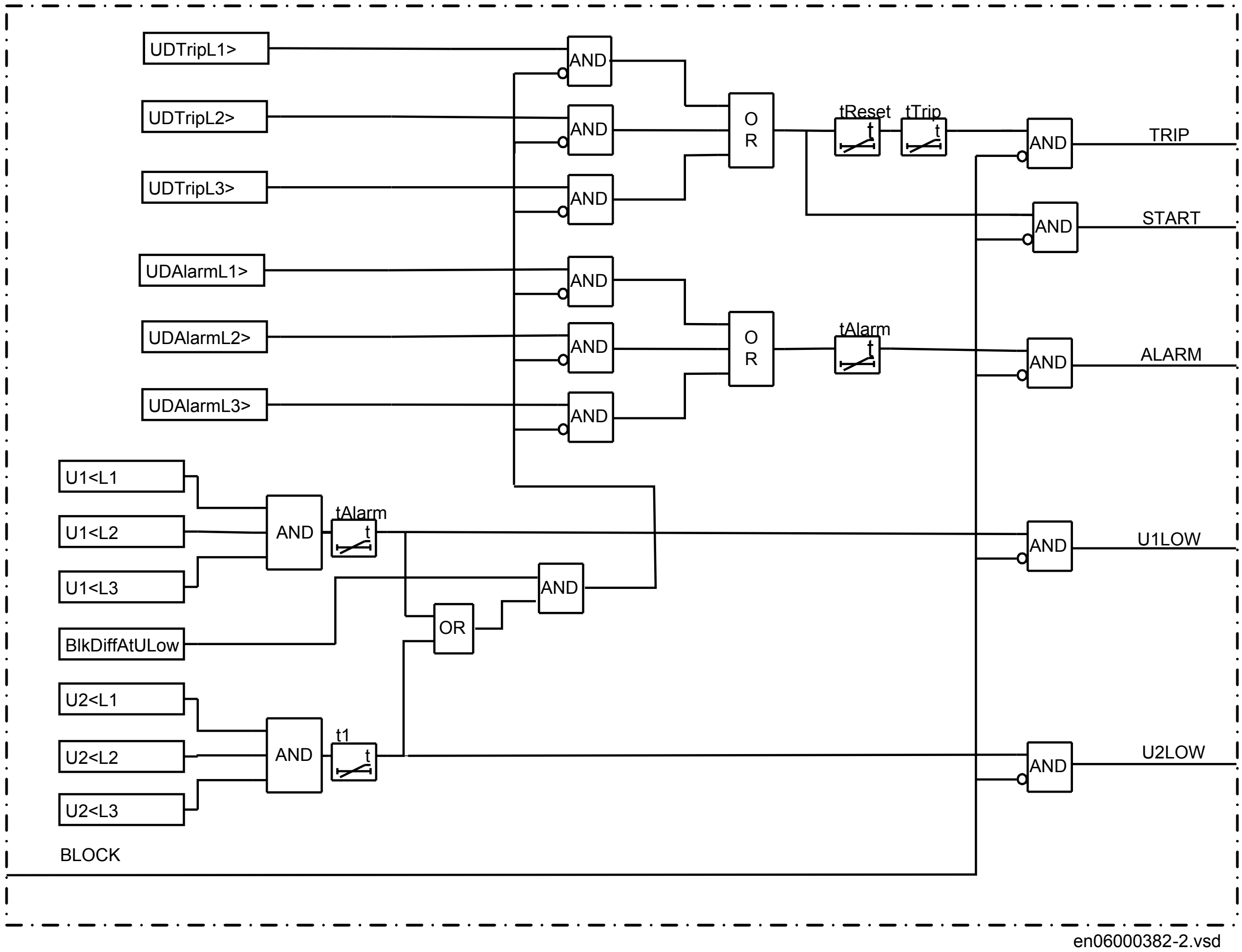


Figure 127: Principle logic for Voltage differential function VDCPTOV

7.4.3 Function block

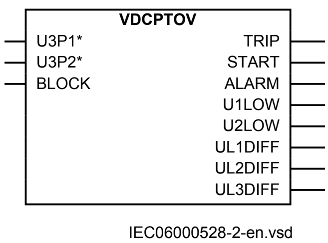


Figure 128: VDCPTOV function block

7.4.4 Input and output signals

Table 149: VDCPTOV Input signals

Name	Type	Default	Description
U3P1	GROUP SIGNAL	-	Bus voltage
U3P2	GROUP SIGNAL	-	Capacitor voltage
BLOCK	BOOLEAN	0	Block of function

Table 150: VDCPTOV Output signals

Name	Type	Description
TRIP	BOOLEAN	Voltage differential protection operated
START	BOOLEAN	Start of voltage differential protection
ALARM	BOOLEAN	Voltage differential protection alarm
U1LOW	BOOLEAN	Loss of U1 voltage
U2LOW	BOOLEAN	Loss of U2 voltage
UL1DIFF	REAL	Differential Voltage phase L1
UL2DIFF	REAL	Differential Voltage phase L2
UL3DIFF	REAL	Differential Voltage phase L3

7.4.5 Setting parameters

Table 151: VDCPTOV Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off/On
UBase	0.50 - 2000.00	kV	0.01	400.00	Base Voltage
BlkDiffAtULow	No Yes	-	-	Yes	Block operation at low voltage
UDTrip	0.0 - 100.0	%UB	0.1	5.0	Operate level, in % of UBase
tTrip	0.000 - 60.000	s	0.001	1.000	Time delay for voltage differential operate, in milliseconds
tReset	0.000 - 60.000	s	0.001	0.000	Time delay for voltage differential reset, in seconds
U1Low	0.0 - 100.0	%UB	0.1	70.0	Input 1 undervoltage level, in % of UBase
U2Low	0.0 - 100.0	%UB	0.1	70.0	Input 2 undervoltage level, in % of UBase
tBlock	0.000 - 60.000	s	0.001	0.000	Reset time for undervoltage block
UDAlarm	0.0 - 100.0	%UB	0.1	2.0	Alarm level, in % of UBase
tAlarm	0.000 - 60.000	s	0.001	2.000	Time delay for voltage differential alarm, in seconds

Table 152: VDCPTOV Group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
RFL1	0.000 - 3.000	-	0.001	1.000	Ratio compensation factor phase L1 U2L1*RFL1=U1L1
RFL2	0.000 - 3.000	-	0.001	1.000	Ratio compensation factor phase L2 U2L2*RFL2=U1L2
RFL3	0.000 - 3.000	-	0.001	1.000	Ratio compensation factor phase L3 U2L3*RFL3=U1L3

7.4.6 Technical data

Table 153: VDCPTOV technical data

Function	Range or value	Accuracy
Voltage difference for alarm and trip	(0.0–100.0) % of *UBase*	± 0.5 % of U_r
Under voltage level	(0.0–100.0) % of *UBase*	± 0.5% of U_r
Timers	(0.000–60.000)s	± 0.5% ± 10 ms

7.5 Loss of voltage check LOVPTUV

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Loss of voltage check	LOVPTUV	-	27

7.5.1 Introduction

Loss of voltage check (LOVPTUV) is suitable for use in networks with an automatic system restoration function. LOVPTUV issues a three-pole trip command to the circuit breaker, if all three phase voltages fall below the set value for a time longer than the set time and the circuit breaker remains closed.

7.5.2 Principle of operation

The operation of Loss of voltage check LOVPTUV is based on line voltage measurement. LOVPTUV is provided with a logic, which automatically recognises if the line was restored for at least *tRestore* before starting the *tTrip* timer. All three phases are required to be low before the output TRIP is activated. The START output signal indicates start.

Additionally, LOVPTUV is automatically blocked if only one or two phase voltages have been detected low for more than *tBlock*.

LOVPTUV operates again only if the line has been restored to full voltage for at least *tRestore*. Operation of the function is also inhibited by fuse failure and open circuit breaker information signals, by their connection to dedicated inputs of the function block.

Due to undervoltage conditions being continuous the trip pulse is limited to a length set by setting *tPulse*.

The operation of LOVPTUV is supervised by the fuse-failure function (VTSU input) and the information about the open position (CBOPEN) of the associated circuit breaker.

The BLOCK input can be connected to a binary input of the IED in order to receive a block command from external devices or can be software connected to other internal functions of the IED itself in order to receive a block command from internal functions. LOVPTUV is also blocked when the IED is in TEST status and the function has been blocked from the HMI test menu. (*Blocked*=*Yes*).

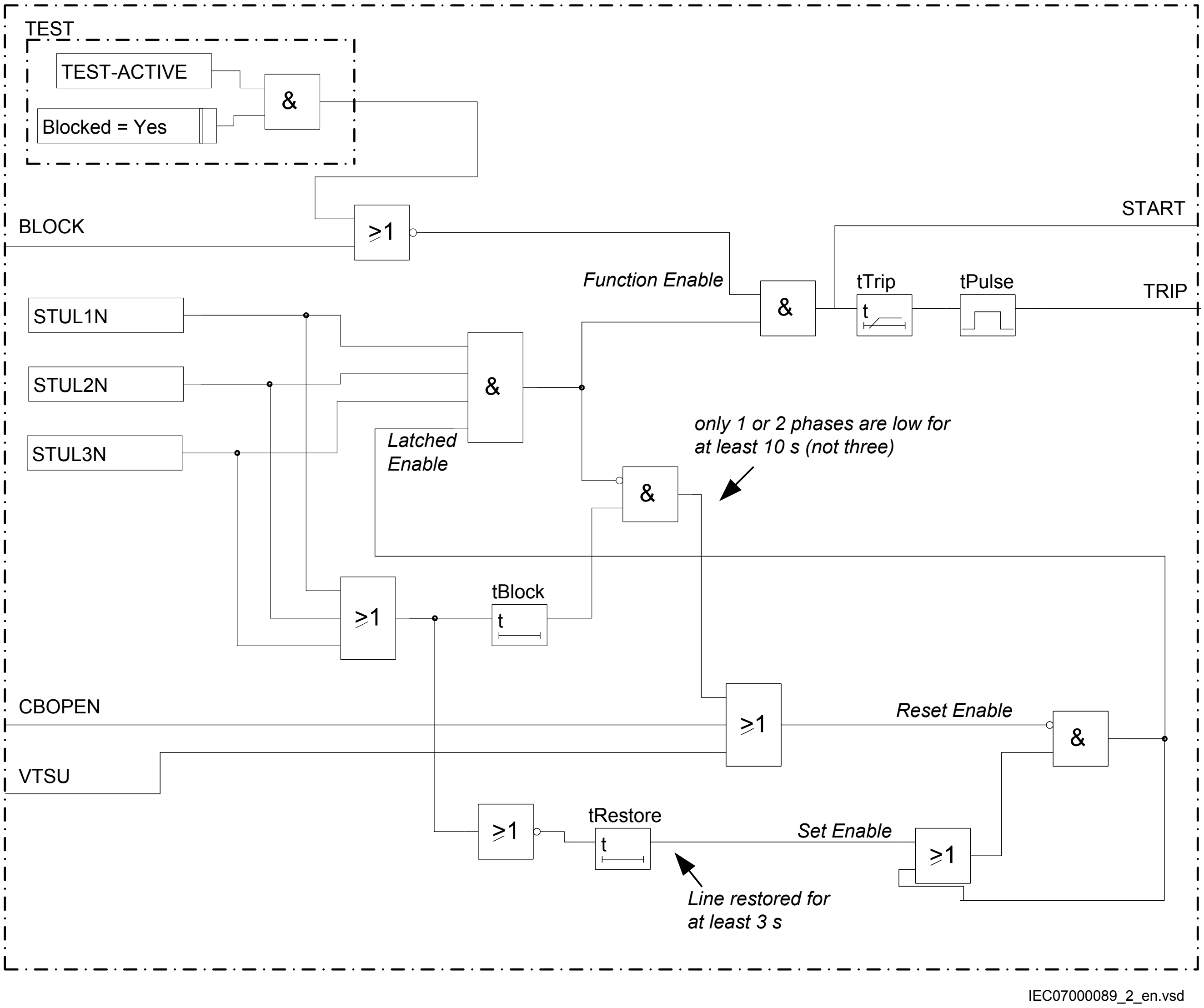


Figure 129: Simplified diagram of Loss of voltage check LOVPTUV

7.5.3 Function block

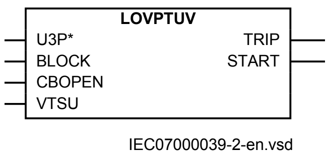


Figure 130: LOVPTUV function block

7.5.4 Input and output signals

Table 154: LOVPTUV Input signals

Name	Type	Default	Description
U3P	GROUP SIGNAL	-	Voltage connection
BLOCK	BOOLEAN	0	Block the all outputs
CBOPEN	BOOLEAN	0	Circuit breaker open
VTSU	BOOLEAN	0	Block from voltage circuit supervision

Table 155: LOVPTUV Output signals

Name	Type	Description
TRIP	BOOLEAN	Trip signal
START	BOOLEAN	Start signal

7.5.5 Setting parameters

Table 156: LOVPTUV Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off/On
UBase	0.1 - 9999.9	kV	0.1	400.0	Base voltage
UPE	1 - 100	%UB	1	70	Operate voltagein% of base voltage Ubase
tTrip	0.000 - 60.000	s	0.001	7.000	Operate time delay

Table 157: LOVPTUV Group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
tPulse	0.050 - 60.000	s	0.001	0.150	Duration of TRIP pulse
tBlock	0.000 - 60.000	s	0.001	5.000	Time delay to block when all 3ph voltages are not low
tRestore	0.000 - 60.000	s	0.001	3.000	Time delay for enable the function after restoration

7.5.6 Technical data

Table 158: LOVPTUV technical data

Function	Range or value	Accuracy
Operate voltage	(0–100)% of UBase	± 0.5% of U_r
Pulse timer	(0.050–60.000) s	± 0.5% ± 10 ms
Timers	(0.000–60.000) s	± 0.5% ± 10 ms

Section 8 Frequency protection

About this chapter

This chapter describes the frequency protection functions. The way the functions work, their setting parameters, function blocks, input and output signals and technical data are included for each function.

8.1 Underfrequency protection SAPTUF

8.1.1 Principle of operation

Underfrequency protection SAPTUF is used to detect low power system frequency. SAPTUF can either have a definite time delay or a voltage magnitude dependent time delay. If the voltage magnitude dependent time delay is applied, the time delay will be longer if the voltage is higher, and the delay will be shorter if the voltage is lower. If the frequency remains below the set value for a time period corresponding to the chosen time delay, the corresponding trip signal is issued. To avoid an unwanted trip due to uncertain frequency measurement at low voltage magnitude, a voltage controlled blocking of the function is available, that is, if the voltage is lower than the set blocking voltage *IntBlockLevel* the function is blocked and no START or TRIP signal is issued.

8.1.1.1 Measurement principle

The fundamental frequency of the measured input voltage is measured continuously, and compared with the set value, *StartFrequency*. The frequency function is dependent on the voltage magnitude. If the voltage magnitude decreases the setting *IntBlockLevel*, SAPTUF gets blocked, and the output BLKDMAGN is issued. All voltage settings are made in percent of the setting *UBase*, which should be set as a phase-phase voltage in kV.

To avoid oscillations of the output START signal, a hysteresis has been included.

8.1.1.2 Time delay

The time delay for underfrequency protection SAPTUF can be either a settable definite time delay or a voltage magnitude dependent time delay, where the time delay depends on the voltage level; a high voltage level gives a longer time delay and a low voltage level causes a short time delay. For the definite time delay, the setting *TimeDlyOperate* sets the time delay.

For the voltage dependent time delay the measured voltage level and the settings *UNom*, *UMin*, *Exponent*, *tMax* and *tMin* set the time delay according to figure 131 and equation 61. The setting *TimerOperation* is used to decide what type of time delay to apply.

Trip signal issuing requires that the underfrequency condition continues for at least the user set time delay *TimeDlyOperate*. If the START condition, with respect to the measured frequency ceases during this user set delay time, and is not fulfilled again within a user defined reset time, *TimeDlyReset*, the START output is reset, after that the defined reset time has elapsed. Here it should be noted that after leaving the hysteresis area, the START condition must be fulfilled again and it is not sufficient for the signal to only return back to the hysteresis area.

On the output of SAPTUF a 100ms pulse is issued, after a time delay corresponding to the setting of *TimeDlyRestore*, when the measured frequency returns to the level corresponding to the setting *RestoreFreq*.

8.1.1.3 Voltage dependent time delay

Since the fundamental frequency in a power system is the same all over the system, except some deviations during power oscillations, another criterion is needed to decide, where to take actions, based on low frequency. In many applications the voltage level is very suitable, and in most cases is load shedding preferable in areas with low voltage. Therefore, a voltage dependent time delay has been introduced, to make sure that load shedding, or other actions, take place at the right location. At constant voltage, U, the voltage dependent time delay is calculated according to equation 61. At non-constant voltage, the actual time delay is integrated in a similar way as for the inverse time characteristic for the undervoltage and overvoltage functions.

$$t = \left[\frac{U - UMin}{UNom - UMin} \right]^{Exponent} \cdot \left(tMax - tMin \right) + tMin$$

(Equation 61)

where:

t	is the voltage dependent time delay (at constant voltage),
U	is the measured voltage
Exponent	is a setting,
UMin, UNom	are voltage settings corresponding to
tMax, tMin	are time settings.

The inverse time characteristics are shown in figure 131, for:

UMin	= 90%
UNom	= 100%
tMax	= 1.0 s
tMin	= 0.0 s
Exponent	= 0, 1, 2, 3 and 4

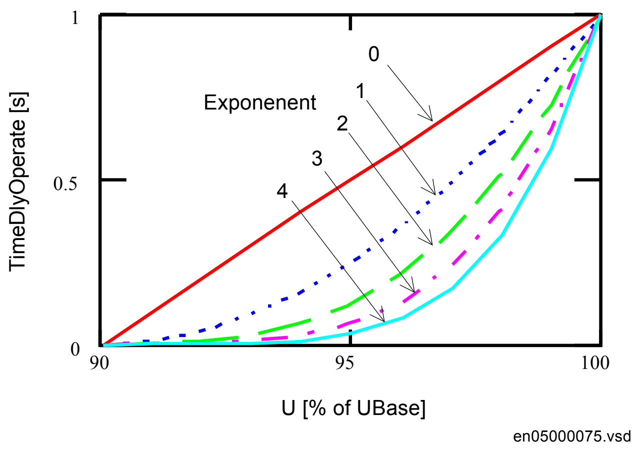


Figure 131: Voltage dependent inverse time characteristics for underfrequency protection SAPTUF. The time delay to operate is plotted as a function of the measured voltage, for the Exponent = 0, 1, 2, 3, 4 respectively.

8.1.1.4 Blocking

It is possible to block underfrequency protection SAPTUF partially or completely, by binary input signals or by parameter settings, where:

BLOCK:	blocks all outputs
BLKTRIP:	blocks the TRIP output
BLKREST:	blocks the RESTORE output

If the measured voltage level decreases below the setting of *IntBlockLevel*, both the START and the TRIP outputs, are blocked.

8.1.1.5 Design

The frequency measuring element continuously measures the frequency of the positive sequence voltage and compares it to the setting *StartFrequency*. The frequency signal is filtered to avoid transients due to switchings and faults. The time integrator can operate either due to a definite delay time or to the special voltage dependent delay time. When the frequency has returned back to the setting of *RestoreFreq*, the RESTORE output is issued after the time delay *TimeDlyRestore*. The design of underfrequency protection SAPTUF is schematically described in figure 132.

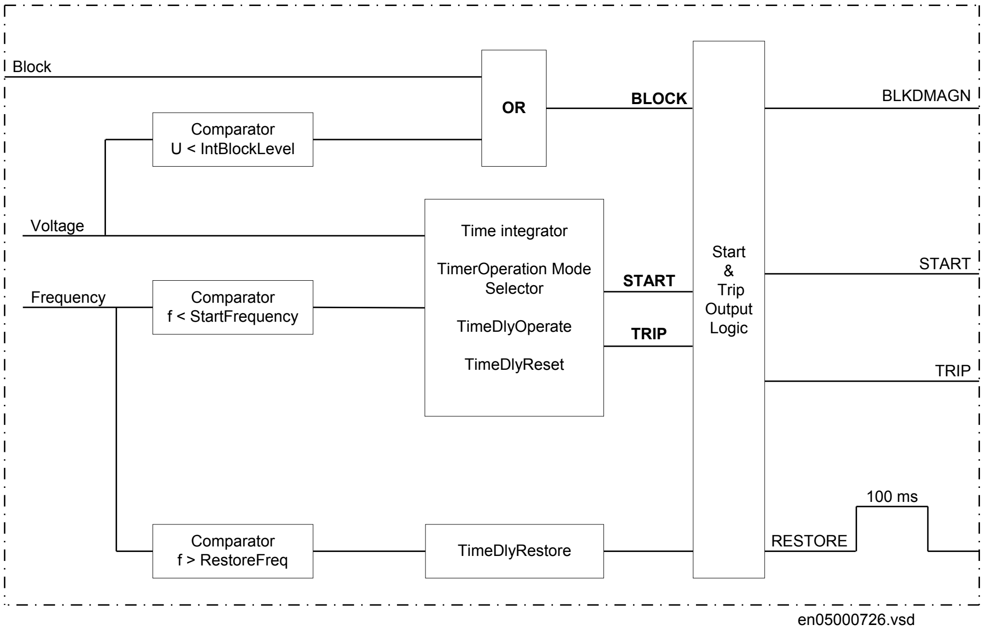


Figure 132: Simplified logic diagram for SAPTUF

8.1.2 Function block

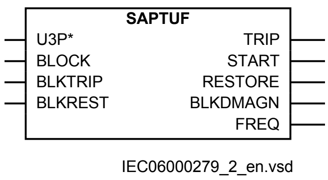


Figure 133: SAPTUF function block

8.1.3 Input and output signals

Table 159: SAPTUF Input signals

Name	Type	Default	Description
U3P	GROUP SIGNAL	-	Voltage connection
BLOCK	BOOLEAN	0	Block of function
BLKTRIP	BOOLEAN	0	Blocking operate output.
BLKREST	BOOLEAN	0	Blocking restore output.

Table 160: SAPTUF Output signals

Name	Type	Description
TRIP	BOOLEAN	Operate/trip signal for frequency.
START	BOOLEAN	Start/pick-up signal for frequency.
RESTORE	BOOLEAN	Restore signal for load restoring purposes.
BLKDMAGN	BOOLEAN	Blocking indication due to low amplitude.
FREQ	REAL	Measured frequency

8.1.4 Setting parameters

Table 161: SAPTUF Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
UBase	0.05 - 2000.00	kV	0.05	400.00	Base voltage
StartFrequency	35.00 - 75.00	Hz	0.01	48.80	Frequency setting/start value.
IntBlockLevel	0 - 100	%UB	1	50	Internal blocking level in % of UBase.
TimeDlyOperate	0.000 - 60.000	s	0.001	0.200	Operate time delay in over/under-frequency mode.
TimeDlyReset	0.000 - 60.000	s	0.001	0.000	Time delay for reset.
TimeDlyRestore	0.000 - 60.000	s	0.001	0.000	Restore time delay.
RestoreFreq	45.00 - 65.00	Hz	0.01	50.10	Restore frequency if frequency is above frequency value.
TimerOperation	Definite timer Volt based timer	-	-	Definite timer	Setting for choosing timer mode.
UNom	50 - 150	%UB	1	100	Nominal voltage in % of UBase for voltage based timer.
UMin	50 - 150	%UB	1	90	Lower operation limit in % of UBase for voltage based timer.
Exponent	0.0 - 5.0	-	0.1	1.0	For calculation of the curve form for voltage based timer.
tMax	0.010 - 60.000	s	0.001	1.000	Maximum time operation limit for voltage based timer.
tMin	0.010 - 60.000	s	0.001	1.000	Minimum time operation limit for voltage based timer.

8.1.5 Technical data

Table 162: SAPTUF technical data

Function	Range or value	Accuracy
Operate value, start function	(35.00-75.00) Hz	± 2.0 mHz
Operate time, start function	100 ms typically	-
Reset time, start function	100 ms typically	-
Table continues on next page		

Function	Range or value	Accuracy
Operate time, definite time function	(0.000-60.000)s	± 0.5% ± 10 ms
Reset time, definite time function	(0.000-60.000)s	± 0.5% ± 10 ms
Voltage dependent time delay $t = \left[\frac{U - UMin}{UNom - UMin} \right]^{Exponent} \cdot \left(tMax - tMin \right) + tMin$ (Equation 62) $U = U_{measured}$	Settings: UNom=(50-150)% of U_{base} UMin=(50-150)% of U_{base} Exponent=0.0-5.0 tMax=(0.000-60.000)s tMin=(0.000-60.000)s	Class 5 + 200 ms

8.2 Overfrequency protection SAPTOF

8.2.1 Introduction

Overfrequency protection function SAPTOF is applicable in all situations, where reliable detection of high fundamental power system frequency is needed.

Overfrequency occurs at sudden load drops or shunt faults in the power network. Close to the generating plant, generator governor problems can also cause over frequency.

SAPTOF is used mainly for generation shedding and remedial action schemes. It is also used as a frequency stage initiating load restoring.

SAPTOF is provided with an undervoltage blocking.

The operation is based on positive sequence voltage measurement and requires two phase-phase or three phase-neutral voltages to be connected. For information about how to connect analog inputs, refer to **Application manual/IED application/ Analog inputs/Setting guidelines**

8.2.2 Principle of operation

Overfrequency protection SAPTOF is used to detect high power system frequency. SAPTOF has a settable definite time delay. If the frequency remains above the set value for a time period corresponding to the chosen time delay, the corresponding TRIP signal is issued. To avoid an unwanted TRIP due to uncertain frequency measurement at low voltage magnitude, a voltage controlled blocking of the function is available from the preprocessing function, that is, if the voltage is lower than the set blocking voltage in the preprocessing function, the function is blocked and no START or TRIP signal is issued.

8.2.2.1 Measurement principle

The fundamental frequency of the positive sequence voltage is measured continuously, and compared with the set value, *StartFrequency*. Overfrequency protection SAPTOF is dependent on the voltage magnitude. If the voltage magnitude decreases below the setting *IntBlockLevel*, SAPTOF is blocked, and the output BLKDMAGN is issued. All voltage settings are made in percent of the *UBase*, which should be set as a phase-phase voltage in kV. To avoid oscillations of the output START signal, a hysteresis has been included.

8.2.2.2 Time delay

The time delay for Overfrequency protection SAPTOF (81) is a settable definite time delay, specified by the setting *TimeDlyOperate*.

TRIP signal issuing requires that the overfrequency condition continues for at least the user set time delay, *TimeDlyReset*. If the START condition, with respect to the measured frequency ceases during this user set delay time, and is not fulfilled again within a user defined reset time, *TimeDlyReset*, the START output is reset, after that the defined reset time has elapsed. It is to be noted that after leaving the hysteresis area, the START condition must be fulfilled again and it is not sufficient for the signal to only return back to the hysteresis area.

8.2.2.3 Blocking

It is possible to block overfrequency protection SAPTOF partially or completely, by binary input signals or by parameter settings, where:

BLOCK:	blocks all outputs
BLKTRIP:	blocks the TRIP output

If the measured voltage level decreases below the setting of *IntBlockLevel*, both the START and the TRIP outputs, are blocked.

8.2.2.4 Design

The frequency measuring element continuously measures the frequency of the positive sequence voltage and compares it to the setting *StartFrequency*. The frequency signal is filtered to avoid transients due to switchings and faults in the power system. The time integrator operates due to a definite delay time. The design of overfrequency protection SAPTOF is schematically described in figure 134.

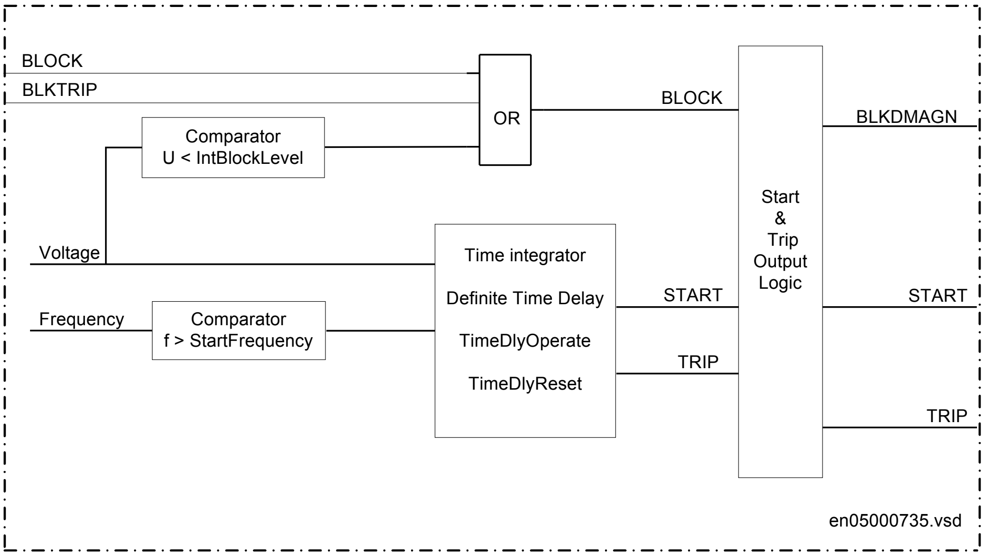


Figure 134: Schematic design of overfrequency protection SAPTOF

8.2.3 Technical data

Table 163: SAPTOF technical data

Function	Range or value	Accuracy
Operate value, start function	(35.00-75.00) Hz	± 2.0 mHz at symmetrical three-phase voltage
Operate time, start function	100 ms typically at f_{set} -0.5 Hz to f_{set} +0.5 Hz	-
Reset time, start function	100 ms typically	-
Operate time, definite time function	(0.000-60.000)s	± 0.5% ± 10 ms
Reset time, definite time function	(0.000-60.000)s	± 0.5% ± 10 ms

8.3 Rate-of-change frequency protection SAPFRC

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Rate-of-change frequency protection	SAPFRC	df/dt ≷	81

8.3.1 Introduction

Rate-of-change frequency protection function (SAPFRC) gives an early indication of a main disturbance in the system. SAPFRC can be used for generation shedding, load shedding and remedial action schemes. SAPFRC can discriminate between positive or negative change of frequency.

SAPFRC is provided with an undervoltage blocking. The operation is based on positive sequence voltage measurement and requires two phase-phase or three phase-neutral voltages to be connected. For information about how to connect analog inputs, refer to **Application manual/IED application/Analog inputs/Setting guidelines**.

8.3.2 Principle of operation

Rate-of-change frequency protection SAPFRC is used to detect fast power system frequency changes, increase as well as, decrease at an early stage. SAPFRC has a settable definite time delay. If the rate-of-change of frequency remains below the set value, for negative rate-of-change, for a time period equal to the chosen time delay, the TRIP signal is issued. If the rate-of-change of frequency remains above the set value, for positive rate-of-change, for a time period equal to the chosen time delay, the TRIP signal is issued. To avoid an unwanted TRIP due to uncertain frequency measurement at low voltage magnitude, a voltage controlled blocking of the function is available, that is if the voltage is lower than the set blocking voltage *IntBlockLevel*, the function is blocked and no START or TRIP signal is issued. If the frequency recovers, after a frequency decrease, a restore signal is issued.

8.3.2.1 Measurement principle

The rate-of-change of the fundamental frequency of the selected voltage is measured continuously, and compared with the set value, *StartFreqGrad*. Rate-of-change frequency protection SAPFRC is also dependent on the voltage magnitude. If the voltage magnitude decreases below the setting *IntBlockLevel*, SAPFRC is blocked, and the output BLKDMAGN is issued. The sign of the setting *StartFreqGrad*, controls if SAPFRC reacts on a positive or on a negative change in frequency. If SAPFRC is used for decreasing frequency that is, the setting *StartFreqGrad* has been given a negative value, and a trip signal has been issued, then a 100 ms pulse is issued on the RESTORE output, when the frequency recovers to a value higher than the setting *RestoreFreq*. A positive setting of *StartFreqGrad*, sets SAPFRC to START and TRIP for frequency increases.

To avoid oscillations of the output START signal, a hysteresis has been included.

8.3.2.2 Time delay

Rate-of-change frequency protection SAPFRC has a settable definite time delay, *tTrip*. .

Trip signal issuing requires that the rate-of-change of frequency condition continues for at least the user set time delay, *tTrip*. If the START condition, with respect to the measured frequency ceases during the delay time, and is not fulfilled again within a user defined reset time, *tReset*, the START output is reset, after that the defined reset time has elapsed. Here it should be noted that after leaving the hysteresis area, the START condition must be fulfilled again and it is not sufficient for the signal to only return back into the hysteresis area.

The RESTORE output of SAPFRC is set, after a time delay equal to the setting of *tRestore*, when the measured frequency has returned to the level corresponding to *RestoreFreq*, after an issue of the TRIP output signal. If *tRestore* is set to *0.000* s the restore functionality is disabled, and no output will be given. The restore functionality is only active for lowering frequency conditions and the restore sequence is disabled if a new negative frequency gradient is detected during the restore period, defined by the settings *RestoreFreq* and *tRestore*.

8.3.2.3 Blocking

Rate-of-change frequency protection (SAPFRC) can be partially or totally blocked, by binary input signals or by parameter settings, where:

BLOCK:	blocks all outputs
BLKTRIP:	blocks the TRIP output
BLKREST:	blocks the RESTORE output

If the measured voltage level decreases below the setting of *IntBlockLevel*, both the START and the TRIP outputs, are blocked.

8.3.2.4 Design

Rate-of-change frequency protection (SAPFRC) measuring element continuously measures the frequency of the selected voltage and compares it to the setting *StartFreqGrad*. The frequency signal is filtered to avoid transients due to power system switchings and faults. The time integrator operates with a definite delay time. When the frequency has returned back to the setting of *RestoreFreq*, the RESTORE output is issued after the time delay *tRestore*, if the TRIP signal has earlier been issued. The sign of the setting *StartFreqGrad* is essential, and controls if the function is used for raising or lowering frequency conditions. The design of SAPFRC is schematically described in figure 135.

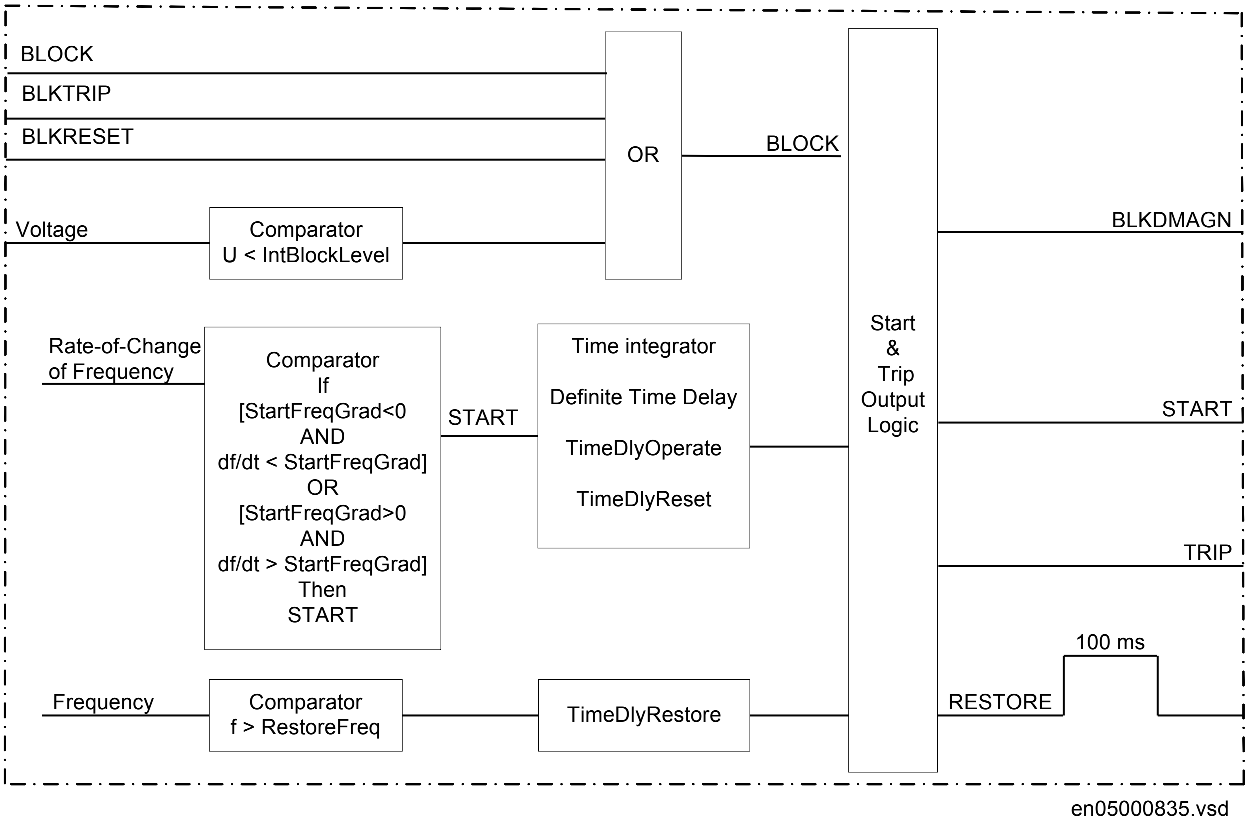


Figure 135: Schematic design of Rate-of-change frequency protection SAPFRC

8.3.3 Function block

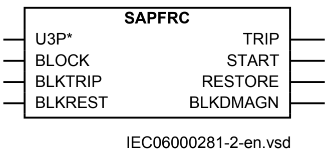


Figure 136: SAPFRC function block

8.3.4 Input and output signals

Table 164: SAPFRC Input signals

Name	Type	Default	Description
U3P	GROUP SIGNAL	-	Group signal for voltage input
BLOCK	BOOLEAN	0	Block of function
BLKTRIP	BOOLEAN	0	Blocking operate output.
BLKREST	BOOLEAN	0	Blocking restore output.

Table 165: SAPFRC Output signals

Name	Type	Description
TRIP	BOOLEAN	Operate/trip signal for frequencyGradient
START	BOOLEAN	Start/pick-up signal for frequencyGradient
RESTORE	BOOLEAN	Restore signal for load restoring purposes.
BLKDMAGN	BOOLEAN	Blocking indication due to low amplitude.

8.3.5 Setting parameters

Table 166: SAPFRC Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
UBase	0.05 - 2000.00	kV	0.05	400.00	Base setting for the phase-phase voltage in kV
StartFreqGrad	-10.00 - 10.00	Hz/s	0.01	0.50	Frequency gradient start value. Sign defines direction.
IntBlockLevel	0 - 100	%UB	1	50	Internal blocking level in % of UBase.
tTrip	0.000 - 60.000	s	0.001	0.200	Operate time delay in pos./neg. frequency gradient mode.
RestoreFreq	45.00 - 65.00	Hz	0.01	49.90	Restore frequency if frequency is above frequency value (Hz)
tRestore	0.000 - 60.000	s	0.001	0.000	Restore time delay.
tReset	0.000 - 60.000	s	0.001	0.000	Time delay for reset.

8.3.6 Technical data

Table 167: SAPFRC Technical data

Function	Range or value	Accuracy
Operate value, start function	(-10.00-10.00) Hz/s	± 10.0 mHz/s
Operate value, internal blocking level	(0-100)% of UBase	± 0.5% of U_r
Operate time, start function	100 ms typically	-

Section 9 Multipurpose protection

About this chapter

This chapter describes Multipurpose protection and includes the General current and voltage function. The way the functions work, their setting parameters, function blocks, input and output signals and technical data are included for each function.

9.1 General current and voltage protection CVGAPC

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
General current and voltage protection	CVGAPC	-	-

9.1.1 Introduction

9.1.2 Principle of operation

9.1.2.1 Measured quantities within CVGAPC

General current and voltage protection (CVGAPC) function is always connected to three-phase current and three-phase voltage input in the configuration tool, but it will always measure only one current and one voltage quantity selected by the end user in the setting tool.

The user can select to measure one of the current quantities shown in table 168.

Table 168: Current selection for CVGAPC function

	Set value for the parameter *CurrentInput*	Comment
1	Phase1	CVGAPC function will measure the phase L1 current phasor
2	Phase2	CVGAPC function will measure the phase L2 current phasor
3	Phase3	CVGAPC function will measure the phase L3 current phasor
4	PosSeq	CVGAPC function will measure internally calculated positive sequence current phasor
5	NegSeq	CVGAPC function will measure internally calculated negative sequence current phasor
Table continues on next page		

	Set value for the parameter *CurrentInput*	Comment
6	3ZeroSeq	CVGAPC function will measure internally calculated zero sequence current phasor multiplied by factor 3
7	MaxPh	CVGAPC function will measure current phasor of the phase with maximum magnitude
8	MinPh	CVGAPC function will measure current phasor of the phase with minimum magnitude
9	UnbalancePh	CVGAPC function will measure magnitude of unbalance current, which is internally calculated as the algebraic magnitude difference between the current phasor of the phase with maximum magnitude and current phasor of the phase with minimum magnitude. Phase angle will be set to 0° all the time
10	Phase1-Phase2	CVGAPC function will measure the current phasor internally calculated as the vector difference between the phase L1 current phasor and phase L2 current phasor (I_{L1}-I_{L2})
11	Phase2-Phase3	CVGAPC function will measure the current phasor internally calculated as the vector difference between the phase L2 current phasor and phase L3 current phasor (I_{L2}-I_{L3})
12	Phase3-Phase1	CVGAPC function will measure the current phasor internally calculated as the vector difference between the phase L3 current phasor and phase L1 current phasor (I_{L3}-I_{L1})
13	MaxPh-Ph	CVGAPC function will measure ph-ph current phasor with the maximum magnitude
14	MinPh-Ph	CVGAPC function will measure ph-ph current phasor with the minimum magnitude
15	UnbalancePh-Ph	CVGAPC function will measure magnitude of unbalance current, which is internally calculated as the algebraic magnitude difference between the ph-ph current phasor with maximum magnitude and ph-ph current phasor with minimum magnitude. Phase angle will be set to 0° all the time

The user can select to measure one of the voltage quantities shown in table 169:

Table 169: Voltage selection for CVGAPC function

	Set value for the parameter *VoltageInput*	Comment
1	Phase1	CVGAPC function will measure the phase L1 voltage phasor
2	Phase2	CVGAPC function will measure the phase L2 voltage phasor
3	Phase3	CVGAPC function will measure the phase L3 voltage phasor
4	PosSeq	CVGAPC function will measure internally calculated positive sequence voltage phasor
5	-NegSeq	CVGAPC function will measure internally calculated negative sequence voltage phasor. This voltage phasor will be intentionally rotated for 180° in order to enable easier settings for the directional feature when used.
6	-3ZeroSeq	CVGAPC function will measure internally calculated zero sequence voltage phasor multiplied by factor 3. This voltage phasor will be intentionally rotated for 180° in order to enable easier settings for the directional feature when used.
Table continues on next page		

	Set value for the parameter *VoltageInput*	Comment
7	MaxPh	CVGAPC function will measure voltage phasor of the phase with maximum magnitude
8	MinPh	CVGAPC function will measure voltage phasor of the phase with minimum magnitude
9	UnbalancePh	CVGAPC function will measure magnitude of unbalance voltage, which is internally calculated as the algebraic magnitude difference between the voltage phasor of the phase with maximum magnitude and voltage phasor of the phase with minimum magnitude. Phase angle will be set to 0° all the time
10	Phase1-Phase2	CVGAPC function will measure the voltage phasor internally calculated as the vector difference between the phase L1 voltage phasor and phase L2 voltage phasor (U_{L1}-U_{L2})
11	Phase2-Phase3	CVGAPC function will measure the voltage phasor internally calculated as the vector difference between the phase L2 voltage phasor and phase L3 voltage phasor (U_{L2}-U_{L3})
12	Phase3-Phase1	CVGAPC function will measure the voltage phasor internally calculated as the vector difference between the phase L3 voltage phasor and phase L1 voltage phasor (U_{L3}-U_{L1})
13	MaxPh-Ph	CVGAPC function will measure ph-ph voltage phasor with the maximum magnitude
14	MinPh-Ph	CVGAPC function will measure ph-ph voltage phasor with the minimum magnitude
15	UnbalancePh-Ph	CVGAPC function will measure magnitude of unbalance voltage, which is internally calculated as the algebraic magnitude difference between the ph-ph voltage phasor with maximum magnitude and ph-ph voltage phasor with minimum magnitude. Phase angle will be set to 0° all the time

It is important to notice that the voltage selection from table 169 is always applicable regardless the actual external VT connections. The three-phase VT inputs can be connected to IED as either three phase-to-ground voltages U_{L1}, U_{L2} & U_{L3} or three phase-to-phase voltages U_{L1L2}, U_{L2L3} & U_{L3L1}). This information about actual VT connection is entered as a setting parameter for the pre-processing block, which will then take automatic care about it.

The user can select one of the current quantities shown in table 170 for built-in current restraint feature:

Table 170: Restraint current selection for CVGAPC function

	Set value for the parameter *RestrCurr*	Comment
1	PosSeq	CVGAPC function will measure internally calculated positive sequence current phasor
2	NegSeq	CVGAPC function will measure internally calculated negative sequence current phasor
3	3ZeroSeq	CVGAPC function will measure internally calculated zero sequence current phasor multiplied by factor 3
4	MaxPh	CVGAPC function will measure current phasor of the phase with maximum magnitude

9.1.2.2 Base quantities for CVGAPC function

The parameter settings for the base quantities, which represent the base (100%) for pickup levels of all measuring stages, shall be entered as setting parameters for every CVGAPC function.

Base current shall be entered as:

1. rated phase current of the protected object in primary amperes, when the measured Current Quantity is selected from 1 to 9, as shown in table 168.
2. rated phase current of the protected object in primary amperes multiplied by √3 (1.732 · Iphase), when the measured Current Quantity is selected from 10 to 15, as shown in table 168.

Base voltage shall be entered as:

1. rated phase-to-earth voltage of the protected object in primary kV, when the measured Voltage Quantity is selected from 1 to 9, as shown in table 169.
2. rated phase-to-phase voltage of the protected object in primary kV, when the measured Voltage Quantity is selected from 10 to 15, as shown in table 169.

9.1.2.3 Built-in overcurrent protection steps

Two overcurrent protection steps are available. They are absolutely identical and therefore only one will be explained here.

Overcurrent step simply compares the magnitude of the measured current quantity (see table 168) with the set pickup level. Non-directional overcurrent step will pickup if the magnitude of the measured current quantity is bigger than this set level. Reset ratio is settable, with default value of 0.96. However depending on other enabled built-in features this overcurrent pickup might not cause the overcurrent step start signal. Start signal will only come if all of the enabled built-in features in the overcurrent step are fulfilled at the same time.

Second harmonic feature

The overcurrent protection step can be restrained by a second harmonic component in the measured current quantity (see table 168). However it shall be noted that this feature is not applicable when one of the following measured currents is selected:

- *PosSeq* (positive sequence current)
- *NegSeq* (negative sequence current)
- *UnbalancePh* (unbalance phase current)
- *UnbalancePh-Ph* (unbalance ph-ph current)

This feature will simple prevent overcurrent step start if the second-to-first harmonic ratio in the measured current exceeds the set level.

Directional feature

The overcurrent protection step operation can be can be made dependent on the relevant phase angle between measured current phasor (see table 168) and measured voltage phasor (see table 169). In protection terminology it means that the General currrent and voltage protection (CVGAPC) function can be made directional by enabling this built-in feature. In that case overcurrent protection step will only operate if the current flow is in accordance with the set direction (*Forward*, which means towards the protected object, or *Reverse*, which means from the protected object). For this feature it is of the outmost importance to understand that the measured voltage phasor (see table 169) and measured current phasor (see table 168) will be used for directional decision. Therefore it is the sole responsibility of the end user to select the appropriate current and voltage signals in order to get a proper directional decision. CVGAPC function will NOT do this automatically. It will just simply use the current and voltage phasors selected by the end user to check for the directional criteria.

Table 171 gives an overview of the typical choices (but not the only possible ones) for these two quantities for traditional directional relays.

Table 171: Typical current and voltage choices for directional feature

Set value for the parameter *CurrentInput*	Set value for the parameter *VoltageInput*	Comment
PosSeq	PosSeq	Directional positive sequence overcurrent function is obtained. Typical setting for *RCADir* is from -45° to -90° depending on the power
NegSeq	-NegSeq	Directional negative sequence overcurrent function is obtained. Typical setting for *RCADir* is from -45° to -90° depending on the power system voltage level (X/R ratio)
3ZeroSeq	-3ZeroSeq	Directional zero sequence overcurrent function is obtained. Typical setting for *RCADir* is from 0° to -90° depending on the power system earthing (that is, solidly earthed, earthed via resistor)
Phase1	Phase2-Phase3	Directional overcurrent function for the first phase is obtained. Typical setting for *RCADir* is +30° or +45°
Phase2	Phase3-Phase1	Directional overcurrent function for the second phase is obtained. Typical setting for *RCADir* is +30° or +45°
Phase3	Phase1-Phase2	Directional overcurrent function for the third phase is obtained. Typical setting for *RCADir* is +30° or +45°

Unbalance current or voltage measurement shall not be used when the directional feature is enabled.

Two types of directional measurement principles are available, *I & U* and *IcosPhi&U*. The first principle, referred to as "*I & U*" in the parameter setting tool, checks that:

- the magnitude of the measured current is bigger than the set pick-up level
- the phasor of the measured current is within the operating region (defined by the relay operate angle, *ROADir* parameter setting; see figure 137).

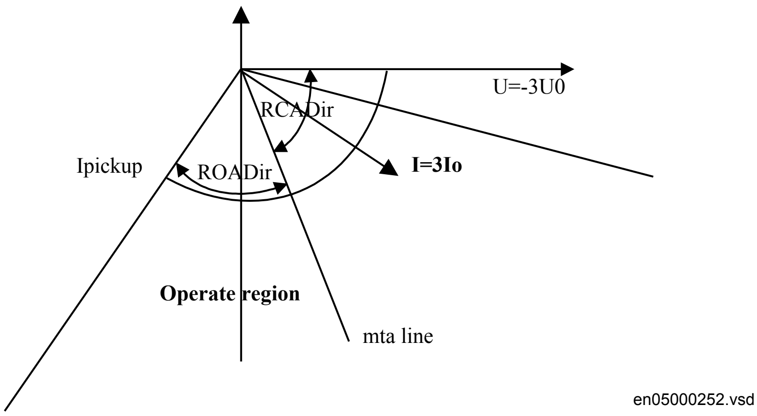


Figure 137: I & U directional operating principle for CVGAPC function

where:

RCADir is -75°

ROADir is 50°

The second principle, referred to as "*IcosPhi&U*" in the parameter setting tool, checks that:

- that the product I·cos(Φ) is bigger than the set pick-up level, where Φ is angle between the current phasor and the mta line
- that the phasor of the measured current is within the operating region (defined by the I·cos(Φ) straight line and the relay operate angle, *ROADir* parameter setting; see figure 137).

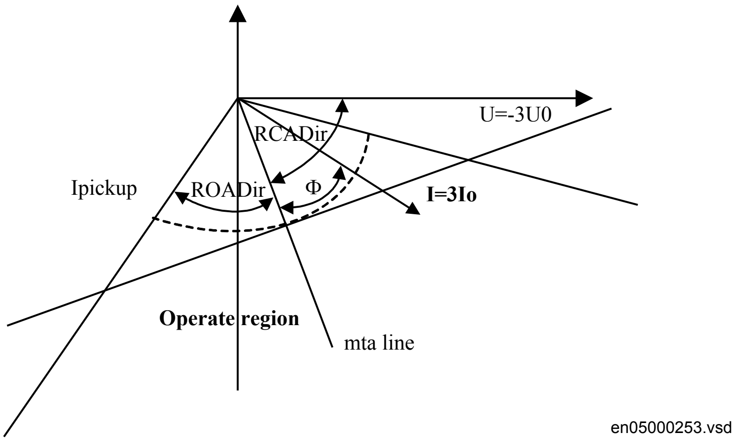


Figure 138: CVGAPC, IcosPhi&U directional operating principle

where:

RCADir is -75°

ROADir is 50°

Note that it is possible to decide by a parameter setting how the directional feature shall behave when the magnitude of the measured voltage phasor falls below the pre-set value. User can select one of the following three options:

- Non-directional (operation allowed for low magnitude of the reference voltage)
- Block (operation prevented for low magnitude of the reference voltage)
- Memory (memory voltage shall be used to determine direction of the current)

It shall also be noted that the memory duration is limited in the algorithm to 100 ms. After that time the current direction will be locked to the one determined during memory time and it will re-set only if the current fails below set pickup level or voltage goes above set voltage memory limit.

Voltage restraint/control feature

The overcurrent protection step operation can be can be made dependent of a measured voltage quantity (see table 169). Practically then the pickup level of the overcurrent step is not constant but instead decreases with the decrease in the magnitude of the measured voltage quantity. Two different types of dependencies are available:

- Voltage restraint overcurrent (when setting parameter *VDepMode_OC1=Slope*)

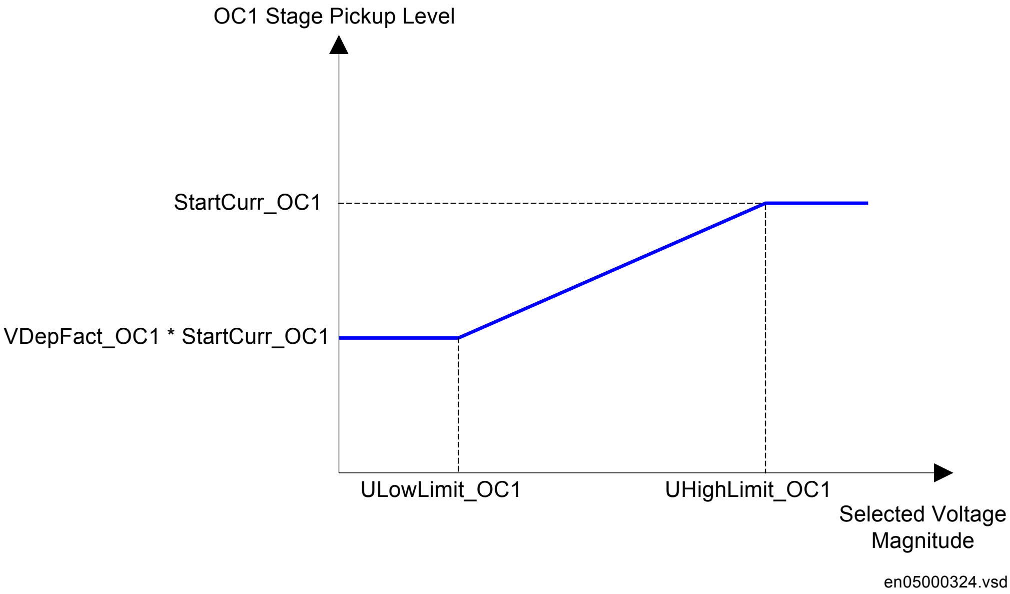


Figure 139: Example for OC1 step current pickup level variation as function of measured voltage magnitude in Slope mode of operation

- Voltage controlled overcurrent (when setting parameter *VDepMode_OC1=Step*)

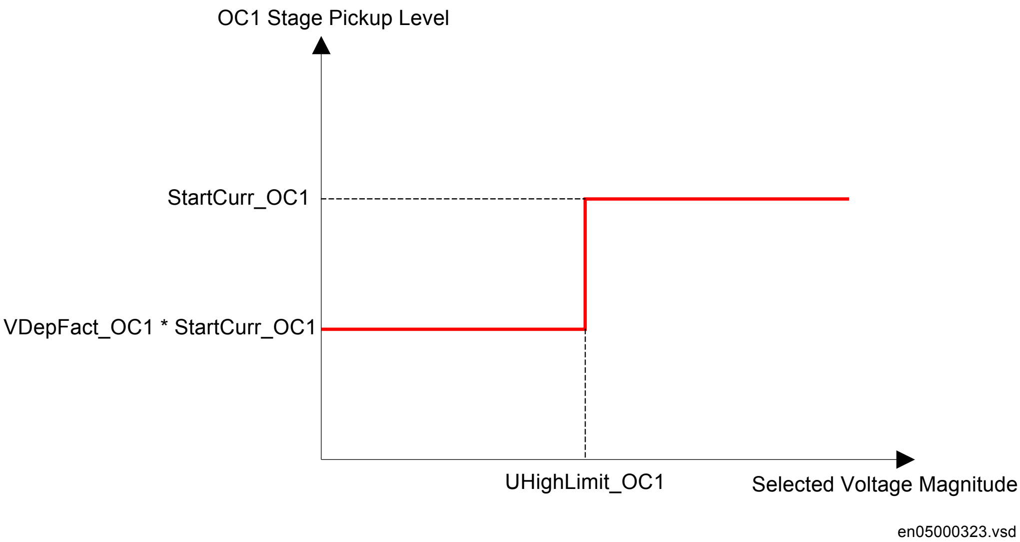


Figure 140: Example for OC1 step current pickup level variation as function of measured voltage magnitude in Step mode of operation

This feature will simply change the set overcurrent pickup level in accordance with magnitude variations of the measured voltage. It shall be noted that this feature will as well affect the pickup current value for calculation of operate times for IDMT curves (overcurrent with IDMT curve will operate faster during low voltage conditions).

Current restraint feature

The overcurrent protection step operation can be made dependent of a restraining current quantity (see table 170). Practically then the pickup level of the overcurrent step is not constant but instead increases with the increase in the magnitude of the restraining current.

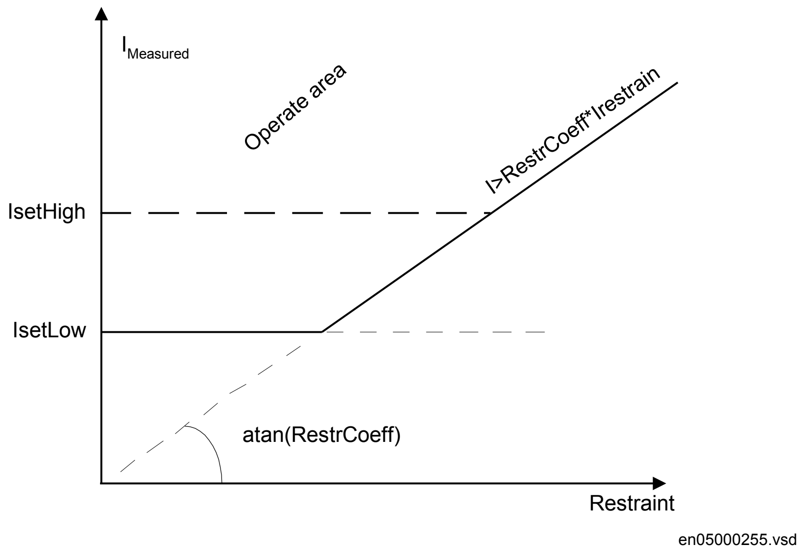


Figure 141: Current pickup variation with restraint current magnitude

This feature will simply prevent overcurrent step to start if the magnitude of the measured current quantity is smaller than the set percentage of the restrain current magnitude. However this feature will not affect the pickup current value for calculation of operate times for IDMT curves. This means that the IDMT curve operate time will not be influenced by the restrain current magnitude.

When set, the start signal will start definite time delay or inverse (IDMT) time delay in accordance with the end user setting. If the start signal has value one for longer time than the set time delay, the overcurrent step will set its trip signal to one. Reset of the start and trip signal can be instantaneous or time delay in accordance with the end user setting.

9.1.2.4 Built-in undercurrent protection steps

Two undercurrent protection steps are available. They are absolutely identical and therefore only one will be explained here. Undercurrent step simply compares the magnitude of the measured current quantity (see table 168) with the set pickup level. The undercurrent step will pickup and set its start signal to one if the magnitude of the measured current quantity is smaller than this set level. The start signal will start definite time delay with set time delay. If the start signal has value one for longer time than the set time delay the undercurrent step will set its trip signal to one. Reset of the start and trip signal can be instantaneous or time delay in accordance with the setting.

9.1.2.5 Built-in overvoltage protection steps

Two overvoltage protection steps are available. They are absolutely identical and therefore only one will be explained here.

Overvoltage step simply compares the magnitude of the measured voltage quantity (see table 169) with the set pickup level. The overvoltage step will pickup if the magnitude of the measured voltage quantity is bigger than this set level. Reset ratio is settable, with default value of 0.99.

The start signal will start definite time delay or inverse (IDMT) time delay in accordance with the end user setting. If the start signal has value one for longer time than the set time delay, the overvoltage step will set its trip signal to one. Reset of the start and trip signal can be instantaneous or time delay in accordance with the end user setting.

9.1.2.6 Built-in undervoltage protection steps

Two undervoltage protection steps are available. They are absolutely identical and therefore only one will be explained here.

Undervoltage step simply compares the magnitude of the measured voltage quantity (see table 169) with the set pickup level. The undervoltage step will pickup if the magnitude of the measured voltage quantity is smaller than this set level. Reset ratio is settable, with default value of 1.01.

The start signal will start definite time delay or inverse (IDMT) time delay in accordance with the end user setting. If the start signal has value one for longer time than the set time delay, the undervoltage step will set its trip signal to one. Reset of the start and trip signal can be instantaneous or time delay in accordance with the end user setting.

9.1.2.7 Logic diagram

The simplified internal logics, for CVGAPC function are shown in the following figures.

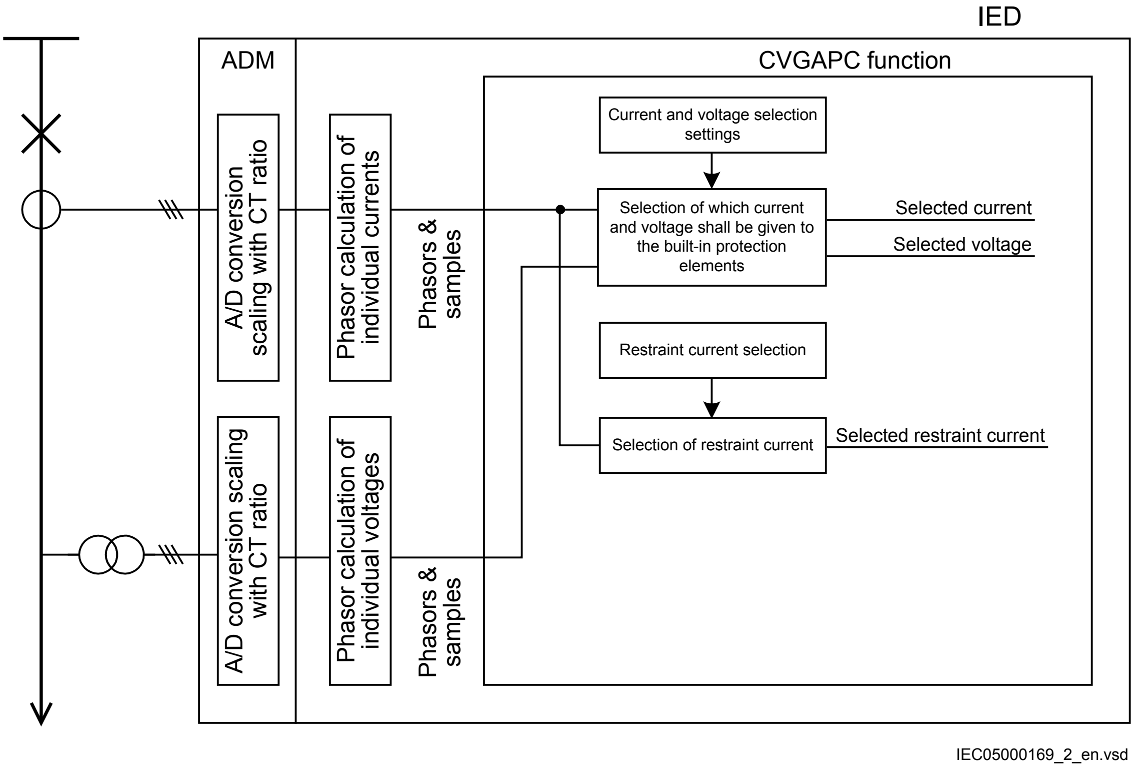


Figure 142: Treatment of measured currents within IED for CVGAPC function

Figure 142 shows how internal treatment of measured currents is done for multipurpose protection function

The following currents and voltages are inputs to the multipurpose protection function. They must all be expressed in true power system (primary) Amperes and kilovolts.

1. Instantaneous values (samples) of currents & voltages from one three-phase current and one three-phase voltage input.
2. Fundamental frequency phasors from one three-phase current and one three-phase voltage input calculated by the pre-processing modules.
3. Sequence currents & voltages from one three-phase current and one three-phase voltage input calculated by the pre-processing modules.

The multipurpose protection function:

1. Selects one current from the three-phase input system (see table 168) for internally measured current.
2. Selects one voltage from the three-phase input system (see table 169) for internally measured voltage.
3. Selects one current from the three-phase input system (see table 170) for internally measured restraint current.

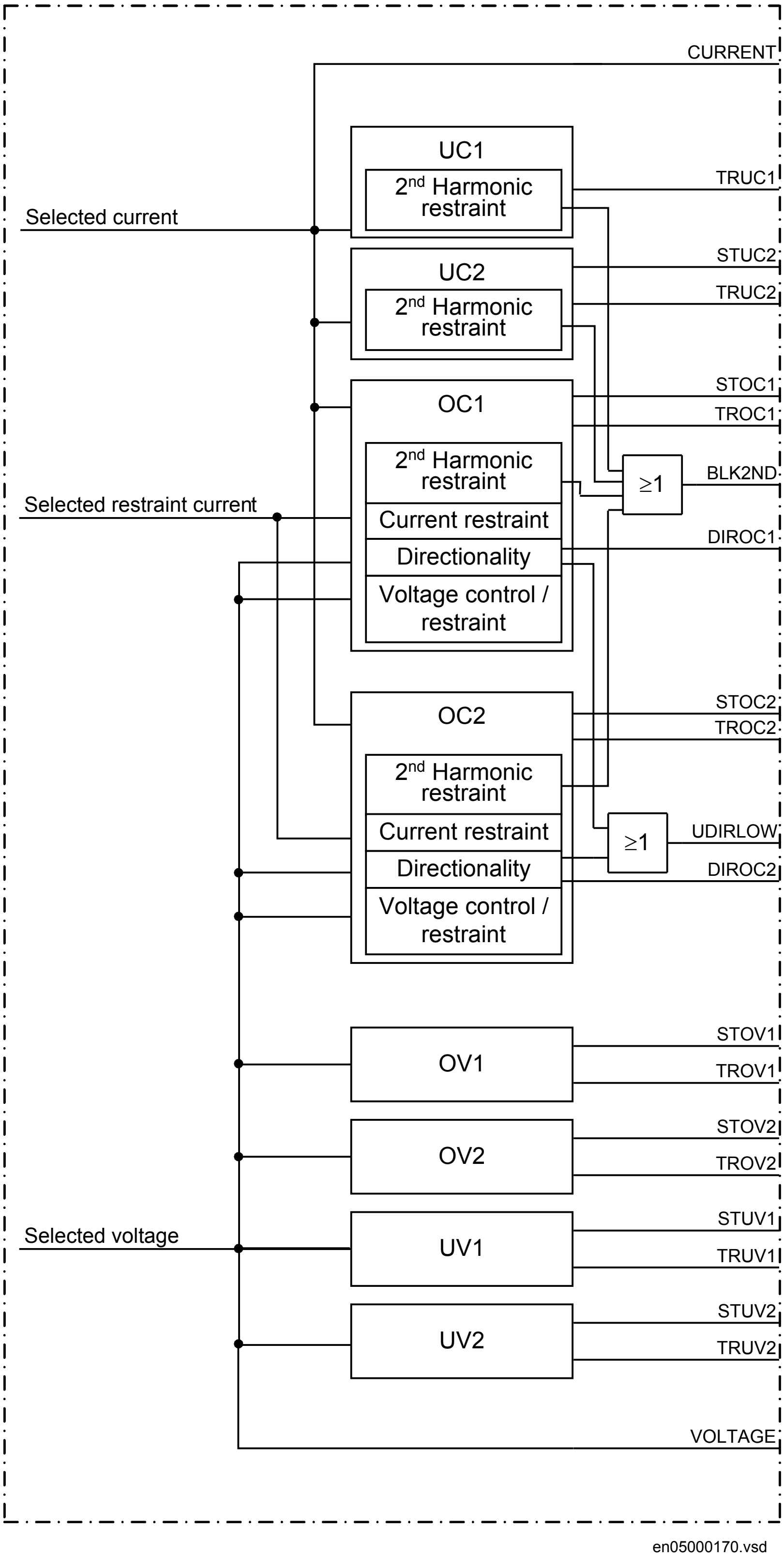


Figure 143: CVGAPC function main logic diagram for built-in protection elements

Logic in figure 143 can be summarized as follows:

1. The selected currents and voltage are given to built-in protection elements. Each protection element and step makes independent decision about status of its START and TRIP output signals.
2. More detailed internal logic for every protection element is given in the following four figures
3. Common START and TRIP signals from all built-in protection elements & steps (internal OR logic) are available from multipurpose function as well.

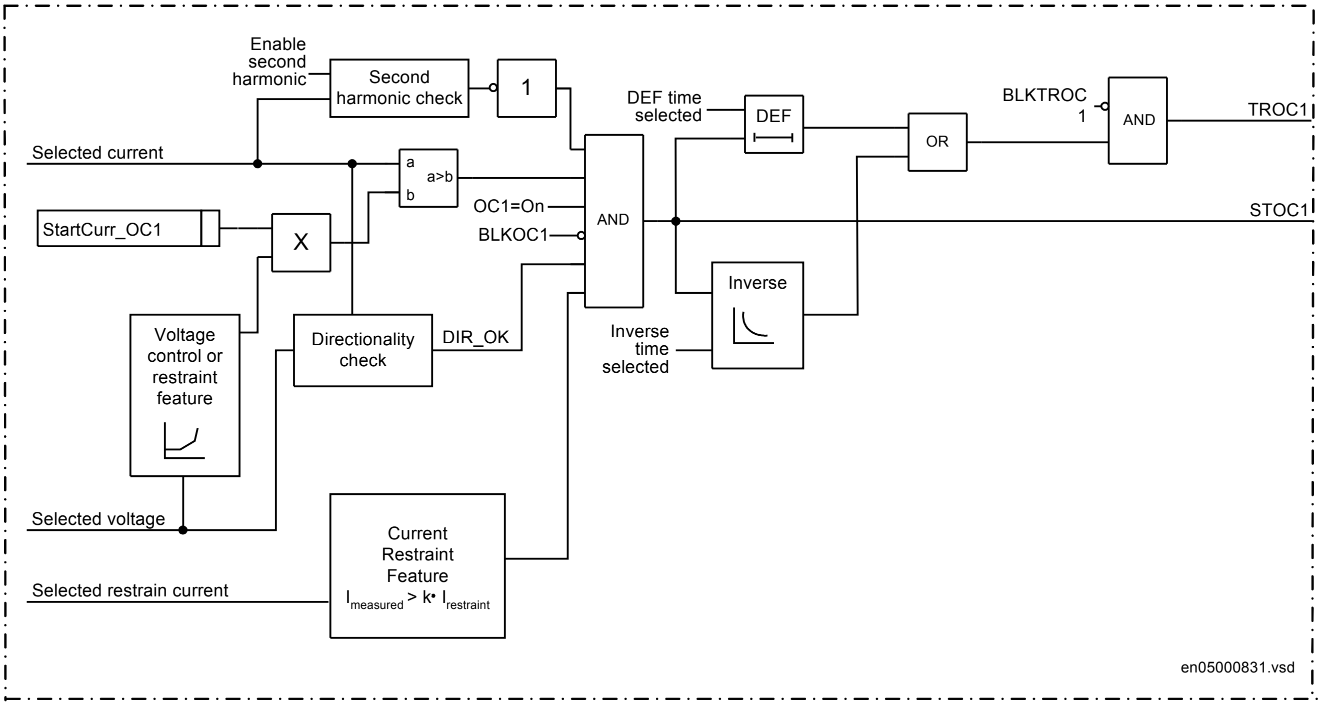


Figure 144: Simplified internal logic diagram for built-in first overcurrent step that is, OC1 (step OC2 has the same internal logic)

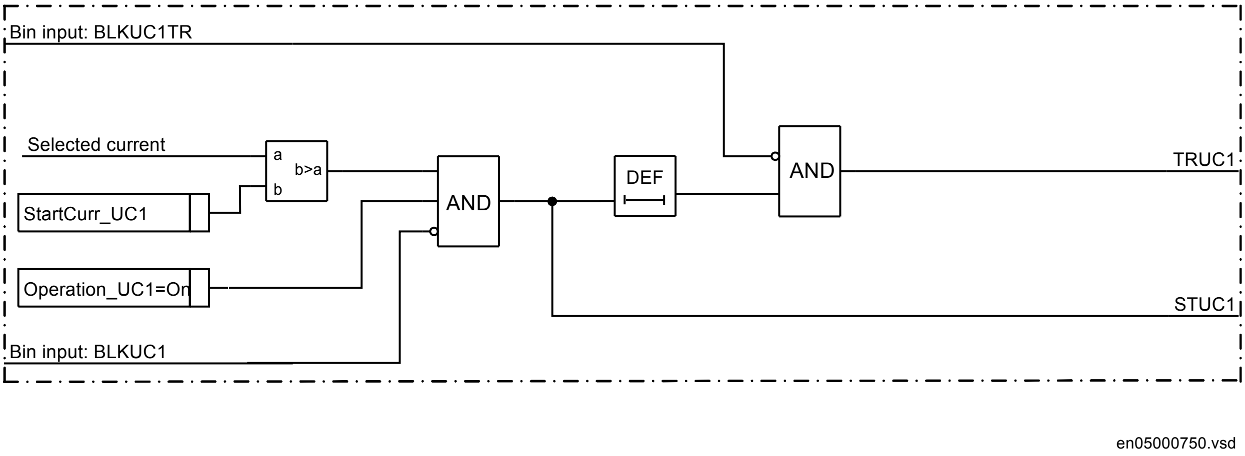


Figure 145: Simplified internal logic diagram for built-in first undercurrent step that is, UC1 (step UC2 has the same internal logic)

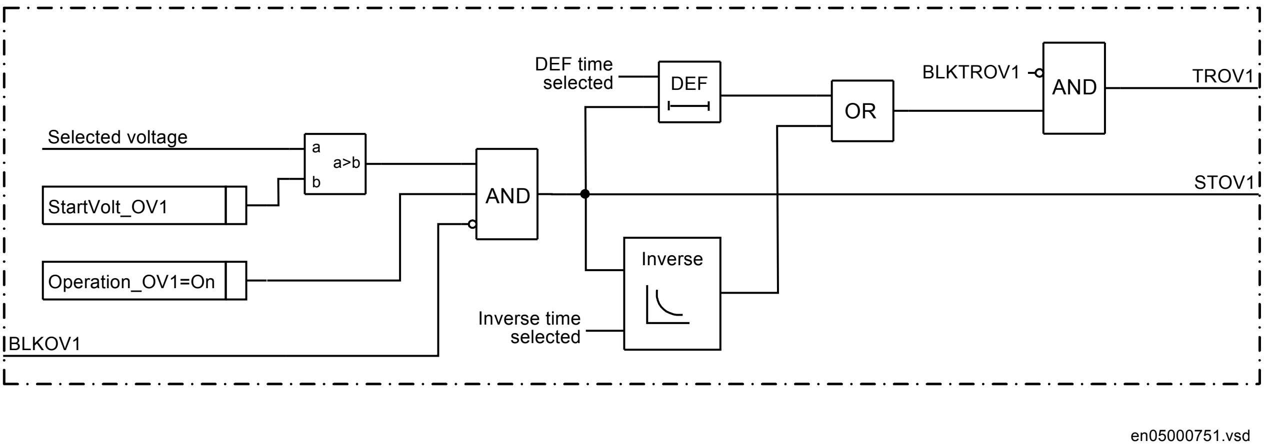


Figure 146: Simplified internal logic diagram for built-in first overvoltage step OV1 (step OV2 has the same internal logic)

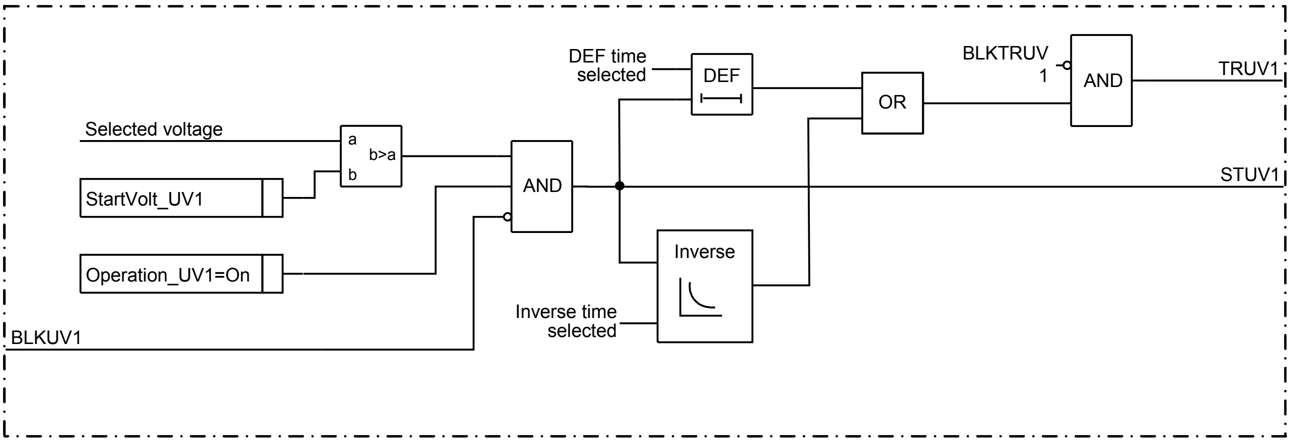


Figure 147: Simplified internal logic diagram for built-in first undervoltage step UV1 (step UV2 has the same internal logic)

9.1.3 Function block

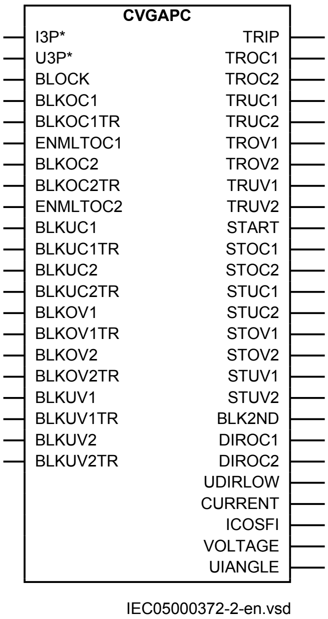


Figure 148: CVGAPC function block

9.1.4 Input and output signals

Table 172: CVGAPC Input signals

Name	Type	Default	Description
I3P	GROUP SIGNAL	-	Group signal for current input
U3P	GROUP SIGNAL	-	Group signal for voltage input
BLOCK	BOOLEAN	0	Block of function
BLKOC1	BOOLEAN	0	Block of over current function OC1
BLKOC1TR	BOOLEAN	0	Block of trip for over current function OC1
ENMLTOC1	BOOLEAN	0	When activated, the current multiplier is in use for OC1
BLKOC2	BOOLEAN	0	Block of over current function OC2
BLKOC2TR	BOOLEAN	0	Block of trip for over current function OC2
ENMLTOC2	BOOLEAN	0	When activated, the current multiplier is in use for OC2
BLKUC1	BOOLEAN	0	Block of under current function UC1
BLKUC1TR	BOOLEAN	0	Block of trip for under current function UC1
BLKUC2	BOOLEAN	0	Block of under current function UC2
BLKUC2TR	BOOLEAN	0	Block of trip for under current function UC2
BLKOV1	BOOLEAN	0	Block of over voltage function OV1
BLKOV1TR	BOOLEAN	0	Block of trip for over voltage function OV1
BLKOV2	BOOLEAN	0	Block of over voltage function OV2
BLKOV2TR	BOOLEAN	0	Block of trip for over voltage function OV2
BLKUV1	BOOLEAN	0	Block of under voltage function UV1
BLKUV1TR	BOOLEAN	0	Block of trip for under voltage function UV1
BLKUV2	BOOLEAN	0	Block of under voltage function UV2
BLKUV2TR	BOOLEAN	0	Block of trip for under voltage function UV2

Table 173: CVGAPC Output signals

Name	Type	Description
TRIP	BOOLEAN	General trip signal
TROC1	BOOLEAN	Trip signal from overcurrent function OC1
TROC2	BOOLEAN	Trip signal from overcurrent function OC2
TRUC1	BOOLEAN	Trip signal from undercurrent function UC1
TRUC2	BOOLEAN	Trip signal from undercurrent function UC2
TROV1	BOOLEAN	Trip signal from overvoltage function OV1
TROV2	BOOLEAN	Trip signal from overvoltage function OV2
TRUV1	BOOLEAN	Trip signal from undervoltage function UV1
TRUV2	BOOLEAN	Trip signal from undervoltage function UV2

Table continues on next page

Name	Type	Description
START	BOOLEAN	General start signal
STOC1	BOOLEAN	Start signal from overcurrent function OC1
STOC2	BOOLEAN	Start signal from overcurrent function OC2
STUC1	BOOLEAN	Start signal from undercurrent function UC1
STUC2	BOOLEAN	Start signal from undercurrent function UC2
STOV1	BOOLEAN	Start signal from overvoltage function OV1
STOV2	BOOLEAN	Start signal from overvoltage function OV2
STUV1	BOOLEAN	Start signal from undervoltage function UV1
STUV2	BOOLEAN	Start signal from undervoltage function UV2
BLK2ND	BOOLEAN	Block from second harmonic detection
DIROC1	INTEGER	Directional mode of OC1 (nondir, forward,reverse)
DIROC2	INTEGER	Directional mode of OC2 (nondir, forward,reverse)
UDIRLOW	BOOLEAN	Low voltage for directional polarization
CURRENT	REAL	Measured current value
ICOSFI	REAL	Measured current multiplied with cos (Phi)
VOLTAGE	REAL	Measured voltage value
UIANGLE	REAL	Angle between voltage and current

9.1.5 Setting parameters

Table 174: CVGAPC Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
CurrentInput	phase1 phase2 phase3 PosSeq NegSeq 3*ZeroSeq MaxPh MinPh UnbalancePh phase1-phase2 phase2-phase3 phase3-phase1 MaxPh-Ph MinPh-Ph UnbalancePh-Ph	-	-	MaxPh	Select current signal which will be measured inside function
IBase	1 - 99999	A	1	3000	Base Current
Table continues on next page					

Name	Values (Range)	Unit	Step	Default	Description
VoltageInput	phase1 phase2 phase3 PosSeq -NegSeq -3*ZeroSeq MaxPh MinPh UnbalancePh phase1-phase2 phase2-phase3 phase3-phase1 MaxPh-Ph MinPh-Ph UnbalancePh-Ph	-	-	MaxPh	Select voltage signal which will be measured inside function
UBase	0.05 - 2000.00	kV	0.05	400.00	Base Voltage
OperHarmRestr	Off On	-	-	Off	Operation of 2nd harmonic restrain Off / On
I_2nd/I_fund	10.0 - 50.0	%	1.0	20.0	Ratio of second to fundamental current harmonic in %
EnRestrainCurr	Off On	-	-	Off	Enable current restrain function On / Off
RestrCurrInput	PosSeq NegSeq 3*ZeroSeq Max	-	-	PosSeq	Select current signal which will be used for curr restrain
RestrCurrCoeff	0.00 - 5.00	-	0.01	0.00	Restraining current coefficient
RCADir	-180 - 180	Deg	1	-75	Relay Characteristic Angle
ROADir	1 - 90	Deg	1	75	Relay Operate Angle
LowVolt_VM	0.0 - 5.0	%UB	0.1	0.5	Below this level in % of Ubase setting ActLowVolt takes over
Operation_OC1	Off On	-	-	Off	Operation OC1 Off / On
StartCurr_OC1	2.0 - 5000.0	%IB	1.0	120.0	Operate current level for OC1 in % of Ibase
CurveType_OC1	ANSI Ext. inv. ANSI Very inv. ANSI Norm. inv. ANSI Mod. inv. ANSI Def. Time L.T.E. inv. L.T.V. inv. L.T. inv. IEC Norm. inv. IEC Very inv. IEC inv. IEC Ext. inv. IEC S.T. inv. IEC L.T. inv. IEC Def. Time Programmable RI type RD type	-	-	ANSI Def. Time	Selection of time delay curve type for OC1
tDef_OC1	0.00 - 6000.00	s	0.01	0.50	Independent (definitive) time delay of OC1

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
k_OC1	0.05 - 999.00	-	0.01	0.30	Time multiplier for the dependent time delay for OC1
IMin1	1 - 10000	%IB	1	100	Minimum operate current for step1 in % of IBase
tMin_OC1	0.00 - 6000.00	s	0.01	0.05	Minimum operate time for IEC IDMT curves for OC1
VCntrlMode_OC1	Voltage control Input control Volt/Input control Off	-	-	Off	Control mode for voltage controlled OC1 function
VDepMode_OC1	Step Slope	-	-	Step	Voltage dependent mode OC1 (step, slope)
VDepFact_OC1	0.02 - 5.00	-	0.01	1.00	Multiplying factor for I pickup when OC1 is U dependent
ULowLimit_OC1	1.0 - 200.0	%UB	0.1	50.0	Voltage low limit setting OC1 in % of Ubase
UHighLimit_OC1	1.0 - 200.0	%UB	0.1	100.0	Voltage high limit setting OC1 in % of Ubase
HarmRestr_OC1	Off On	-	-	Off	Enable block of OC1 by 2nd harmonic restrain
DirMode_OC1	Non-directional Forward Reverse	-	-	Non-directional	Directional mode of OC1 (nondir, forward,reverse)
DirPrinc_OC1	I&U IcosPhi&U	-	-	I&U	Measuring on IandU or IcosPhiandU for OC1
ActLowVolt1_VM	Non-directional Block Memory	-	-	Non-directional	Low voltage level action for Dir_OC1 (Nodir, Blk, Mem)
Operation_OC2	Off On	-	-	Off	Operation OC2 Off / On
StartCurr_OC2	2.0 - 5000.0	%IB	1.0	120.0	Operate current level for OC2 in % of Ibase
CurveType_OC2	ANSI Ext. inv. ANSI Very inv. ANSI Norm. inv. ANSI Mod. inv. ANSI Def. Time L.T.E. inv. L.T.V. inv. L.T. inv. IEC Norm. inv. IEC Very inv. IEC inv. IEC Ext. inv. IEC S.T. inv. IEC L.T. inv. IEC Def. Time Programmable RI type RD type	-	-	ANSI Def. Time	Selection of time delay curve type for OC2
tDef_OC2	0.00 - 6000.00	s	0.01	0.50	Independent (definitive) time delay of OC2
k_OC2	0.05 - 999.00	-	0.01	0.30	Time multiplier for the dependent time delay for OC2

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
IMin2	1 - 10000	%IB	1	50	Minimum operate current for step2 in % of IBase
tMin_OC2	0.00 - 6000.00	s	0.01	0.05	Minimum operate time for IEC IDMT curves for OC2
VCntrlMode_OC2	Voltage control Input control Volt/Input control Off	-	-	Off	Control mode for voltage controlled OC2 function
VDepMode_OC2	Step Slope	-	-	Step	Voltage dependent mode OC2 (step, slope)
VDepFact_OC2	0.02 - 5.00	-	0.01	1.00	Multiplying factor for I pickup when OC2 is U dependent
ULowLimit_OC2	1.0 - 200.0	%UB	0.1	50.0	Voltage low limit setting OC2 in % of Ubase
UHighLimit_OC2	1.0 - 200.0	%UB	0.1	100.0	Voltage high limit setting OC2 in % of Ubase
HarmRestr_OC2	Off On	-	-	Off	Enable block of OC2 by 2nd harmonic restrain
DirMode_OC2	Non-directional Forward Reverse	-	-	Non-directional	Directional mode of OC2 (nondir, forward,reverse)
DirPrinc_OC2	I&U IcosPhi&U	-	-	I&U	Measuring on IandU or IcosPhiandU for OC2
ActLowVolt2_VM	Non-directional Block Memory	-	-	Non-directional	Low voltage level action for Dir_OC2 (Nodir, Blk, Mem)
Operation_UC1	Off On	-	-	Off	Operation UC1 Off / On
EnBlkLowI_UC1	Off On	-	-	Off	Enable internal low current level blocking for UC1
BlkLowCurr_UC1	0 - 150	%IB	1	20	Internal low current blocking level for UC1 in % of Ibase
StartCurr_UC1	2.0 - 150.0	%IB	1.0	70.0	Operate undercurrent level for UC1 in % of Ibase
tDef_UC1	0.00 - 6000.00	s	0.01	0.50	Independent (definitive) time delay of UC1
tResetDef_UC1	0.00 - 6000.00	s	0.01	0.00	Reset time delay used in IEC Definite Time curve UC1
HarmRestr_UC1	Off On	-	-	Off	Enable block of UC1 by 2nd harmonic restrain
Operation_UC2	Off On	-	-	Off	Operation UC2 Off / On
EnBlkLowI_UC2	Off On	-	-	Off	Enable internal low current level blocking for UC2
BlkLowCurr_UC2	0 - 150	%IB	1	20	Internal low current blocking level for UC2 in % of Ibase
StartCurr_UC2	2.0 - 150.0	%IB	1.0	70.0	Operate undercurrent level for UC2 in % of Ibase
tDef_UC2	0.00 - 6000.00	s	0.01	0.50	Independent (definitive) time delay of UC2
HarmRestr_UC2	Off On	-	-	Off	Enable block of UC2 by 2nd harmonic restrain

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
Operation_OV1	Off On	-	-	Off	Operation OV1 Off / On
StartVolt_OV1	2.0 - 200.0	%UB	0.1	150.0	Operate voltage level for OV1 in % of Ubase
CurveType_OV1	Definite time Inverse curve A Inverse curve B Inverse curve C Prog. inv. curve	-	-	Definite time	Selection of time delay curve type for OV1
tDef_OV1	0.00 - 6000.00	s	0.01	1.00	Operate time delay in sec for definite time use of OV1
tMin_OV1	0.00 - 6000.00	s	0.01	0.05	Minimum operate time for IDMT curves for OV1
k_OV1	0.05 - 999.00	-	0.01	0.30	Time multiplier for the dependent time delay for OV1
Operation_OV2	Off On	-	-	Off	Operation OV2 Off / On
StartVolt_OV2	2.0 - 200.0	%UB	0.1	150.0	Operate voltage level for OV2 in % of Ubase
CurveType_OV2	Definite time Inverse curve A Inverse curve B Inverse curve C Prog. inv. curve	-	-	Definite time	Selection of time delay curve type for OV2
tDef_OV2	0.00 - 6000.00	s	0.01	1.00	Operate time delay in sec for definite time use of OV2
tMin_OV2	0.00 - 6000.00	s	0.01	0.05	Minimum operate time for IDMT curves for OV2
k_OV2	0.05 - 999.00	-	0.01	0.30	Time multiplier for the dependent time delay for OV2
Operation_UV1	Off On	-	-	Off	Operation UV1 Off / On
StartVolt_UV1	2.0 - 150.0	%UB	0.1	50.0	Operate undervoltage level for UV1 in % of Ubase
CurveType_UV1	Definite time Inverse curve A Inverse curve B Prog. inv. curve	-	-	Definite time	Selection of time delay curve type for UV1
tDef_UV1	0.00 - 6000.00	s	0.01	1.00	Operate time delay in sec for definite time use of UV1
tMin_UV1	0.00 - 6000.00	s	0.01	0.05	Minimum operate time for IDMT curves for UV1
k_UV1	0.05 - 999.00	-	0.01	0.30	Time multiplier for the dependent time delay for UV1
EnBlkLowV_UV1	Off On	-	-	On	Enable internal low voltage level blocking for UV1
BlkLowVolt_UV1	0.0 - 5.0	%UB	0.1	0.5	Internal low voltage blocking level for UV1 in % of Ubase
Operation_UV2	Off On	-	-	Off	Operation UV2 Off / On

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
StartVolt_UV2	2.0 - 150.0	%UB	0.1	50.0	Operate undervoltage level for UV2 in % of Ubase
CurveType_UV2	Definite time Inverse curve A Inverse curve B Prog. inv. curve	-	-	Definite time	Selection of time delay curve type for UV2
tDef_UV2	0.00 - 6000.00	s	0.01	1.00	Operate time delay in sec for definite time use of UV2
tMin_UV2	0.00 - 6000.00	s	0.01	0.05	Minimum operate time for IDMT curves for UV2
k_UV2	0.05 - 999.00	-	0.01	0.30	Time multiplier for the dependent time delay for UV2
EnBlkLowV_UV2	Off On	-	-	On	Enable internal low voltage level blocking for UV2
BlkLowVolt_UV2	0.0 - 5.0	%UB	0.1	0.5	Internal low voltage blocking level for UV2 in % of Ubase

Table 175: CVGAPC Group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
CurrMult_OC1	1.0 - 10.0	-	0.1	2.0	Multiplier for scaling the current setting value for OC1
ResCrvType_OC1	Instantaneous IEC Reset ANSI reset	-	-	Instantaneous	Selection of reset curve type for OC1
tResetDef_OC1	0.00 - 6000.00	s	0.01	0.00	Reset time delay used in IEC Definite Time curve OC1
P_OC1	0.001 - 10.000	-	0.001	0.020	Parameter P for customer programmable curve for OC1
A_OC1	0.000 - 999.000	-	0.001	0.140	Parameter A for customer programmable curve for OC1
B_OC1	0.000 - 99.000	-	0.001	0.000	Parameter B for customer programmable curve for OC1
C_OC1	0.000 - 1.000	-	0.001	1.000	Parameter C for customer programmable curve for OC1
PR_OC1	0.005 - 3.000	-	0.001	0.500	Parameter PR for customer programmable curve for OC1
TR_OC1	0.005 - 600.000	-	0.001	13.500	Parameter TR for customer programmable curve for OC1
CR_OC1	0.1 - 10.0	-	0.1	1.0	Parameter CR for customer programmable curve for OC1
CurrMult_OC2	1.0 - 10.0	-	0.1	2.0	Multiplier for scaling the current setting value for OC2
ResCrvType_OC2	Instantaneous IEC Reset ANSI reset	-	-	Instantaneous	Selection of reset curve type for OC2
tResetDef_OC2	0.00 - 6000.00	s	0.01	0.00	Reset time delay used in IEC Definite Time curve OC2
P_OC2	0.001 - 10.000	-	0.001	0.020	Parameter P for customer programmable curve for OC2

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
A_OC2	0.000 - 999.000	-	0.001	0.140	Parameter A for customer programmable curve for OC2
B_OC2	0.000 - 99.000	-	0.001	0.000	Parameter B for customer programmable curve for OC2
C_OC2	0.000 - 1.000	-	0.001	1.000	Parameter C for customer programmable curve for OC2
PR_OC2	0.005 - 3.000	-	0.001	0.500	Parameter PR for customer programmable curve for OC2
TR_OC2	0.005 - 600.000	-	0.001	13.500	Parameter TR for customer programmable curve for OC2
CR_OC2	0.1 - 10.0	-	0.1	1.0	Parameter CR for customer programmable curve for OC2
tResetDef_UC2	0.00 - 6000.00	s	0.01	0.00	Reset time delay used in IEC Definite Time curve UC2
ResCrvType_OV1	Instantaneous Frozen timer Linearly decreased	-	-	Instantaneous	Selection of reset curve type for OV1
tResetDef_OV1	0.00 - 6000.00	s	0.01	0.00	Reset time delay in sec for definite time use of OV1
tResetIDMT_OV1	0.00 - 6000.00	s	0.01	0.00	Reset time delay in sec for IDMT curves for OV1
A_OV1	0.005 - 999.000	-	0.001	0.140	Parameter A for customer programmable curve for OV1
B_OV1	0.500 - 99.000	-	0.001	1.000	Parameter B for customer programmable curve for OV1
C_OV1	0.000 - 1.000	-	0.001	1.000	Parameter C for customer programmable curve for OV1
D_OV1	0.000 - 10.000	-	0.001	0.000	Parameter D for customer programmable curve for OV1
P_OV1	0.001 - 10.000	-	0.001	0.020	Parameter P for customer programmable curve for OV1
ResCrvType_OV2	Instantaneous Frozen timer Linearly decreased	-	-	Instantaneous	Selection of reset curve type for OV2
tResetDef_OV2	0.00 - 6000.00	s	0.01	0.00	Reset time delay in sec for definite time use of OV2
tResetIDMT_OV2	0.00 - 6000.00	s	0.01	0.00	Reset time delay in sec for IDMT curves for OV2
A_OV2	0.005 - 999.000	-	0.001	0.140	Parameter A for customer programmable curve for OV2
B_OV2	0.500 - 99.000	-	0.001	1.000	Parameter B for customer programmable curve for OV2
C_OV2	0.000 - 1.000	-	0.001	1.000	Parameter C for customer programmable curve for OV2
D_OV2	0.000 - 10.000	-	0.001	0.000	Parameter D for customer programmable curve for OV2
P_OV2	0.001 - 10.000	-	0.001	0.020	Parameter P for customer programmable curve for OV2

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
ResCrvType_UV1	Instantaneous Frozen timer Linearly decreased	-	-	Instantaneous	Selection of reset curve type for UV1
tResetDef_UV1	0.00 - 6000.00	s	0.01	0.00	Reset time delay in sec for definite time use of UV1
tResetIDMT_UV1	0.00 - 6000.00	s	0.01	0.00	Reset time delay in sec for IDMT curves for UV1
A_UV1	0.005 - 999.000	-	0.001	0.140	Parameter A for customer programmable curve for UV1
B_UV1	0.500 - 99.000	-	0.001	1.000	Parameter B for customer programmable curve for UV1
C_UV1	0.000 - 1.000	-	0.001	1.000	Parameter C for customer programmable curve for UV1
D_UV1	0.000 - 10.000	-	0.001	0.000	Parameter D for customer programmable curve for UV1
P_UV1	0.001 - 10.000	-	0.001	0.020	Parameter P for customer programmable curve for UV1
ResCrvType_UV2	Instantaneous Frozen timer Linearly decreased	-	-	Instantaneous	Selection of reset curve type for UV2
tResetDef_UV2	0.00 - 6000.00	s	0.01	0.00	Reset time delay in sec for definite time use of UV2
tResetIDMT_UV2	0.00 - 6000.00	s	0.01	0.00	Reset time delay in sec for IDMT curves for UV2
A_UV2	0.005 - 999.000	-	0.001	0.140	Parameter A for customer programmable curve for UV2
B_UV2	0.500 - 99.000	-	0.001	1.000	Parameter B for customer programmable curve for UV2
C_UV2	0.000 - 1.000	-	0.001	1.000	Parameter C for customer programmable curve for UV2
D_UV2	0.000 - 10.000	-	0.001	0.000	Parameter D for customer programmable curve for UV2
P_UV2	0.001 - 10.000	-	0.001	0.020	Parameter P for customer programmable curve for UV2

9.1.6 Technical data

Table 176: CVGAPC technical data

Function	Range or value	Accuracy
Measuring current input	phase1, phase2, phase3, PosSeq, NegSeq, 3*ZeroSeq, MaxPh, MinPh, UnbalancePh, phase1-phase2, phase2-phase3, phase3-phase1, MaxPh-Ph, MinPh-Ph, UnbalancePh-Ph	-
Base current	(1 - 99999) A	-
Measuring voltage input	phase1, phase2, phase3, PosSeq, -NegSeq, -3*ZeroSeq, MaxPh, MinPh, UnbalancePh, phase1-phase2, phase2-phase3, phase3-phase1, MaxPh-Ph, MinPh-Ph, UnbalancePh-Ph	-
Base voltage	(0.05 - 2000.00) kV	-
Start overcurrent, step 1 and 2	(2 - 5000)% of IBase	± 1.0% of I_r for $I<I_r$ ± 1.0% of I for $I>I_r$
Start undercurrent, step 1 and 2	(2 - 150)% of IBase	± 1.0% of I_r for $I<I_r$ ± 1.0% of I for $I>I_r$
Definite time delay	(0.00 - 6000.00) s	± 0.5% ± 10 ms
Operate time start overcurrent	25 ms typically at 0 to 2 x I_{set}	-
Reset time start overcurrent	25 ms typically at 2 to 0 x I_{set}	-
Operate time start undercurrent	25 ms typically at 2 to 0 x I_{set}	-
Reset time start undercurrent	25 ms typically at 0 to 2 x I_{set}	-
See table 483 and table 484	Parameter ranges for customer defined characteristic no 17: k: 0.05 - 999.00 A: 0.0000 - 999.0000 B: 0.0000 - 99.0000 C: 0.0000 - 1.0000 P: 0.0001 - 10.0000 PR: 0.005 - 3.000 TR: 0.005 - 600.000 CR: 0.1 - 10.0	See table 483 and table 484
Voltage level where voltage memory takes over	(0.0 - 5.0)% of UBase	± 0.5% of U_r
Start overvoltage, step 1 and 2	(2.0 - 200.0)% of UBase	± 0.5% of U_r for $U<U_r$ ± 0.5% of U for $U>U_r$
Start undervoltage, step 1 and 2	(2.0 - 150.0)% of UBase	± 0.5% of U_r for $U<U_r$ ± 0.5% of U for $U>U_r$
Operate time, start overvoltage	25 ms typically at 0 to 2 x U_{set}	-
Reset time, start overvoltage	25 ms typically at 2 to 0 x U_{set}	-
Operate time start undervoltage	25 ms typically 2 to 0 x U_{set}	-
Table continues on next page		

Function	Range or value	Accuracy
Reset time start undervoltage	25 ms typically at 0 to 2 x U_{set}	-
High and low voltage limit, voltage dependent operation	(1.0 - 200.0)% of UBase	± 1.0% of U_r for $U<U_r$ ± 1.0% of U for $U>U_r$
Directional function	Settable: NonDir, forward and reverse	-
Relay characteristic angle	(-180 to +180) degrees	± 2.0 degrees
Relay operate angle	(1 to 90) degrees	± 2.0 degrees
Reset ratio, overcurrent	> 95%	-
Reset ratio, undercurrent	< 105%	-
Reset ratio, overvoltage	> 95%	-
Reset ratio, undervoltage	< 105%	-
Overcurrent: Critical impulse time Impulse margin time	 10 ms typically at 0 to 2 x I_{set} 15 ms typically	 - -
Undercurrent: Critical impulse time Impulse margin time	 10 ms typically at 2 to 0 x I_{set} 15 ms typically	 - -
Overvoltage: Critical impulse time Impulse margin time	 10 ms typically at 0 to 2 x U_{set} 15 ms typically	 - -
Undervoltage: Critical impulse time Impulse margin time	 10 ms typically at 2 to 0 x U_{set} 15 ms typically	 - -

Section 10 Secondary system supervision

About this chapter

This chapter describes functions like Current circuit supervision and Fuse failure supervision. The way the functions work, their setting parameters, function blocks, input and output signals and technical data are included for each function.

10.1 Fuse failure supervision SDDRFUF

10.1.1 Introduction

The aim of the fuse failure supervision function (SDDRFUF) is to block voltage measuring functions at failures in the secondary circuits between the voltage transformer and the IED in order to avoid unwanted operations that otherwise might occur.

The fuse failure supervision function basically has three different algorithms, negative sequence and zero sequence based algorithms and an additional delta voltage and delta current algorithm.

The negative sequence detection algorithm is recommended for IEDs used in isolated or high-impedance earthed networks. It is based on the negative-sequence measuring quantities, a high value of voltage $3U_2$ without the presence of the negative-sequence current $3I_2$.

The zero sequence detection algorithm is recommended for IEDs used in directly or low impedance earthed networks. It is based on the zero sequence measuring quantities, a high value of voltage $3U_0$ without the presence of the residual current $3I_0$.

For better adaptation to system requirements, an operation mode setting has been introduced which makes it possible to select the operating conditions for negative sequence and zero sequence based function. The selection of different operation modes makes it possible to choose different interaction possibilities between the negative sequence and zero sequence based algorithm.

A criterion based on delta current and delta voltage measurements can be added to the fuse failure supervision function in order to detect a three phase fuse failure, which in practice is more associated with voltage transformer switching during station operations.

10.1.2 Principle of operation

10.1.2.1 Zero and negative sequence detection

The zero and negative sequence function continuously measures the currents and voltages in all three phases and calculates, see figure 149:

- the zero-sequence voltage $3U_0$
- the zero-sequence current $3I_0$
- the negative sequence current $3I_2$
- the negative sequence voltage $3U_2$

The measured signals are compared with their respective set values *3U0<* and *3I0>*, *3U2<* and *3I2>*.

The function enable the internal signal FuseFailDetZeroSeq if the measured zero-sequence voltage is higher than the set value *3U0>* and the measured zero-sequence current is below the set value *3I0<*.

The function enable the internal signal FuseFailDetNegSeq if the measured negative sequence voltage is higher than the set value *3U2>* and the measured negative sequence current is below the set value *3I2<*.

A drop off delay of 100 ms for the measured zero-sequence and negative sequence current will prevent a false fuse failure detection at un-equal breaker opening at the two line ends.

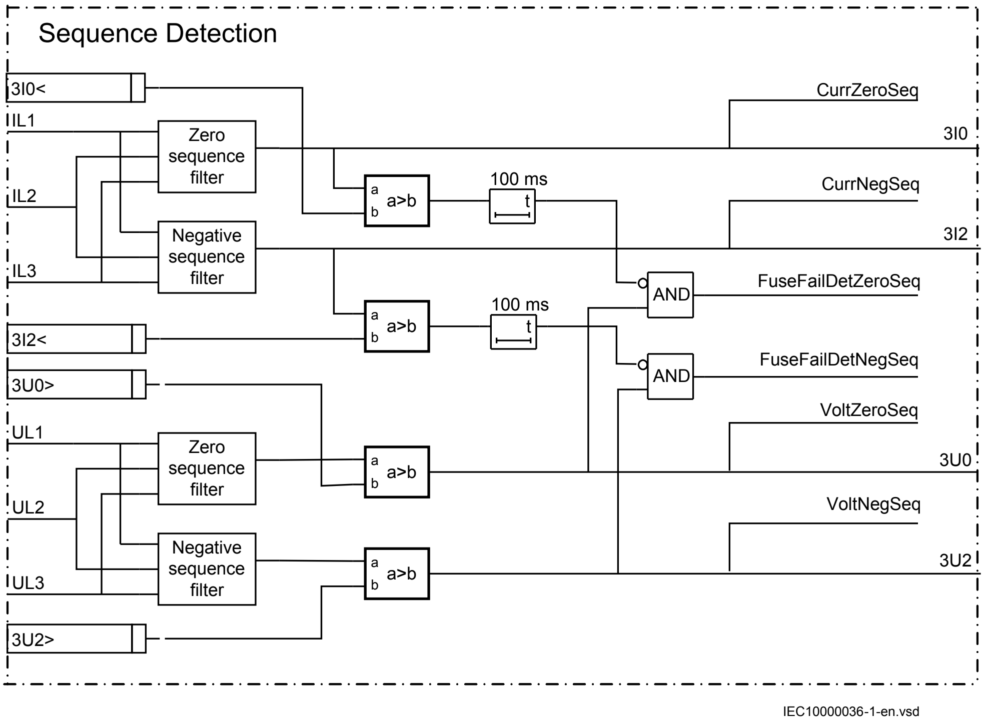


Figure 149: Simplified logic diagram for sequence detection part

The calculated values $3U_0$, $3I_0$, $3I_2$ and $3U_2$ are available as service values on local HMI and monitoring tool in PCM600.

Input and output signals

The output signals 3PH, BLKU and BLKZ can be blocked in the following conditions:

- The input BLOCK is activated
- The input BLKTRIP is activated at the same time as the internal signal fufailStarted is not present
- The operation mode selector *OpMode* is set to *Off*.
- The IED is in TEST status (TEST-ACTIVE is high) and the function has been blocked from the HMI (*BlockFUSE=Yes*)

The input BLOCK signal is a general purpose blocking signal of the fuse failure supervision function. It can be connected to a binary input of the IED in order to receive a block command from external devices or can be software connected to other internal functions of the IED itself in order to receive a block command from internal functions. Through OR gate it can be connected to both binary inputs and internal function outputs.

The input BLKSP is intended to be connected to the trip output at any of the protection functions included in the IED. When activated for more than 20 ms, the operation of the fuse failure is blocked during a fixed time of 100 ms. The aim is to increase the security against unwanted operations during the opening of the breaker, which might cause unbalance conditions for which the fuse failure might operate.

The output signal BLKZ will also be blocked if the internal dead line detection is activated. The block signal has a 200 ms drop-out time delay.

The input signal MCBOP is supposed to be connected via a terminal binary input to the N.C. auxiliary contact of the miniature circuit breaker protecting the VT secondary circuit. The MCBOP signal sets the output signals BLKU and BLKZ in order to block all the voltage related functions when the MCB is open independent of the setting of *OpMode* selector. The additional drop-out timer of 150 ms prolongs the presence of MCBOP signal to prevent the unwanted operation of voltage dependent function due to non simultaneous closing of the main contacts of the miniature circuit breaker.

The input signal DISCPOS is supposed to be connected via a terminal binary input to the N.C. auxiliary contact of the line disconnector. The DISCPOS signal sets the output signal BLKU in order to block the voltage related functions when the line disconnector is open. The impedance protection function is not affected by the position of the line disconnector since there will be no line currents that can cause malfunction of the distance protection. If DISCPOS=0 it signifies that the line is connected to the system and when the DISCPOS=1 it signifies that the line is disconnected from the system and the block signal BLKU is generated.

The output BLKU can be used for blocking the voltage related measuring functions (undervoltage protection, synchro-check and so on) except for the impedance protection.

The function output BLKZ shall be used for blocking the impedance protection function.

10.1.2.2 Delta current and delta voltage detection

A simplified diagram for the functionality is found in figure 150. The calculation of the change is based on vector change which means that it detects both amplitude and phase angle changes. The calculated delta quantities are compared with their respective set values DI< and DU> and the algorithm, detects a fuse failure if a sufficient change in voltage without a sufficient change in current is detected in each phase separately. The following quantities are calculated in all three phases:

- The change in voltage DU
- The change in current DI

The internal FuseFailDetDUDI signal is activated if the following conditions are fulfilled for a phase:

- The magnitude of the phase-ground voltage has been above UPh> for more than 1.5 cycle
- The magnitude of DU is higher than the corresponding setting DU>
- The magnitude of DI is below the setting DI>

and at least one of the following conditions are fulfilled:

- The magnitude of the phase current in the same phase is higher than the setting IPh>
- The circuit breaker is closed (CBCLOSED = True)

The first criterion means that detection of failure in one phase together with high current for the same phase will set the output. The measured phase current is used to reduce the risk of false fuse failure detection. If the current on the protected line is low, a voltage drop in the system (not caused by fuse failure) is not by certain followed by current change and a false fuse failure might occur

The second criterion requires that the delta condition shall be fulfilled in any phase at the same time as circuit breaker is closed. Opening circuit breaker at one end and energizing the line from other end onto a fault could lead to wrong start of the fuse failure function at the end with the open breaker. If this is considering to be an important disadvantage, connect the CBCLOSED input to FALSE. In this way only the first criterion can activate the delta function.

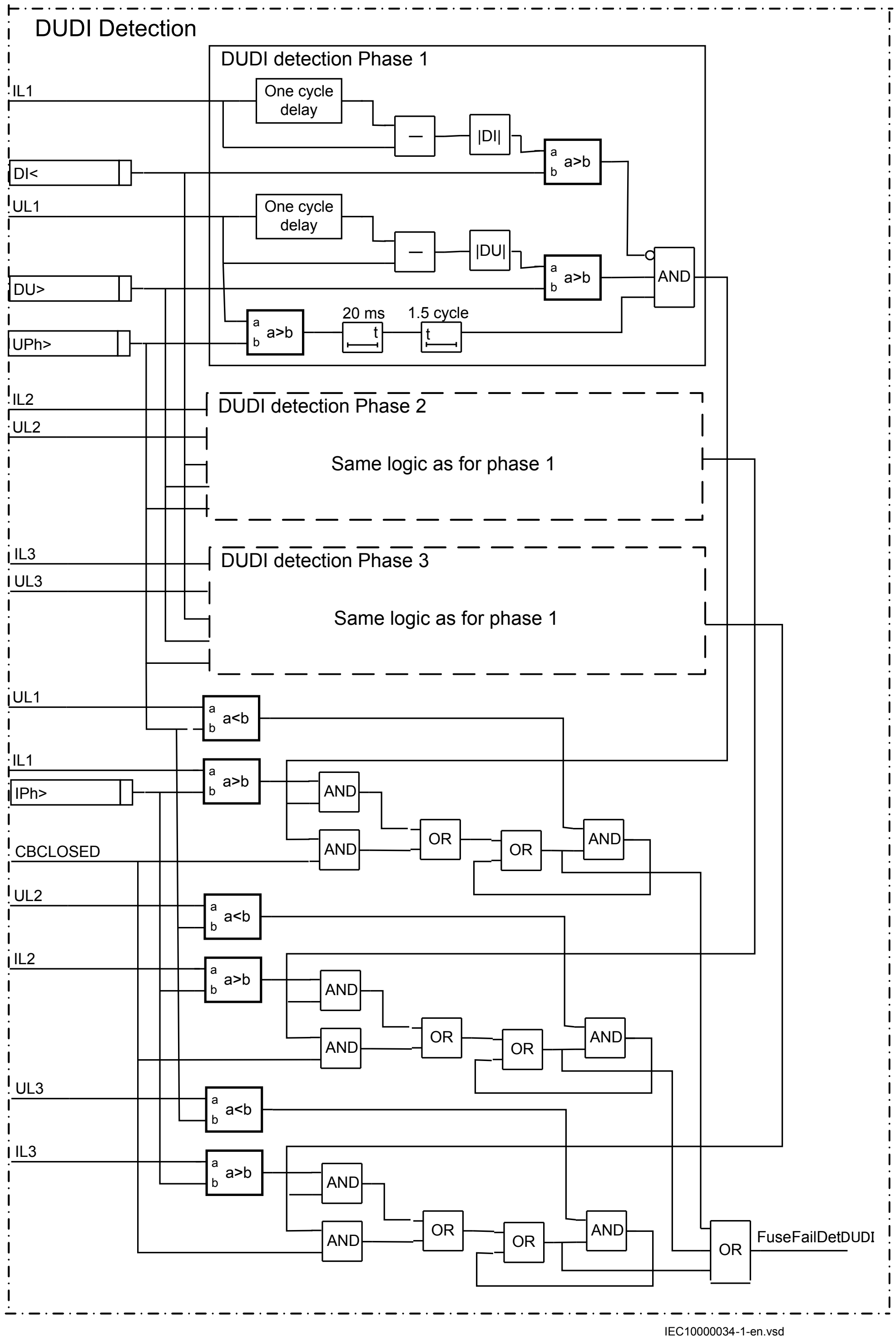


Figure 150: Simplified logic diagram for DU/DI detection part

10.1.2.3 Dead line detection

A simplified diagram for the functionality is found in figure 151. A dead phase condition is indicated if both the voltage and the current in one phase is below their respective setting values *UDLD*< and *IDLD*<. If at least one phase is considered to be dead the output DLD1PH and the internal signal DeadLineDet1Ph is activated. If all three phases are considered to be dead the output DLD3PH is activated

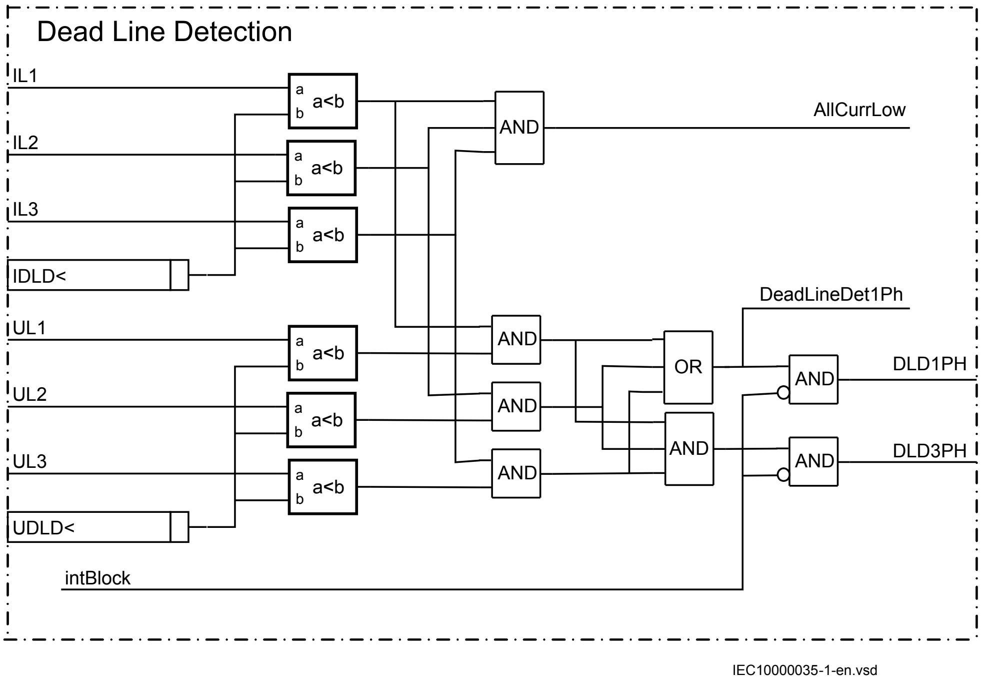


Figure 151: Simplified logic diagram for Dead Line detection part

10.1.2.4 Main logic

A simplified diagram for the functionality is found in figure 152. The fuse failure supervision function (SDDRFUF) can be switched on or off by the setting parameter *Operation* to *On* or *Off*.

For increased flexibility and adaptation to system requirements an operation mode selector, *OpMode*, has been introduced to make it possible to select different operating modes for the negative and zero sequence based algorithms. The different operation modes are:

- *Off*; The negative and zero sequence function is switched off
- *UNsINs*; Negative sequence is selected
- *UZsIZs*; Zero sequence is selected

- *UZsIZsORUNsINs*; Both negative and zero sequence is activated and working in parallel in an OR-condition
- *UZsIZs AND UNsINs*; Both negative and zero sequence is activated and working in series (AND-condition for operation)
- *OptimZsNs*; Optimum of negative and zero sequence (the function that has the highest magnitude of measured negative and zero sequence current will be activated)

The delta function can be activated by setting the parameter *OpDUDI* to *On*. When selected it operates in parallel with the sequence based algorithms.

As soon as any fuse failure situation is detected, signals FuseFailDetZeroSeq, FuseFailDetNegSeq or FuseFailDetDUDI, and the specific functionality is released, the function will activate the output signal BLKU. The output signal BLKZ will be activated as well if not the internal dead phase detection, DeadLineDet1Ph, is activated at the same time. The output BLKU can be used for blocking voltage related measuring functions (under voltage protection, synchro-check, and so on). For blocking of impedance protection functions output BLKZ shall be used.

If the fuse failure situation is present for more than 5 seconds and the setting parameter *SealIn* is set to *On* it will be sealed in over under-voltage as long as at least one phase voltages is below the set value *USealIn<*. This will keep the BLKU and BLKZ signals activated as long as any phase voltage is below the set value *USealIn<*. If all three phase voltages drop below the set value *USealIn<* and the setting parameter *SealIn* is set to *On* also the output signal 3PH will be activated. The signals 3PH, BLKU and BLKZ signals will now be active as long as any phase voltage is below the set value *USealIn<*.

If *SealIn* is set to *On* fuse failure condition is stored in the non volatile memory in the IED. At start-up (due to auxiliary power interruption or re-start due to configuration change) the IED checks the stored value in its non volatile memory and re-establishes the conditions present before the shut down. All phase voltages must became above *USealIn<* before fuse failure is de-activated and inhibits the block of different protection functions.

The output signal BLKU will also be active if all phase voltages have been above the setting *USealIn<* for more than 60 seconds, the zero or negative sequence voltage has been above the set value *3U0>* and *3U2>* for more than 5 seconds, all phase currents are below the setting *IDLD<* (operate level for dead line detection) and the circuit breaker is closed (input CBCLOSED is activated).

The input signal MCBOP is supposed to be connected via a terminal binary input to the N.C. auxiliary contact of the miniature circuit breaker protecting the VT secondary circuit. The MCBOP signal sets the output signals BLKU and BLKZ in order to block all the voltage related functions when the MCB is open independent of the setting of *OpMode* or *OpDUDI*. An additional drop-out timer of 150 ms prolongs the presence of MCBOP signal to prevent the unwanted operation of voltage dependent function due to non simultaneous closing of the main contacts of the miniature circuit breaker.

The input signal DISCPOS is supposed to be connected via a terminal binary input to the N.C. auxiliary contact of the line disconnector. The DISCPOS signal sets the output signal BLKU in order to block the voltage related functions when the line disconnector is open. The impedance protection function does not have to be affected since there will be no line currents that can cause malfunction of the distance protection.

The output signals 3PH, BLKU and BLKZ as well as the signals DLD1PH and DLD3PH from dead line detections are blocked if any of the following conditions occur:

- The operation mode selector *OpMode* is set to *Off*
- The input BLOCK is activated
- The input BLKTRIP is activated at the same time as no fuse failure indication is present
- The IED is in TEST status (TEST-ACTIVE is high) and the function has been blocked from the HMI (BlockFUSE=Yes)

The input BLOCK is a general purpose blocking signal of the fuse failure supervision function. It can be connected to a binary input of the IED in order to receive a block command from external devices or can be software connected to other internal functions of the IED. Through OR gate it can be connected to both binary inputs and internal function outputs.

The input BLKTRIP is intended to be connected to the trip output of any of the protection functions included in the IED and/or trip from external equipments via binary inputs. When activated for more than 20 ms without any fuse fail detected, the operation of the fuse failure is blocked during a fixed time of 100 ms. The aim is to increase the security against unwanted operations during the opening of the breaker, which might cause unbalance conditions for which the fuse failure might operate.

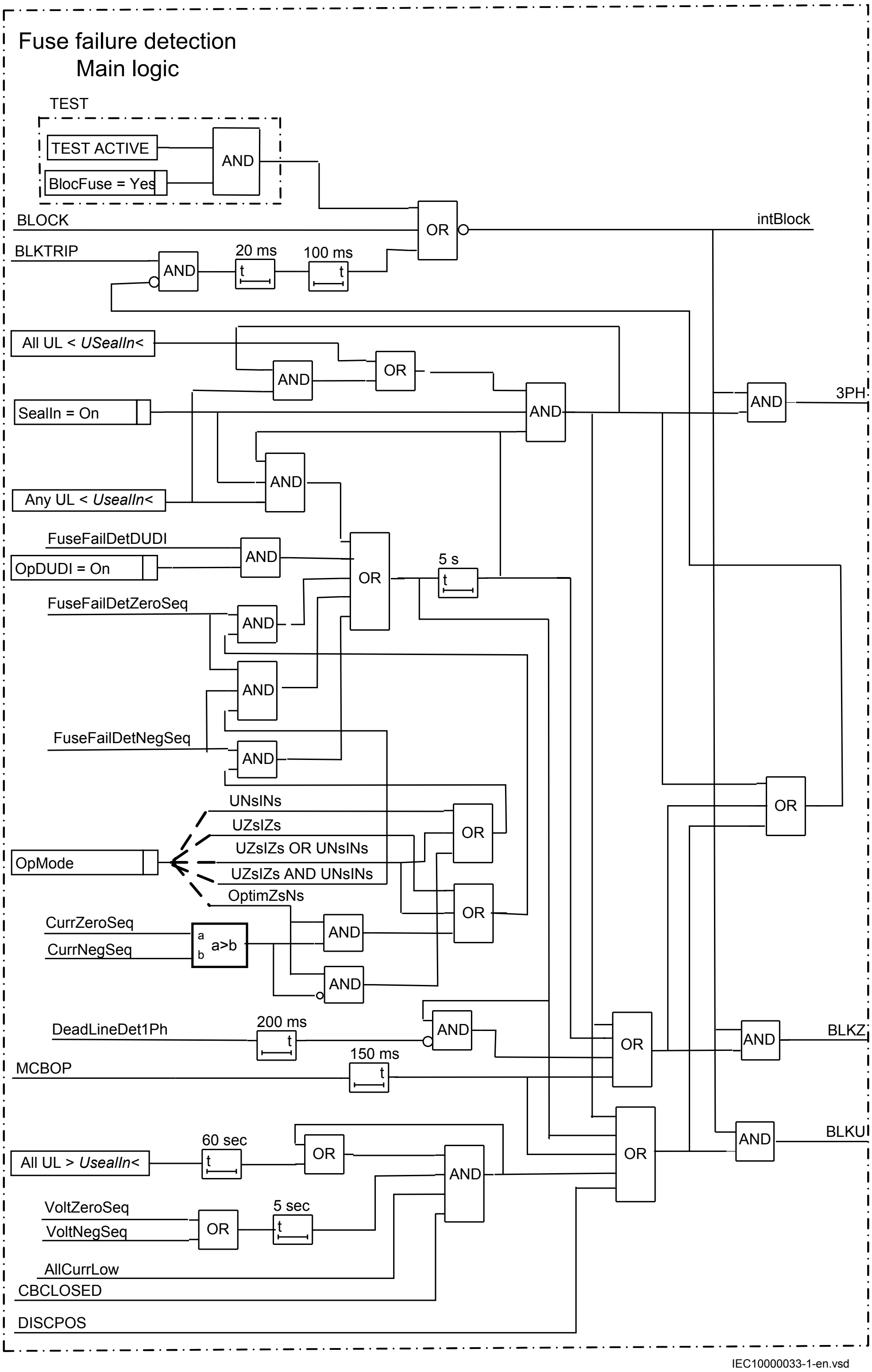


Figure 152: Simplified logic diagram for fuse failure supervision function, Main logic

10.1.3 Function block

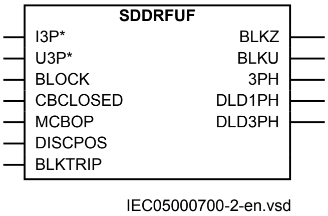


Figure 153: SDDRFUF function block

10.1.4 Input and output signals

Table 177: SDDRFUF Input signals

Name	Type	Default	Description
I3P	GROUP SIGNAL	-	Current connection
U3P	GROUP SIGNAL	-	Voltage connection
BLOCK	BOOLEAN	0	Block of function
CBCLOSED	BOOLEAN	0	Active when circuit breaker is closed
MCBOP	BOOLEAN	0	Active when external MCB opens protected voltage circuit
DISCPOS	BOOLEAN	0	Active when line disconnector is open
BLKTRIP	BOOLEAN	0	Blocks operation of function when active

Table 178: SDDRFUF Output signals

Name	Type	Description
BLKZ	BOOLEAN	Start of current and voltage controlled function
BLKU	BOOLEAN	General start of function
3PH	BOOLEAN	Three-phase start of function
DLD1PH	BOOLEAN	Dead line condition in at least one phase
DLD3PH	BOOLEAN	Dead line condition in all three phases

10.1.5 Setting parameters

Table 179: SDDRFUF Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	On	Operation Off / On
IBase	1 - 99999	A	1	3000	Base current
UBase	0.05 - 2000.00	kV	0.05	400.00	Base voltage
Table continues on next page					

Name	Values (Range)	Unit	Step	Default	Description
OpMode	Off UNsINs UZsIZs UZsIZs OR UNsINs UZsIZs AND UNsINs OptimZsNs	-	-	UZsIZs	Operating mode selection
3U0>	1 - 100	%UB	1	30	Operate level of residual overvoltage element in % of UBase
3I0<	1 - 100	%IB	1	10	Operate level of residual undercurrent element in % of IBase
3U2>	1 - 100	%UB	1	30	Operate level of neg seq overvoltage element in % of UBase
3I2<	1 - 100	%IB	1	10	Operate level of neg seq undercurrent element in % of IBase
OpDUDI	Off On	-	-	Off	Operation of change based function Off/On
DU>	1 - 100	%UB	1	60	Operate level of change in phase voltage in % of UBase
DI<	1 - 100	%IB	1	15	Operate level of change in phase current in % of IBase
UPh>	1 - 100	%UB	1	70	Operate level of phase voltage in % of UBase
IPh>	1 - 100	%IB	1	10	Operate level of phase current in % of IBase
SealIn	Off On	-	-	On	Seal in functionality Off/On
USealIn<	1 - 100	%UB	1	70	Operate level of seal-in phase voltage in % of UBase
IDLD<	1 - 100	%IB	1	5	Operate level for open phase current detection in % of IBase
UDLD<	1 - 100	%UB	1	60	Operate level for open phase voltage detection in % of UBase

10.1.6 Technical data

Table 180: SDDRFUF technical data

Function	Range or value	Accuracy
Operate voltage, zero sequence	(1-100)% of UBase	± 1.0% of U_r
Operate current, zero sequence	(1–100)% of IBase	± 1.0% of I_r
Operate voltage, negative sequence	(1–100)% of UBase	± 0.5% of U_r
Operate current, negative sequence	(1–100)% of IBase	± 1.0% of I_r
Operate voltage change level	(1–100)% of UBase	± 5.0% of U_r
Operate current change level	(1–100)% of IBase	± 5.0% of I_r
Operate phase voltage	(1-100)% of UBase	± 0.5% of U_r
Operate phase current	(1-100)% of IBase	± 1.0% of I_r
Table continues on next page		

Function	Range or value	Accuracy
Operate phase dead line voltage	(1-100)% of UBase	± 0.5% of U_r
Operate phase dead line current	(1-100)% of IBase	± 1.0% of I_r
Operate time, start function	25 ms typically at 1 to 0 Ubase	-
Reset time, start function	35 ms typically at 0 to 1 Ubase	-

Section 11 Control

About this chapter

This chapter describes the control functions. The way the functions work, their setting parameters, function blocks, input and output signals and technical data are included for each function.

11.1 Autorecloser SMBRREC

Function Description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Autorecloser	SMBRREC	O->I	79

11.1.1 Introduction

The autoreclosing function provides high-speed and/or delayed three pole autoreclosing. The autoreclosing can be used for delayed busbar restoration. One Autorecloser (SMBRREC) per zone can be made available.

11.1.2 Principle of operation

11.1.2.1 Logic Diagrams

The logic diagrams below illustrate the principles applicable in the understanding of the functionality.

11.1.2.2 Auto-reclosing operation *Off* and *On*

Operation of the automatic reclosing can be set to Off or On via the setting parameters and through external control. With the setting *Operation* = *On*, the function is activated while with the setting *Operation* = *Off* the function is deactivated. With the setting *Operation* = *External ctrl*, the activation/deactivation is made by input signal pulses, for example, from a control system.

When the function is set *On* and is operative the output SETON is activated (high). Other input conditions such as CBPOS and CBREADY must also be fulfilled. At this point the automatic recloser is prepared to start the reclosing cycle and the output signal READY on the SMBRREC function block is activated (high).

11.1.2.3 Auto-reclosing mode selection

The Auto-reclosing mode is selected with setting *ARMode* = *3phase(0)*, *1/2/3ph(1)*, *1/2ph(2)*, *1ph+1*2ph(3)*, *1/2ph+1*3ph(4)*, *1ph+1*2/3ph(5)*. The selected mode can be read as integer as per above list on output MODE.

As an alternative to setting the mode can be selected by connecting an integer, for example from function block B16I to input MODEINT.

Following integers shall be used: *1=3phase*, *2=1/2/3ph*, *3=1/2ph*, *4=1ph+1*2ph*, *5=1/2ph+1*3ph* or *6=1ph+1*2/3ph*.

When INTZERO from Fixed signal function block is connected to the input MODEINT the parameter setting selected will be valid.

11.1.2.4 Start auto-reclosing and conditions for start of a reclosing cycle

The usual way in which to start a reclosing cycle, or sequence, is to start it when a line protection tripping has occurred, by applying a signal to the START input. It should be necessary to adjust three-phase auto-reclosing open time, (dead time) for different power system configurations or during tripping at different protection stages, the input STARTHS (start high-speed reclosing) can also be used.

For a new auto-reclosing cycle to be started, a number of conditions need to be met. They are linked to dedicated inputs. The inputs are:

- CBREADY: CB ready for a reclosing cycle, for example, charged operating gear
- CBPOS: to ensure that the CB was closed when the line fault occurred and start was applied
- No blocking or inhibit signal shall be present.

After the start has been accepted, it is latched in and an internal signal “Started” is set. It can be interrupted by certain events, like an inhibit signal.

To start auto-reclosing by CB position Open instead of from protection trip signals, one has to configure the CB Open position signal to inputs CBPOS and START and set a parameter *StartByCBOpen* = *On* and *CBAuxContType* = *NormClosed* (normally closed). One also has to configure and connect signals from manual trip commands to input INHIBIT.

The logic for switching the auto-recloser *On/Off* and the starting of the reclosing is shown in figure 154. The following should be considered:

- Setting *Operation* can be set to *Off*, *External ctrl* or *On*. *External ctrl* offers the possibility of switching by external switches to inputs ON and OFF, communication commands to the same inputs, and so on.
- SMBRREC is normally started by tripping. It is either a Zone 1 and Communication aided trip, or a general trip. If the general trip is used the function must be blocked from all back-up tripping connected to INHIBIT. In both alternatives the breaker failure function must be connected to inhibit the function. START makes a first attempt with synchrocheck, STARTHS makes its first attempt without synchrocheck. TRSOTF starts shots 2-5.
- Circuit breaker checks that the breaker was closed for a certain length of time before the starting occurred and that the CB has sufficient stored energy to perform an auto-reclosing sequence and is connected to inputs CBPOS and CBREADY.

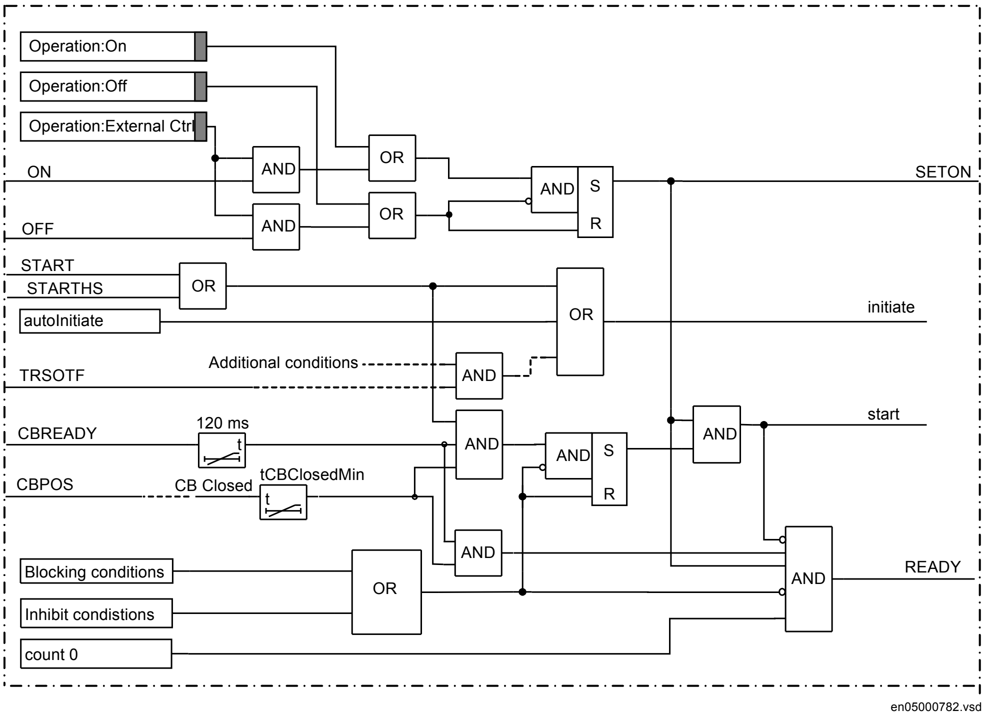


Figure 154: Auto-reclosing Off/On and start

11.1.2.5 Control of the auto-reclosing open time for shot 1

It is possible to use up to four different time settings for the first shot, and one extension time. There are separate settings for single- , two- and three-phase auto-reclosing open times, *t1 1Ph, t1 2Ph, t1 3Ph*. If no particular input signal is applied, and an auto-reclosing program with single-phase reclosing is selected, the auto-reclosing open time *t1 1Ph* will be used. If one of the inputs TR2P or TR3P is activated in connection with the input START, the auto-reclosing open time for two-phase or three-phase reclosing is used. There is also a separate time setting facility for three-phase high-speed auto-reclosing, *t1 3PhHS* available for use when required. It is activated by input STARTHS.

An auto-reclosing open time extension delay, *tExtended t1*, can be added to the normal shot 1 delay. It is intended to come into use if the communication channel for permissive line protection is lost. In a case like this there can be a significant time difference in fault clearance at the two line ends. A longer auto-reclosing open time can then be useful. This extension time is controlled by setting parameter *Extended t1 = On* and the input PLCLOST.

11.1.2.6 Long trip signal

In normal circumstances the trip command resets quickly due to fault clearing. The user can set a maximum trip pulse duration *tTrip*. When trip signals are longer, the auto-reclosing open time is extended by *tExtended t1*. If *Extended t1 = Off*, a long trip signal interrupts the reclosing sequence in the same way as a signal to input INHIBIT.

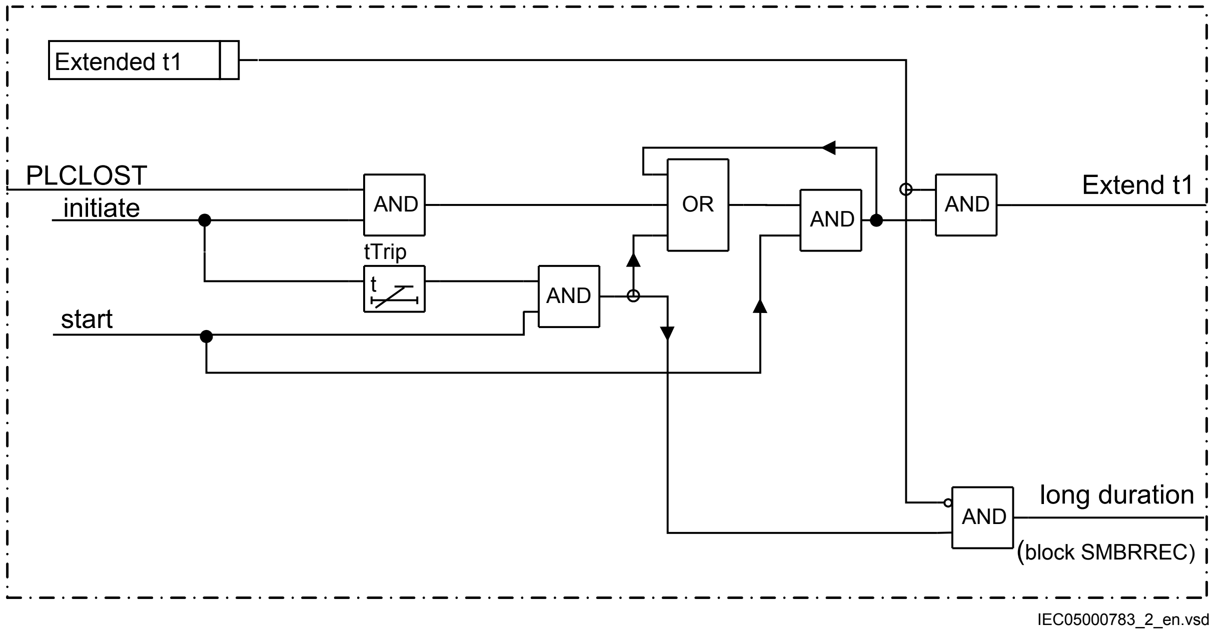


Figure 155: Control of extended auto-reclosing open time and long trip pulse detection

Reclosing checks and the reclaim timer

When dead time has elapsed during the auto-reclosing procedure certain conditions must be fulfilled before the CB closing command is issued. To achieve this, signals are exchanged between program modules to check that these conditions are met. In three-phase reclosing a synchronizing and/or energizing check can be used. It is possible to use a synchrocheck function in the same physical device or an external one. The release signal is configured by connecting to the auto-reclosing function input SYNC. If reclosing without checking is preferred the SYNC input can be set to TRUE (set high). Another possibility is to set the output of the synchro-check function to a permanently activated state. At confirmation from the synchro-check, or if the reclosing is of single-phase or two-phase type, the signal passes on. At single-phase, two-phase reclosing and at three-phase high-speed reclosing started by STARTHS, synchronization is not checked, and the state of the SYNC input is disregarded.

By choosing *CBReadyType = CO* (CB ready for a Close-Open sequence) the readiness of the circuit breaker is also checked before issuing the CB closing command. If the CB has a readiness contact of type *CBReadyType = OCO* (CB ready for an Open-Close-Open sequence) this condition may not be complied with after the tripping and at the moment of reclosure. The Open-Close-Open condition was however checked at the start of the reclosing cycle and it is then likely that the CB is prepared for a Close-Open sequence.

The synchro-check or energizing check must be fulfilled within a set time interval, *tSync*. If it is not, or if other conditions are not met, the reclosing is interrupted and blocked.

The reclaim timer defines a time from the issue of the reclosing command, after which the reclosing function resets. Should a new trip occur during this time, it is treated as a continuation of the first fault. The reclaim timer is started when the CB closing command is given.

A number of outputs for Autoreclosing state control keeps track of the actual state in the reclosing sequence.

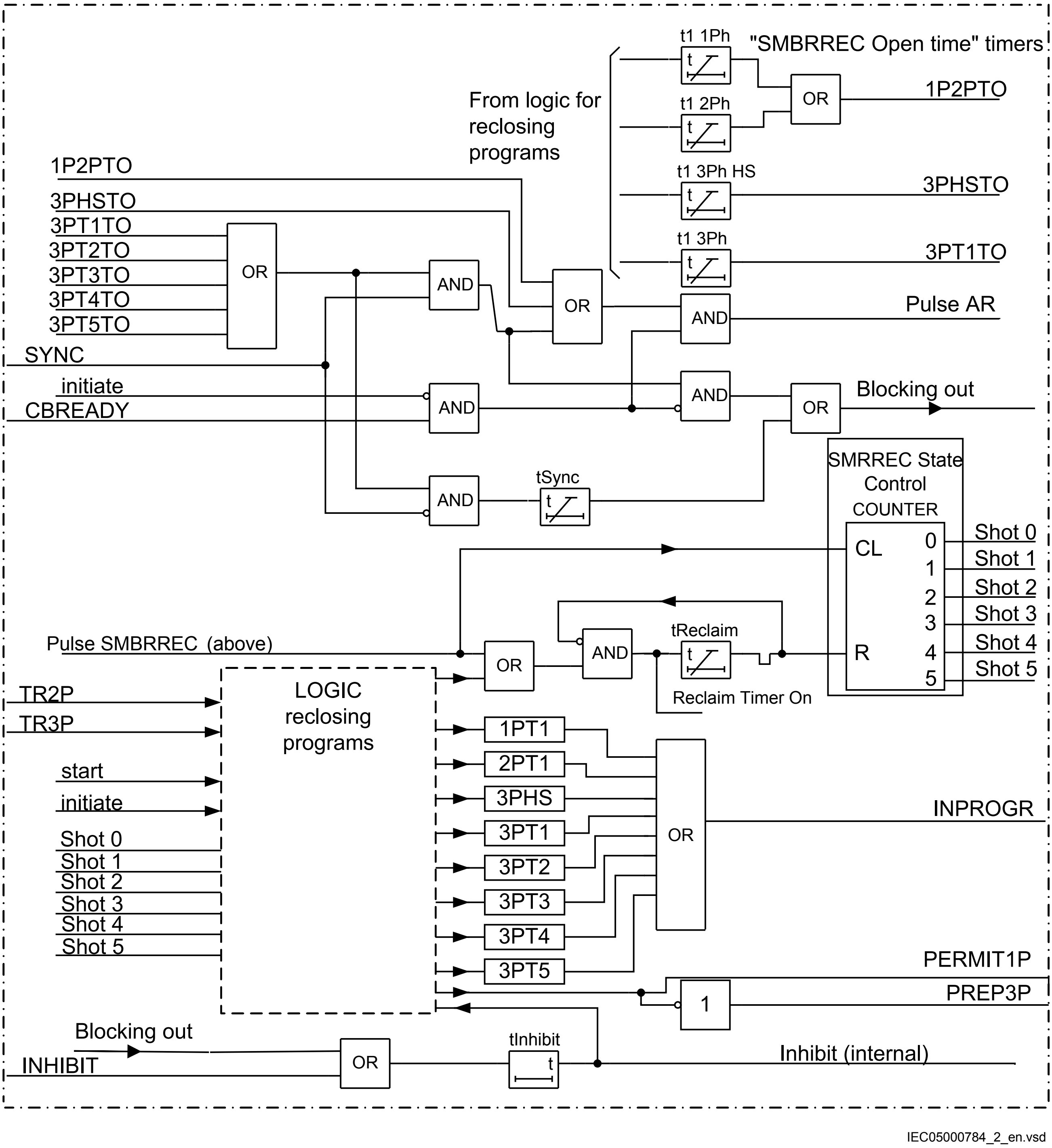


Figure 156: *Reclosing Reclaim and Inhibit timers*

Pulsing of the CB closing command

The CB closing command, CLOSECB is a pulse with a duration set by parameter *tPulse*. For circuit-breakers without anti-pumping function, the close pulse cutting described below can be used. This is done by selecting the parameter

CutPulse=On. In case of a new trip pulse, the closing command pulse is cut (interrupted). The minimum duration of the pulse is always 50 ms. See figure 157

When a reclosing command is issued, the appropriate reclosing operation counter is incremented. There is a counter for each type of reclosing and one for the total number of reclosing commands issued.

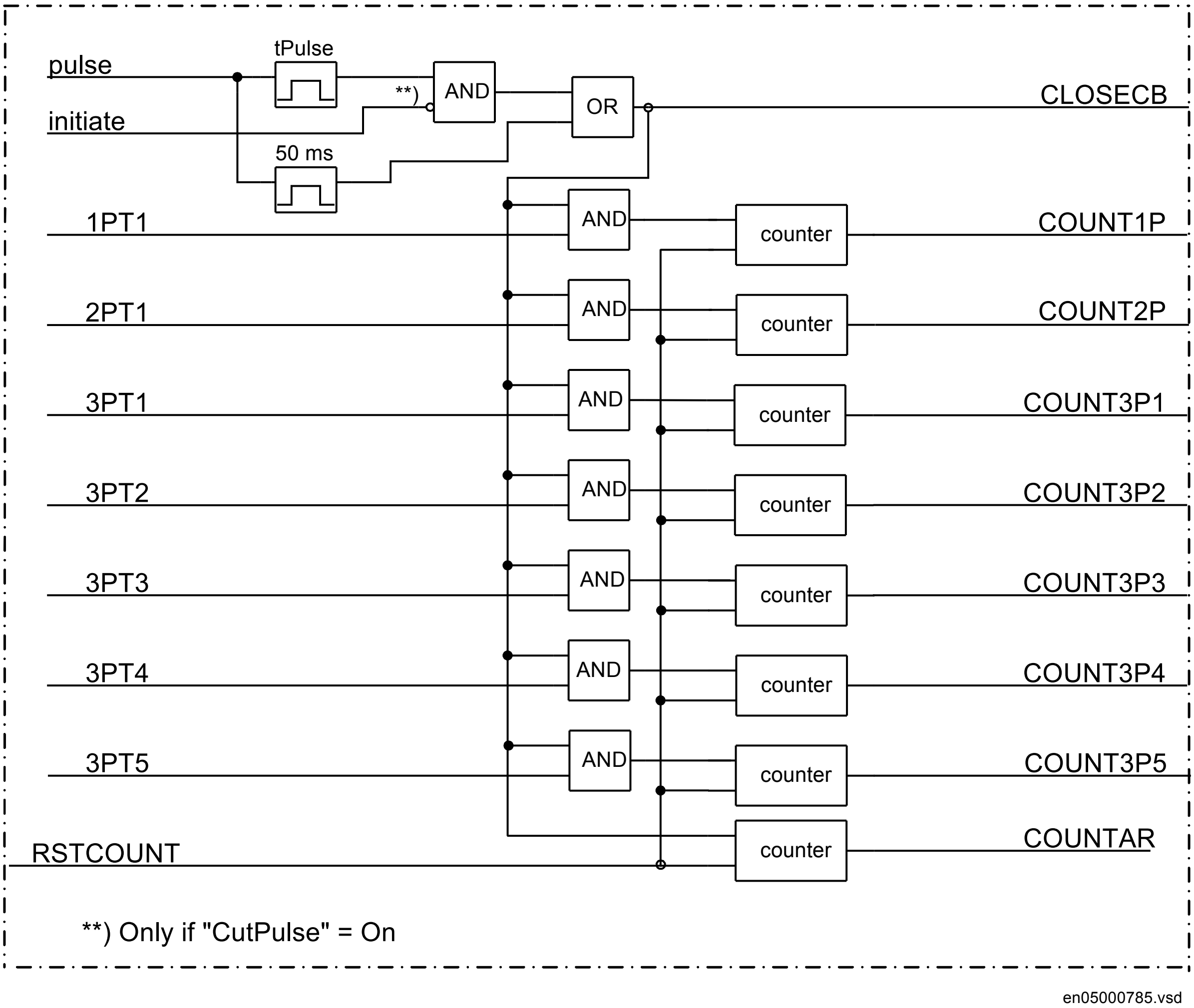


Figure 157: Pulsing of closing command and driving the operation counters

Transient fault

After the reclosing command the reclaim timer *tReclaim* starts running for the set time. If no tripping occurs within this time, the auto-reclosing will reset.

Permanent fault and reclosing unsuccessful signal

If a new trip occurs after the CB closing command, and a new input signal START or TRSOTF appears, the output UNSUCCL (unsuccessful closing) is set high. The timers for the first shot can no longer be started. Depending on the setting for the number of reclosing shots, further shots may be made or the reclosing sequence will be ended. After the reclaim time has elapsed, the auto-reclosing function resets but the CB remains open. The CB closed data at the CBPOS input will be missing. Because of this, the reclosing function will not be ready for a new reclosing cycle.

Normally the signal UNSUCCL appears when a new trip and start is received after the last reclosing shot has been made and the auto-reclosing function is blocked. The signal resets once the reclaim time has elapsed. The “unsuccessful“ signal can also be made to depend on CB position input. The parameter *UnsucClByCBChk* should then be set to *CBCheck*, and a timer *tUnsucCl* should also be set. If the CB does not respond to the closing command and does not close, but remains open, the output UNSUCCL is set high after time *tUnsucCl*.

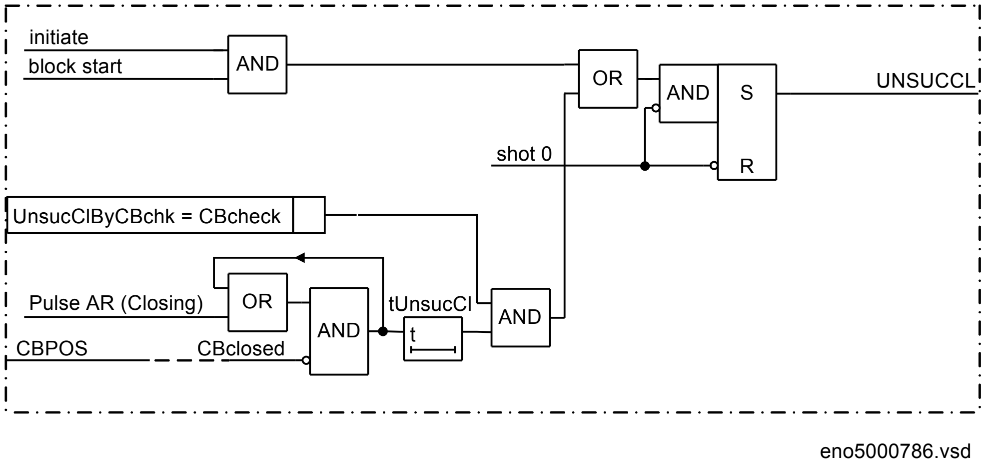


Figure 158: Issue of signal UNSUCCL, unsuccessful reclosing

Automatic continuation of the reclosing sequence

The auto-reclosing function can be programmed to proceed to the following reclosing shots (if selected) even if the start signals are not received from the protection functions, but the breaker is still not closed. This is done by setting parameter *AutoCont* = *On* and *tAutoContWait* to the required delay for the function to proceed without a new start.

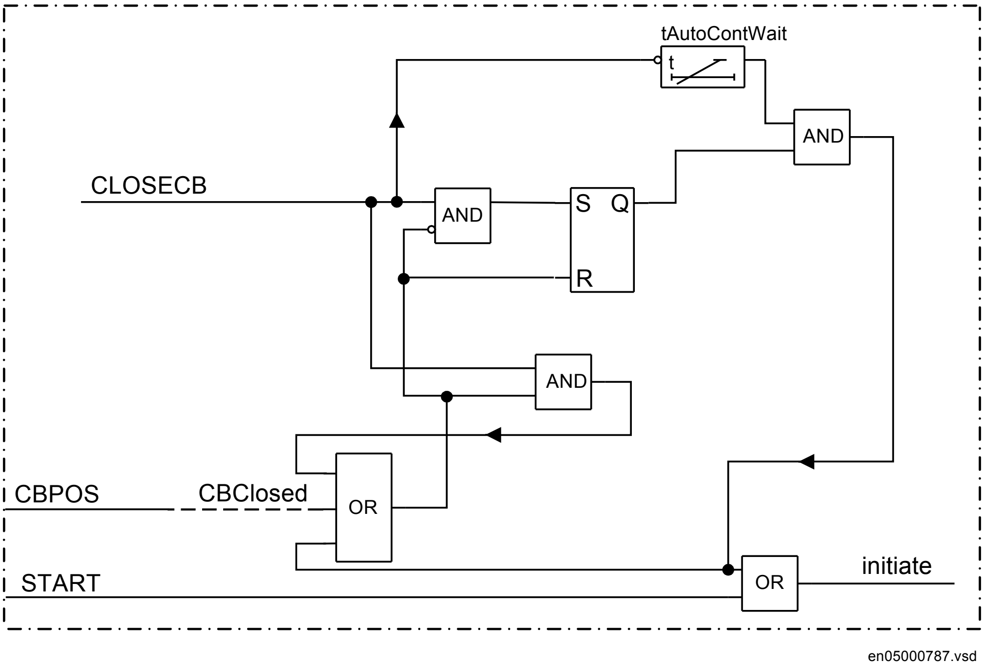


Figure 159: Automatic proceeding of shot 2 to 5

Start of reclosing from CB open information

If a user wants to apply starting of auto-reclosing from CB open position instead of from protection trip signals, the function offers such a possibility. This starting mode is selected by a setting parameter *StartByCBOpen* = *On*. One needs then to block reclosing at all manual trip operations. Typically, one also set *CBAuxContType = NormClosed* and connect a CB auxiliary contact of type NC (normally closed) to inputs CBPOS and START. When the signal changes from CB closed to CB open an auto-reclosing start pulse of limited length is generated and latched in the function, subject to the usual checks. Then the reclosing sequence continues as usual. One needs to connect signals from manual tripping and other functions, which shall prevent reclosing, to the input INHIBIT.

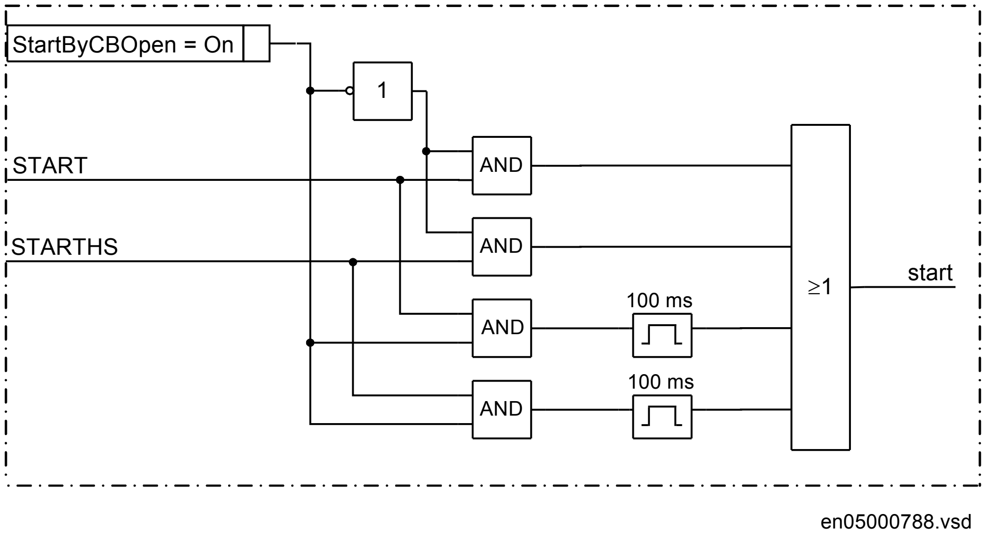


Figure 160: Pulsing of the start inputs

11.1.2.7 Time sequence diagrams

Some examples of the timing of internal and external signals at typical transient and permanent faults are shown below in figures 161 to 164.

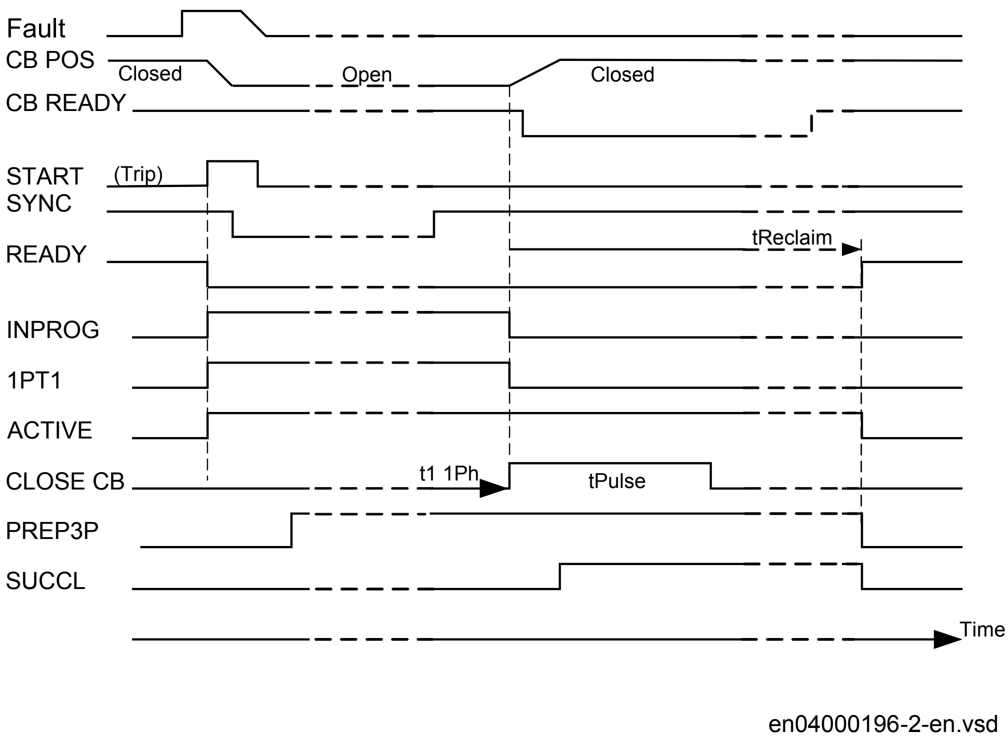


Figure 161: Transient single-phase fault. Single -phase reclosing

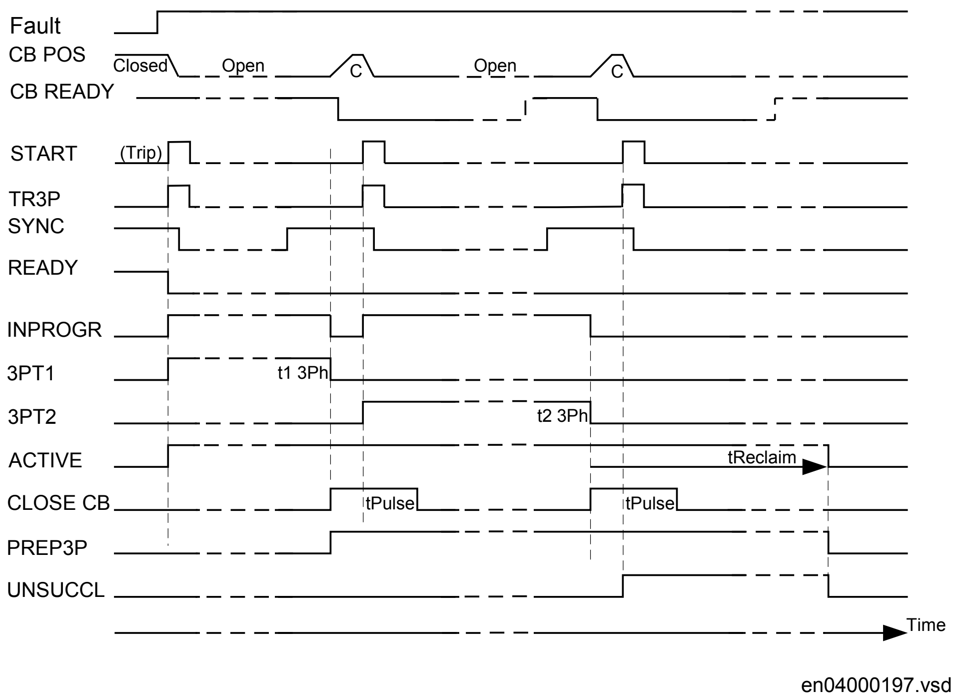


Figure 162: Permanent fault. Three-phase trip. Two-shot reclosing

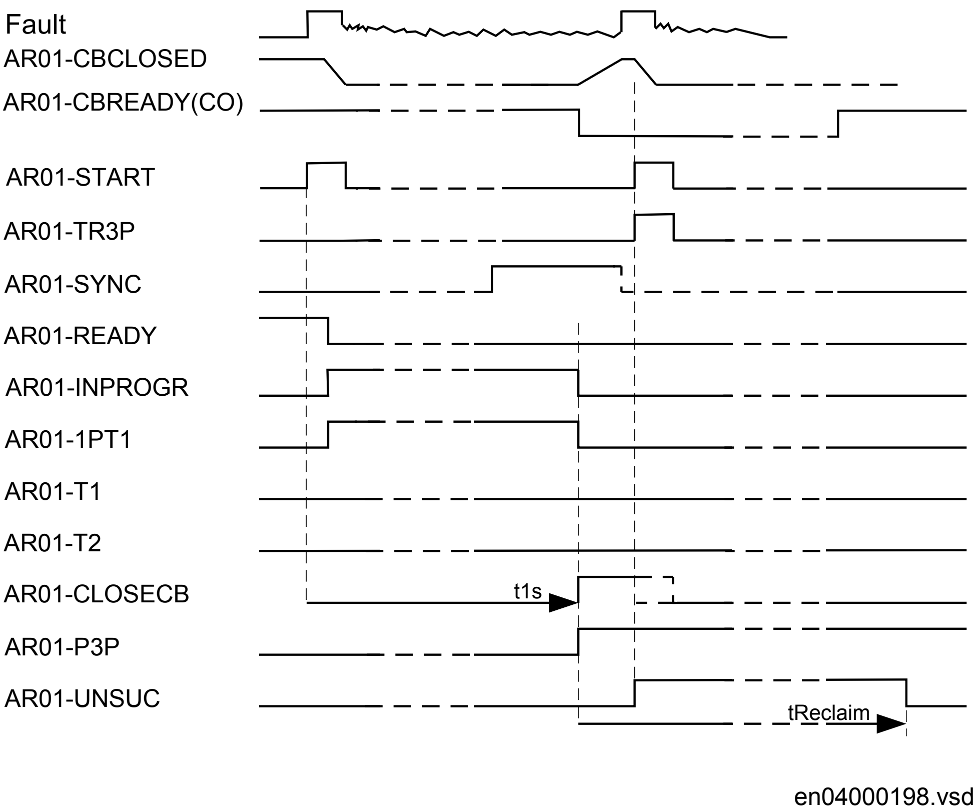


Figure 163: Permanent single-phase fault. Program 1/2/3ph, single-phase single-shot reclosing

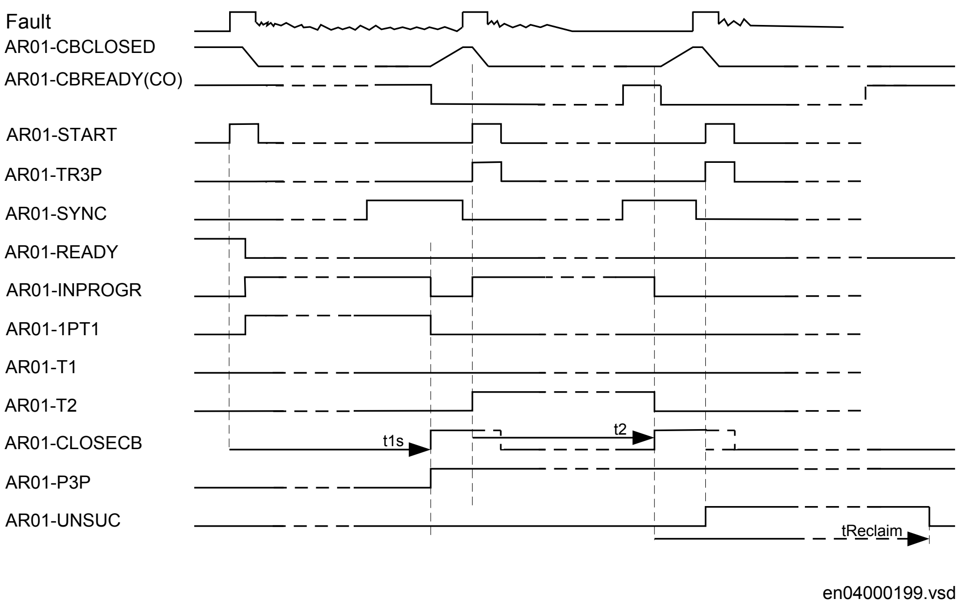


Figure 164: Permanent single-phase fault. Program 1ph + 3ph or 1/2ph + 3ph, two-shot reclosing

11.1.3 Function block

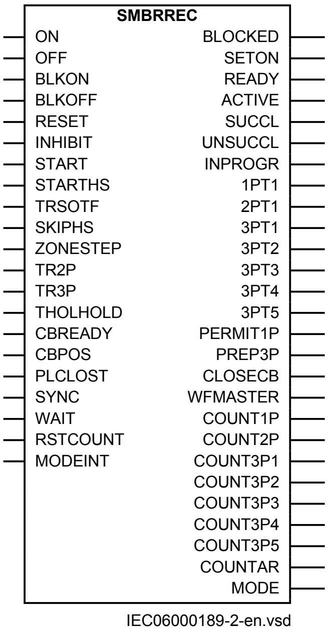


Figure 165: SMBRREC function block

11.1.4 Input and output signals

Table 181: SMBRREC Input signals

Name	Type	Default	Description
ON	BOOLEAN	0	Switches the AR On (at Operation = ExternalCtrl)
OFF	BOOLEAN	0	Switches the AR Off (at Operation = ExternalCtrl)
BLKON	BOOLEAN	0	Sets the AR in blocked state
BLKOFF	BOOLEAN	0	Releases the AR from the blocked state
RESET	BOOLEAN	0	Resets the AR to initial conditions
INHIBIT	BOOLEAN	0	Interrupts and inhibits reclosing sequence
START	BOOLEAN	0	Reclosing sequence starts by a protection trip signal
STARTHS	BOOLEAN	0	Start HS reclosing without SC: t13PhHS
TRSOTF	BOOLEAN	0	Makes AR to continue to shots 2-5 at a trip from SOTF
SKIPHS	BOOLEAN	0	Will skip the high speed shot and continue on delayed shots
ZONESTEP	BOOLEAN	0	Coordination between local AR and down stream devices
TR2P	BOOLEAN	0	Signal to the AR that a two-phase tripping occurred
TR3P	BOOLEAN	0	Signal to the AR that a three-phase tripping occurred

Table continues on next page

Name	Type	Default	Description
THOLHOLD	BOOLEAN	0	Hold the AR in wait state
CBREADY	BOOLEAN	0	CB must be ready for CO/OCO operation to allow start / close
CBPOS	BOOLEAN	0	Status of the circuit breaker Closed/Open
PLCLOST	BOOLEAN	0	Power line carrier or other form of permissive signal lost
SYNC	BOOLEAN	0	Synchronizing check fulfilled (for 3Ph attempts)
WAIT	BOOLEAN	0	Wait for master (in Multi-breaker arrangements)
RSTCOUNT	BOOLEAN	0	Resets all counters
MODEINT	INTEGER	0	Integer input used to set the reclosingMode, alternative to setting

Table 182: SMBRREC Output signals

Name	Type	Description
BLOCKED	BOOLEAN	The AR is in blocked state
SETON	BOOLEAN	The AR operation is switched on, operative
READY	BOOLEAN	Indicates that the AR function is ready for a new sequence
ACTIVE	BOOLEAN	Reclosing sequence in progress
SUCCL	BOOLEAN	Activated if CB closes during the time tUnsucCl
UNSUCCL	BOOLEAN	Reclosing unsuccessful, signal resets after the reclaim time
INPROGR	BOOLEAN	Reclosing shot in progress, activated during open time
1PT1	BOOLEAN	Single-phase reclosing is in progress, shot 1
2PT1	BOOLEAN	Two-phase reclosing is in progress, shot 1
3PT1	BOOLEAN	Three-phase reclosing in progress, shot 1
3PT2	BOOLEAN	Three-phase reclosing in progress, shot 2
3PT3	BOOLEAN	Three-phase reclosing in progress, shot 3
3PT4	BOOLEAN	Three-phase reclosing in progress, shot 4
3PT5	BOOLEAN	Three-phase reclosing in progress, shot 5
PERMIT1P	BOOLEAN	Permit single-phase trip, inverse signal to PREP3P
PREP3P	BOOLEAN	Prepare three-phase trip, control of the next trip operation
CLOSECB	BOOLEAN	Closing command for CB
WFMASTER	BOOLEAN	Signal to Slave issued by Master for sequential reclosing
COUNT1P	INTEGER	Counting the number of single-phase reclosing shots
COUNT2P	INTEGER	Counting the number of two-phase reclosing shots
COUNT3P1	INTEGER	Counting the number of three-phase reclosing shot 1

Table continues on next page

Name	Type	Description
COUNT3P2	INTEGER	Counting the number of three-phase reclosing shot 2
COUNT3P3	INTEGER	Counting the number of three-phase reclosing shot 3
COUNT3P4	INTEGER	Counting the number of three-phase reclosing shot 4
COUNT3P5	INTEGER	Counting the number of three-phase reclosing shot 5
COUNTAR	INTEGER	Counting total number of reclosing shots
MODE	INTEGER	Integer output for reclosing mode

11.1.5 Setting parameters

Table 183: SMBRREC Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off External ctrl On	-	-	External ctrl	Off, ExternalCtrl, On
ARMode	3 phase 1/2/3ph 1/2ph 1ph+1*2ph 1/2ph+1*3ph 1ph+1*2/3ph	-	-	1/2/3ph	The AR mode selection e.g. 3ph, 1/3ph
t1 1Ph	0.000 - 60.000	s	0.001	1.000	Open time for shot 1, single-phase
t1 3Ph	0.000 - 60.000	s	0.001	6.000	Open time for shot 1, delayed reclosing 3ph
t1 3PhHS	0.000 - 60.000	s	0.001	0.400	Open time for shot 1, high speed reclosing 3ph
tReclaim	0.00 - 6000.00	s	0.01	60.00	Duration of the reclaim time
tSync	0.00 - 6000.00	s	0.01	30.00	Maximum wait time for synchrocheck OK
tTrip	0.000 - 60.000	s	0.001	0.200	Maximum trip pulse duration
tPulse	0.000 - 60.000	s	0.001	0.200	Duration of the circuit breaker closing pulse
tCBClosedMin	0.00 - 6000.00	s	0.01	5.00	Min time that CB must be closed before new sequence allows
tUnsucCl	0.00 - 6000.00	s	0.01	30.00	Wait time for CB before indicating Unsuccessful/Successful
Priority	None Low High	-	-	None	Priority selection between adjacent terminals None/Low/High
tWaitForMaster	0.00 - 6000.00	s	0.01	60.00	Maximum wait time for release from Master

Table 184: SMBRREC Group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
NoOfShots	1 2 3 4 5	-	-	1	Max number of reclosing shots 1-5
StartByCBOpen	Off On	-	-	Off	To be set ON if AR is to be started by CB open position
CBAuxContType	NormClosed NormOpen	-	-	NormOpen	Select the CB aux contact type NC/NO for CBPOS input
CBReadyType	CO OCO	-	-	CO	Select type of circuit breaker ready signal CO/OCO
t1 2Ph	0.000 - 60.000	s	0.001	1.000	Open time for shot 1, two-phase
t2 3Ph	0.00 - 6000.00	s	0.01	30.00	Open time for shot 2, three-phase
t3 3Ph	0.00 - 6000.00	s	0.01	30.00	Open time for shot 3, three-phase
t4 3Ph	0.00 - 6000.00	s	0.01	30.00	Open time for shot 4, three-phase
t5 3Ph	0.00 - 6000.00	s	0.01	30.00	Open time for shot 5, three-phase
Extended t1	Off On	-	-	Off	Extended open time at loss of permissive channel Off/On
tExtended t1	0.000 - 60.000	s	0.001	0.500	3Ph Dead time is extended with this value at loss of perm ch
tInhibit	0.000 - 60.000	s	0.001	5.000	Inhibit reclosing reset time
CutPulse	Off On	-	-	Off	Shorten closing pulse at a new trip Off/On
Follow CB	Off On	-	-	Off	Advance to next shot if CB has been closed during dead time
AutoCont	Off On	-	-	Off	Continue with next reclosing-shot if breaker did not close
tAutoContWait	0.000 - 60.000	s	0.001	2.000	Wait time after close command before proceeding to next shot
UnsucClByCBChk	NoCBCheck CB check	-	-	NoCBCheck	Unsuccessful closing signal obtained by checking CB position
BlockByUnsucCl	Off On	-	-	Off	Block AR at unsuccessful reclosing
ZoneSeqCoord	Off On	-	-	Off	Coordination of down stream devices to local prot unit's AR

11.1.6 Technical data

Table 185: SMBRREC technical data

Function	Range or value	Accuracy
Number of autoreclosing shots	1 - 5	-
Autoreclosing open time: shot 1 - t1 1Ph shot 1 - t1 2Ph shot 1 - t1 3PhHS shot 1 - t1 3PhDld	(0.000-60.000) s	± 0.5% ± 10 ms
shot 2 - t2 shot 3 - t3 shot 4 - t4 shot 5 - t5	(0.00-6000.00) s	
Extended autorecloser open time	(0.000-60.000) s	
Autorecloser maximum wait time for sync	(0.00-6000.00) s	
Maximum trip pulse duration	(0.000-60.000) s	
Inhibit reset time	(0.000-60.000) s	
Reclaim time	(0.00-6000.00) s	
Minimum time CB must be closed before AR becomes ready for autoreclosing cycle	(0.00-6000.00) s	
Circuit breaker closing pulse length	(0.000-60.000) s	
CB check time before unsuccessful	(0.00-6000.00) s	
Wait for master release	(0.00-6000.00) s	
Wait time after close command before proceeding to next shot	(0.000-60.000) s	

11.2 Apparatus control APC

11.2.1 Introduction

The apparatus control functions are used for control and supervision of circuit breakers, disconnectors and earthing switches within a bay. Permission to operate is given after evaluation of conditions from other functions such as interlocking, synchrocheck, operator place selection and external or internal blockings.

In normal security, the command is processed and the resulting position is not supervised. However with enhanced security, the command is processed and the resulting position is supervised.

11.2.2 Error handling

Depending on the error that occurs during the command sequence the error signal will be set with a value. Table 186 describes vendor specific cause values in addition to these specified in IEC 61850-8-1 standard. The list of values of the "cause" are in order of priority. The values are available over the IEC 61850. An output L_CAUSE on the function block for Switch controller (SCSWI), Circuit breaker (SXCBR) and Circuit switch (SXSWI) indicates the latest value of the error during the command.

Table 186: Values for "cause" signal in priority order

	Attribute value	Description	Supported
Defined in IEC 61850	0	no error	X
	1	serviceError-type	
	2	blocked-by-switching-hierarchy	X
	3	select-failed	X
	4	invalid-position	X
	5	position-reached	X
	6	parameter-change-in-execution	X
	7	step-limit	X
	8	blocked-by-mode	X
	9	blocked-by-process	X
	10	blocked-by-interlocking	X
	11	blocked-by-synchrocheck	X
	12	command-already-in-execution	X
	13	blocked-by-health	X
	14	1-of-n-control	X
	15	abortion-by-cancel	X
	16	time-limit-over	X
	17	abortion-by-trip	X
	18	object-not-selected	X
	19	Not in use	

Table continues on next page

	Attribute value	Description	Supported
Vendor specific	-20	Not in use	
	-21	Not in use	
	-23	blocked-for-command	X
	-24	blocked-for-open-command	X
	-25	blocked-for-close-command	X
	-26	Not in use	
	-27	Not in use	
	-28	Not in use	
	-29	Not in use	
	-30	long-operation-time	X
	-31	switch-not-start-moving	X
	-32	persisting-intermediate-state	X
	-33	switch-returned-to-initial-position	X
	-34	switch-in-bad-state	X
	-35	not-expected-final-position	X

11.2.3 Bay control QCBAY

11.2.3.1 Introduction

The bay control (QCBAY) function is used to handle the selection of the operator place per bay. QCBAY also provides blocking functions that can be distributed to different apparatuses within the bay.

11.2.3.2 Function block

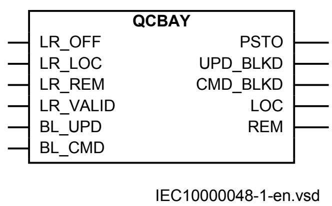


Figure 166: QCBAY function block

11.2.3.3 Input and output signals

Table 187: QCBAY Input signals

Name	Type	Default	Description
LR_OFF	BOOLEAN	0	External Local/Remote switch is in Off position
LR_LOC	BOOLEAN	0	External Local/Remote switch is in Local position
LR_REM	BOOLEAN	0	External Local/Remote switch is in Remote position
LR_VALID	BOOLEAN	0	Data representing the L/R switch position is valid
BL_UPD	BOOLEAN	0	Steady signal to block the position updates
BL_CMD	BOOLEAN	0	Steady signal to block the command

Table 188: QCBAY Output signals

Name	Type	Description
PSTO	INTEGER	Value for the operator place allocation
UPD_BLKD	BOOLEAN	Update of position is blocked
CMD_BLKD	BOOLEAN	Function is blocked for commands
LOC	BOOLEAN	Local operation allowed
REM	BOOLEAN	Remote operation allowed

11.2.3.4 Setting parameters

Table 189: QCBAY Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
AllPSTOValid	Priority No priority	-	-	Priority	Priority of originators

11.2.4 Local/Remote switch

11.2.4.1 Introduction

The signals from the local HMI or from an external local/remote switch are applied via function blocks LOCREM and LOCREMCTRL to the Bay control (QCBAY) function block. A parameter in function block LOCREM is set to choose if the switch signals are coming from the local HMI or from an external hardware switch connected via binary inputs.

11.2.4.2 Principle of operation

The function block Local remote (LOCREM) handles the signals coming from the local/remote switch. The connections are seen in figure 167, where the inputs on function block LOCREM are connected to binary inputs if an external switch is used. When a local HMI is used, the inputs are not used and are set to FALSE in the configuration. The outputs from the LOCREM function block control the output PSTO (Permitted Source To Operate) on Bay control (QCBAY).

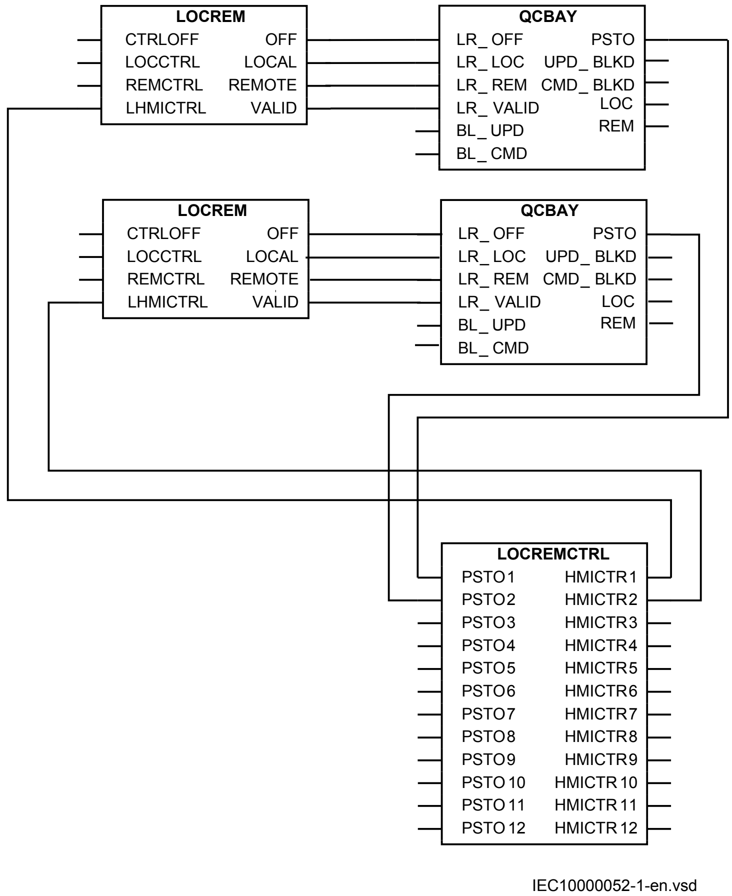
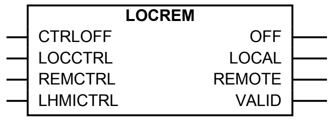


Figure 167: Configuration for the local/remote handling for a local HMI with two bays and two screen pages

If the IED contains control functions for several bays, the local/remote position can be different for the included bays. When the local HMI is used the position of the local/remote switch can be different depending on which single line diagram screen page that is presented on the local HMI. The function block Local remote control (LOCREMCTRL) controls the presentation of the LEDs for the local/remote position to applicable bay and screen page.

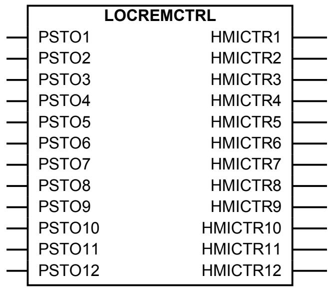
The switching of the local/remote switch requires at least system operator level. The password will be requested at an attempt to operate if authority levels have been defined in the IED. Otherwise the default authority level, SuperUser, can handle the control without LogOn. The users and passwords are defined in PCM600.

11.2.4.3 Function block



IEC05000360-2-en.vsd

Figure 168: LOCREM function block



IEC05000361-2-en.vsd

Figure 169: LOCREMCTRL function block

11.2.4.4 Input and output signals

Table 190: LOCREM Input signals

Name	Type	Default	Description
CTRLOFF	BOOLEAN	0	Disable control
LOCCTRL	BOOLEAN	0	Local in control
REMCTRL	BOOLEAN	0	Remote in control
LHMICTRL	INTEGER	0	LHMI control

Table 191: LOCREM Output signals

Name	Type	Description
OFF	BOOLEAN	Control is disabled
LOCAL	BOOLEAN	Local control is activated
REMOTE	BOOLEAN	Remote control is activated
VALID	BOOLEAN	Outputs are valid

Table 192: LOCREMCTRL Input signals

Name	Type	Default	Description
PSTO1	INTEGER	0	PSTO input channel 1
PSTO2	INTEGER	0	PSTO input channel 2
PSTO3	INTEGER	0	PSTO input channel 3
PSTO4	INTEGER	0	PSTO input channel 4
PSTO5	INTEGER	0	PSTO input channel 5
PSTO6	INTEGER	0	PSTO input channel 6
PSTO7	INTEGER	0	PSTO input channel 7
PSTO8	INTEGER	0	PSTO input channel 8
PSTO9	INTEGER	0	PSTO input channel 9
PSTO10	INTEGER	0	PSTO input channel 10
PSTO11	INTEGER	0	PSTO input channel 11
PSTO12	INTEGER	0	PSTO input channel 12

Table 193: LOCREMCTRL Output signals

Name	Type	Description
HMICTR1	INTEGER	Bitmask output 1 to local remote LHMI input
HMICTR2	INTEGER	Bitmask output 2 to local remote LHMI input
HMICTR3	INTEGER	Bitmask output 3 to local remote LHMI input
HMICTR4	INTEGER	Bitmask output 4 to local remote LHMI input
HMICTR5	INTEGER	Bitmask output 5 to local remote LHMI input
HMICTR6	INTEGER	Bitmask output 6 to local remote LHMI input
HMICTR7	INTEGER	Bitmask output 7 to local remote LHMI input
HMICTR8	INTEGER	Bitmask output 8 to local remote LHMI input
HMICTR9	INTEGER	Bitmask output 9 to local remote LHMI input
HMICTR10	INTEGER	Bitmask output 10 to local remote LHMI input
HMICTR11	INTEGER	Bitmask output 11 to local remote LHMI input
HMICTR12	INTEGER	Bitmask output 12 to local remote LHMI input

11.2.4.5 Setting parameters

Table 194: LOCREM Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
ControlMode	Internal LR-switch External LR-switch	-	-	Internal LR-switch	Control mode for internal/external LR-switch

11.2.5 Switch controller SCSWI

11.2.5.1 Introduction

The Switch controller (SCSWI) initializes and supervises all functions to properly select and operate switching primary apparatuses. The Switch controller may handle and operate on one three-phase device.

11.2.5.2 Principle of operation

The Switch controller (SCSWI) is provided with verification checks for the select - execute sequence, that is, checks the conditions prior each step of the operation. The involved functions for these condition verifications are interlocking, reservation, blockings and synchrocheck.

Control handling

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Two types of control models can be used. The two control models are "direct with normal security" and "SBO (Select-Before-Operate) with enhanced security". The parameter *CtlModel* defines which one of the two control models is used. The control model "direct with normal security" does not require a select whereas, the "SBO with enhanced security" command model requires a select before execution.

Normal security means that only the command is evaluated and the resulting position is not supervised. Enhanced security means that the command sequence is supervised in three steps, the selection, command evaluation and the supervision of position. Each step ends up with a pulsed signal to indicate that the respective step in the command sequence is finished. If an error occurs in one of the steps in the command sequence, the sequence is terminated and the error is mapped into the enumerated variable "cause" attribute belonging to the pulsed response signal for the IEC 61850 communication. The last cause L_CAUSE can be read from the function block and used for example at commissioning.

There is no relation between the command direction and the actual position. For example, if the switch is in close position it is possible to execute a close command.

Before an execution command, an evaluation of the position is done. If the parameter *PosDependent* is true and the position is in intermediate state or in bad state no execution command is sent. If the parameter is false the execution command is sent independent of the position value.

Evaluation of position

In the case when there are three one-phase switches connected to the switch control function, the switch control will "merge" the position of the three switches to the resulting three-phase position. In the case when the position differ between the one-phase switches, following principles will be applied:

The position output from switch (SXCBR or SXSWI) is connected to SCSWI. With the group signal connection the SCSWI obtains the position, time stamps and quality attributes of the position which is used for further evaluation.

All switches in open position:	switch control position = open
All switches in close position:	switch control position = close
One switch =open, two switches= close (or inversely):	switch control position = intermediate
Any switch in intermediate position:	switch control position = intermediate
Any switch in bad state:	switch control position = bad state

The time stamp of the output three-phase position from switch control will have the time stamp of the last changed phase when it goes to end position. When it goes to intermediate position or bad state, it will get the time stamp of the first changed phase.

In addition, there is also the possibility that one of the one-phase switches will change position at any time due to a trip. Such situation is here called pole discordance and is supervised by this function. In case of a pole discordance situation, that is, the position of the one-phase switches are not equal for a time longer than the setting *tPoleDiscord*, an error signal POLEDISC will be set.

In the supervision phase, the switch controller function evaluates the "cause" values from the switch modules Circuit breaker (SXCBR)/ Circuit switch (SXSWI). At error the "cause" value with highest priority is shown.

Blocking principles

The blocking signals are normally coming from the bay control function (QCBAY) and via the IEC 61850 communication from the operator place.

The different blocking possibilities are:

- Block/deblock of command. It is used to block command for operation of position.
- Blocking of function, BLOCK, signal from DO (Data Object) Behavior (IEC 61850). If DO Behavior is set to "blocked" it means that the function is active, but no outputs are generated, no reporting, control commands are rejected and functional and configuration data is visible.

The different block conditions will only affect the operation of this function, that is, no blocking signals will be "forwarded" to other functions. The above blocking outputs are stored in a non-volatile memory.

Interaction with synchrocheck and synchronizing functions

The Switch controller (SCSWI) works in conjunction with the synchrocheck and the synchronizing function (SESRSYN). It is assumed that the synchrocheck function is continuously in operation and gives the result to SCSWI. The result from the synchrocheck function is evaluated during the close execution. If the operator performs an override of the synchrocheck, the evaluation of the synchrocheck state is omitted. When there is a positive confirmation from the synchrocheck function, SCSWI will send the close signal EXE_CL to the switch function Circuit breaker (SXCBR).

When there is no positive confirmation from the synchrocheck function, SCSWI will send a start signal START_SY to the synchronizing function, which will send the closing command to SXCBR when the synchronizing conditions are fulfilled, see figure 170. If no synchronizing function is included, the timer for supervision of the "synchronizing in progress signal" is set to 0, which means no start of the synchronizing function. SCSWI will then set the attribute "blocked-by-synchrocheck" in the "cause" signal. See also the time diagram in figure 174.

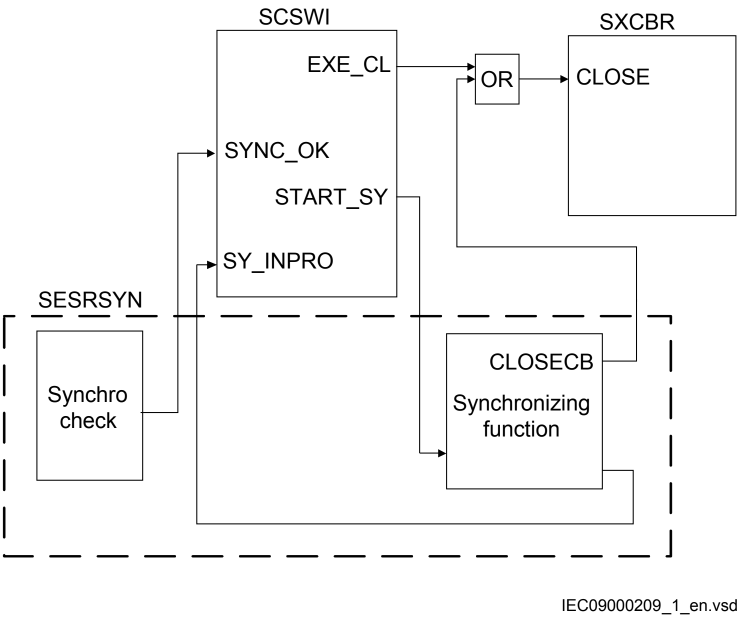


Figure 170: Example of interaction between SCSWI, SESRSYN (synchrocheck and synchronizing function) and SXCBR function

Time diagrams

The Switch controller (SCSWI) function has timers for evaluating different time supervision conditions. These timers are explained here.

The timer *tSelect* is used for supervising the time between the select and the execute command signal, that is, the time the operator has to perform the command execution after the selection of the object to operate.

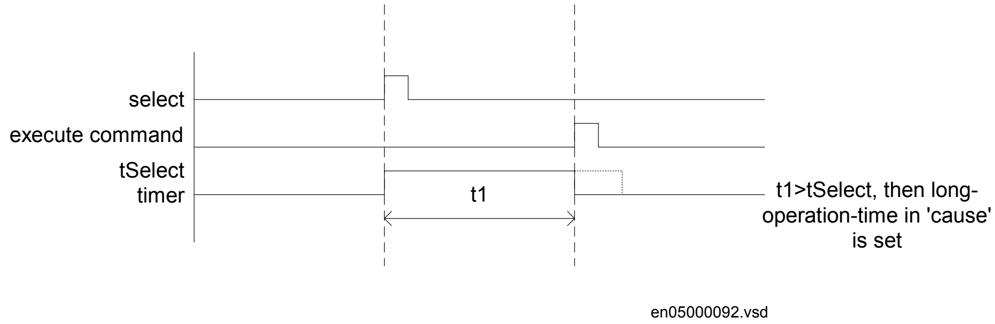


Figure 171: tSelect

The parameter *tResResponse* is used to set the maximum allowed time to make the reservation, that is, the time between reservation request and the feedback reservation granted from all bays involved in the reservation function.

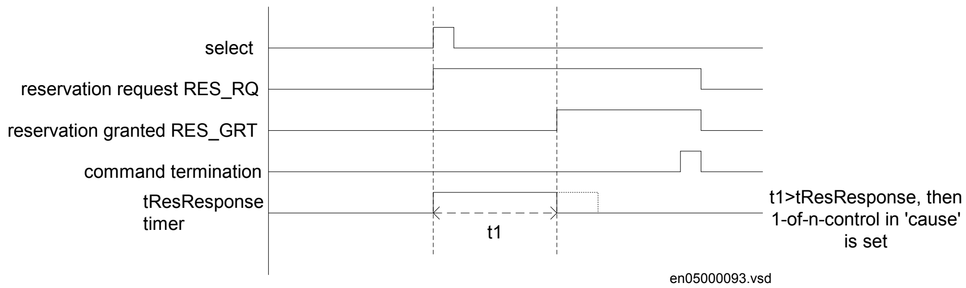


Figure 172: tResResponse

The timer *tExecutionFB* supervises the time between the execute command and the command termination, see figure 173.

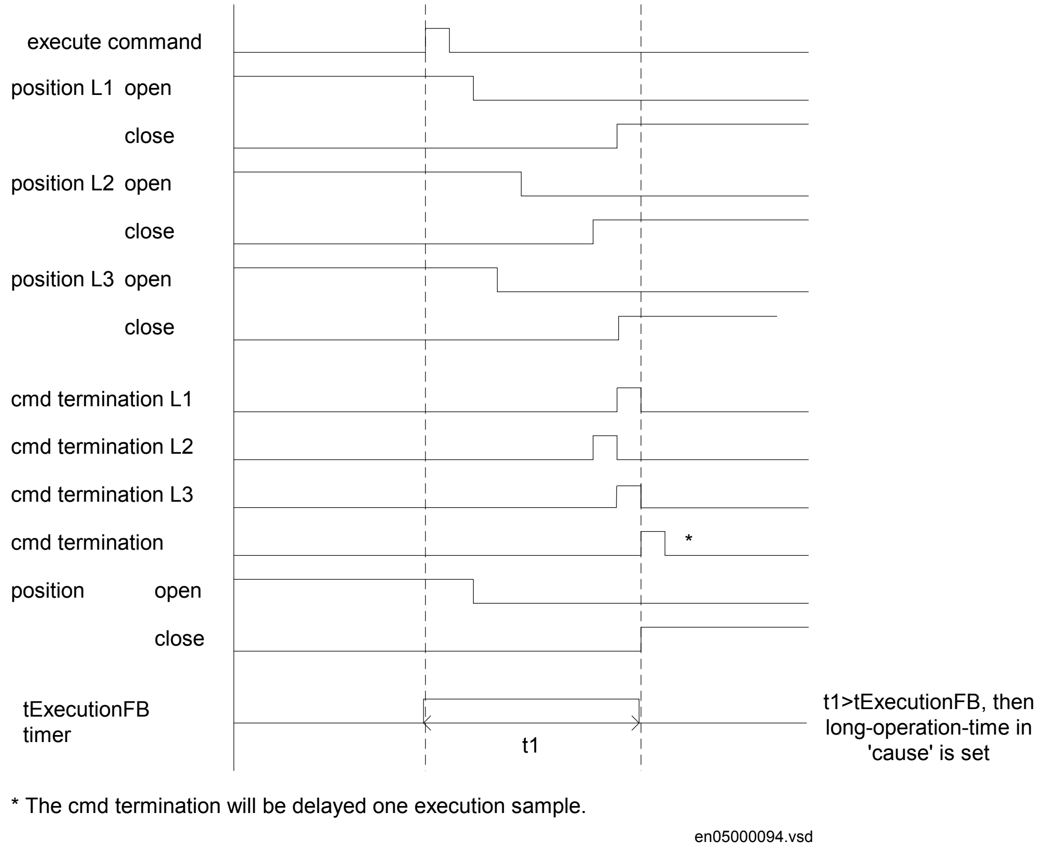


Figure 173: tExecutionFB

The parameter *tSynchrocheck* is used to define the maximum allowed time between the execute command and the input SYNC_OK to become true. If SYNC_OK=true at the time the execute command signal is received, the timer "tSynchrocheck" will not start. The start signal for the synchronizing is obtained if the synchrocheck conditions are not fulfilled.

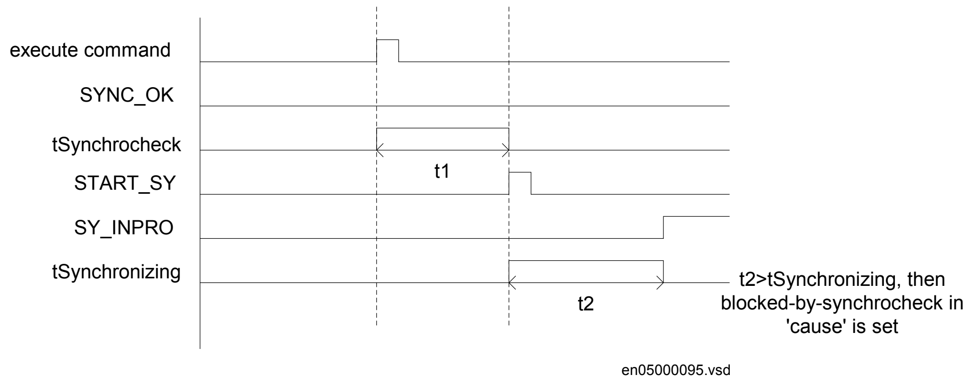


Figure 174: tSynchroCheck and tSynchronizing

11.2.5.3 Function block

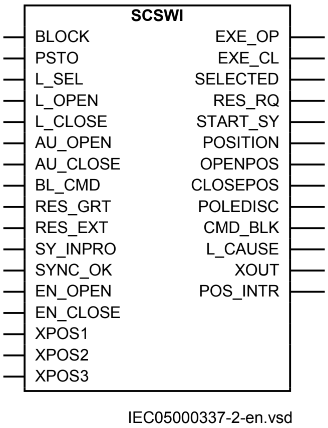


Figure 175: SCSWI function block

11.2.5.4 Input and output signals

Table 195: SCSWI Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of function
PSTO	INTEGER	2	Operator place selection
L_SEL	BOOLEAN	0	Select signal from local panel
L_OPEN	BOOLEAN	0	Open signal from local panel
L_CLOSE	BOOLEAN	0	Close signal from local panel
AU_OPEN	BOOLEAN	0	Used for local automation function
AU_CLOSE	BOOLEAN	0	Used for local automation function
BL_CMD	BOOLEAN	0	Steady signal for block of the command
RES_GRT	BOOLEAN	0	Positive acknowledge that all reservations are made
RES_EXT	BOOLEAN	0	Reservation is made externally
SY_INPRO	BOOLEAN	0	Synchronizing function in progress
SYNC_OK	BOOLEAN	0	Closing is permitted at set to true by the synchrocheck
EN_OPEN	BOOLEAN	0	Enables open operation
EN_CLOSE	BOOLEAN	0	Enables close operation
XPOS1	GROUP SIGNAL	-	Group signal from XCBR/XSWI per phase
XPOS2	GROUP SIGNAL	-	Group signal from XCBR/XSWI per phase
XPOS3	GROUP SIGNAL	-	Group signal from XCBR/XSWI per phase

Table 196: SCSWI Output signals

Name	Type	Description
EXE_OP	BOOLEAN	Execute command for open direction
EXE_CL	BOOLEAN	Execute command for close direction
SELECTED	BOOLEAN	Select conditions are fulfilled
RES_RQ	BOOLEAN	Request signal to the reservation function
START_SY	BOOLEAN	Starts the synchronizing function
POSITION	INTEGER	Position indication
OPENPOS	BOOLEAN	Open position indication
CLOSEPOS	BOOLEAN	Closed position indication
POLEDISC	BOOLEAN	The positions for poles L1-L3 are not equal after a set time
CMD_BLK	BOOLEAN	Commands are blocked
L_CAUSE	INTEGER	Latest value of the error indication during command
XOUT	BOOLEAN	Execution information to XCBR/XSWI
POS_INTR	BOOLEAN	Stopped in intermediate position

11.2.5.5 Setting parameters

Table 197: SCSWI Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
CtlModel	Dir Norm SBO Enh	-	-	SBO Enh	Specifies control model type
PosDependent	Always permitted Not perm at 00/11	-	-	Always permitted	Permission to operate depending on the position
tSelect	0.00 - 600.00	s	0.01	30.00	Maximum time between select and execute signals
tResResponse	0.000 - 60.000	s	0.001	5.000	Allowed time from reservation request to reservation granted
tSynchrocheck	0.00 - 600.00	s	0.01	10.00	Allowed time for synchrocheck to fulfil close conditions
tSynchronizing	0.00 - 600.00	s	0.01	0.00	Supervision time to get the signal synchronizing in progress
tExecutionFB	0.00 - 600.00	s	0.01	30.00	Maximum time from command execution to termination
tPoleDiscord	0.000 - 60.000	s	0.001	2.000	Allowed time to have discrepancy between the poles

11.2.6 Circuit breaker SXCBR

11.2.6.1 Introduction

The purpose of Circuit breaker (SXCBR) is to provide the actual status of positions and to perform the control operations, that is, pass all the commands to primary apparatuses in the form of circuit breakers via output boards and to supervise the switching operation and position.

11.2.6.2 Principle of operation

The users of the Circuit breaker function (SXCBR) is other functions such as for example, switch controller, protection functions, autorecloser function or an IEC 61850 client residing in another IED or the operator place. This switch function executes commands, evaluates block conditions and evaluates different time supervision conditions. Only if all conditions indicate a switch operation to be allowed, the function performs the execution command. In case of erroneous conditions, the function indicates an appropriate "cause" value.

SXCBR has an operation counter for closing and opening commands. The counter value can be read remotely from the operator place. The value is reset from a binary input or remotely from the operator place by configuring a signal from the Single Point Generic Control 8 signals (SPC8GGIO) for example.

Local/Remote switch

One binary input signal LR_SWI is included in SXCBR to indicate the local/ remote switch position from switchyard provided via the I/O board. If this signal is set to TRUE it means that change of position is allowed only from switchyard level. If the signal is set to FALSE it means that command from IED or higher level is permitted. When the signal is set to TRUE all commands (for change of position) from internal IED clients are rejected, even trip commands from protection functions are rejected. The functionality of the local/remote switch is described in figure 176.

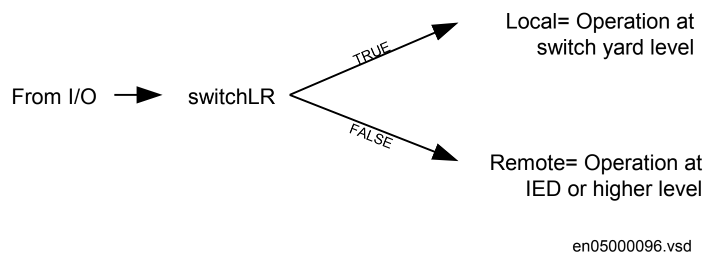


Figure 176: Local/Remote switch

Blocking principles

SXCBR includes several blocking principles. The basic principle for all blocking signals is that they will affect commands from all other clients for example, operators place, protection functions, autoreclosure and so on.

The blocking possibilities are:

- Block/deblock for open command. It is used to block operation for open command. Note that this block signal also affects the input OPEN for immediate command.
- Block/deblock for close command. It is used to block operation for close command. Note that this block signal also affects the input CLOSE for immediate command.
- Update block/deblock of positions. It is used to block the updating of position values. Other signals related to the position will be reset.
- Blocking of function, BLOCK, signal from DO (Data Object) Behavior (IEC 61850). If DO Behavior is set to "blocked" it means that the function is active, but no outputs are generated, no reporting, control commands are rejected and functional and configuration data is visible.

The above blocking outputs are stored in a non-volatile memory.

Substitution

The substitution part in SXCBR is used for manual set of the position for the switch. The typical use of substitution is that an operator enters a manual value because that the real process value is erroneous for some reason. SXCBR will then use the manually entered value instead of the value for positions determined by the process.

It is always possible to make a substitution, independently of the position indication and the status information of the I/O board. When substitution is enabled, the position values are blocked for updating and other signals related to the position are reset. The substituted values are stored in a non-volatile memory.

Time diagrams

There are two timers for supervising of the execute phase, *tStartMove* and *tIntermediate*. *tStartMove* supervises that the primary device starts moving after the execute output pulse is sent. *tIntermediate* defines the maximum allowed time for intermediate position. Figure 177 explains these two timers during the execute phase.

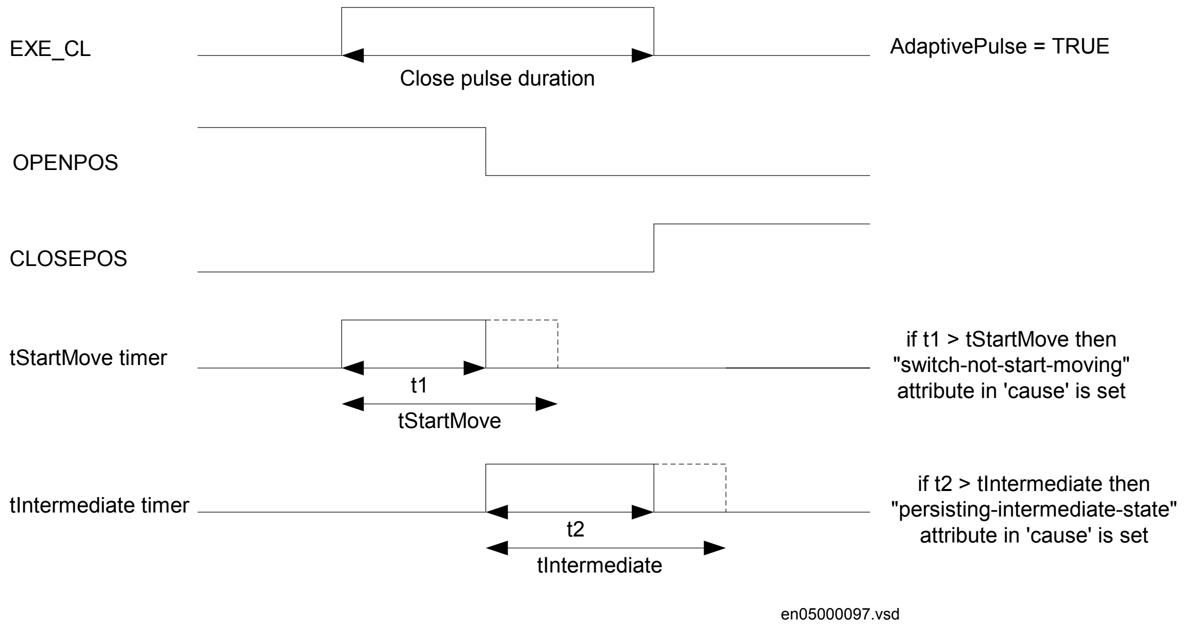


Figure 177: The timers tStartMove and tIntermediate

The timers *tOpenPulse* and *tClosePulse* are the length of the execute output pulses to be sent to the primary equipment. Note that the output pulses for open and close command can have different pulse lengths. The pulses can also be set to be adaptive with the configuration parameter *AdaptivePulse*. Figure 178 shows the principle of the execute output pulse. The *AdaptivePulse* parameter will have affect on both execute output pulses.

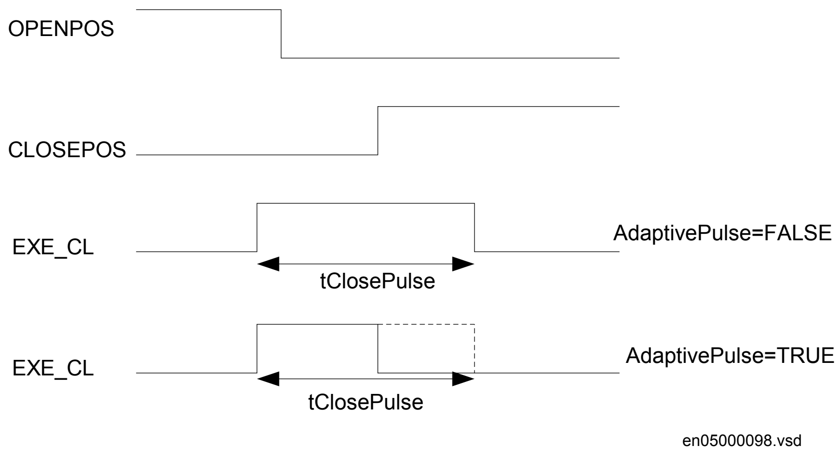


Figure 178: Execute output pulse

If the pulse is set to be adaptive, it is not possible for the pulse to exceed *tOpenPulse* or *tClosePulse*.

The execute output pulses are reset when:

- the new expected final position is reached and the configuration parameter *AdaptivePulse* is set to true
- the timer *tOpenPulse* or *tClosePulse* has elapsed
- an error occurs due to the switch does not start moving, that is, *tStartMove* has elapsed.

There is one exception from the first item above. If the primary device is in open position and an open command is executed or if the primary device is in closed position and a close command is executed. In these cases, with the additional condition that the configuration parameter *AdaptivePulse* is true, the execute output pulse is always activated and resets when *tStartMove* has elapsed. If the configuration parameter *AdaptivePulse* is set to false the execution output remains active until the pulse duration timer has elapsed.

If the start position indicates bad state (OPENPOS=1 and CLOSEPOS =1) when a command is executed the execute output pulse resets only when timer *tOpenPulse* or *tClosePulse* has elapsed.

An example of when a primary device is open and an open command is executed is shown in figure 179 .

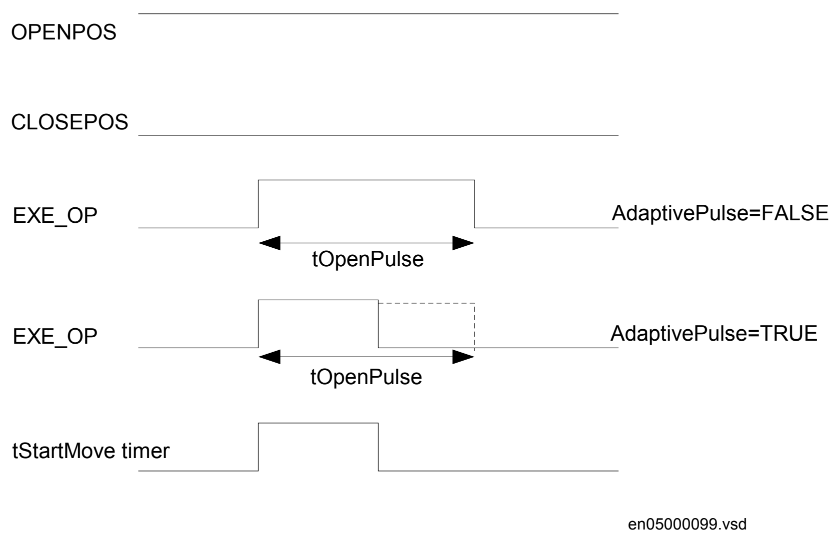


Figure 179: Open command with open position indication

11.2.6.3 Function block

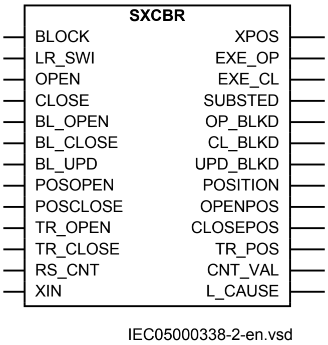


Figure 180: SXCBR function block

11.2.6.4 Input and output signals

Table 198: SXCBR Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of function
LR_SWI	BOOLEAN	0	Local/Remote switch indication from switchyard
OPEN	BOOLEAN	0	Pulsed signal used to immediately open the switch
CLOSE	BOOLEAN	0	Pulsed signal used to immediately close the switch
BL_OPEN	BOOLEAN	0	Signal to block the open command
BL_CLOSE	BOOLEAN	0	Signal to block the close command
BL_UPD	BOOLEAN	0	Steady signal for block of the position updating
POSOPEN	BOOLEAN	0	Signal for open position of apparatus from I/O
POSCLOSE	BOOLEAN	0	Signal for close position of apparatus from I/O
TR_OPEN	BOOLEAN	0	Signal for open position of truck from I/O
TR_CLOSE	BOOLEAN	0	Signal for close position of truck from I/O
RS_CNT	BOOLEAN	0	Resets the operation counter
XIN	BOOLEAN	0	Execution information from CSWI

Table 199: SXCBR Output signals

Name	Type	Description
XPOS	GROUP SIGNAL	Group signal for XCBR output
EXE_OP	BOOLEAN	Executes the command for open direction
EXE_CL	BOOLEAN	Executes the command for close direction
SUBSTED	BOOLEAN	Indication that the position is substituted
OP_BLKD	BOOLEAN	Indication that the function is blocked for open commands
CL_BLKD	BOOLEAN	Indication that the function is blocked for close commands

Table continues on next page

Name	Type	Description
UPD_BLKD	BOOLEAN	Update of position indication is blocked
POSITION	INTEGER	Apparatus position indication
OPENPOS	BOOLEAN	Apparatus open position
CLOSEPOS	BOOLEAN	Apparatus closed position
TR_POS	INTEGER	Truck position indication
CNT_VAL	INTEGER	Operation counter value
L_CAUSE	INTEGER	Latest value of the error indication during command

11.2.6.5 Setting parameters

Table 200: SXCBR Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
tStartMove	0.000 - 60.000	s	0.001	0.100	Supervision time for the apparatus to move after a command
tIntermediate	0.000 - 60.000	s	0.001	0.150	Allowed time for intermediate position
AdaptivePulse	Not adaptive Adaptive	-	-	Not adaptive	Output resets when a new correct end position is reached
tOpenPulse	0.000 - 60.000	s	0.001	0.200	Output pulse length for open command
tClosePulse	0.000 - 60.000	s	0.001	0.200	Output pulse length for close command
SuppressMidPos	Off On	-	-	On	Mid-position is suppressed during the time tIntermediate

11.2.7 Circuit switch SXSWI

11.2.7.1 Introduction

The purpose of Circuit switch (SXSWI) function is to provide the actual status of positions and to perform the control operations, that is, pass all the commands to primary apparatuses in the form of disconnectors or earthing switches via output boards and to supervise the switching operation and position.

11.2.7.2 Principle of operation

The users of the Circuit switch (SXSWI) is other functions such as for example, switch controller, protection functions, autorecloser function, or a 61850 client residing in another IED or the operator place. SXSWI executes commands, evaluates block conditions and evaluates different time supervision conditions. Only if all conditions indicate a switch operation to be allowed, SXSWI performs the execution command. In case of erroneous conditions, the function indicates an appropriate "cause" value.

SXSWI has an operation counter for closing and opening commands. The counter value can be read remotely from the operator place. The value is reset from a binary input or remotely from the operator place by configuring a signal from the Single Point Generic Control 8 signals (SPC8GGIO) for example.

Local/Remote switch

One binary input signal LR_SWI is included in SXSWI to indicate the local/remote switch position from switchyard provided via the I/O board. If this signal is set to TRUE it means that change of position is allowed only from switchyard level. If the signal is set to FALSE it means that command from IED or higher level is permitted. When the signal is set to TRUE all commands (for change of position) from internal IED clients are rejected, even trip commands from protection functions are rejected. The functionality of the local/remote switch is described in figure 181.

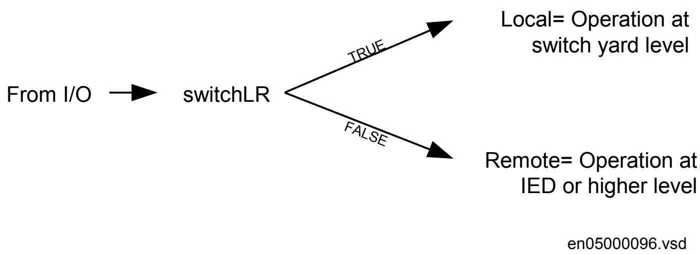


Figure 181: Local/Remote switch

Blocking principles

SXSWI includes several blocking principles. The basic principle for all blocking signals is that they will affect commands from all other clients for example, operators place, protection functions, autorecloser and so on.

The blocking possibilities are:

- Block/deblock for open command. It is used to block operation for open command. Note that this block signal also affects the input OPEN for immediate command.
- Block/deblock for close command. It is used to block operation for close command. Note that this block signal also affects the input CLOSE for immediate command.
- Update block/deblock of positions. It is used to block the updating of position values. Other signals related to the position will be reset.
- Blocking of function, BLOCK, signal from DO (Data Object) Behavior (IEC 61850). If DO Behavior is set to "blocked" it means that the function is active, but no outputs are generated, no reporting, control commands are rejected and functional and configuration data is visible.

The above blocking outputs are stored in a non-volatile memory.

Substitution

The substitution part in SXSWI is used for manual set of the position for the switch. The typical use of substitution is that an operator enters a manual value because the real process value is erroneous of some reason. SXSWI will then use the manually entered value instead of the value for positions determined by the process.

It is always possible to make a substitution, independently of the position indication and the status information of the I/O board. When substitution is enabled, the position values are blocked for updating and other signals related to the position are reset. The substituted values are stored in a non-volatile memory.

Time diagrams

There are two timers for supervising of the execute phase, *tStartMove* and *tIntermediate*. *tStartMove* supervises that the primary device starts moving after the execute output pulse is sent. *tIntermediate* defines the maximum allowed time for intermediate position. Figure 182 explains these two timers during the execute phase.

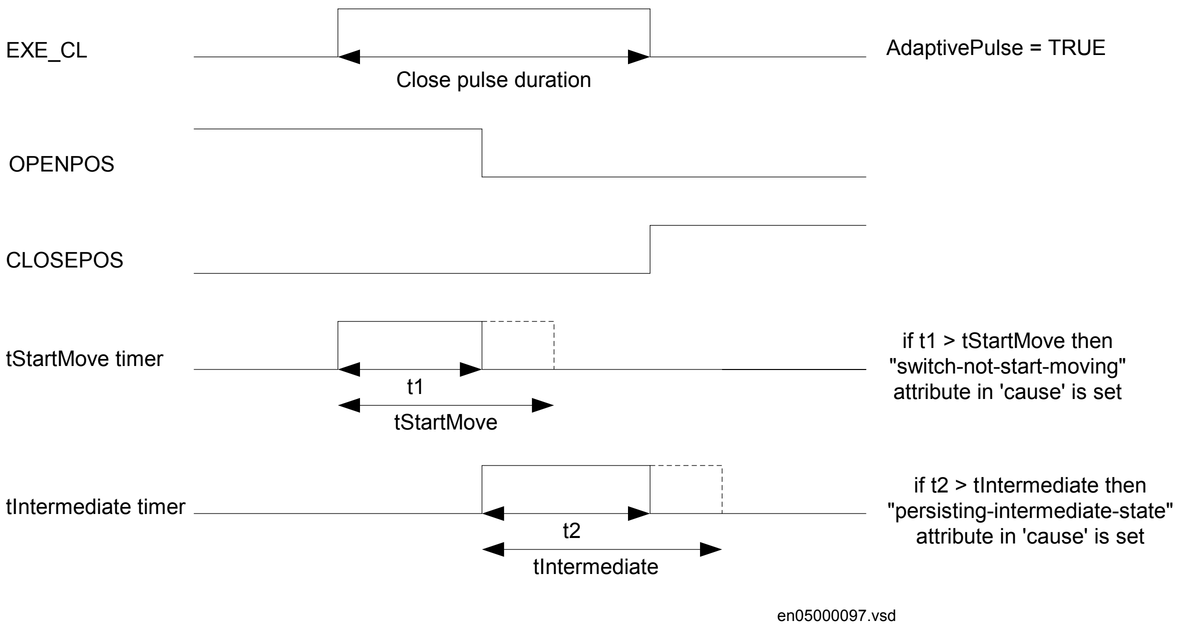


Figure 182: The timers tStartMove and tIntermediate

The timers *tOpenPulse* and *tClosePulse* are the length of the execute output pulses to be sent to the primary equipment. Note that the output pulses for open and close command can have different pulse lengths. The pulses can also be set to be adaptive with the configuration parameter *AdaptivePulse*. Figure 183 shows the principle of the execute output pulse. The *AdaptivePulse* parameter will have affect on both execute output pulses.

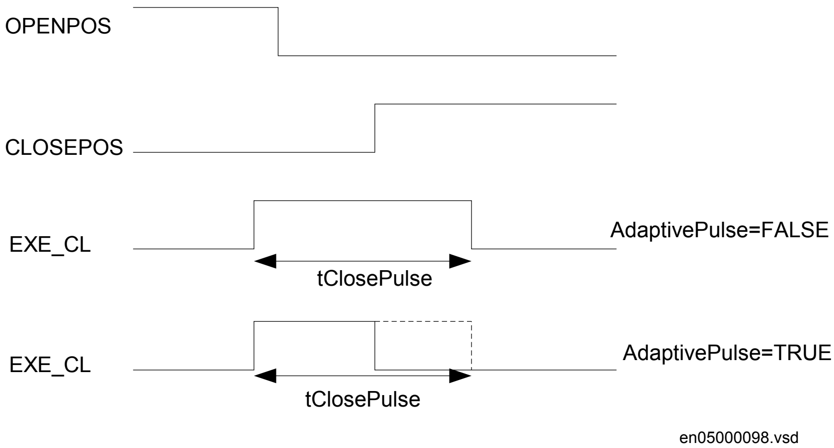


Figure 183: Execute output pulse

If the pulse is set to be adaptive, it is not possible for the pulse to exceed *tOpenPulse* or *tClosePulse*.

The execute output pulses are reset when:

If the start position indicates bad state (OPENPOS=1 and CLOSEPOS =1) when a command is executed the execute output pulse resets only when timer *tOpenPulse* or *tClosePulse* has elapsed.

- the new expected final position is reached and the configuration parameter *AdaptivePulse* is set to true
- the timer *tOpenPulse* or *tClosePulse* has elapsed
- an error occurs due to the switch does not start moving, that is, *tStartMove* has elapsed.

There is one exception from the first item above. If the primary device is in open position and an open command is executed or if the primary device is in close position and a close command is executed. In these cases, with the additional condition that the configuration parameter *AdaptivePulse* is true, the execute output pulse is always activated and resets when *tStartMove* has elapsed. If the configuration parameter *AdaptivePulse* is set to false the execution output remains active until the pulse duration timer has elapsed.

An example when a primary device is open and an open command is executed is shown in figure 184.

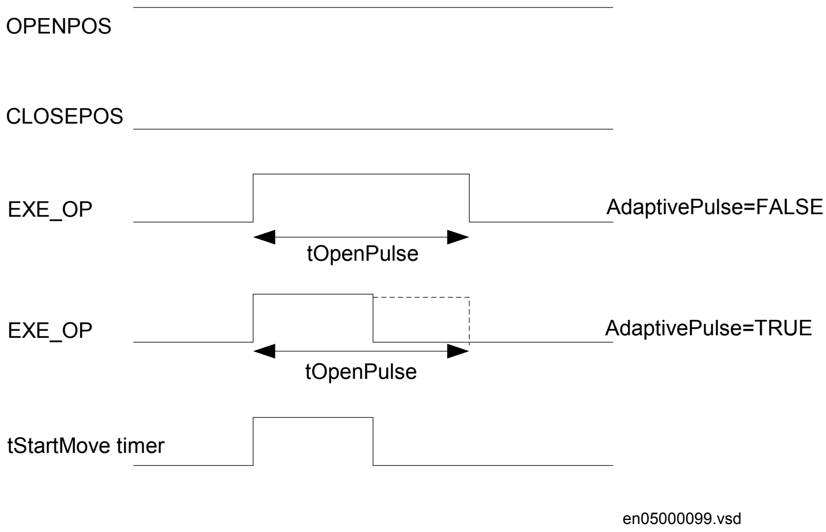


Figure 184: Open command with open position indication

11.2.7.3 Function block

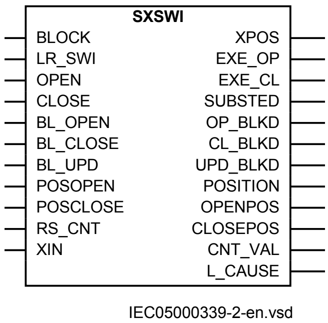


Figure 185: SXSWI function block

11.2.7.4 Input and output signals

Table 201: SXSWI Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of function
LR_SWI	BOOLEAN	0	Local/Remote switch indication from switchyard
OPEN	BOOLEAN	0	Pulsed signal used to immediately open the switch
CLOSE	BOOLEAN	0	Pulsed signal used to immediately close the switch
BL_OPEN	BOOLEAN	0	Signal to block the open command
BL_CLOSE	BOOLEAN	0	Signal to block the close command
BL_UPD	BOOLEAN	0	Steady signal for block of the position updating
POSOPEN	BOOLEAN	0	Signal for open position of apparatus from I/O

Table continues on next page

Name	Type	Default	Description
POSCLOSE	BOOLEAN	0	Signal for close position of apparatus from I/O
RS_CNT	BOOLEAN	0	Resets the operation counter
XIN	BOOLEAN	0	Execution information from CSWI

Table 202: SXSWI Output signals

Name	Type	Description
XPOS	GROUP SIGNAL	Group signal for XSWI output
EXE_OP	BOOLEAN	Executes the command for open direction
EXE_CL	BOOLEAN	Executes the command for close direction
SUBSTED	BOOLEAN	Indication that the position is substituted
OP_BLKD	BOOLEAN	Indication that the function is blocked for open commands
CL_BLKD	BOOLEAN	Indication that the function is blocked for close commands
UPD_BLKD	BOOLEAN	Update of position indication is blocked
POSITION	INTEGER	Apparatus position indication
OPENPOS	BOOLEAN	Apparatus open position
CLOSEPOS	BOOLEAN	Apparatus closed position
CNT_VAL	INTEGER	Operation counter value
L_CAUSE	INTEGER	Latest value of the error indication during command

11.2.7.5 Setting parameters

Table 203: SXSWI Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
tStartMove	0.000 - 60.000	s	0.001	3.000	Supervision time for the apparatus to move after a command
tIntermediate	0.000 - 60.000	s	0.001	15.000	Allowed time for intermediate position
AdaptivePulse	Not adaptive Adaptive	-	-	Not adaptive	Output resets when a new correct end position is reached
tOpenPulse	0.000 - 60.000	s	0.001	0.200	Output pulse length for open command
tClosePulse	0.000 - 60.000	s	0.001	0.200	Output pulse length for close command
SwitchType	Load Break Disconnector Earthing Switch HS Earthing Switch	-	-	Disconnector	1=LoadBreak,2=Disconnector, 3=EarthSw,4=HighSpeedEarthSw
SuppressMidPos	Off On	-	-	On	Mid-position is suppressed during the time tIntermediate

11.2.8 Bay reserve QCRSV

11.2.8.1 Introduction

The purpose of the reservation function is primarily to transfer interlocking information between IEDs in a safe way and to prevent double operation in a bay, switchyard part, or complete substation.

11.2.8.2 Principle of operation

The Bay reserve (QCRSV) function handles the reservation. QCRSV function starts to operate in two ways. It starts when there is a request for reservation of the own bay or if there is a request for reservation from another bay. It is only possible to reserve the function if it is not currently reserved. The signal that can reserve the own bay is the input signal RES_RQx (x=1-8) coming from switch controller (SCWI). The signals for request from another bay are the outputs RE_RQ_B and V_RE_RQ from function block RESIN. These signals are included in signal EXCH_OUT from RESIN and are connected to RES_DATA in QCRSV.

The parameters *ParamRequestx (x=1-8)* are chosen at reservation of the own bay only (TRUE) or other bays (FALSE). To reserve the own bay only means that no reservation request RES_BAYS is created.

Reservation request of own bay

If the reservation request comes from the own bay, the function QCRSV has to know which apparatus the request comes from. This information is available with the input signal RES_RQx and parameter *ParamRequestx* (where x=1-8 is the number of the requesting apparatus). In order to decide if a reservation request of the current bay can be permitted QCRSV has to know whether the own bay already is reserved by itself or another bay. This information is available in the output signal RESERVED.

If the RESERVED output is not set, the selection is made with the output RES_GRTx (where x=1-8 is the number of the requesting apparatus), which is connected to switch controller SCSWI. If the bay already is reserved the command sequence will be reset and the SCSWI will set the attribute "1-of-n-control" in the "cause" signal.

Reservation of other bays

When the function QCRSV receives a request from an apparatus in the own bay that requires other bays to be reserved as well, it checks if it already is reserved. If not, it will send a request to the other bays that are predefined (to be reserved) and wait for their response (acknowledge). The request of reserving other bays is done by activating the output RES_BAYS.

When it receives acknowledge from the bays via the input RES_DATA, it sets the output RES_GRTx (where x=1-8 is the number of the requesting apparatus). If not acknowledgement from all bays is received within a certain time defined in SCSWI (*tResResponse*), the SCSWI will reset the reservation and set the attribute "1-of-n-control" in the "cause" signal.

Reservation request from another bay

When another bay requests for reservation, the input BAY_RES in corresponding function block RESIN is activated. The signal for reservation request is grouped into the output signal EXCH_OUT in RESIN, which is connected to input RES_DATA in QCRSV. If the bay is not reserved, the bay will be reserved and the acknowledgment from output ACK_T_B is sent back to the requested bay. If the bay already is reserved the reservation is kept and no acknowledgment is sent.

Blocking and overriding of reservation

If QCRSV function is blocked (input BLK_RES is set to true) the reservation is blocked. That is, no reservation can be made from the own bay or any other bay. This can be set, for example, via a binary input from an external device to prevent operations from another operator place at the same time.

The reservation function can also be overridden in the own bay with the OVERRIDE input signal, that is, reserving the own bay without waiting for the external acknowledge.

Bay with more than eight apparatuses

If only one instance of QCRSV is used for a bay that is, use of up to eight apparatuses, the input EXCH_IN must be set to FALSE.

If there are more than eight apparatuses in the bay there has to be one additional QCRSV. The two QCRSV functions have to communicate and this is done through the input EXCH_IN and EXCH_OUT according to figure 186. If more then one QCRSV are used, the execution order is very important. The execution order must be in the way that the first QCRSV has a lower number than the next one.

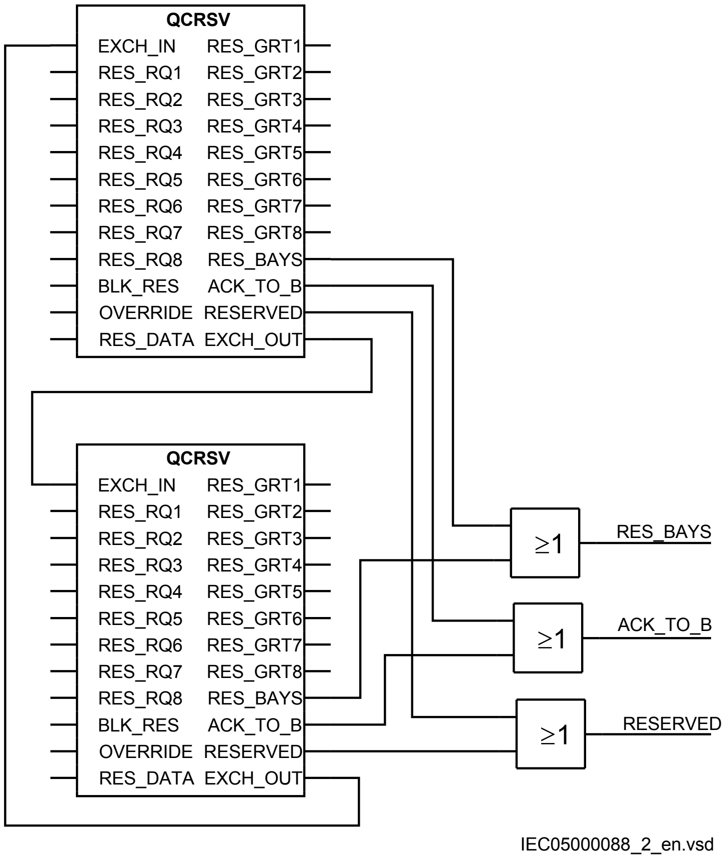


Figure 186: Connection of two QCRSV function blocks

11.2.8.3 Function block

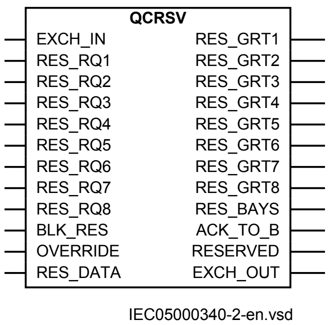


Figure 187: QCRSV function block

11.2.8.4 Input and output signals

Table 204: QCRSV Input signals

Name	Type	Default	Description
EXCH_IN	INTEGER	0	Used for exchange signals between different BayRes blocks
RES_RQ1	BOOLEAN	0	Signal for app. 1 that requests to do a reservation
RES_RQ2	BOOLEAN	0	Signal for app. 2 that requests to do a reservation
RES_RQ3	BOOLEAN	0	Signal for app. 3 that requests to do a reservation
RES_RQ4	BOOLEAN	0	Signal for app. 4 that requests to do a reservation
RES_RQ5	BOOLEAN	0	Signal for app. 5 that requests to do a reservation
RES_RQ6	BOOLEAN	0	Signal for app. 6 that requests to do a reservation
RES_RQ7	BOOLEAN	0	Signal for app. 7 that requests to do a reservation
RES_RQ8	BOOLEAN	0	Signal for app. 8 that requests to do a reservation
BLK_RES	BOOLEAN	0	Reservation is not possible and the output signals are reset
OVERRIDE	BOOLEAN	0	Signal to override the reservation
RES_DATA	INTEGER	0	Reservation data coming from function block ResIn

Table 205: QCRSV Output signals

Name	Type	Description
RES_GRT1	BOOLEAN	Reservation is made and the app. 1 is allowed to operate
RES_GRT2	BOOLEAN	Reservation is made and the app. 2 is allowed to operate
RES_GRT3	BOOLEAN	Reservation is made and the app. 3 is allowed to operate
RES_GRT4	BOOLEAN	Reservation is made and the app. 4 is allowed to operate
RES_GRT5	BOOLEAN	Reservation is made and the app. 5 is allowed to operate
RES_GRT6	BOOLEAN	Reservation is made and the app. 6 is allowed to operate
RES_GRT7	BOOLEAN	Reservation is made and the app. 7 is allowed to operate
RES_GRT8	BOOLEAN	Reservation is made and the app. 8 is allowed to operate
RES_BAYS	BOOLEAN	Request for reservation of other bays
ACK_TO_B	BOOLEAN	Acknowledge to other bays that this bay is reserved
RESERVED	BOOLEAN	Indicates that the bay is reserved
EXCH_OUT	INTEGER	Used for exchange signals between different BayRes blocks

11.2.8.5 Setting parameters

Table 206: QCRSV Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
tCancelRes	0.000 - 60.000	s	0.001	10.000	Supervision time for canceling the reservation
ParamRequest1	Other bays res. Only own bay res.	-	-	Only own bay res.	Reservation of the own bay only, at selection of apparatus 1
ParamRequest2	Other bays res. Only own bay res.	-	-	Only own bay res.	Reservation of the own bay only, at selection of apparatus 2
ParamRequest3	Other bays res. Only own bay res.	-	-	Only own bay res.	Reservation of the own bay only, at selection of apparatus 3
ParamRequest4	Other bays res. Only own bay res.	-	-	Only own bay res.	Reservation of the own bay only, at selection of apparatus 4
ParamRequest5	Other bays res. Only own bay res.	-	-	Only own bay res.	Reservation of the own bay only, at selection of apparatus 5
ParamRequest6	Other bays res. Only own bay res.	-	-	Only own bay res.	Reservation of the own bay only, at selection of apparatus 6
ParamRequest7	Other bays res. Only own bay res.	-	-	Only own bay res.	Reservation of the own bay only, at selection of apparatus 7
ParamRequest8	Other bays res. Only own bay res.	-	-	Only own bay res.	Reservation of the own bay only, at selection of apparatus 8

11.2.9 Reservation input RESIN

11.2.9.1 Introduction

The Reservation input (RESIN) function receives the reservation information from other bays. The number of instances is the same as the number of involved bays (up to 60 instances are available).

11.2.9.2 Principle of operation

The reservation input (RESIN) function is based purely on Boolean logic conditions. The logic diagram in figure 188 shows how the output signals are created. The inputs of the function block are connected to a receive function block representing signals transferred over the station bus from another bay.

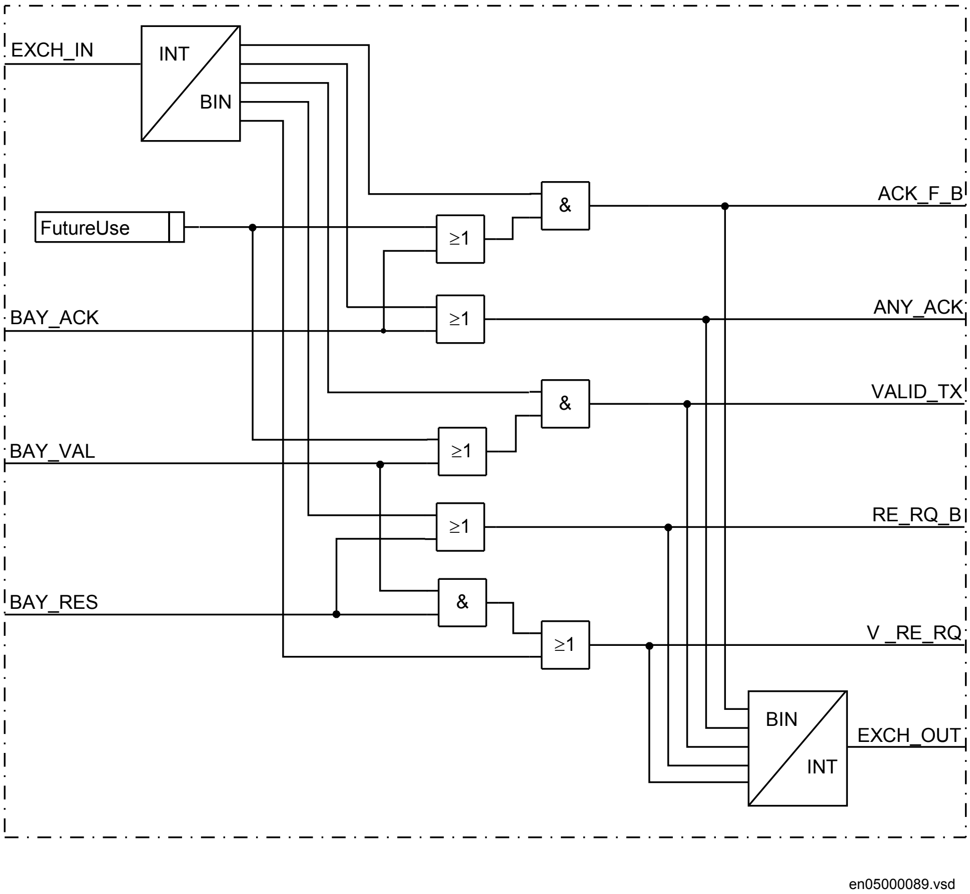


Figure 188: Logic diagram for RESIN

Figure 189 describes the principle of the data exchange between all RESIN modules in the current bay. There is one RESIN function block per "other bay" used in the reservation mechanism. The output signal EXCH_OUT in the last RESIN functions are connected to the module bay reserve (QCRSV) that handles the reservation function in the own bay. The value to the input EXCH_IN on the first RESIN module in the chain has the integer value 5. This is provided by the use of instance number one of the function block RESIN, where the input EXCH_IN is set to #5, but is hidden for the user.

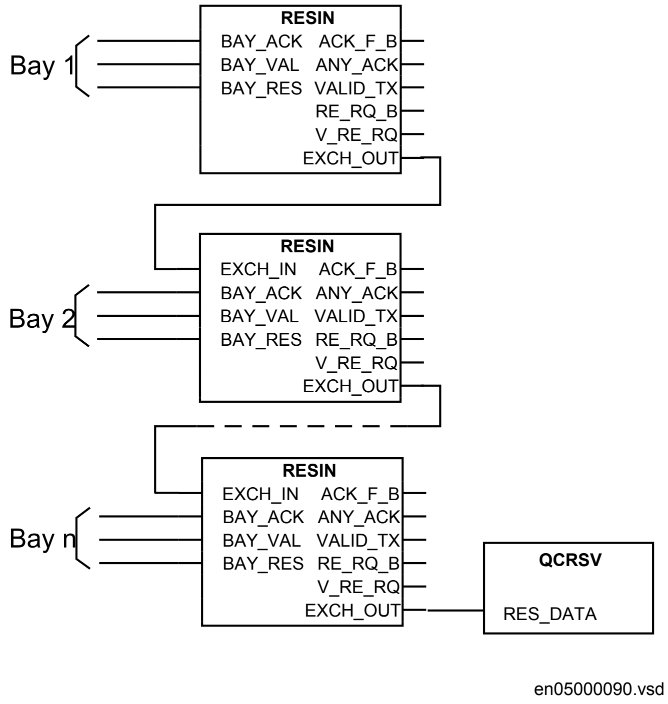


Figure 189: Diagram of the chaining principle for RESIN

11.2.9.3 Function block

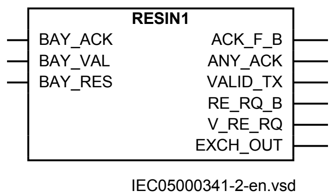


Figure 190: RESIN1 function block

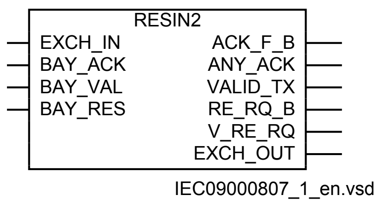


Figure 191: RESIN2 function block

11.2.9.4 Input and output signals

Table 207: RESIN1 Input signals

Name	Type	Default	Description
BAY_ACK	BOOLEAN	0	Another bay has acknow. the reservation req. from this bay
BAY_VAL	BOOLEAN	0	The reserv. and acknow. signals from another bay are valid
BAY_RES	BOOLEAN	0	Request from other bay to reserve this bay

Table 208: RESIN1 Output signals

Name	Type	Description
ACK_F_B	BOOLEAN	All other bays have acknow. the reserv. req. from this bay
ANY_ACK	BOOLEAN	Any other bay has acknow. the reserv. req. from this bay
VALID_TX	BOOLEAN	The reserv. and acknow. signals from other bays are valid
RE_RQ_B	BOOLEAN	Request from other bay to reserve this bay
V_RE_RQ	BOOLEAN	Check if the request of reserving this bay is valid
EXCH_OUT	INTEGER	Used for exchange signals between different ResIn blocks

Table 209: RESIN2 Input signals

Name	Type	Default	Description
EXCH_IN	INTEGER	5	Used for exchange signals between different ResIn blocks
BAY_ACK	BOOLEAN	0	Another bay has acknow. the reservation req. from this bay
BAY_VAL	BOOLEAN	0	The reserv. and acknow. signals from another bay are valid
BAY_RES	BOOLEAN	0	Request from other bay to reserve this bay

Table 210: RESIN2 Output signals

Name	Type	Description
ACK_F_B	BOOLEAN	All other bays have acknow. the reserv. req. from this bay
ANY_ACK	BOOLEAN	Any other bay has acknow. the reserv. req. from this bay
VALID_TX	BOOLEAN	The reserv. and acknow. signals from other bays are valid
RE_RQ_B	BOOLEAN	Request from other bay to reserve this bay
V_RE_RQ	BOOLEAN	Check if the request of reserving this bay is valid
EXCH_OUT	INTEGER	Used for exchange signals between different ResIn blocks

11.2.9.5 Setting parameters

Table 211: RESIN1 Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
FutureUse	Bay in use Bay future use	-	-	Bay in use	The bay for this ResIn block is for future use

Table 212: RESIN2 Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
FutureUse	Bay in use Bay future use	-	-	Bay in use	The bay for this ResIn block is for future use

11.3 Interlocking

11.3.1 Introduction

The interlocking function blocks the possibility to operate high-voltage switching devices, for instance when a disconnector is under load, in order to prevent material damage and/or accidental human injury.

Each control IED has interlocking functions for different switchyard arrangements, each handling the interlocking of one bay. The function is distributed to each control IED and not dependent on any central function. For the station-wide interlocking, the IEDs communicate via the station bus or by using hard wired binary inputs/outputs.

The interlocking conditions depend on the circuit configuration and status of the installation at any given time.

11.3.2 Principle of operation

The interlocking function consists of software modules located in each control IED. The function is distributed and not dependent on any central function. Communication between modules in different bays is performed via the station bus.

The reservation function (see section "Introduction") is used to ensure that HV apparatuses that might affect the interlock are blocked during the time gap, which arises between position updates. This can be done by means of the communication system, reserving all HV apparatuses that might influence the interlocking condition of the intended operation. The reservation is maintained until the operation is performed.

After the selection and reservation of an apparatus, the function has complete data on the status of all apparatuses in the switchyard that are affected by the selection.

Other operators cannot interfere with the reserved apparatus or the status of switching devices that may affect it.

The open or closed positions of the HV apparatuses are inputs to software modules distributed in the control IEDs. Each module contains the interlocking logic for a bay. The interlocking logic in a module is different, depending on the bay function and the switchyard arrangements, that is, double-breaker or 1 1/2 breaker bays have different modules. Specific interlocking conditions and connections between standard interlocking modules are performed with an engineering tool. Bay-level interlocking signals can include the following kind of information:

- Positions of HV apparatuses (sometimes per phase)
- Valid positions (if evaluated in the control module)
- External release (to add special conditions for release)
- Line voltage (to block operation of line earthing switch)
- Output signals to release the HV apparatus

The interlocking module is connected to the surrounding functions within a bay as shown in figure 192.

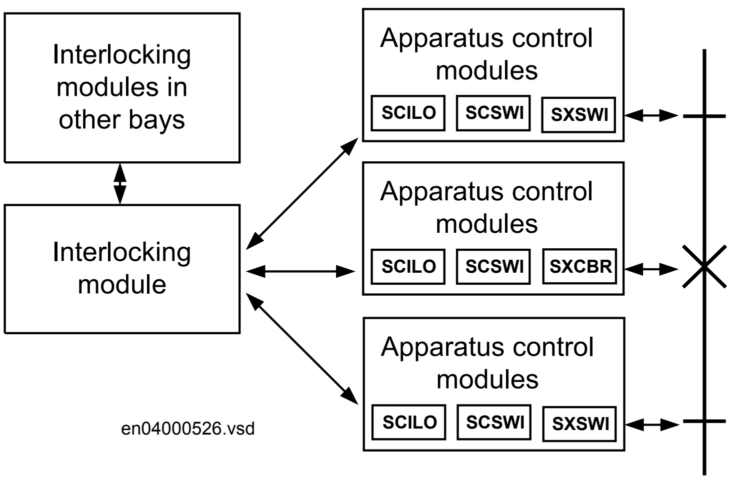


Figure 192: Interlocking module on bay level

Bays communicate via the station bus and can convey information regarding the following:

- Unearthed busbars
- Busbars connected together
- Other bays connected to a busbar
- Received data from other bays is valid

Figure 193 illustrates the data exchange principle.

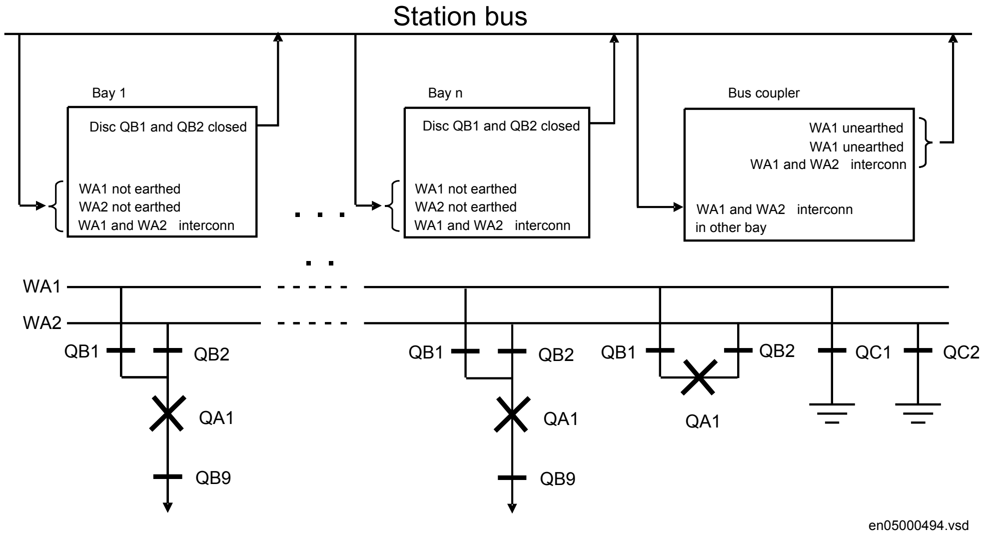


Figure 193: Data exchange between interlocking modules

When invalid data such as intermediate position, loss of a control IED, or input board error are used as conditions for the interlocking condition in a bay, a release for execution of the function will not be given.

On the local HMI an override function exists, which can be used to bypass the interlocking function in cases where not all the data required for the condition is valid.

For all interlocking modules these general rules apply:

- The interlocking conditions for opening or closing of disconnectors and earthing switches are always identical.
- Earthing switches on the line feeder end, for example, rapid earthing switches, are normally interlocked only with reference to the conditions in the bay where they are located, not with reference to switches on the other side of the line. So a line voltage indication may be included into line interlocking modules. If there is no line voltage supervision within the bay, then the appropriate inputs must be set to *no voltage*, and the operator must consider this when operating.
- Earthing switches can only be operated on isolated sections for example, without load/voltage. Circuit breaker contacts cannot be used to isolate a section, that is, the status of the circuit breaker is irrelevant as far as the earthing switch operation is concerned.
- Disconnectors cannot break power current or connect different voltage systems. Disconnectors in series with a circuit breaker can only be operated if the circuit breaker is open, or if the disconnectors operate in parallel with other closed connections. Other disconnectors can be operated if one side is completely isolated, or if the disconnectors operate in parallel to other closed connections, or if they are earthed on both sides.
- Circuit breaker closing is only interlocked against running disconnectors in its bay or additionally in a transformer bay against the disconnectors and earthing

switch on the other side of the transformer, if there is no disconnector between CB and transformer.
- Circuit breaker opening is only interlocked in a bus-coupler bay, if a bus bar transfer is in progress.

To make the implementation of the interlocking function easier, a number of standardized and tested software interlocking modules containing logic for the interlocking conditions are available:

- Line for double and transfer busbars, ABC_LINE
- Bus for double and transfer busbars, ABC_BC
- Transformer bay for double busbars, AB_TRAFO
- Bus-section breaker for double busbars, A1A2_BS
- Bus-section disconnector for double busbars, A1A2_DC
- Busbar earthing switch, BB_ES
- Double CB Bay, DB_BUS_A, DB_LINE, DB_BUS_B
- 1 1/2-CB diameter, BH_LINE_A, BH_CONN, BH_LINE_B

The interlocking conditions can be altered, to meet the customer specific requirements, by adding configurable logic by means of the graphical configuration tool PCM600. The inputs Qx_EXy on the interlocking modules are used to add these specific conditions.

The input signals EXDU_xx shall be set to true if there is no transmission error at the transfer of information from other bays. Required signals with designations ending in TR are intended for transfer to other bays.

11.3.3 Logical node for interlocking SCILO

11.3.3.1 Introduction

The Logical node for interlocking SCILO function is used to enable a switching operation if the interlocking conditions permit. SCILO function itself does not provide any interlocking functionality. The interlocking conditions are generated in separate function blocks containing the interlocking logic.

11.3.3.2 Logic diagram

The function contains logic to enable the open and close commands respectively if the interlocking conditions are fulfilled. That means also, if the switch has a defined end position for example, open, then the appropriate enable signal (in this case EN_OPEN) is false. The enable signals EN_OPEN and EN_CLOSE can be true at the same time only in the intermediate and bad position state and if they are enabled by the interlocking function. The position inputs come from the logical nodes Circuit breaker/Circuit switch (SXCBR/SXSWI) and the enable signals come from the interlocking logic. The outputs are connected to the logical node Switch controller (SCSWI). One instance per switching device is needed.

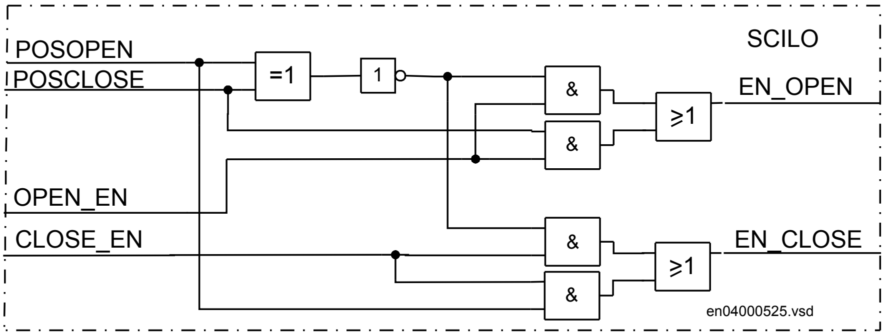


Figure 194: SCILO function logic diagram

11.3.3.3 Function block

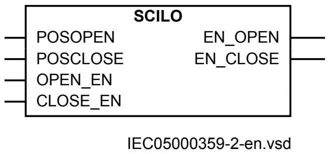


Figure 195: SCILO function block

11.3.3.4 Input and output signals

Table 213: SCILO Input signals

Name	Type	Default	Description
POSOPEN	BOOLEAN	0	Open position of switch device
POSCLOSE	BOOLEAN	0	Closed position of switch device
OPEN_EN	BOOLEAN	0	Open operation from interlocking logic is enabled
CLOSE_EN	BOOLEAN	0	Close operation from interlocking logic is enabled

Table 214: SCILO Output signals

Name	Type	Description
EN_OPEN	BOOLEAN	Open operation at closed or interm. or bad pos. is enabled
EN_CLOSE	BOOLEAN	Close operation at open or interm. or bad pos. is enabled

11.3.4 Interlocking for busbar earthing switch BB_ES

11.3.4.1 Introduction

The interlocking for busbar earthing switch (BB_ES) function is used for one busbar earthing switch on any busbar parts according to figure 196.

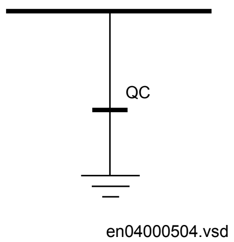


Figure 196: Switchyard layout BB_ES

11.3.4.2 Function block

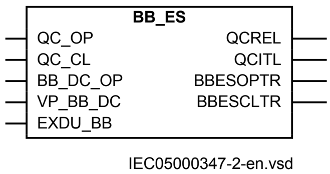
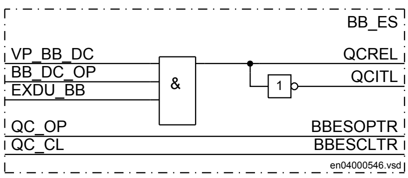


Figure 197: BB_ES function block

11.3.4.3 Logic diagram



11.3.4.4 Input and output signals

Table 215: BB_ES Input signals

Name	Type	Default	Description
QC_OP	BOOLEAN	0	Busbar earthing switch QC is in open position
QC_CL	BOOLEAN	0	Busbar earthing switch QC is in closed position
BB_DC_OP	BOOLEAN	0	All disconnectors on this busbar part are open
VP_BB_DC	BOOLEAN	0	Status for all disconnectors on this busbar part are valid
EXDU_BB	BOOLEAN	0	No transm error from bays with disc on this busbar part

Table 216: BB_ES Output signals

Name	Type	Description
QCREL	BOOLEAN	Switching of QC is allowed
QCITL	BOOLEAN	Switching of QC is forbidden
BBESOPTR	BOOLEAN	QC on this busbar part is in open position
BBESCLTR	BOOLEAN	QC on this busbar part is in closed position

11.3.5 Interlocking for bus-section breaker A1A2_BS

11.3.5.1 Introduction

The interlocking for bus-section breaker (A1A2_BS) function is used for one bus-section circuit breaker between section 1 and 2 according to figure 198. The function can be used for different busbars, which includes a bus-section circuit breaker.

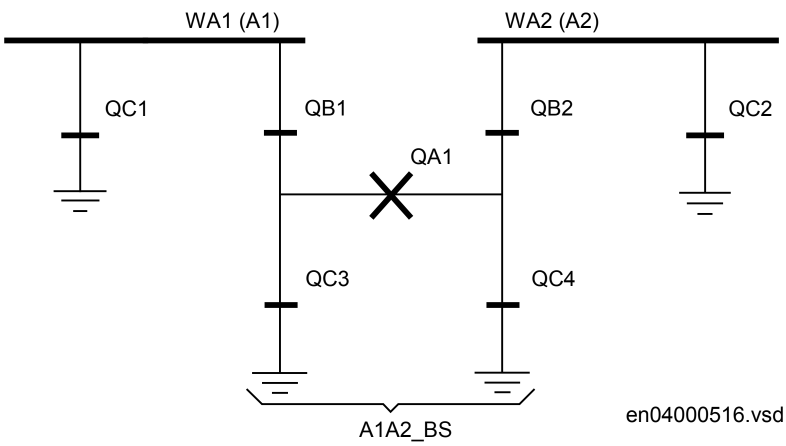


Figure 198: Switchyard layout A1A2_BS

11.3.5.2 Function block

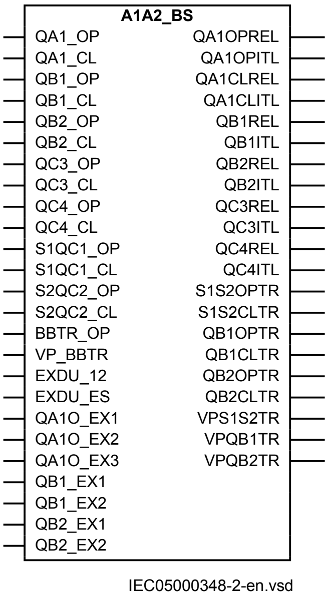
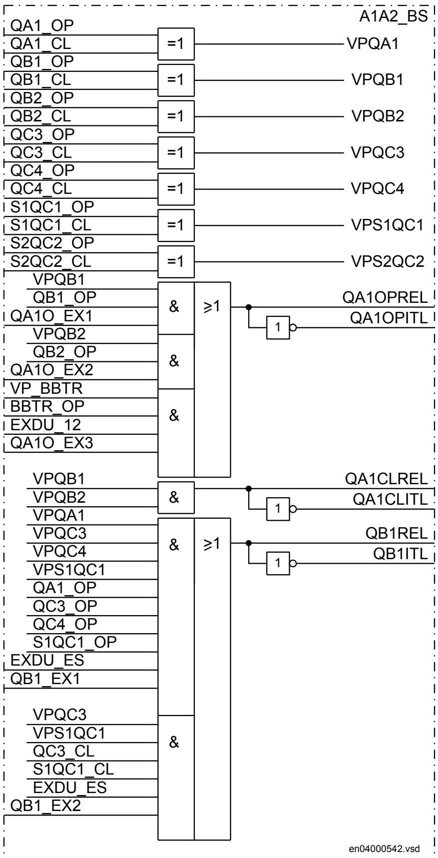
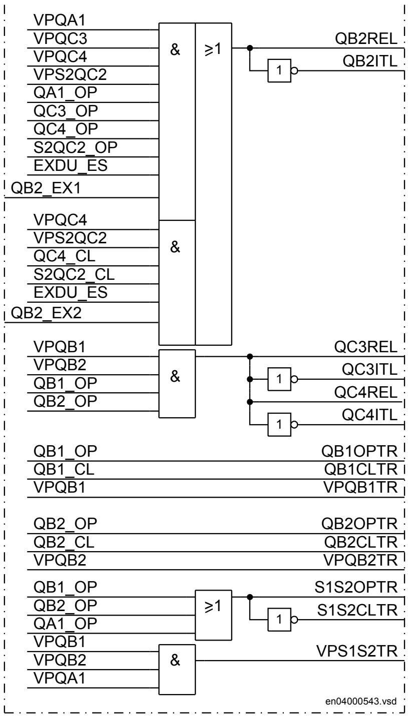


Figure 199: A1A2_BS function block

11.3.5.3 Logic diagram





11.3.5.4 Input and output signals

Table 217: A1A2_BS Input signals

Name	Type	Default	Description
QA1_OP	BOOLEAN	0	QA1 is in open position
QA1_CL	BOOLEAN	0	QA1 is in closed position
QB1_OP	BOOLEAN	0	QB1 is in open position
QB1_CL	BOOLEAN	0	QB1 is in closed position
QB2_OP	BOOLEAN	0	QB2 is in open position
QB2_CL	BOOLEAN	0	QB2 is in closed position
QC3_OP	BOOLEAN	0	QC3 is in open position
QC3_CL	BOOLEAN	0	QC3 is in closed position
QC4_OP	BOOLEAN	0	QC4 is in open position
QC4_CL	BOOLEAN	0	QC4 is in closed position
S1QC1_OP	BOOLEAN	0	QC1 on bus section 1 is in open position
S1QC1_CL	BOOLEAN	0	QC1 on bus section 1 is in closed position
S2QC2_OP	BOOLEAN	0	QC2 on bus section 2 is in open position
S2QC2_CL	BOOLEAN	0	QC2 on bus section 2 is in closed position
BBTR_OP	BOOLEAN	0	No busbar transfer is in progress
VP_BBTR	BOOLEAN	0	Status are valid for app. involved in the busbar transfer

Table continues on next page

Name	Type	Default	Description
EXDU_12	BOOLEAN	0	No transm error from any bay connected to busbar 1 and 2
EXDU_ES	BOOLEAN	0	No transm error from bays containing earth. sw. QC1 or QC2
QA1O_EX1	BOOLEAN	0	External open condition for apparatus QA1
QA1O_EX2	BOOLEAN	0	External open condition for apparatus QA1
QA1O_EX3	BOOLEAN	0	External open condition for apparatus QA1
QB1_EX1	BOOLEAN	0	External condition for apparatus QB1
QB1_EX2	BOOLEAN	0	External condition for apparatus QB1
QB2_EX1	BOOLEAN	0	External condition for apparatus QB2
QB2_EX2	BOOLEAN	0	External condition for apparatus QB2

Table 218: A1A2_BS Output signals

Name	Type	Description
QA1OPREL	BOOLEAN	Opening of QA1 is allowed
QA1OPITL	BOOLEAN	Opening of QA1 is forbidden
QA1CLREL	BOOLEAN	Closing of QA1 is allowed
QA1CLITL	BOOLEAN	Closing of QA1 is forbidden
QB1REL	BOOLEAN	Switching of QB1 is allowed
QB1ITL	BOOLEAN	Switching of QB1 is forbidden
QB2REL	BOOLEAN	Switching of QB2 is allowed
QB2ITL	BOOLEAN	Switching of QB2 is forbidden
QC3REL	BOOLEAN	Switching of QC3 is allowed
QC3ITL	BOOLEAN	Switching of QC3 is forbidden
QC4REL	BOOLEAN	Switching of QC4 is allowed
QC4ITL	BOOLEAN	Switching of QC4 is forbidden
S1S2OPTR	BOOLEAN	No bus section connection between bus section 1 and 2
S1S2CLTR	BOOLEAN	Bus coupler connection between bus section 1 and 2 exists
QB1OPTR	BOOLEAN	QB1 is in open position
QB1CLTR	BOOLEAN	QB1 is in closed position
QB2OPTR	BOOLEAN	QB2 is in open position
QB2CLTR	BOOLEAN	QB2 is in closed position
VPS1S2TR	BOOLEAN	Status of the app. between bus section 1 and 2 are valid
VPQB1TR	BOOLEAN	Switch status of QB1 is valid (open or closed)
VPQB2TR	BOOLEAN	Switch status of QB2 is valid (open or closed)

11.3.6 Interlocking for bus-section disconnector A1A2_DC

11.3.6.1 Introduction

The interlocking for bus-section disconnector (A1A2_DC) function is used for one bus-section disconnector between section 1 and 2 according to figure 200. A1A2_DC function can be used for different busbars, which includes a bus-section disconnector.

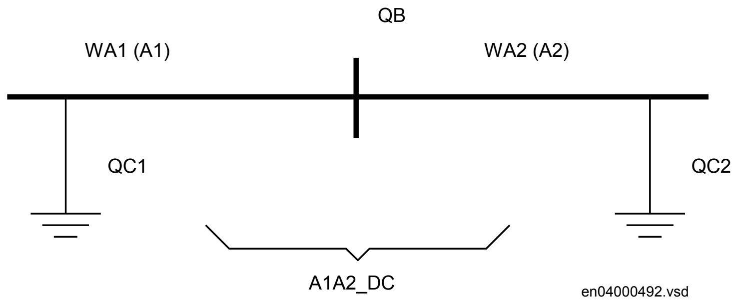


Figure 200: Switchyard layout A1A2_DC

11.3.6.2 Function block

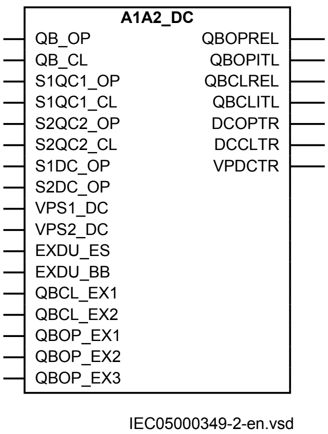
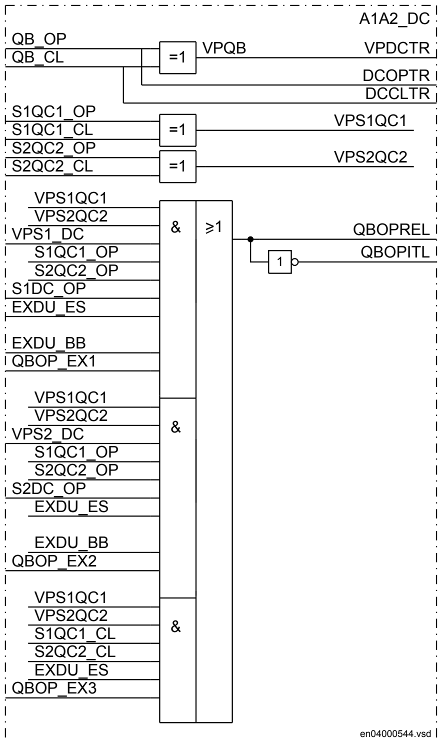
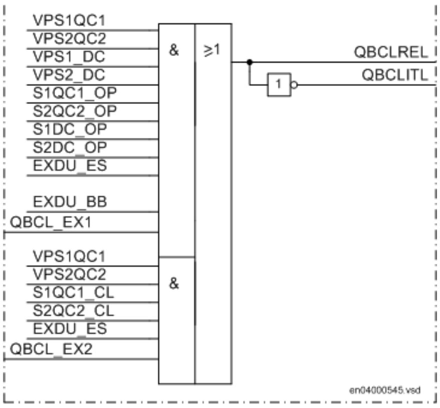


Figure 201: A1A2_DC function block

11.3.6.3 Logic diagram





11.3.6.4 Input and output signals

Table 219: A1A2_DC Input signals

Name	Type	Default	Description
QB_OP	BOOLEAN	0	QB is in open position
QB_CL	BOOLEAN	0	QB is in closed position
S1QC1_OP	BOOLEAN	0	QC1 on bus section 1 is in open position
S1QC1_CL	BOOLEAN	0	QC1 on bus section 1 is in closed position
Table continues on next page			

Name	Type	Default	Description
S2QC2_OP	BOOLEAN	0	QC2 on bus section 2 is in open position
S2QC2_CL	BOOLEAN	0	QC2 on bus section 2 is in closed position
S1DC_OP	BOOLEAN	0	All disconnectors on bus section 1 are in open position
S2DC_OP	BOOLEAN	0	All disconnectors on bus section 2 are in open position
VPS1_DC	BOOLEAN	0	Switch status of disconnectors on bus section 1 are valid
VPS2_DC	BOOLEAN	0	Switch status of disconnectors on bus section 2 are valid
EXDU_ES	BOOLEAN	0	No transm error from bays containing earth. sw. QC1 or QC2
EXDU_BB	BOOLEAN	0	No transm error from bays with disc conn to section 1 and 2
QBCL_EX1	BOOLEAN	0	External close condition for section disconnector QB
QBCL_EX2	BOOLEAN	0	External close condition for section disconnector QB
QBOP_EX1	BOOLEAN	0	External open condition for section disconnector QB
QBOP_EX2	BOOLEAN	0	External open condition for section disconnector QB
QBOP_EX3	BOOLEAN	0	External open condition for section disconnector QB

Table 220: A1A2_DC Output signals

Name	Type	Description
QBOPREL	BOOLEAN	Opening of QB is allowed
QBOPITL	BOOLEAN	Opening of QB is forbidden
QBCLREL	BOOLEAN	Closing of QB is allowed
QBCLITL	BOOLEAN	Closing of QB is forbidden
DCOPTR	BOOLEAN	The bus section disconnector is in open position
DCCLTR	BOOLEAN	The bus section disconnector is in closed position
VPDCTR	BOOLEAN	Switch status of QB is valid (open or closed)

11.3.7 Interlocking for bus-coupler bay ABC_BC

11.3.7.1 Introduction

The interlocking for bus-coupler bay (ABC_BC) function is used for a bus-coupler bay connected to a double busbar arrangement according to figure 202. The function can also be used for a single busbar arrangement with transfer busbar or double busbar arrangement without transfer busbar.

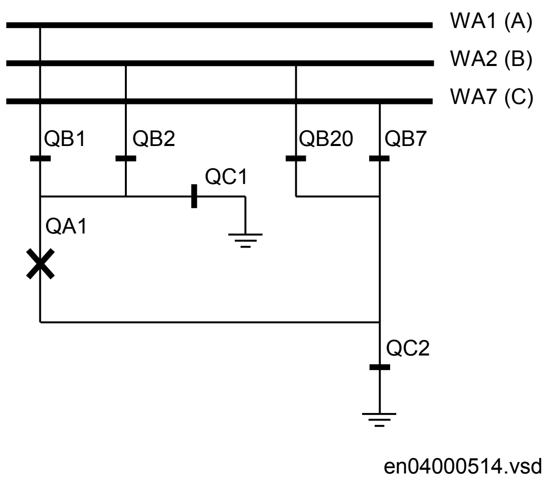


Figure 202: Switchyard layout ABC_BC

11.3.7.2 Function block

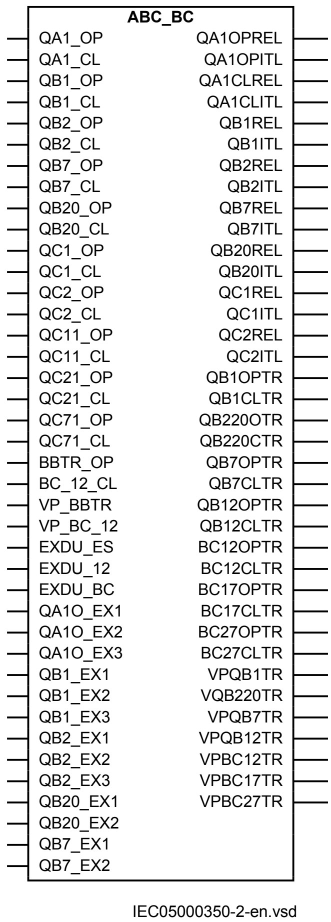
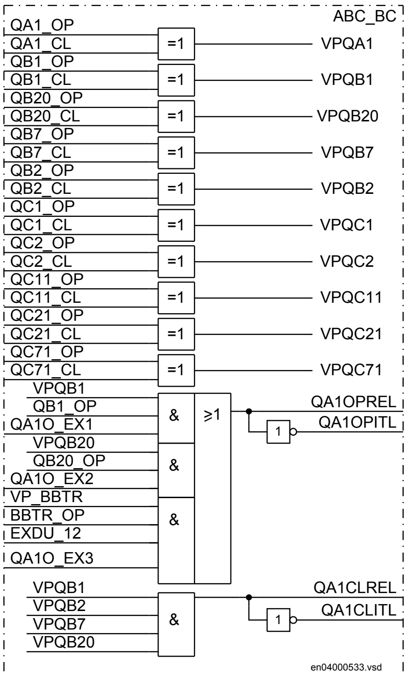
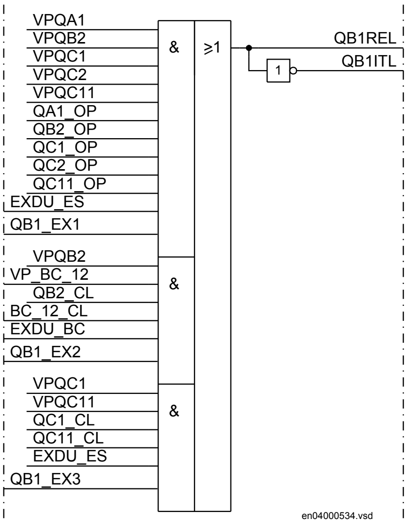
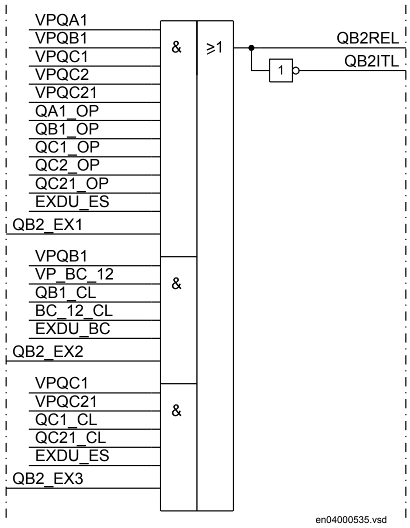


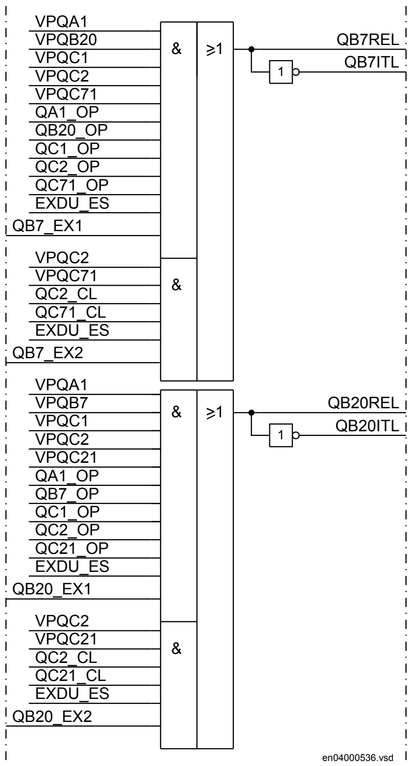
Figure 203: ABC_BC function block

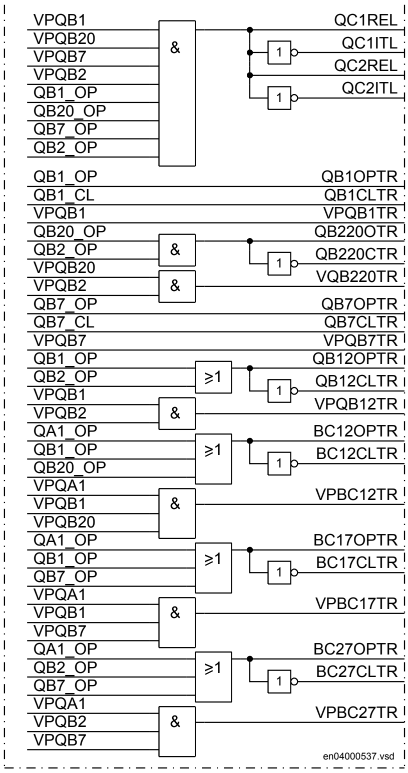
11.3.7.3 Logic diagram






VPQA1
VPQB1
VPQC1
VPQC2
VPQC21
QA1_OP
QB1_OP
QC1_OP
QC2_OP
QC21_OP
EXDU_ES
QB2_EX1
VPQB1
VP_BC_12
QB1_CL
BC_12_CL
EXDU_BC
QB2_EX2
VPQC1
VPQC21
QC1_CL
QC21_CL
EXDU_ES
QB2_EX3
&
&
&
≥1
1
QB2REL
QB2ITL
en04000535.vsd


VPQA1
VPQB20
VPQC1
VPQC2
VPQC71
QA1_OP
QB20_OP
QC1_OP
QC2_OP
QC71_OP
EXDU_ES
QB7_EX1
VPQC2
VPQC71
QC2_CL
QC71_CL
EXDU_ES
QB7_EX2
&
&
≥1
1
QB7REL
QB7ITL
VPQA1
VPQB7
VPQC1
VPQC2
VPQC21
QA1_OP
QB7_OP
QC1_OP
QC2_OP
QC21_OP
EXDU_ES
QB20_EX1
VPQC2
VPQC21
QC2_CL
QC21_CL
EXDU_ES
QB20_EX2
&
&
≥1
1
QB20REL
QB20ITL
en04000536.vsd



11.3.7.4 Input and output signals

Table 221: ABC_BC Input signals

Name	Type	Default	Description
QA1_OP	BOOLEAN	0	QA1 is in open position
QA1_CL	BOOLEAN	0	QA1 is in closed position
QB1_OP	BOOLEAN	0	QB1 is in open position
QB1_CL	BOOLEAN	0	QB1 is in closed position
QB2_OP	BOOLEAN	0	QB2 is in open position
QB2_CL	BOOLEAN	0	QB2 is in closed position
QB7_OP	BOOLEAN	0	QB7 is in open position
QB7_CL	BOOLEAN	0	QB7 is in closed position
QB20_OP	BOOLEAN	0	QB20 is in open position
QB20_CL	BOOLEAN	0	QB20 is in closed position
QC1_OP	BOOLEAN	0	QC1 is in open position
QC1_CL	BOOLEAN	0	QC1 is in closed position
QC2_OP	BOOLEAN	0	QC2 is in open position
QC2_CL	BOOLEAN	0	QC2 is in closed position
QC11_OP	BOOLEAN	0	Earthing switch QC11 on busbar WA1 is in open position
Table continues on next page			

Name	Type	Default	Description
QC11_CL	BOOLEAN	0	Earthing switch QC11 on busbar WA1 is in closed position
QC21_OP	BOOLEAN	0	Earthing switch QC21 on busbar WA2 is in open position
QC21_CL	BOOLEAN	0	Earthing switch QC21 on busbar WA2 is in closed position
QC71_OP	BOOLEAN	0	Earthing switch QC71 on busbar WA7 is in open position
QC71_CL	BOOLEAN	0	Earthing switch QC71 on busbar WA7 is in closed position
BBTR_OP	BOOLEAN	0	No busbar transfer is in progress
BC_12_CL	BOOLEAN	0	A bus coupler connection exists between busbar WA1 and WA2
VP_BBTR	BOOLEAN	0	Status are valid for app. involved in the busbar transfer
VP_BC_12	BOOLEAN	0	Status of the bus coupler app. between WA1 and WA2 are valid
EXDU_ES	BOOLEAN	0	No transm error from any bay containing earthing switches
EXDU_12	BOOLEAN	0	No transm error from any bay connected to WA1/ WA2 busbars
EXDU_BC	BOOLEAN	0	No transmission error from any other bus coupler bay
QA1O_EX1	BOOLEAN	0	External open condition for apparatus QA1
QA1O_EX2	BOOLEAN	0	External open condition for apparatus QA1
QA1O_EX3	BOOLEAN	0	External open condition for apparatus QA1
QB1_EX1	BOOLEAN	0	External condition for apparatus QB1
QB1_EX2	BOOLEAN	0	External condition for apparatus QB1
QB1_EX3	BOOLEAN	0	External condition for apparatus QB1
QB2_EX1	BOOLEAN	0	External condition for apparatus QB2
QB2_EX2	BOOLEAN	0	External condition for apparatus QB2
QB2_EX3	BOOLEAN	0	External condition for apparatus QB2
QB20_EX1	BOOLEAN	0	External condition for apparatus QB20
QB20_EX2	BOOLEAN	0	External condition for apparatus QB20
QB7_EX1	BOOLEAN	0	External condition for apparatus QB7
QB7_EX2	BOOLEAN	0	External condition for apparatus QB7

Table 222: ABC_BC Output signals

Name	Type	Description
QA1OPREL	BOOLEAN	Opening of QA1 is allowed
QA1OPITL	BOOLEAN	Opening of QA1 is forbidden
QA1CLREL	BOOLEAN	Closing of QA1 is allowed
QA1CLITL	BOOLEAN	Closing of QA1 is forbidden
Table continues on next page		

Name	Type	Description
QB1REL	BOOLEAN	Switching of QB1 is allowed
QB1ITL	BOOLEAN	Switching of QB1 is forbidden
QB2REL	BOOLEAN	Switching of QB2 is allowed
QB2ITL	BOOLEAN	Switching of QB2 is forbidden
QB7REL	BOOLEAN	Switching of QB7 is allowed
QB7ITL	BOOLEAN	Switching of QB7 is forbidden
QB20REL	BOOLEAN	Switching of QB20 is allowed
QB20ITL	BOOLEAN	Switching of QB20 is forbidden
QC1REL	BOOLEAN	Switching of QC1 is allowed
QC1ITL	BOOLEAN	Switching of QC1 is forbidden
QC2REL	BOOLEAN	Switching of QC2 is allowed
QC2ITL	BOOLEAN	Switching of QC2 is forbidden
QB1OPTR	BOOLEAN	QB1 is in open position
QB1CLTR	BOOLEAN	QB1 is in closed position
QB220OTR	BOOLEAN	QB2 and QB20 are in open position
QB220CTR	BOOLEAN	QB2 or QB20 or both are not in open position
QB7OPTR	BOOLEAN	QB7 is in open position
QB7CLTR	BOOLEAN	QB7 is in closed position
QB12OPTR	BOOLEAN	QB1 or QB2 or both are in open position
QB12CLTR	BOOLEAN	QB1 and QB2 are not in open position
BC12OPTR	BOOLEAN	No connection via the own bus coupler between WA1 and WA2
BC12CLTR	BOOLEAN	Conn. exists via the own bus coupler between WA1 and WA2
BC17OPTR	BOOLEAN	No connection via the own bus coupler between WA1 and WA7
BC17CLTR	BOOLEAN	Conn. exists via the own bus coupler between WA1 and WA7
BC27OPTR	BOOLEAN	No connection via the own bus coupler between WA2 and WA7
BC27CLTR	BOOLEAN	Conn. exists via the own bus coupler between WA2 and WA7
VPQB1TR	BOOLEAN	Switch status of QB1 is valid (open or closed)
VQB220TR	BOOLEAN	Switch status of QB2 and QB20 are valid (open or closed)
VPQB7TR	BOOLEAN	Switch status of QB7 is valid (open or closed)
VPQB12TR	BOOLEAN	Switch status of QB1 and QB2 are valid (open or closed)
VPBC12TR	BOOLEAN	Status of the bus coupler app. between WA1 and WA2 are valid
VPBC17TR	BOOLEAN	Status of the bus coupler app. between WA1 and WA7 are valid
VPBC27TR	BOOLEAN	Status of the bus coupler app. between WA2 and WA7 are valid

11.3.8 Interlocking for 1 1/2 CB BH

11.3.8.1 Introduction

The interlocking for 1 1/2 breaker diameter (BH_CONN, BH_LINE_A, BH_LINE_B) functions are used for lines connected to a 1 1/2 breaker diameter according to figure 204.

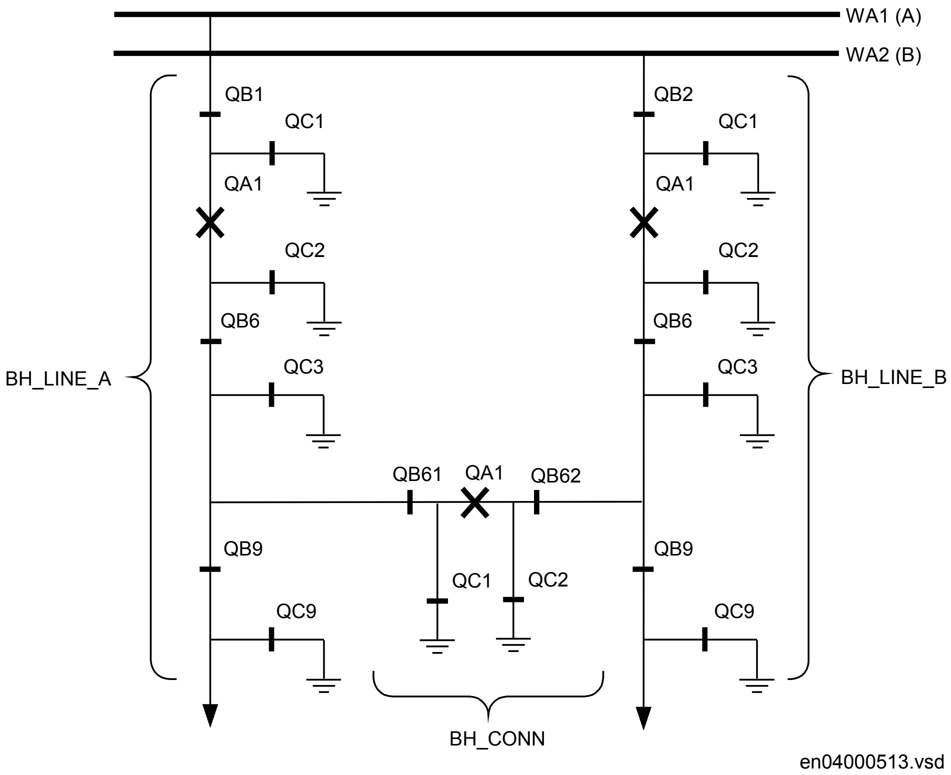


Figure 204: Switchyard layout 1 1/2 breaker

Three types of interlocking modules per diameter are defined. BH_LINE_A and BH_LINE_B are the connections from a line to a busbar. BH_CONN is the connection between the two lines of the diameter in the 1 1/2 breaker switchyard layout.

11.3.8.2 Function blocks

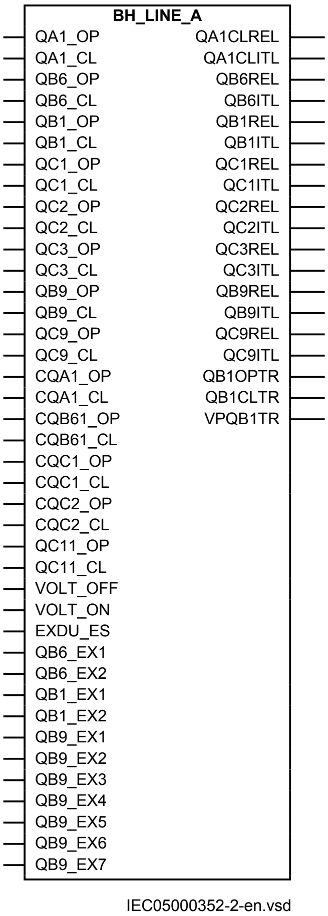


Figure 205: BH_LINE_A function block

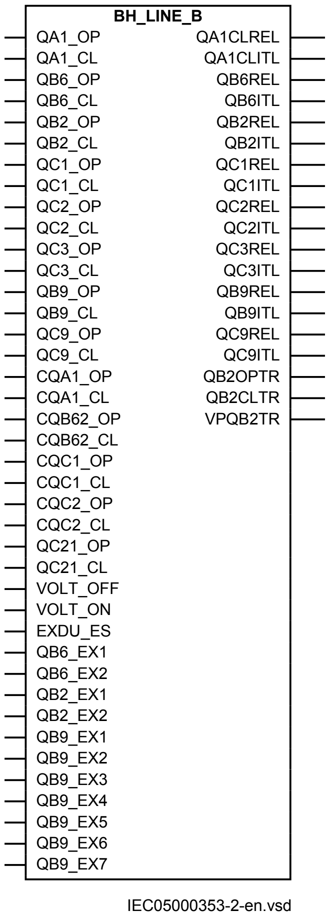


Figure 206: *BH_LINE_B function block*

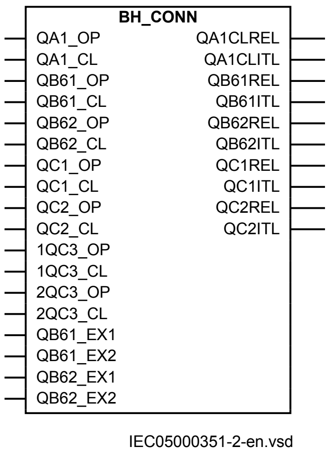
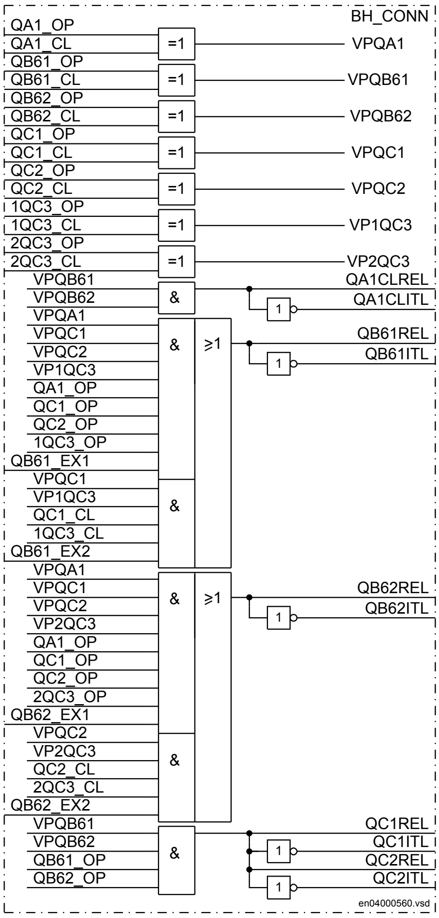
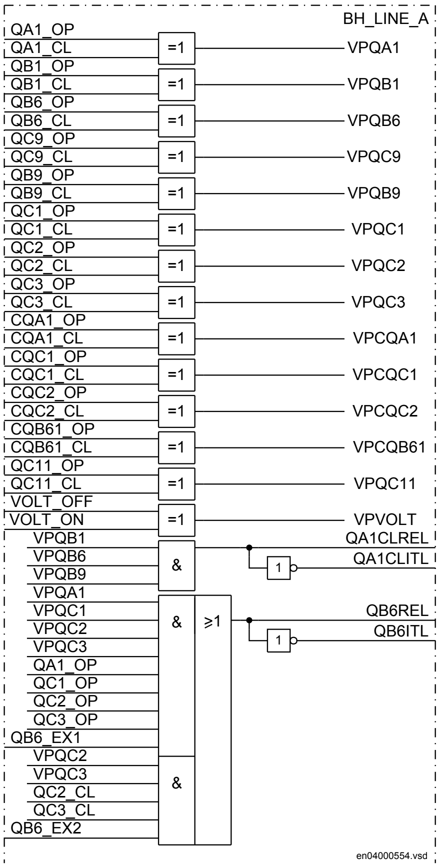
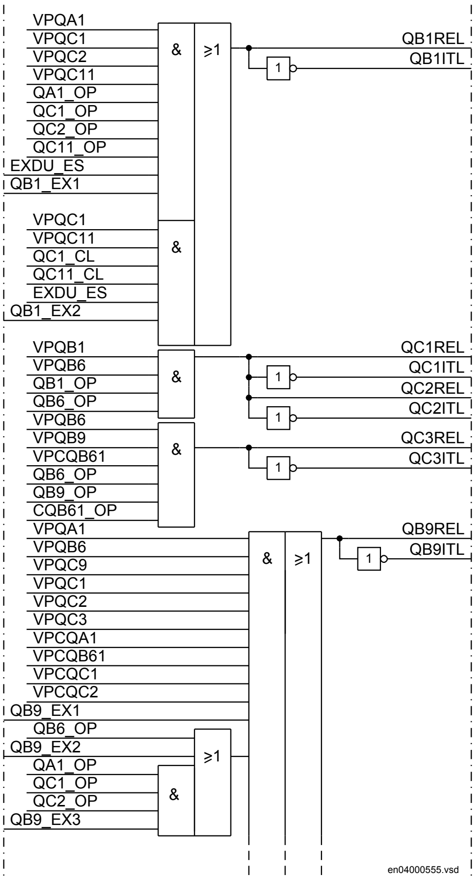


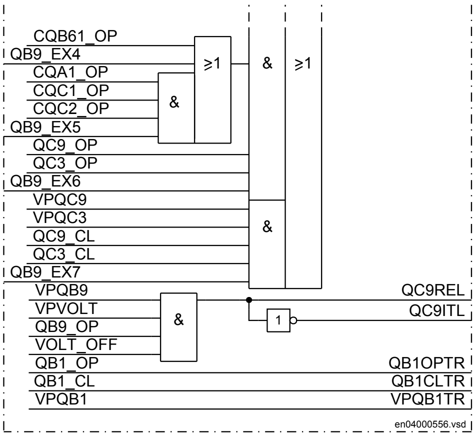
Figure 207: *BH_CONN function block*

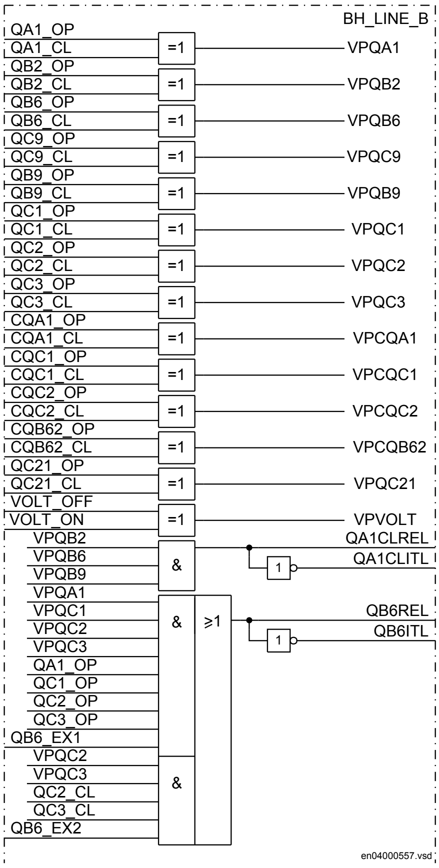
11.3.8.3 Logic diagrams

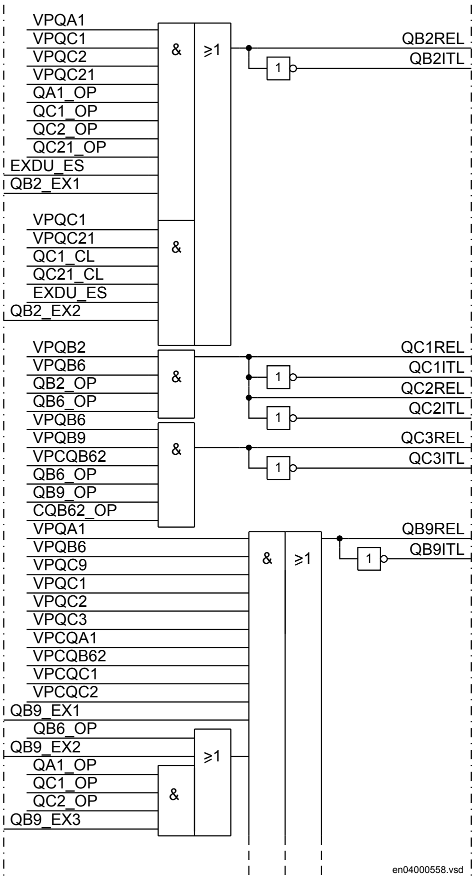


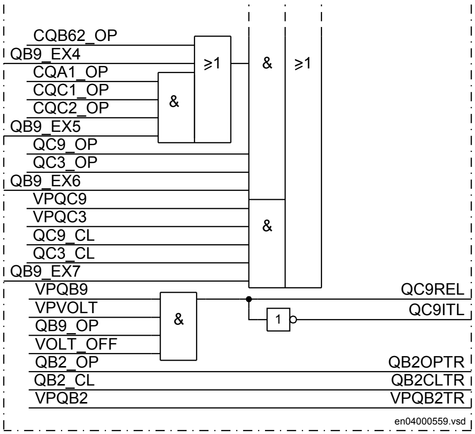

BH_LINE_A
QA1_OP
QA1_CL
QB1_OP
QB1_CL
QB6_OP
QB6_CL
QC9_OP
QC9_CL
QB9_OP
QB9_CL
QC1_OP
QC1_CL
QC2_OP
QC2_CL
QC3_OP
QC3_CL
CQA1_OP
CQA1_CL
CQC1_OP
CQC1_CL
CQC2_OP
CQC2_CL
CQB61_OP
CQB61_CL
QC11_OP
QC11_CL
VOLT_OFF
VOLT_ON
=1
VPQA1
VPQB1
VPQB6
VPQC9
VPQB9
VPQC1
VPQC2
VPQC3
VPCQA1
VPCQC1
VPCQC2
VPCQB61
VPQC11
VPVOLT
VPQB1
VPQB6
VPQB9
&
QA1CLREL
QA1CLITL
1
VPQA1
VPQC1
VPQC2
VPQC3
QA1_OP
QC1_OP
QC2_OP
QC3_OP
QB6_EX1
≥1
QB6REL
QB6ITL
VPQC2
VPQC3
QC2_CL
QC3_CL
QB6_EX2
en04000554.vsd


VPQA1
VPQC1
VPQC2
VPQC11
QA1_OP
QC1_OP
QC2_OP
QC11_OP
EXDU_ES
QB1_EX1
VPQC1
VPQC11
QC1_CL
QC11_CL
EXDU_ES
QB1_EX2
QB1REL
QB1ITL
VPQB1
VPQB6
QB1_OP
QB6_OP
VPQB6
VPQB9
VPCQB61
QB6_OP
QB9_OP
CQB61_OP
QC1REL
QC1ITL
QC2REL
QC2ITL
QC3REL
QC3ITL
VPQA1
VPQB6
VPQC9
VPQC1
VPQC2
VPQC3
VPCQA1
VPCQB61
VPCQC1
VPCQC2
QB9_EX1
QB6_OP
QB9_EX2
QA1_OP
QC1_OP
QC2_OP
QB9_EX3
QB9REL
QB9ITL
en04000555.vsd


CQB61_OP
QB9_EX4
CQA1_OP
CQC1_OP
CQC2_OP
QB9_EX5
QC9_OP
QC3_OP
QB9_EX6
VPQC9
VPQC3
QC9_CL
QC3_CL
QB9_EX7
VPQB9
VPVOLT
QB9_OP
VOLT_OFF
QB1_OP
QB1_CL
VPQB1
QC9REL
QC9ITL
QB1OPTR
QB1CLTR
VPQB1TR
en04000556.vsd


BH_LINE_B
QA1_OP
QA1_CL
QB2_OP
QB2_CL
QB6_OP
QB6_CL
QC9_OP
QC9_CL
QB9_OP
QB9_CL
QC1_OP
QC1_CL
QC2_OP
QC2_CL
QC3_OP
QC3_CL
CQA1_OP
CQA1_CL
CQC1_OP
CQC1_CL
CQC2_OP
CQC2_CL
CQB62_OP
CQB62_CL
QC21_OP
QC21_CL
VOLT_OFF
VOLT_ON
=1
VPQA1
VPQB2
VPQB6
VPQC9
VPQB9
VPQC1
VPQC2
VPQC3
VPCQA1
VPCQC1
VPCQC2
VPCQB62
VPQC21
VPVOLT
VPQB2
VPQB6
VPQB9
&
QA1CLREL
1
QA1CLITL
VPQA1
VPQC1
VPQC2
VPQC3
QA1_OP
QC1_OP
QC2_OP
QC3_OP
QB6_EX1
&
≥1
QB6REL
1
QB6ITL
VPQC2
VPQC3
QC2_CL
QC3_CL
QB6_EX2
&
en04000557.vsd


VPQA1
VPQC1
VPQC2
VPQC21
QA1_OP
QC1_OP
QC2_OP
QC21_OP
EXDU_ES
QB2_EX1
VPQC1
VPQC21
QC1_CL
QC21_CL
EXDU_ES
QB2_EX2
VPQB2
VPQB6
QB2_OP
QB6_OP
VPQB6
VPQB9
VPCQB62
QB6_OP
QB9_OP
CQB62_OP
VPQA1
VPQB6
VPQC9
VPQC1
VPQC2
VPQC3
VPCQA1
VPCQB62
VPCQC1
VPCQC2
QB9_EX1
QB6_OP
QB9_EX2
QA1_OP
QC1_OP
QC2_OP
QB9_EX3
QB2REL
QB2ITL
QC1REL
QC1ITL
QC2REL
QC2ITL
QC3REL
QC3ITL
QB9REL
QB9ITL
en04000558.vsd


CQB62_OP
QB9_EX4
CQA1_OP
CQC1_OP
CQC2_OP
QB9_EX5
QC9_OP
QC3_OP
QB9_EX6
VPQC9
VPQC3
QC9_CL
QC3_CL
QB9_EX7
VPQB9
VPVOLT
QB9_OP
VOLT_OFF
QB2_OP
QB2_CL
VPQB2
QC9REL
QC9ITL
QB2OPTR
QB2CLTR
VPQB2TR
en04000559.vsd

11.3.8.4 Input and output signals

Table 223: BH_LINE_A Input signals

Name	Type	Default	Description
QA1_OP	BOOLEAN	0	QA1 is in open position
QA1_CL	BOOLEAN	0	QA1 is in closed position
QB6_OP	BOOLEAN	0	QB6 is in open position
QB6_CL	BOOLEAN	0	QB6 is in close position
QB1_OP	BOOLEAN	0	QB1 is in open position
QB1_CL	BOOLEAN	0	QB1 is in closed position
QC1_OP	BOOLEAN	0	QC1 is in open position
QC1_CL	BOOLEAN	0	QC1 is in closed position
QC2_OP	BOOLEAN	0	QC2 is in open position
QC2_CL	BOOLEAN	0	QC2 is in closed position
QC3_OP	BOOLEAN	0	QC3 is in open position
QC3_CL	BOOLEAN	0	QC3 is in closed position
QB9_OP	BOOLEAN	0	QB9 is in open position
QB9_CL	BOOLEAN	0	QB9 is in closed position
QC9_OP	BOOLEAN	0	QC9 is in open position
QC9_CL	BOOLEAN	0	QC9 is in closed position
CQA1_OP	BOOLEAN	0	QA1 in module BH_CONN is in open position
CQA1_CL	BOOLEAN	0	QA1 in module BH_CONN is in closed position
CQB61_OP	BOOLEAN	0	QB61 in module BH_CONN is in open position
CQB61_CL	BOOLEAN	0	QB61 in module BH_CONN is in closed position
CQC1_OP	BOOLEAN	0	QC1 in module BH_CONN is in open position
CQC1_CL	BOOLEAN	0	QC1 in module BH_CONN is in closed position
CQC2_OP	BOOLEAN	0	QC2 in module BH_CONN is in open position
CQC2_CL	BOOLEAN	0	QC2 in module BH_CONN is in closed position
QC11_OP	BOOLEAN	0	Earthing switch QC11 on busbar WA1 is in open position
QC11_CL	BOOLEAN	0	Earthing switch QC11 on busbar WA1 is in closed position
VOLT_OFF	BOOLEAN	0	There is no voltage on line and not VT (fuse) failure
VOLT_ON	BOOLEAN	0	There is voltage on the line or there is a VT (fuse) failure
EXDU_ES	BOOLEAN	0	No transm error from bay containing earthing switch QC11
QB6_EX1	BOOLEAN	0	External condition for apparatus QB6
QB6_EX2	BOOLEAN	0	External condition for apparatus QB6
QB1_EX1	BOOLEAN	0	External condition for apparatus QB1
QB1_EX2	BOOLEAN	0	External condition for apparatus QB1
QB9_EX1	BOOLEAN	0	External condition for apparatus QB9

Table continues on next page

Name	Type	Default	Description
QB9_EX2	BOOLEAN	0	External condition for apparatus QB9
QB9_EX3	BOOLEAN	0	External condition for apparatus QB9
QB9_EX4	BOOLEAN	0	External condition for apparatus QB9
QB9_EX5	BOOLEAN	0	External condition for apparatus QB9
QB9_EX6	BOOLEAN	0	External condition for apparatus QB9
QB9_EX7	BOOLEAN	0	External condition for apparatus QB9

Table 224: BH_LINE_A Output signals

Name	Type	Description
QA1CLREL	BOOLEAN	Closing of QA1 is allowed
QA1CLITL	BOOLEAN	Closing of QA1 is forbidden
QB6REL	BOOLEAN	Switching of QB6 is allowed
QB6ITL	BOOLEAN	Switching of QB6 is forbidden
QB1REL	BOOLEAN	Switching of QB1 is allowed
QB1ITL	BOOLEAN	Switching of QB1 is forbidden
QC1REL	BOOLEAN	Switching of QC1 is allowed
QC1ITL	BOOLEAN	Switching of QC1 is forbidden
QC2REL	BOOLEAN	Switching of QC2 is allowed
QC2ITL	BOOLEAN	Switching of QC2 is forbidden
QC3REL	BOOLEAN	Switching of QC3 is allowed
QC3ITL	BOOLEAN	Switching of QC3 is forbidden
QB9REL	BOOLEAN	Switching of QB9 is allowed
QB9ITL	BOOLEAN	Switching of QB9 is forbidden
QC9REL	BOOLEAN	Switching of QC9 is allowed
QC9ITL	BOOLEAN	Switching of QC9 is forbidden
QB1OPTR	BOOLEAN	QB1 is in open position
QB1CLTR	BOOLEAN	QB1 is in closed position
VPQB1TR	BOOLEAN	Switch status of QB1 is valid (open or closed)

Table 225: BH_LINE_B Input signals

Name	Type	Default	Description
QA1_OP	BOOLEAN	0	QA1 is in open position
QA1_CL	BOOLEAN	0	QA1 is in closed position
QB6_OP	BOOLEAN	0	QB6 is in open position
QB6_CL	BOOLEAN	0	QB6 is in close position
QB2_OP	BOOLEAN	0	QB2 is in open position
QB2_CL	BOOLEAN	0	QB2 is in closed position
QC1_OP	BOOLEAN	0	QC1 is in open position

Table continues on next page

Name	Type	Default	Description
QC1_CL	BOOLEAN	0	QC1 is in closed position
QC2_OP	BOOLEAN	0	QC2 is in open position
QC2_CL	BOOLEAN	0	QC2 is in closed position
QC3_OP	BOOLEAN	0	QC3 is in open position
QC3_CL	BOOLEAN	0	QC3 is in closed position
QB9_OP	BOOLEAN	0	QB9 is in open position
QB9_CL	BOOLEAN	0	QB9 is in closed position
QC9_OP	BOOLEAN	0	QC9 is in open position
QC9_CL	BOOLEAN	0	QC9 is in closed position
CQA1_OP	BOOLEAN	0	QA1 in module BH_CONN is in open position
CQA1_CL	BOOLEAN	0	QA1 in module BH_CONN is in closed position
CQB62_OP	BOOLEAN	0	QB62 in module BH_CONN is in open position
CQB62_CL	BOOLEAN	0	QB62 in module BH_CONN is in closed position
CQC1_OP	BOOLEAN	0	QC1 in module BH_CONN is in open position
CQC1_CL	BOOLEAN	0	QC1 in module BH_CONN is in closed position
CQC2_OP	BOOLEAN	0	QC2 in module BH_CONN is in open position
CQC2_CL	BOOLEAN	0	QC2 in module BH_CONN is in closed position
QC21_OP	BOOLEAN	0	Earthing switch QC21 on busbar WA2 is in open position
QC21_CL	BOOLEAN	0	Earthing switch QC21 on busbar WA2 is in closed position
VOLT_OFF	BOOLEAN	0	There is no voltage on line and not VT (fuse) failure
VOLT_ON	BOOLEAN	0	There is voltage on the line or there is a VT (fuse) failure
EXDU_ES	BOOLEAN	0	No transm error from bay containing earthing switch QC21
QB6_EX1	BOOLEAN	0	External condition for apparatus QB6
QB6_EX2	BOOLEAN	0	External condition for apparatus QB6
QB2_EX1	BOOLEAN	0	External condition for apparatus QB2
QB2_EX2	BOOLEAN	0	External condition for apparatus QB2
QB9_EX1	BOOLEAN	0	External condition for apparatus QB9
QB9_EX2	BOOLEAN	0	External condition for apparatus QB9
QB9_EX3	BOOLEAN	0	External condition for apparatus QB9
QB9_EX4	BOOLEAN	0	External condition for apparatus QB9
QB9_EX5	BOOLEAN	0	External condition for apparatus QB9
QB9_EX6	BOOLEAN	0	External condition for apparatus QB9
QB9_EX7	BOOLEAN	0	External condition for apparatus QB9

Table 226: BH_LINE_B Output signals

Name	Type	Description
QA1CLREL	BOOLEAN	Closing of QA1 is allowed
QA1CLITL	BOOLEAN	Closing of QA1 is forbidden
QB6REL	BOOLEAN	Switching of QB6 is allowed
QB6ITL	BOOLEAN	Switching of QB6 is forbidden
QB2REL	BOOLEAN	Switching of QB2 is allowed
QB2ITL	BOOLEAN	Switching of QB2 is forbidden
QC1REL	BOOLEAN	Switching of QC1 is allowed
QC1ITL	BOOLEAN	Switching of QC1 is forbidden
QC2REL	BOOLEAN	Switching of QC2 is allowed
QC2ITL	BOOLEAN	Switching of QC2 is forbidden
QC3REL	BOOLEAN	Switching of QC3 is allowed
QC3ITL	BOOLEAN	Switching of QC3 is forbidden
QB9REL	BOOLEAN	Switching of QB9 is allowed
QB9ITL	BOOLEAN	Switching of QB9 is forbidden
QC9REL	BOOLEAN	Switching of QC9 is allowed
QC9ITL	BOOLEAN	Switching of QC9 is forbidden
QB2OPTR	BOOLEAN	QB2 is in open position
QB2CLTR	BOOLEAN	QB2 is in closed position
VPQB2TR	BOOLEAN	Switch status of QB2 is valid (open or closed)

Table 227: BH_CONN Input signals

Name	Type	Default	Description
QA1_OP	BOOLEAN	0	QA1 is in open position
QA1_CL	BOOLEAN	0	QA1 is in closed position
QB61_OP	BOOLEAN	0	QB61 is in open position
QB61_CL	BOOLEAN	0	QB61 is in closed position
QB62_OP	BOOLEAN	0	QB62 is in open position
QB62_CL	BOOLEAN	0	QB62 is in closed position
QC1_OP	BOOLEAN	0	QC1 is in open position
QC1_CL	BOOLEAN	0	QC1 is in closed position
QC2_OP	BOOLEAN	0	QC2 is in open position
QC2_CL	BOOLEAN	0	QC2 is in closed position
1QC3_OP	BOOLEAN	0	QC3 on line 1 is in open position
1QC3_CL	BOOLEAN	0	QC3 on line 1 is in closed position
2QC3_OP	BOOLEAN	0	QC3 on line 2 is in open position
2QC3_CL	BOOLEAN	0	QC3 on line 2 is in closed position
QB61_EX1	BOOLEAN	0	External condition for apparatus QB61

Table continues on next page

Name	Type	Default	Description
QB61_EX2	BOOLEAN	0	External condition for apparatus QB61
QB62_EX1	BOOLEAN	0	External condition for apparatus QB62
QB62_EX2	BOOLEAN	0	External condition for apparatus QB62

Table 228: BH_CONN Output signals

Name	Type	Description
QA1CLREL	BOOLEAN	Closing of QA1 is allowed
QA1CLITL	BOOLEAN	Closing of QA1 is forbidden
QB61REL	BOOLEAN	Switching of QB61 is allowed
QB61ITL	BOOLEAN	Switching of QB61 is forbidden
QB62REL	BOOLEAN	Switching of QB62 is allowed
QB62ITL	BOOLEAN	Switching of QB62 is forbidden
QC1REL	BOOLEAN	Switching of QC1 is allowed
QC1ITL	BOOLEAN	Switching of QC1 is forbidden
QC2REL	BOOLEAN	Switching of QC2 is allowed
QC2ITL	BOOLEAN	Switching of QC2 is forbidden

11.3.9 Interlocking for double CB bay DB

11.3.9.1 Introduction

The interlocking for 1 1/2 breaker diameter including DB_BUS_A, DB_BUS_B, DB_LINEfunctions are used for a line connected to a double circuit breaker arrangement according to figure 208.

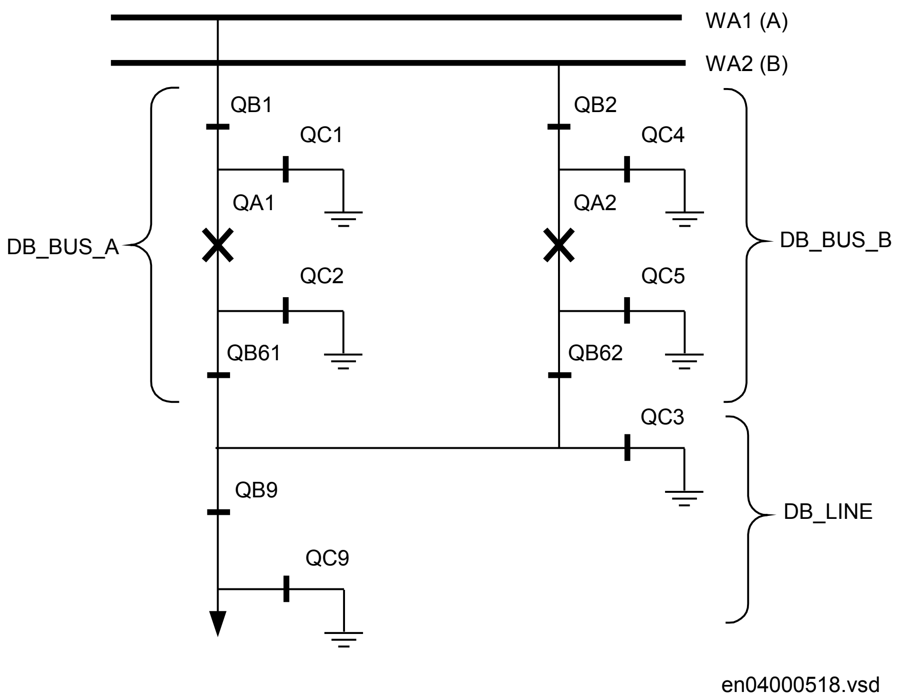


Figure 208: Switchyard layout double circuit breaker

Three types of interlocking modules per double circuit breaker bay are defined. DB_LINE is the connection from the line to the circuit breaker parts that are connected to the busbars. DB_BUS_A and DB_BUS_B are the connections from the line to the busbars.

11.3.9.2 Function block

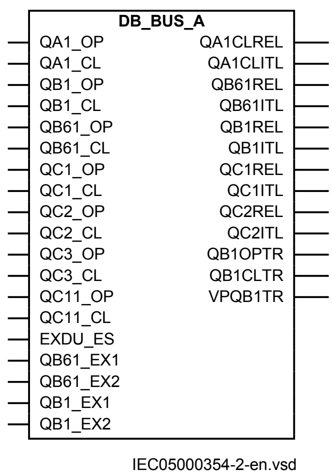


Figure 209: DB_BUS_A function block

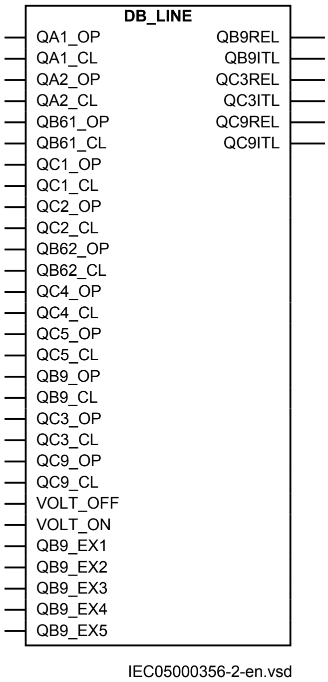


Figure 210: DB_LINE function block

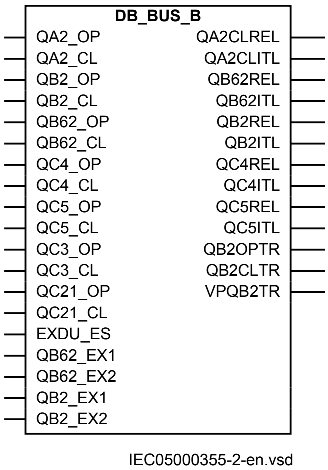
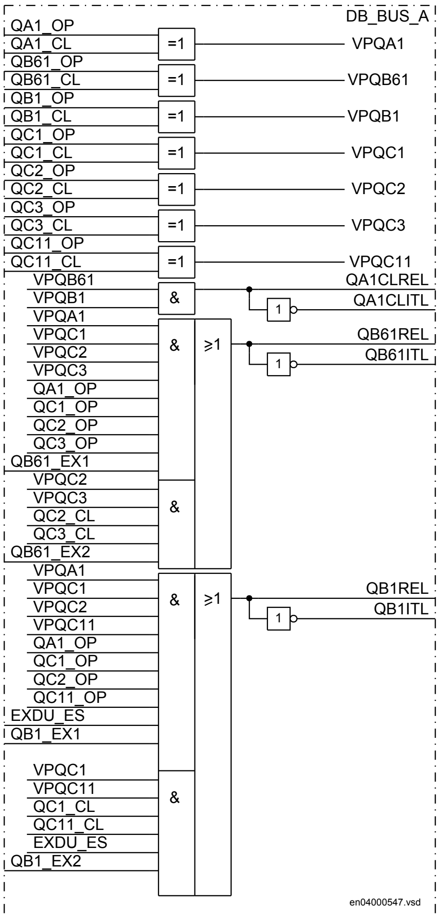
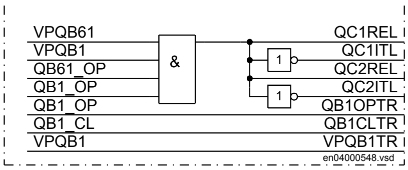
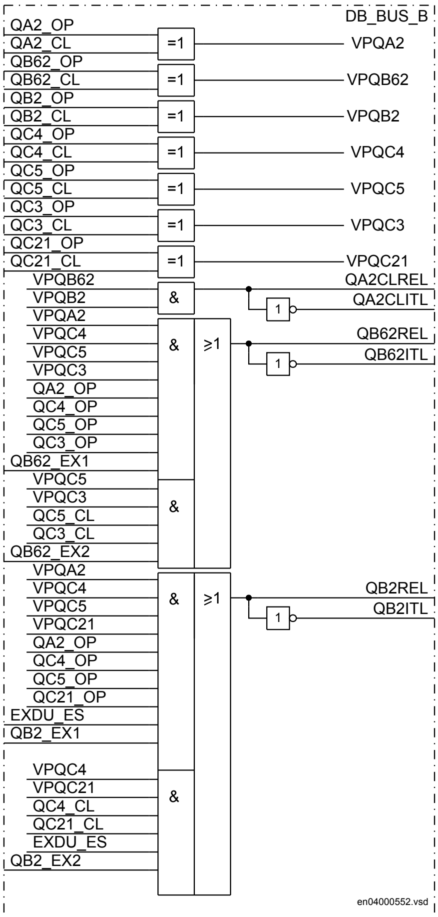


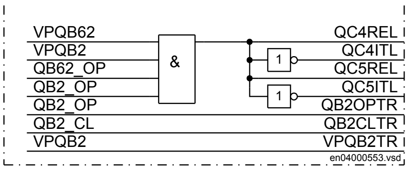
Figure 211: DB_BUS_B function block

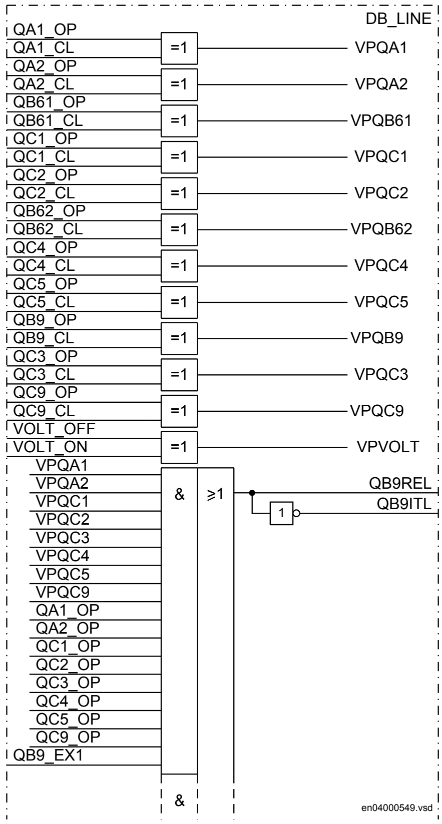
11.3.9.3 Logic diagrams

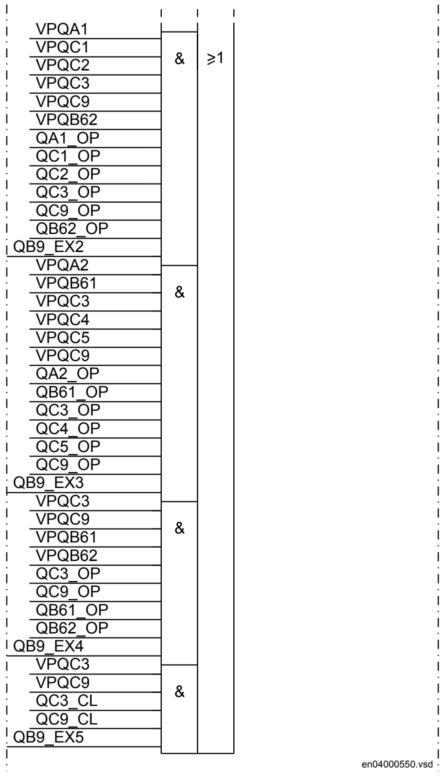


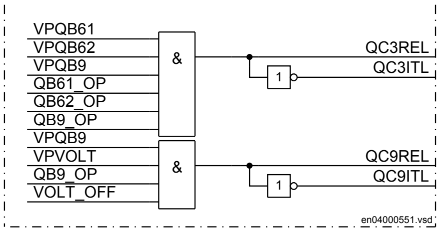



DB_BUS_B
QA2_OP
QA2_CL
=1
VPQA2
QB62_OP
QB62_CL
=1
VPQB62
QB2_OP
QB2_CL
=1
VPQB2
QC4_OP
QC4_CL
=1
VPQC4
QC5_OP
QC5_CL
=1
VPQC5
QC3_OP
QC3_CL
=1
VPQC3
QC21_OP
QC21_CL
=1
VPQC21
VPQB62
VPQB2
&
QA2CLREL
1
QA2CLITL
VPQA2
VPQC4
VPQC5
VPQC3
QA2_OP
QC4_OP
QC5_OP
QC3_OP
QB62_EX1
&
≥1
QB62REL
1
QB62ITL
VPQC5
VPQC3
QC5_CL
QC3_CL
QB62_EX2
&
VPQA2
VPQC4
VPQC5
VPQC21
QA2_OP
QC4_OP
QC5_OP
QC21_OP
EXDU_ES
QB2_EX1
&
≥1
QB2REL
1
QB2ITL
VPQC4
VPQC21
QC4_CL
QC21_CL
EXDU_ES
QB2_EX2
&
en04000552.vsd


VPQB62
VPQB2
QB62_OP
QB2_OP
&
QC4REL
1
QC4ITL
QC5REL
1
QC5ITL
QB2_OP
QB2OPTR
QB2_CL
QB2CLTR
VPQB2
VPQB2TR
en04000553.vsd


DB_LINE
QA1_OP
QA1_CL
=1
VPQA1
QA2_OP
QA2_CL
=1
VPQA2
QB61_OP
QB61_CL
=1
VPQB61
QC1_OP
QC1_CL
=1
VPQC1
QC2_OP
QC2_CL
=1
VPQC2
QB62_OP
QB62_CL
=1
VPQB62
QC4_OP
QC4_CL
=1
VPQC4
QC5_OP
QC5_CL
=1
VPQC5
QB9_OP
QB9_CL
=1
VPQB9
QC3_OP
QC3_CL
=1
VPQC3
QC9_OP
QC9_CL
=1
VPQC9
VOLT_OFF
VOLT_ON
=1
VPVOLT
VPQA1
VPQA2
VPQC1
VPQC2
VPQC3
VPQC4
VPQC5
VPQC9
QA1_OP
QA2_OP
QC1_OP
QC2_OP
QC3_OP
QC4_OP
QC5_OP
QC9_OP
QB9_EX1
&
≥1
QB9REL
1
QB9ITL
&
en04000549.vsd


VPQA1
VPQC1
VPQC2
VPQC3
VPQC9
VPQB62
QA1_OP
QC1_OP
QC2_OP
QC3_OP
QC9_OP
QB62_OP
QB9_EX2
&
≥1
VPQA2
VPQB61
VPQC3
VPQC4
VPQC5
VPQC9
QA2_OP
QB61_OP
QC3_OP
QC4_OP
QC5_OP
QC9_OP
QB9_EX3
&
VPQC3
VPQC9
VPQB61
VPQB62
QC3_OP
QC9_OP
QB61_OP
QB62_OP
QB9_EX4
&
VPQC3
VPQC9
QC3_CL
QC9_CL
QB9_EX5
&
en04000550.vsd



11.3.9.4 Input and output signals

Table 229: DB_BUS_A Input signals

Name	Type	Default	Description
QA1_OP	BOOLEAN	0	QA1 is in open position
QA1_CL	BOOLEAN	0	QA1 is in closed position
QB1_OP	BOOLEAN	0	QB1 is in open position
QB1_CL	BOOLEAN	0	QB1 is in closed position
QB61_OP	BOOLEAN	0	QB61 is in open position
QB61_CL	BOOLEAN	0	QB61 is in closed position
QC1_OP	BOOLEAN	0	QC1 is in open position
QC1_CL	BOOLEAN	0	QC1 is in closed position
QC2_OP	BOOLEAN	0	QC2 is in open position
QC2_CL	BOOLEAN	0	QC2 is in closed position
QC3_OP	BOOLEAN	0	QC3 is in open position
QC3_CL	BOOLEAN	0	QC3 is in closed position
QC11_OP	BOOLEAN	0	Earthing switch QC11 on busbar WA1 is in open position
QC11_CL	BOOLEAN	0	Earthing switch QC11 on busbar WA1 is in closed position
EXDU_ES	BOOLEAN	0	No transm error from bay containing earthing switch QC11
QB61_EX1	BOOLEAN	0	External condition for apparatus QB61
QB61_EX2	BOOLEAN	0	External condition for apparatus QB61
QB1_EX1	BOOLEAN	0	External condition for apparatus QB1
QB1_EX2	BOOLEAN	0	External condition for apparatus QB1

Table 230: DB_BUS_A Output signals

Name	Type	Description
QA1CLREL	BOOLEAN	Closing of QA1 is allowed
QA1CLITL	BOOLEAN	Closing of QA1 is forbidden
QB61REL	BOOLEAN	Switching of QB61 is allowed
QB61ITL	BOOLEAN	Switching of QB61 is forbidden
QB1REL	BOOLEAN	Switching of QB1 is allowed
Table continues on next page		

Name	Type	Description
QB1ITL	BOOLEAN	Switching of QB1 is forbidden
QC1REL	BOOLEAN	Switching of QC1 is allowed
QC1ITL	BOOLEAN	Switching of QC1 is forbidden
QC2REL	BOOLEAN	Switching of QC2 is allowed
QC2ITL	BOOLEAN	Switching of QC2 is forbidden
QB1OPTR	BOOLEAN	QB1 is in open position
QB1CLTR	BOOLEAN	QB1 is in closed position
VPQB1TR	BOOLEAN	Switch status of QB1 is valid (open or closed)

Table 231: DB_LINE Input signals

Name	Type	Default	Description
QA1_OP	BOOLEAN	0	QA1 is in open position
QA1_CL	BOOLEAN	0	QA1 is in closed position
QA2_OP	BOOLEAN	0	QA2 is in open position
QA2_CL	BOOLEAN	0	QA2 is in closed position
QB61_OP	BOOLEAN	0	QB61 is in open position
QB61_CL	BOOLEAN	0	QB61 is in closed position
QC1_OP	BOOLEAN	0	QC1 is in open position
QC1_CL	BOOLEAN	0	QC1 is in closed position
QC2_OP	BOOLEAN	0	QC2 is in open position
QC2_CL	BOOLEAN	0	QC2 is in closed position
QB62_OP	BOOLEAN	0	QB62 is in open position
QB62_CL	BOOLEAN	0	QB62 is in closed position
QC4_OP	BOOLEAN	0	QC4 is in open position
QC4_CL	BOOLEAN	0	QC4 is in closed position
QC5_OP	BOOLEAN	0	QC5 is in open position
QC5_CL	BOOLEAN	0	QC5 is in closed position
QB9_OP	BOOLEAN	0	QB9 is in open position
QB9_CL	BOOLEAN	0	QB9 is in closed position
QC3_OP	BOOLEAN	0	QC3 is in open position
QC3_CL	BOOLEAN	0	QC3 is in closed position
QC9_OP	BOOLEAN	0	QC9 is in open position
QC9_CL	BOOLEAN	0	QC9 is in closed position
VOLT_OFF	BOOLEAN	0	There is no voltage on the line and not VT (fuse) failure
VOLT_ON	BOOLEAN	0	There is voltage on the line or there is a VT (fuse) failure
QB9_EX1	BOOLEAN	0	External condition for apparatus QB9
QB9_EX2	BOOLEAN	0	External condition for apparatus QB9
Table continues on next page			

Name	Type	Default	Description
QB9_EX3	BOOLEAN	0	External condition for apparatus QB9
QB9_EX4	BOOLEAN	0	External condition for apparatus QB9
QB9_EX5	BOOLEAN	0	External condition for apparatus QB9

Table 232: DB_LINE Output signals

Name	Type	Description
QB9REL	BOOLEAN	Switching of QB9 is allowed
QB9ITL	BOOLEAN	Switching of QB9 is forbidden
QC3REL	BOOLEAN	Switching of QC3 is allowed
QC3ITL	BOOLEAN	Switching of QC3 is forbidden
QC9REL	BOOLEAN	Switching of QC9 is allowed
QC9ITL	BOOLEAN	Switching of QC9 is forbidden

Table 233: DB_BUS_B Input signals

Name	Type	Default	Description
QA2_OP	BOOLEAN	0	QA2 is in open position
QA2_CL	BOOLEAN	0	QA2 is in closed position
QB2_OP	BOOLEAN	0	QB2 is in open position
QB2_CL	BOOLEAN	0	QB2 is in closed position
QB62_OP	BOOLEAN	0	QB62 is in open position
QB62_CL	BOOLEAN	0	QB62 is in closed position
QC4_OP	BOOLEAN	0	QC4 is in open position
QC4_CL	BOOLEAN	0	QC4 is in closed position
QC5_OP	BOOLEAN	0	QC5 is in open position
QC5_CL	BOOLEAN	0	QC5 is in closed position
QC3_OP	BOOLEAN	0	QC3 is in open position
QC3_CL	BOOLEAN	0	QC3 is in closed position
QC21_OP	BOOLEAN	0	Earthing switch QC21 on busbar WA2 is in open position
QC21_CL	BOOLEAN	0	Earthing switch QC21 on busbar WA2 is in closed position
EXDU_ES	BOOLEAN	0	No transm error from bay containing earthing switch QC21
QB62_EX1	BOOLEAN	0	External condition for apparatus QB62
QB62_EX2	BOOLEAN	0	External condition for apparatus QB62
QB2_EX1	BOOLEAN	0	External condition for apparatus QB2
QB2_EX2	BOOLEAN	0	External condition for apparatus QB2

Table 234: DB_BUS_B Output signals

Name	Type	Description
QA2CLREL	BOOLEAN	Closing of QA2 is allowed
QA2CLITL	BOOLEAN	Closing of QA2 is forbidden
QB62REL	BOOLEAN	Switching of QB62 is allowed
QB62ITL	BOOLEAN	Switching of QB62 is forbidden
QB2REL	BOOLEAN	Switching of QB2 is allowed
QB2ITL	BOOLEAN	Switching of QB2 is forbidden
QC4REL	BOOLEAN	Switching of QC4 is allowed
QC4ITL	BOOLEAN	Switching of QC4 is forbidden
QC5REL	BOOLEAN	Switching of QC5 is allowed
QC5ITL	BOOLEAN	Switching of QC5 is forbidden
QB2OPTR	BOOLEAN	QB2 is in open position
QB2CLTR	BOOLEAN	QB2 is in closed position
VPQB2TR	BOOLEAN	Switch status of QB2 is valid (open or closed)

11.3.10 Interlocking for line bay ABC_LINE

11.3.10.1 Introduction

The interlocking for line bay (ABC_LINE) function is used for a line connected to a double busbar arrangement with a transfer busbar according to figure 212. The function can also be used for a double busbar arrangement without transfer busbar or a single busbar arrangement with/without transfer busbar.

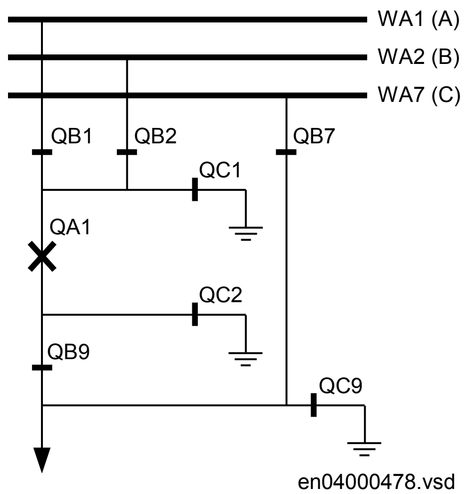


Figure 212: Switchyard layout ABC_LINE

11.3.10.2 Function block

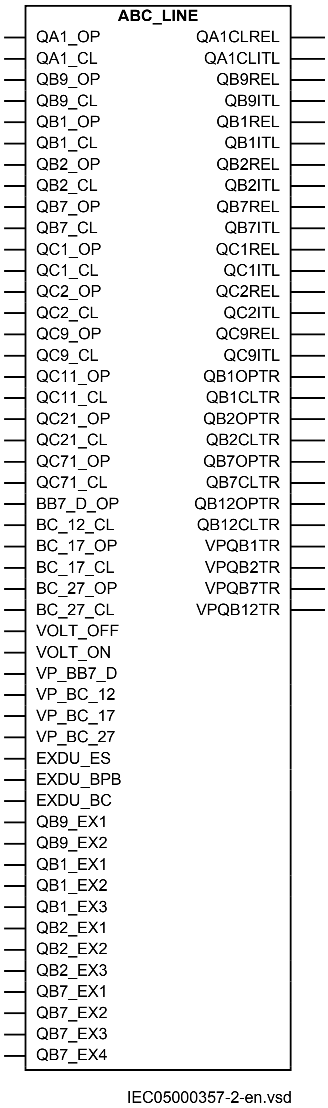
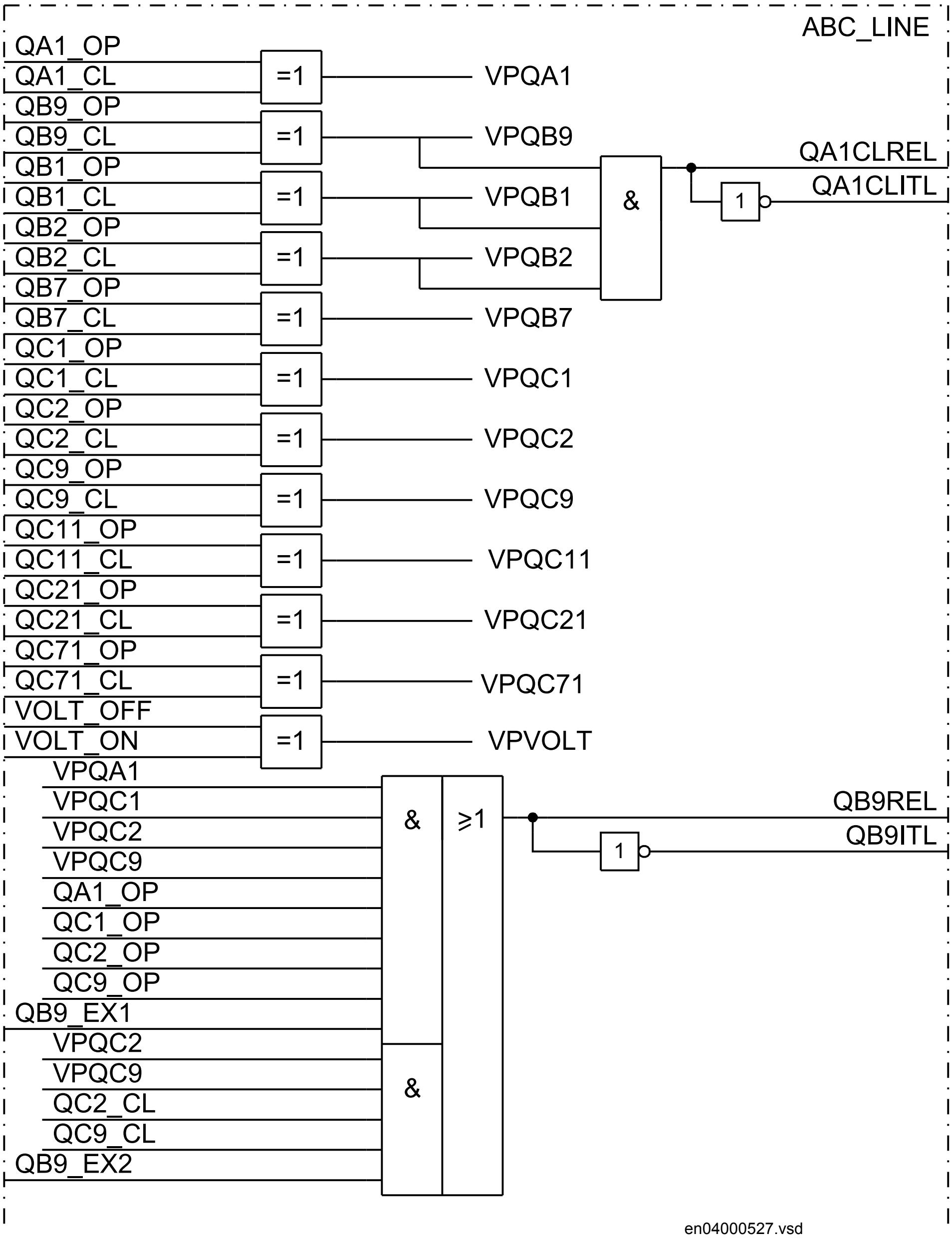
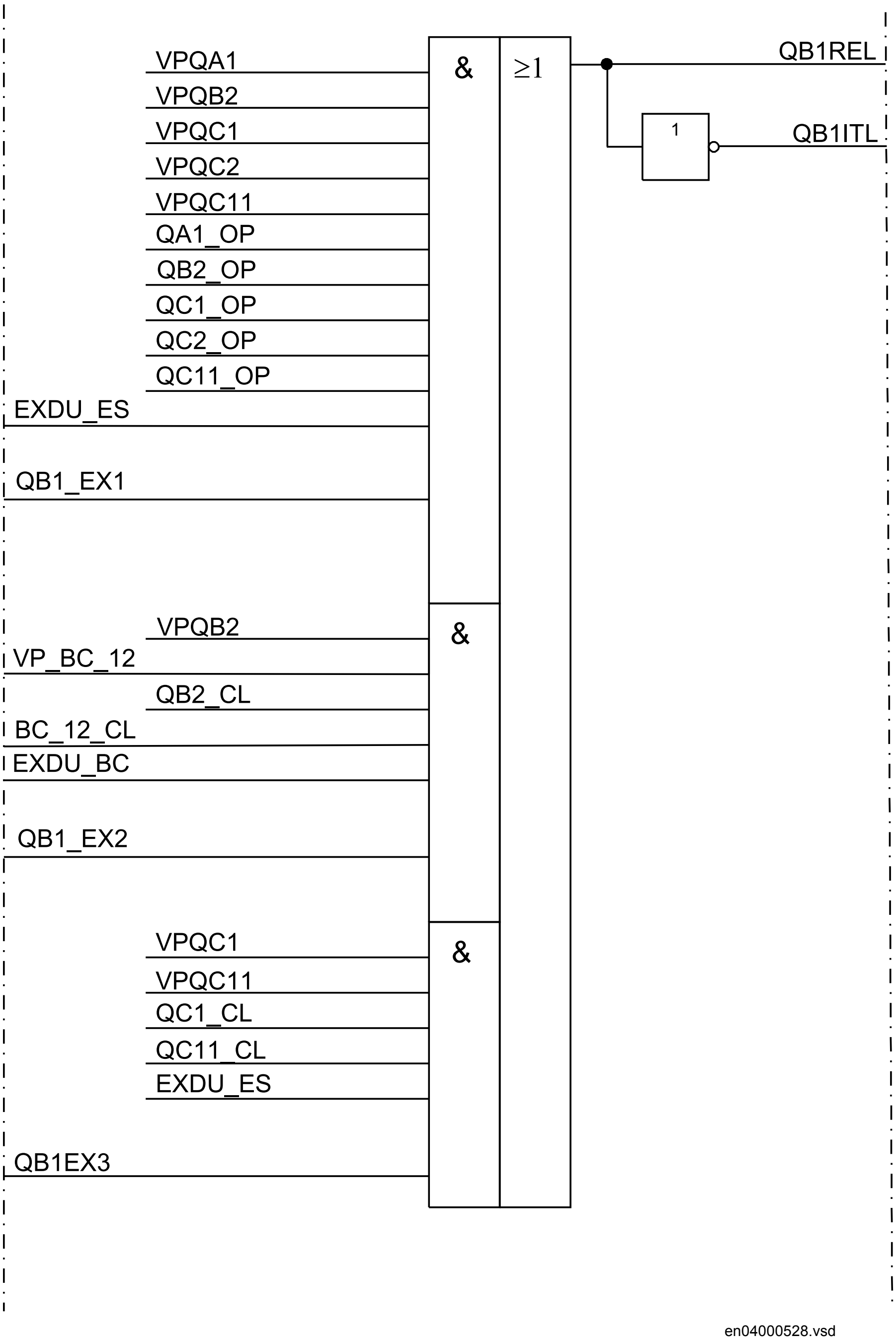
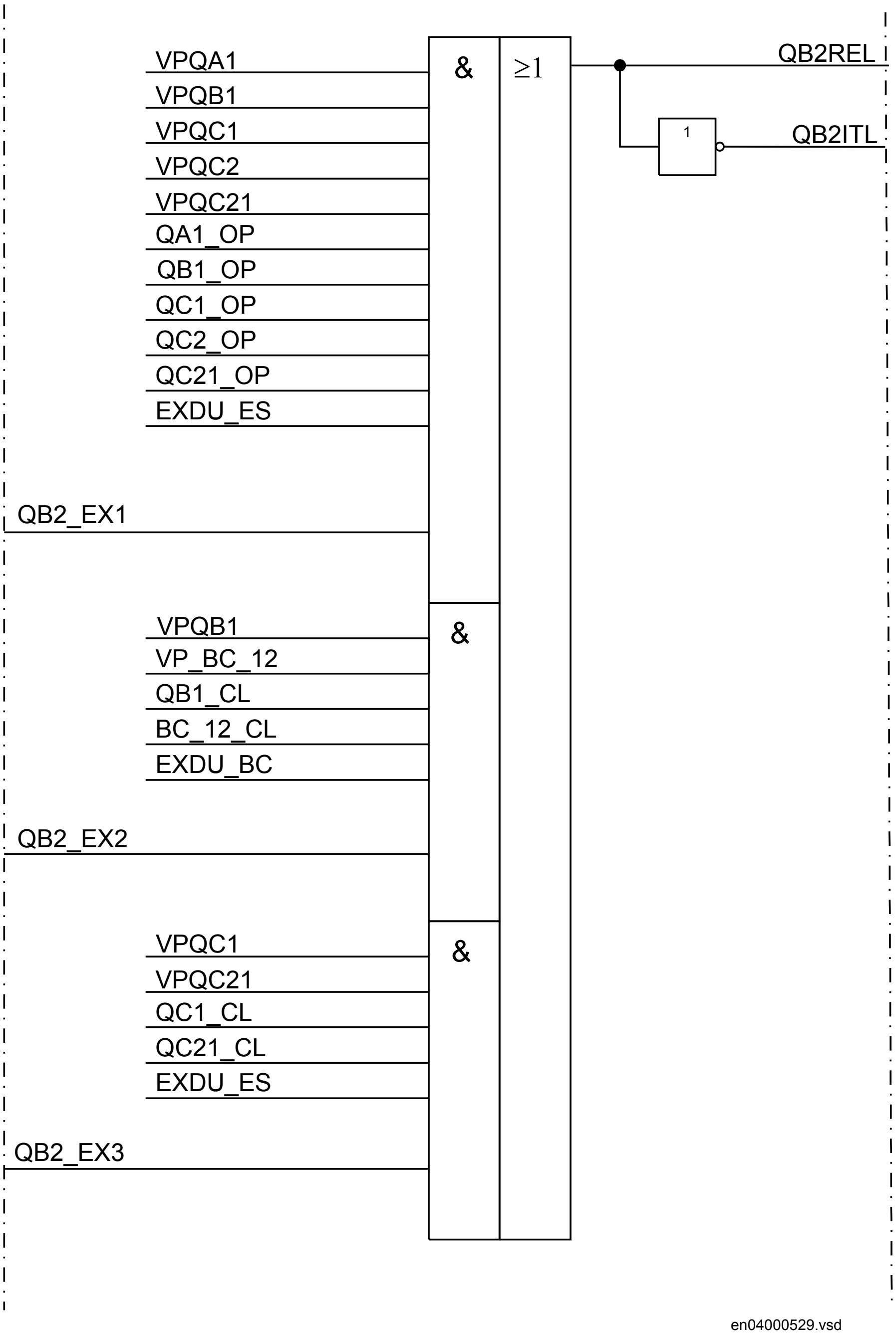


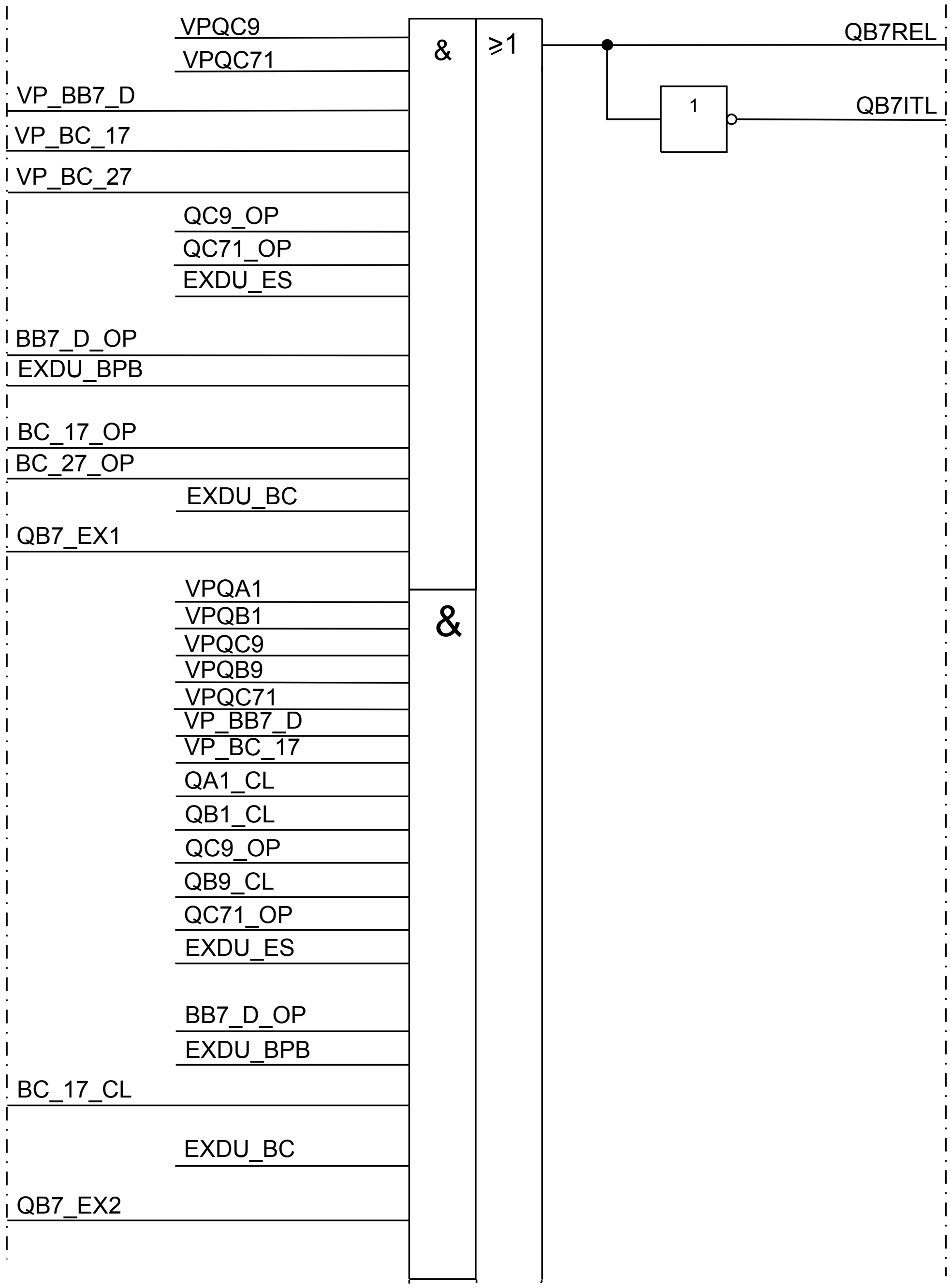
Figure 213: ABC_LINE function block

11.3.10.3 Logic diagram




VPQA1
VPQB2
VPQC1
VPQC2
VPQC11
QA1_OP
QB2_OP
QC1_OP
QC2_OP
QC11_OP
EXDU_ES
QB1_EX1
VPQB2
VP_BC_12
QB2_CL
BC_12_CL
EXDU_BC
QB1_EX2
VPQC1
VPQC11
QC1_CL
QC11_CL
EXDU_ES
QB1EX3
&
&
&
≥1
1
QB1REL
QB1ITL
en04000528.vsd


VPQA1
VPQB1
VPQC1
VPQC2
VPQC21
QA1_OP
QB1_OP
QC1_OP
QC2_OP
QC21_OP
EXDU_ES
QB2_EX1
VPQB1
VP_BC_12
QB1_CL
BC_12_CL
EXDU_BC
QB2_EX2
VPQC1
VPQC21
QC1_CL
QC21_CL
EXDU_ES
QB2_EX3
&
&
&
≥1
1
QB2REL
QB2ITL
en04000529.vsd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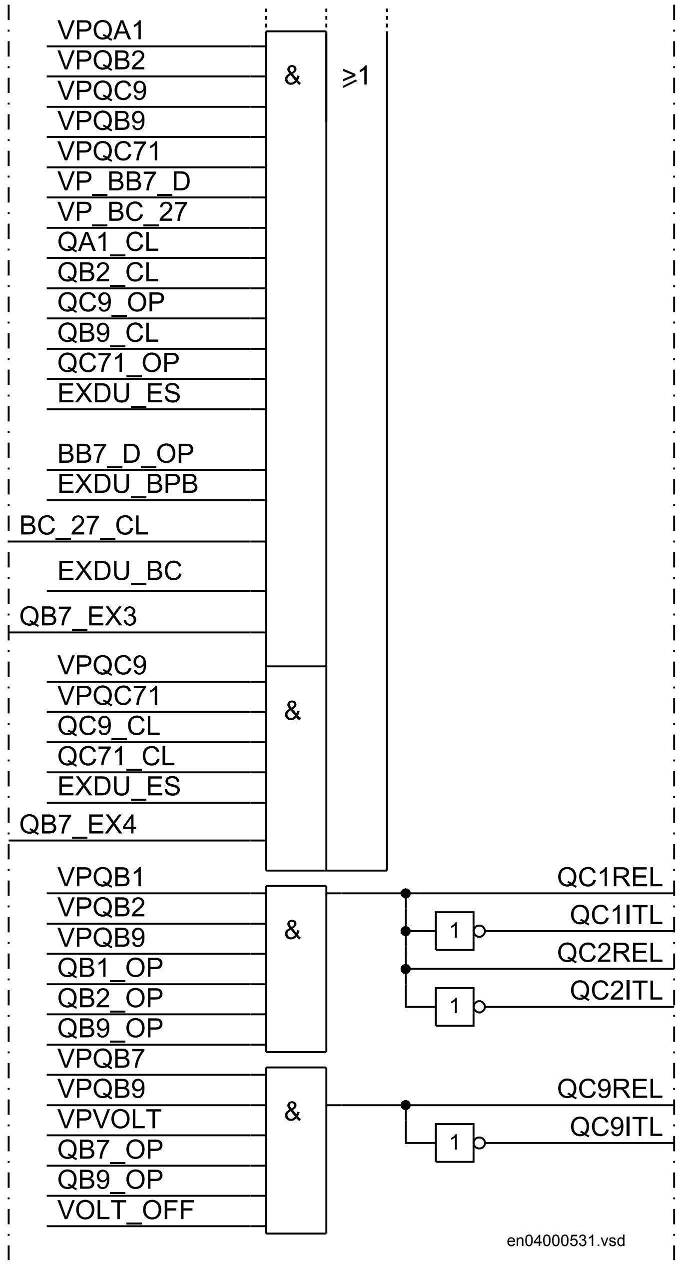
VPQC71
VP_BB7_D
VP_BC_17
VP_BC_27
QC9_OP
QC71_OP
EXDU_ES
BB7_D_OP
EXDU_BPB
BC_17_OP
BC_27_OP
EXDU_BC
QB7_EX1
VPQA1
VPQB1
VPQC9
VPQB9
VPQC71
VP_BB7_D
VP_BC_17
QA1_CL
QB1_CL
QC9_OP
QB9_CL
QC71_OP
EXDU_ES
BB7_D_OP
EXDU_BPB
BC_17_CL
EXDU_BC
QB7_EX2
&
&
≥1
1
QB7REL
QB7ITL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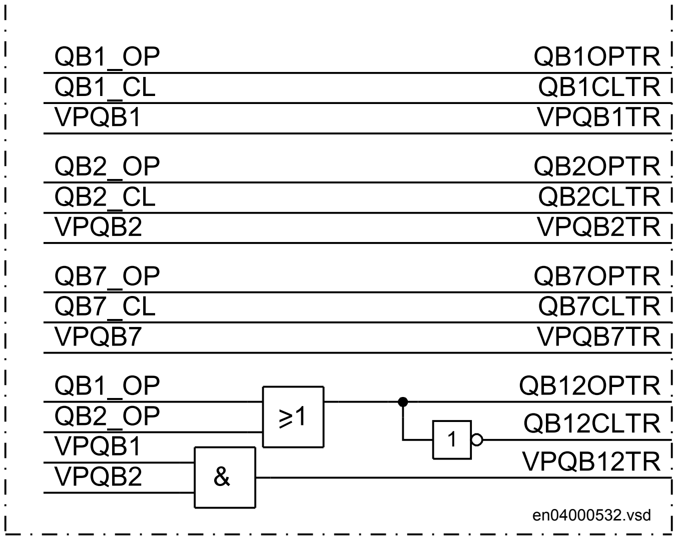
VPQC9
VPQB9
VPQC71
VP_BB7_D
VP_BC_27
QA1_CL
QB2_CL
QC9_OP
QB9_CL
QC71_OP
EXDU_ES
BB7_D_OP
EXDU_BPB
BC_27_CL
EXDU_BC
QB7_EX3
VPQC9
VPQC71
QC9_CL
QC71_CL
EXDU_ES
QB7_EX4
&
≥1
&
VPQB1
VPQB2
VPQB9
QB1_OP
QB2_OP
QB9_OP
&
QC1REL
QC1ITL
QC2REL
QC2ITL
1
1
VPQB7
VPQB9
VPVOLT
QB7_OP
QB9_OP
VOLT_OFF
&
QC9REL
QC9ITL
1
en04000531.vsd



11.3.10.4 Input and output signals

Table 235: ABC_LINE Input signals

Name	Type	Default	Description
QA1_OP	BOOLEAN	0	QA1 is in open position
QA1_CL	BOOLEAN	0	QA1 is in closed position
QB9_OP	BOOLEAN	0	QB9 is in open position
QB9_CL	BOOLEAN	0	QB9 is in closed position
QB1_OP	BOOLEAN	0	QB1 is in open position
QB1_CL	BOOLEAN	0	QB1 is in closed position
QB2_OP	BOOLEAN	0	QB2 is in open position
QB2_CL	BOOLEAN	0	QB2 is in closed position
QB7_OP	BOOLEAN	0	QB7 is in open position
QB7_CL	BOOLEAN	0	QB7 is in closed position
QC1_OP	BOOLEAN	0	QC1 is in open position
QC1_CL	BOOLEAN	0	QC1 is in closed position
QC2_OP	BOOLEAN	0	QC2 is in open position
QC2_CL	BOOLEAN	0	QC2 is in closed position
QC9_OP	BOOLEAN	0	QC9 is in open position
QC9_CL	BOOLEAN	0	QC9 is in closed position
QC11_OP	BOOLEAN	0	Earthing switch QC11 on busbar WA1 is in open position
QC11_CL	BOOLEAN	0	Earthing switch QC11 on busbar WA1 is in closed position
QC21_OP	BOOLEAN	0	Earthing switch QC21 on busbar WA2 is in open position

Table continues on next page

Name	Type	Default	Description
QC21_CL	BOOLEAN	0	Earthing switch QC21 on busbar WA2 is in closed position
QC71_OP	BOOLEAN	0	Earthing switch QC71 on busbar WA7 is in open position
QC71_CL	BOOLEAN	0	Earthing switch QC71 on busbar WA7 is in closed position
BB7_D_OP	BOOLEAN	0	Disconnectors on busbar WA7 except in the own bay are open
BC_12_CL	BOOLEAN	0	A bus coupler connection exists between busbar WA1 and WA2
BC_17_OP	BOOLEAN	0	No bus coupler connection exists between busbar WA1 and WA7
BC_17_CL	BOOLEAN	0	A bus coupler connection exists between busbar WA1 and WA7
BC_27_OP	BOOLEAN	0	No bus coupler connection exists between busbar WA2 and WA7
BC_27_CL	BOOLEAN	0	A bus coupler connection exists between busbar WA2 and WA7
VOLT_OFF	BOOLEAN	0	There is no voltage on the line and not VT (fuse) failure
VOLT_ON	BOOLEAN	0	There is voltage on the line or there is a VT (fuse) failure
VP_BB7_D	BOOLEAN	0	Switch status of the disconnectors on busbar WA7 are valid
VP_BC_12	BOOLEAN	0	Status of the bus coupler app. between WA1 and WA2 are valid
VP_BC_17	BOOLEAN	0	Status of the bus coupler app. between WA1 and WA7 are valid
VP_BC_27	BOOLEAN	0	Status of the bus coupler app. between WA2 and WA7 are valid
EXDU_ES	BOOLEAN	0	No transm error from any bay containing earthing switches
EXDU_BPB	BOOLEAN	0	No transm error from any bay with disconnectors on WA7
EXDU_BC	BOOLEAN	0	No transmission error from any bus coupler bay
QB9_EX1	BOOLEAN	0	External condition for apparatus QB9
QB9_EX2	BOOLEAN	0	External condition for apparatus QB9
QB1_EX1	BOOLEAN	0	External condition for apparatus QB1
QB1_EX2	BOOLEAN	0	External condition for apparatus QB1
QB1_EX3	BOOLEAN	0	External condition for apparatus QB1
QB2_EX1	BOOLEAN	0	External condition for apparatus QB2
QB2_EX2	BOOLEAN	0	External condition for apparatus QB2
QB2_EX3	BOOLEAN	0	External condition for apparatus QB2
QB7_EX1	BOOLEAN	0	External condition for apparatus QB7

Table continues on next page

Name	Type	Default	Description
QB7_EX2	BOOLEAN	0	External condition for apparatus QB7
QB7_EX3	BOOLEAN	0	External condition for apparatus QB7
QB7_EX4	BOOLEAN	0	External condition for apparatus QB7

Table 236: ABC_LINE Output signals

Name	Type	Description
QA1CLREL	BOOLEAN	Closing of QA1 is allowed
QA1CLITL	BOOLEAN	Closing of QA1 is forbidden
QB9REL	BOOLEAN	Switching of QB9 is allowed
QB9ITL	BOOLEAN	Switching of QB9 is forbidden
QB1REL	BOOLEAN	Switching of QB1 is allowed
QB1ITL	BOOLEAN	Switching of QB1 is forbidden
QB2REL	BOOLEAN	Switching of QB2 is allowed
QB2ITL	BOOLEAN	Switching of QB2 is forbidden
QB7REL	BOOLEAN	Switching of QB7 is allowed
QB7ITL	BOOLEAN	Switching of QB7 is forbidden
QC1REL	BOOLEAN	Switching of QC1 is allowed
QC1ITL	BOOLEAN	Switching of QC1 is forbidden
QC2REL	BOOLEAN	Switching of QC2 is allowed
QC2ITL	BOOLEAN	Switching of QC2 is forbidden
QC9REL	BOOLEAN	Switching of QC9 is allowed
QC9ITL	BOOLEAN	Switching of QC9 is forbidden
QB1OPTR	BOOLEAN	QB1 is in open position
QB1CLTR	BOOLEAN	QB1 is in closed position
QB2OPTR	BOOLEAN	QB2 is in open position
QB2CLTR	BOOLEAN	QB2 is in closed position
QB7OPTR	BOOLEAN	QB7 is in open position
QB7CLTR	BOOLEAN	QB7 is in closed position
QB12OPTR	BOOLEAN	QB1 or QB2 or both are in open position
QB12CLTR	BOOLEAN	QB1 and QB2 are not in open position
VPQB1TR	BOOLEAN	Switch status of QB1 is valid (open or closed)
VPQB2TR	BOOLEAN	Switch status of QB2 is valid (open or closed)
VPQB7TR	BOOLEAN	Switch status of QB7 is valid (open or closed)
VPQB12TR	BOOLEAN	Switch status of QB1 and QB2 are valid (open or closed)

11.3.11 Interlocking for transformer bay AB_TRAFO

11.3.11.1 Introduction

The interlocking for transformer bay (AB_TRAFO) function is used for a transformer bay connected to a double busbar arrangement according to figure 214. The function is used when there is no disconnector between circuit breaker and transformer. Otherwise, the interlocking for line bay (ABC_LINE) function can be used. This function can also be used in single busbar arrangements.

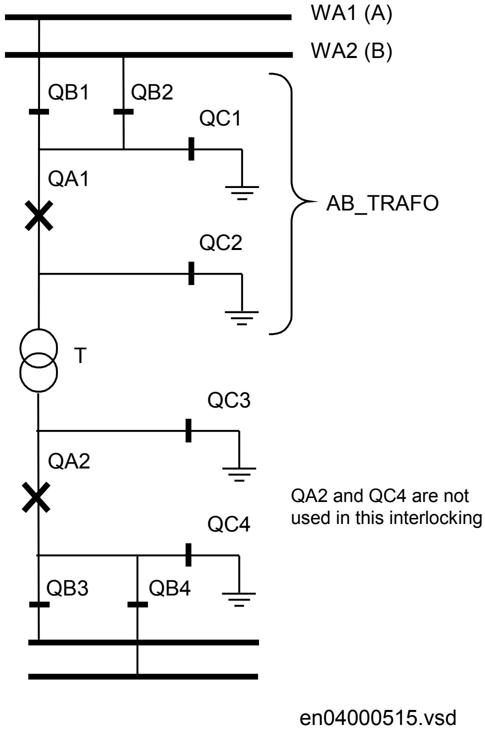


Figure 214: Switchyard layout AB_TRAFO

11.3.11.2 Function block

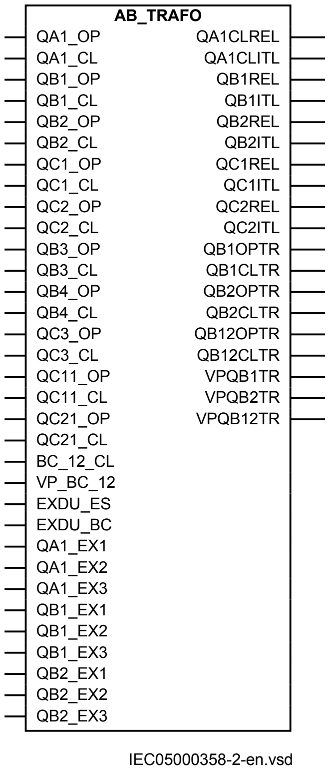
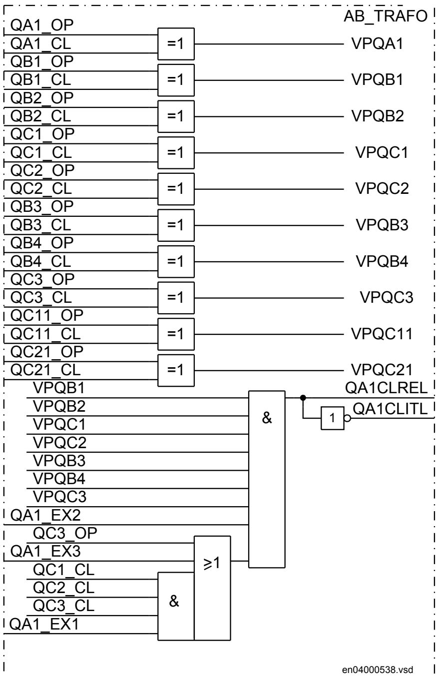
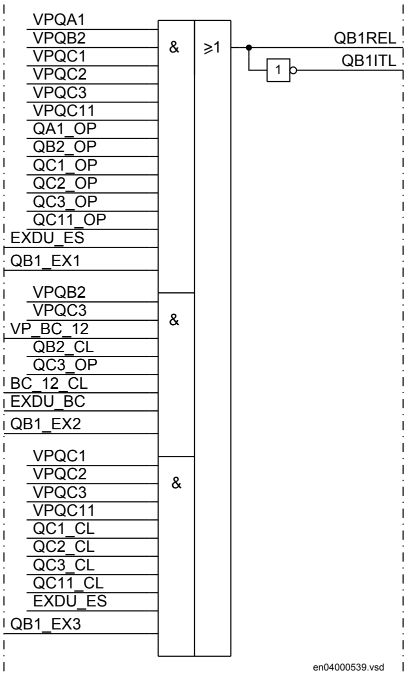
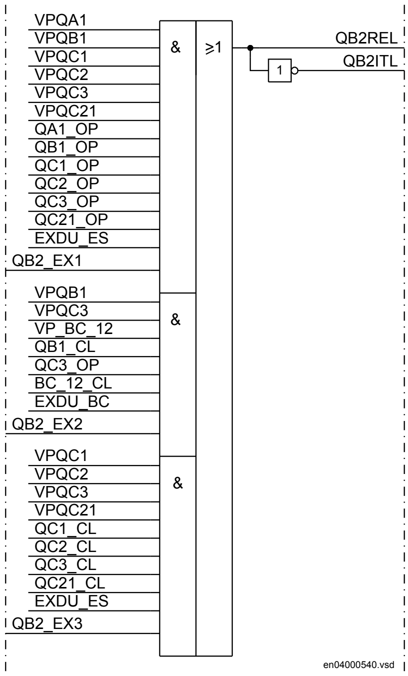


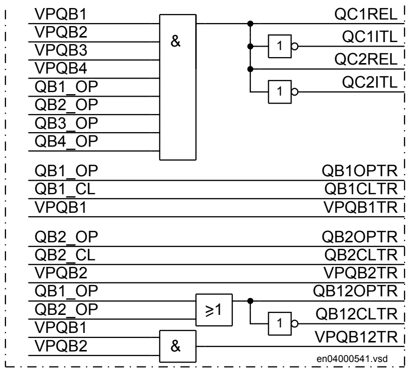
Figure 215: AB_TRAFO function block

11.3.11.3 Logic diagram









11.3.11.4 Input and output signals

Table 237: AB_TRAFO Input signals

Name	Type	Default	Description
QA1_OP	BOOLEAN	0	QA1 is in open position
QA1_CL	BOOLEAN	0	QA1 is in closed position
QB1_OP	BOOLEAN	0	QB1 is in open position
QB1_CL	BOOLEAN	0	QB1 is in closed position
QB2_OP	BOOLEAN	0	QB2 is in open position
QB2_CL	BOOLEAN	0	QB2 is in closed position
QC1_OP	BOOLEAN	0	QC1 is in open position
QC1_CL	BOOLEAN	0	QC1 is in closed position
Table continues on next page			

Name	Type	Default	Description
QC2_OP	BOOLEAN	0	QC2 is in open position
QC2_CL	BOOLEAN	0	QC2 is in closed position
QB3_OP	BOOLEAN	0	QB3 is in open position
QB3_CL	BOOLEAN	0	QB3 is in closed position
QB4_OP	BOOLEAN	0	QB4 is in open position
QB4_CL	BOOLEAN	0	QB4 is in closed position
QC3_OP	BOOLEAN	0	QC3 is in open position
QC3_CL	BOOLEAN	0	QC3 is in closed position
QC11_OP	BOOLEAN	0	QC11 on busbar WA1 is in open position
QC11_CL	BOOLEAN	0	QC11 on busbar WA1 is in closed position
QC21_OP	BOOLEAN	0	QC21 on busbar WA2 is in open position
QC21_CL	BOOLEAN	0	QC21 on busbar WA2 is in closed position
BC_12_CL	BOOLEAN	0	A bus coupler connection exists between busbar WA1 and WA2
VP_BC_12	BOOLEAN	0	Status of the bus coupler app. between WA1 and WA2 are valid
EXDU_ES	BOOLEAN	0	No transm error from any bay containing earthing switches
EXDU_BC	BOOLEAN	0	No transmission error from any bus coupler bay
QA1_EX1	BOOLEAN	0	External condition for apparatus QA1
QA1_EX2	BOOLEAN	0	External condition for apparatus QA1
QA1_EX3	BOOLEAN	0	External condition for apparatus QA1
QB1_EX1	BOOLEAN	0	External condition for apparatus QB1
QB1_EX2	BOOLEAN	0	External condition for apparatus QB1
QB1_EX3	BOOLEAN	0	External condition for apparatus QB1
QB2_EX1	BOOLEAN	0	External condition for apparatus QB2
QB2_EX2	BOOLEAN	0	External condition for apparatus QB2
QB2_EX3	BOOLEAN	0	External condition for apparatus QB2

Table 238: AB_TRAFO Output signals

Name	Type	Description
QA1CLREL	BOOLEAN	Closing of QA1 is allowed
QA1CLITL	BOOLEAN	Closing of QA1 is forbidden
QB1REL	BOOLEAN	Switching of QB1 is allowed
QB1ITL	BOOLEAN	Switching of QB1 is forbidden
QB2REL	BOOLEAN	Switching of QB2 is allowed
QB2ITL	BOOLEAN	Switching of QB2 is forbidden
QC1REL	BOOLEAN	Switching of QC1 is allowed
QC1ITL	BOOLEAN	Switching of QC1 is forbidden
QC2REL	BOOLEAN	Switching of QC2 is allowed

Table continues on next page

Name	Type	Description
QC2ITL	BOOLEAN	Switching of QC2 is forbidden
QB1OPTR	BOOLEAN	QB1 is in open position
QB1CLTR	BOOLEAN	QB1 is in closed position
QB2OPTR	BOOLEAN	QB2 is in open position
QB2CLTR	BOOLEAN	QB2 is in closed position
QB12OPTR	BOOLEAN	QB1 or QB2 or both are in open position
QB12CLTR	BOOLEAN	QB1 and QB2 are not in open position
VPQB1TR	BOOLEAN	Switch status of QB1 is valid (open or closed)
VPQB2TR	BOOLEAN	Switch status of QB2 is valid (open or closed)
VPQB12TR	BOOLEAN	Switch status of QB1 and QB2 are valid (open or closed)

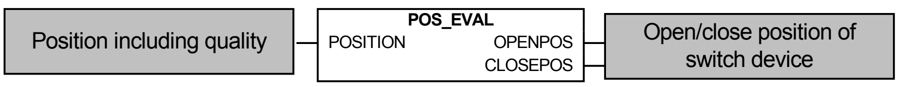
11.3.12 Position evaluation POS_EVAL

11.3.12.1 Introduction

Position evaluation (POS_EVAL) function converts the input position data signal POSITION, consisting of value, time and signal status, to binary signals OPENPOS or CLOSEPOS.

The output signals are used by other functions in the interlocking scheme.

11.3.12.2 Logic diagram



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Only the value, open/close, and status is used in this function. Time information is not used.

Input position (Value)	Signal quality	Output OPENPOS	Output CLOSEPOS
0 (Breaker intermediate)	Good	0	0
1 (Breaker open)	Good	1	0
2 (Breaker closed)	Good	0	1
3 (Breaker faulty)	Good	0	0
Any	Invalid	0	0
Any	Oscillatory	0	0

11.3.12.3 Function block

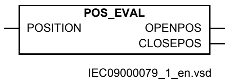

Figure 216: POS_EVAL function block

11.3.12.4 Input and output signals

Table 239: POS_EVAL Input signals

Name	Type	Default	Description
POSITION	INTEGER	0	Position status including quality

Table 240: POS_EVAL Output signals

Name	Type	Description
OPENPOS	BOOLEAN	Open position
CLOSEPOS	BOOLEAN	Close position

11.4 Logic rotating switch for function selection and LHMI presentation SLGGIO

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Logic rotating switch for function selection and LHMI presentation	SLGGIO	-	-

11.4.1 Introduction

The logic rotating switch for function selection and LHMI presentation function (SLGGIO) (or the selector switch function block) is used to get a selector switch functionality similar to the one provided by a hardware selector switch. Hardware selector switches are used extensively by utilities, in order to have different functions operating on pre-set values. Hardware switches are however sources for maintenance issues, lower system reliability and an extended purchase portfolio. The logic selector switches eliminate all these problems.

11.4.2 Principle of operation

The logic rotating switch for function selection and LHMI presentation (SLGGIO) function has two operating inputs – UP and DOWN. When a signal is received on the UP input, the block will activate the output next to the present activated output, in ascending order (if the present activated output is 3 – for example and one operates the UP input, then the output 4 will be activated). When a signal is received on the DOWN input, the block will activate the output next to the present activated output, in descending order (if the present activated output is 3 – for example and one operates the DOWN input, then the output 2 will be activated). Depending on the output settings the output signals can be steady or pulsed. In case of steady signals, in case of UP or DOWN operation, the previously active output will be deactivated. Also, depending on the settings one can have a time delay between the UP or DOWN activation signal positive front and the output activation.

Besides the inputs visible in the application configuration in the Application Configuration tool, there are other possibilities that will allow an user to set the desired position directly (without activating the intermediate positions), either locally or remotely, using a “select before execute” dialog. One can block the function operation, by activating the BLOCK input. In this case, the present position will be kept and further operation will be blocked. The operator place (local or remote) is specified through the PSTO input. If any operation is allowed the signal INTONE from the Fixed signal function block can be connected. SLGGIO function block has also an integer value output, that generates the actual position number. The positions and the block names are fully settable by the user. These names will appear in the menu, so the user can see the position names instead of a number.

11.4.2.1 Functionality and behaviour

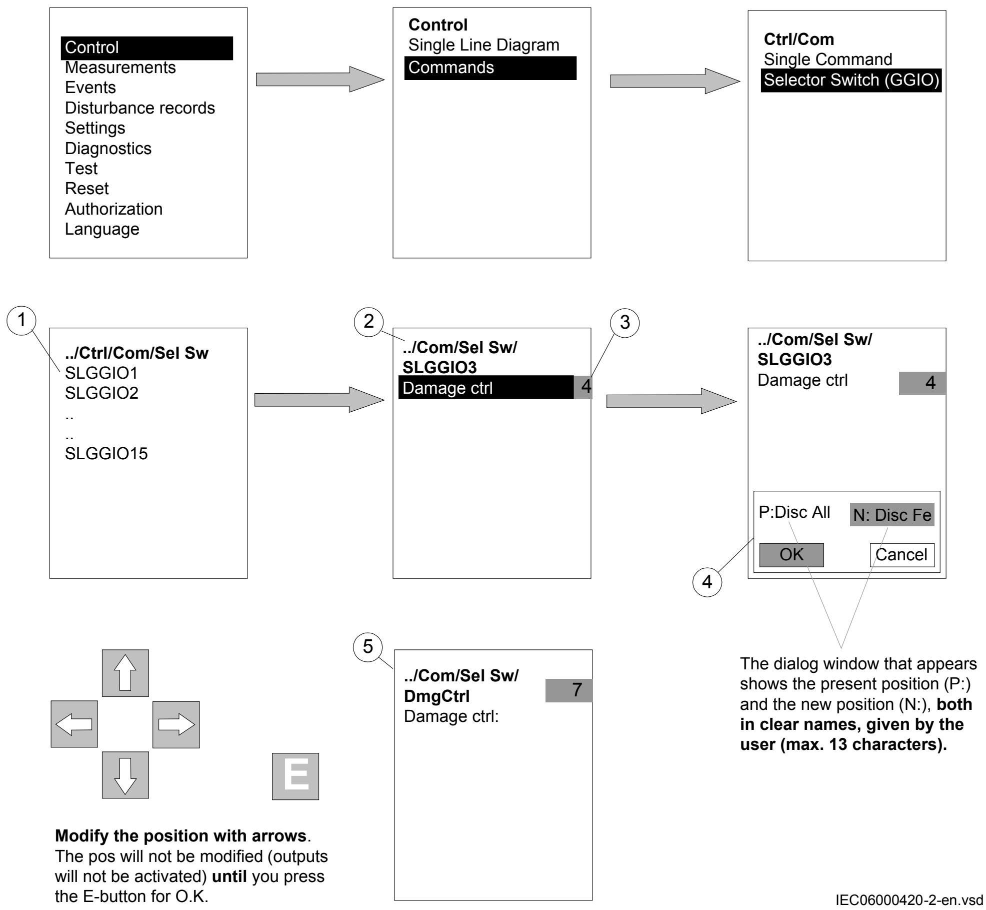

Figure 217: Example 1 on handling the switch from the local HMI.

From the local HMI:

1 SLGGIO instances in the ACT application configuration

2 Switch name given by the user (max 13 characters)

3 Position number, up to 32 positions

4 Change position

5 New position

11.4.2.2 Graphical display

There are two possibilities for SLGGIO

- if it is used just for the monitoring, the switches will be listed with their actual position names, as defined by the user (max. 13 characters).
- if it is used for control, the switches will be listed with their actual positions, but only the first three letters of the name will be used.

In both cases, the switch full name will be shown, but the user has to redefine it when building the Graphical Display Editor, under the "Caption". If used for the control, the following sequence of commands will ensure:

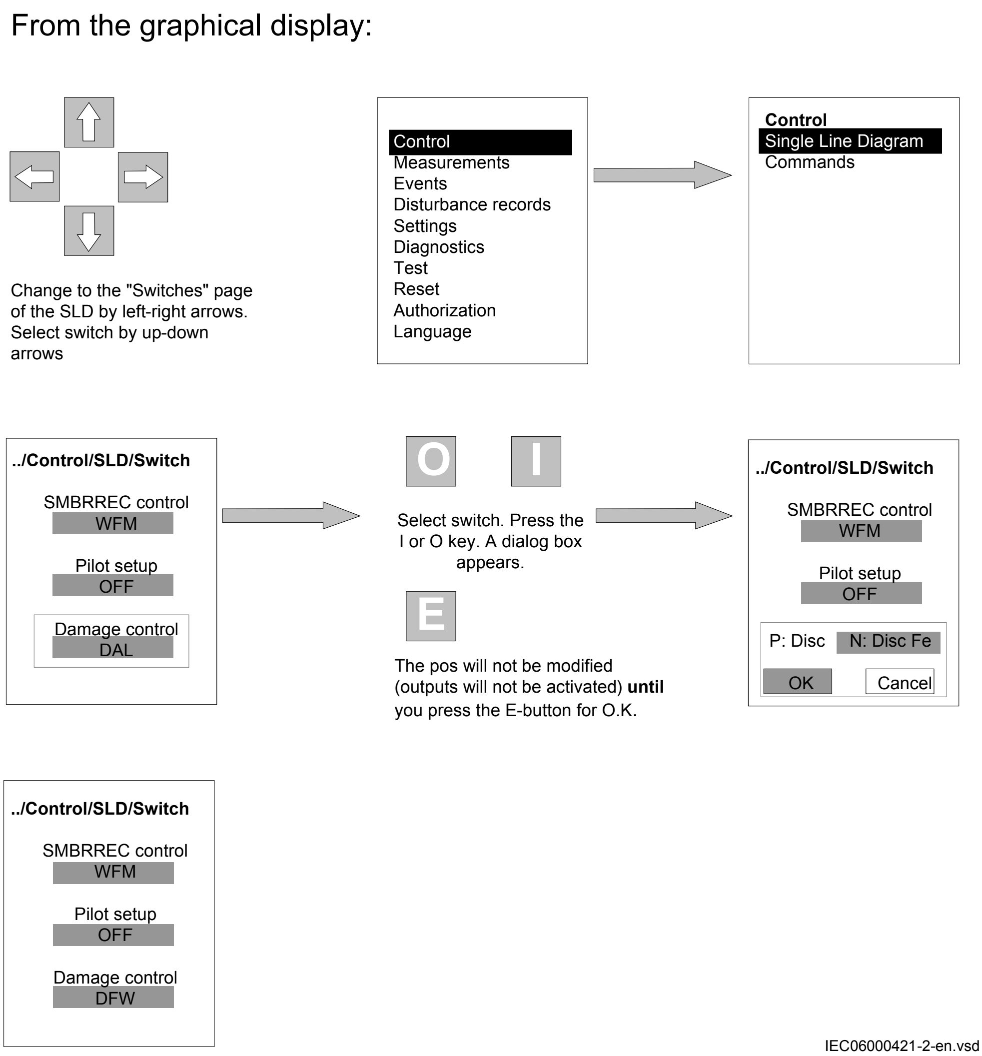

Figure 218: Example 2 on handling the switch from the local HMI.

From the single line diagram on local HMI.

11.4.3 Function block

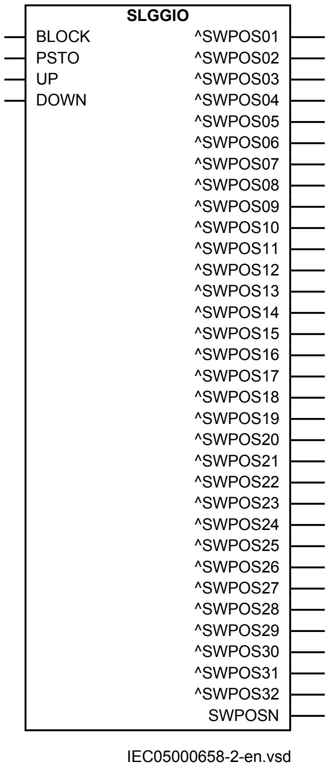

Figure 219: SLGGIO function block

11.4.4 Input and output signals

Table 241: SLGGIO Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of function
PSTO	INTEGER	0	Operator place selection
UP	BOOLEAN	0	Binary "UP" command
DOWN	BOOLEAN	0	Binary "DOWN" command

Table 242: SLGGIO Output signals

Name	Type	Description
SWPOS01	BOOLEAN	Selector switch position 1
SWPOS02	BOOLEAN	Selector switch position 2
SWPOS03	BOOLEAN	Selector switch position 3
SWPOS04	BOOLEAN	Selector switch position 4
SWPOS05	BOOLEAN	Selector switch position 5
Table continues on next page		

Name	Type	Description
SWPOS06	BOOLEAN	Selector switch position 6
SWPOS07	BOOLEAN	Selector switch position 7
SWPOS08	BOOLEAN	Selector switch position 8
SWPOS09	BOOLEAN	Selector switch position 9
SWPOS10	BOOLEAN	Selector switch position 10
SWPOS11	BOOLEAN	Selector switch position 11
SWPOS12	BOOLEAN	Selector switch position 12
SWPOS13	BOOLEAN	Selector switch position 13
SWPOS14	BOOLEAN	Selector switch position 14
SWPOS15	BOOLEAN	Selector switch position 15
SWPOS16	BOOLEAN	Selector switch position 16
SWPOS17	BOOLEAN	Selector switch position 17
SWPOS18	BOOLEAN	Selector switch position 18
SWPOS19	BOOLEAN	Selector switch position 19
SWPOS20	BOOLEAN	Selector switch position 20
SWPOS21	BOOLEAN	Selector switch position 21
SWPOS22	BOOLEAN	Selector switch position 22
SWPOS23	BOOLEAN	Selector switch position 23
SWPOS24	BOOLEAN	Selector switch position 24
SWPOS25	BOOLEAN	Selector switch position 25
SWPOS26	BOOLEAN	Selector switch position 26
SWPOS27	BOOLEAN	Selector switch position 27
SWPOS28	BOOLEAN	Selector switch position 28
SWPOS29	BOOLEAN	Selector switch position 29
SWPOS30	BOOLEAN	Selector switch position 30
SWPOS31	BOOLEAN	Selector switch position 31
SWPOS32	BOOLEAN	Selector switch position 32
SWPOSN	INTEGER	Switch position (integer)

11.4.5 Setting parameters

Table 243: SLGGIO Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off/On
NrPos	2 - 32	-	1	32	Number of positions in the switch
OutType	Pulsed Steady	-	-	Steady	Output type, steady or pulse
Table continues on next page					

Name	Values (Range)	Unit	Step	Default	Description
tPulse	0.000 - 60.000	s	0.001	0.200	Operate pulse duration, in [s]
tDelay	0.000 - 60000.000	s	0.010	0.000	Time delay on the output, in [s]
StopAtExtremes	Disabled Enabled	-	-	Disabled	Stop when min or max position is reached

11.5 Selector mini switch VSGGIO

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Selector mini switch	VSGGIO	-	-

11.5.1 Introduction

The Selector mini switch VSGGIO function block is a multipurpose function used for a variety of applications, as a general purpose switch.

VSGGIO can be controlled from the menu or from a symbol on the single line diagram (SLD) on the local HMI.

11.5.2 Principle of operation

Selector mini switch (VSGGIO) function can be used for double purpose, in the same way as switch controller (SCSWI) functions are used:

- for indication on the single line diagram (SLD). Position is received through the IPOS1 and IPOS2 inputs and distributed in the configuration through the POS1 and POS2 outputs, or to IEC 61850 through reporting, or GOOSE.
- for commands that are received via the local HMI or IEC 61850 and distributed in the configuration through outputs CMDPOS12 and CMDPOS21. The output CMDPOS12 is set when the function receives a CLOSE command from the local HMI when the SLD is displayed and the object is chosen. The output CMDPOS21 is set when the function receives an OPEN command from the local HMI when the SLD is displayed and the object is chosen.

It is important for indication in the SLD that the a symbol is associated with a controllable object, otherwise the symbol won't be displayed on the screen. A symbol is created and configured in GDE tool in PCM600.

The PSTO input is connected to the Local remote switch to have a selection of operators place , operation from local HMI (Local) or through IEC 61850

(Remote). An INTONE connection from Fixed signal function block (FXDSIGN) will allow operation from local HMI.

As it can be seen, both indications and commands are done in double-bit representation, where a combination of signals on both inputs/outputs generate the desired result.

The following table shows the relationship between IPOS1/IPOS2 inputs and the name of the string that is shown on the SLD. The value of the strings are set in PST.

IPOS1	IPOS2	Name of displayed string	Default string value
0	0	PosUndefined	P00
1	0	Position1	P01
0	1	Position2	P10
1	1	PosBadState	P11

11.5.3 Function block

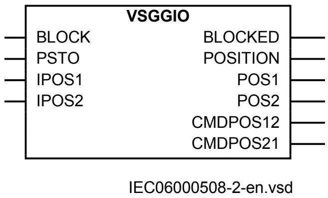

Figure 220: VSGGIO function block

11.5.4 Input and output signals

Table 244: VSGGIO Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of function
PSTO	INTEGER	0	Operator place selection
IPOS1	BOOLEAN	0	Position 1 indicating input
IPOS2	BOOLEAN	0	Position 2 indicating input

Table 245: VSGGIO Output signals

Name	Type	Description
BLOCKED	BOOLEAN	The function is active but the functionality is blocked
POSITION	INTEGER	Position indication, integer
POS1	BOOLEAN	Position 1 indication, logical signal
Table continues on next page		

Name	Type	Description
POS2	BOOLEAN	Position 2 indication, logical signal
CMDPOS12	BOOLEAN	Execute command from position 1 to position 2
CMDPOS21	BOOLEAN	Execute command from position 2 to position 1

11.5.5 Setting parameters

Table 246: VSGGIO Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
CtlModel	Dir Norm SBO Enh	-	-	Dir Norm	Specifies the type for control model according to IEC 61850
Mode	Steady Pulsed	-	-	Pulsed	Operation mode
tSelect	0.000 - 60.000	s	0.001	30.000	Max time between select and execute signals
tPulse	0.000 - 60.000	s	0.001	0.200	Command pulse lenght

11.6 Single point generic control 8 signals SPC8GGIO

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Single point generic control 8 signals	SPC8GGIO	-	-

11.6.1 Introduction

The Single point generic control 8 signals (SPC8GGIO) function block is a collection of 8 single point commands, designed to bring in commands from REMOTE (SCADA) to those parts of the logic configuration that do not need extensive command receiving functionality (for example, SCSWI). In this way, simple commands can be sent directly to the IED outputs, without confirmation. Confirmation (status) of the result of the commands is supposed to be achieved by other means, such as binary inputs and SPGGIO function blocks. The commands can be pulsed or steady.

11.6.2 Principle of operation

The PSTO input will determine which the allowed position for the operator (LOCAL, REMOTE, ALL) is. Upon sending a command from an allowed operator position, one of the 8 outputs will be activated. The settings *Latchedx* and *tPulsex* (where x is the respective output) will determine if the signal will be pulsed (and how long the pulse is) or latched (steady). BLOCK will block the operation of the function – in case a command is sent, no output will be activated.

PSTO is the universal operator place selector for all control functions. Even if PSTO can be configured to allow LOCAL or ALL operator positions, the only functional position usable with the SPC8GGIO function block is REMOTE.

11.6.3 Function block

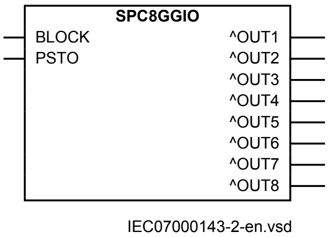

Figure 221: SPC8GGIO function block

11.6.4 Input and output signals

Table 247: SPC8GGIO Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Blocks the function operation
PSTO	INTEGER	2	Operator place selection

Table 248: SPC8GGIO Output signals

Name	Type	Description
OUT1	BOOLEAN	Output 1
OUT2	BOOLEAN	Output2
OUT3	BOOLEAN	Output3
OUT4	BOOLEAN	Output4
OUT5	BOOLEAN	Output5
OUT6	BOOLEAN	Output6
OUT7	BOOLEAN	Output7
OUT8	BOOLEAN	Output8

11.6.5 Setting parameters

Table 249: SPC8GGIO Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off/On
Latched1	Pulsed Latched	-	-	Pulsed	Setting for pulsed/latched mode for output 1
tPulse1	0.01 - 6000.00	s	0.01	0.10	Output1 Pulse Time
Latched2	Pulsed Latched	-	-	Pulsed	Setting for pulsed/latched mode for output 2
tPulse2	0.01 - 6000.00	s	0.01	0.10	Output2 Pulse Time
Latched3	Pulsed Latched	-	-	Pulsed	Setting for pulsed/latched mode for output 3
tPulse3	0.01 - 6000.00	s	0.01	0.10	Output3 Pulse Time
Latched4	Pulsed Latched	-	-	Pulsed	Setting for pulsed/latched mode for output 4
tPulse4	0.01 - 6000.00	s	0.01	0.10	Output4 Pulse Time
Latched5	Pulsed Latched	-	-	Pulsed	Setting for pulsed/latched mode for output 5
tPulse5	0.01 - 6000.00	s	0.01	0.10	Output5 Pulse Time
Latched6	Pulsed Latched	-	-	Pulsed	Setting for pulsed/latched mode for output 6
tPulse6	0.01 - 6000.00	s	0.01	0.10	Output6 Pulse Time
Latched7	Pulsed Latched	-	-	Pulsed	Setting for pulsed/latched mode for output 7
tPulse7	0.01 - 6000.00	s	0.01	0.10	Output7 Pulse Time
Latched8	Pulsed Latched	-	-	Pulsed	Setting for pulsed/latched mode for output 8
tPulse8	0.01 - 6000.00	s	0.01	0.10	Output8 pulse time

11.7 AutomationBits, command function for DNP3.0 AUTOBITS

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
AutomationBits, command function for DNP3.0	AUTOBITS	-	-

11.7.1 Introduction

AutomationBits function for DNP3 (AUTOBITS) is used within PCM600 to get into the configuration of the commands coming through the DNP3 protocol. The

AUTOBITS function plays the same role as functions GOOSEBINRCV (for IEC 61850) and MULTICMDRCV (for LON).

11.7.2 Principle of operation

AutomationBits function (AUTOBITS) has 32 individual outputs which each can be mapped as a Binary Output point in DNP3. The output is operated by a "Object 12" in DNP3. This object contains parameters for control-code, count, on-time and off-time. To operate an AUTOBITS output point, send a control-code of latch-On, latch-Off, pulse-On, pulse-Off, Trip or Close. The remaining parameters will be regarded were appropriate. ex: pulse-On, on-time=100, off-time=300, count=5 would give 5 positive 100 ms pulses, 300 ms apart.

There is a BLOCK input signal, which will disable the operation of the function, in the same way the setting *Operation*: *On/Off* does. That means that, upon activation of the BLOCK input, all 32 CMDBITxx outputs will be set to 0. The BLOCK acts like an overriding, the function still receives data from the DNP3 master. Upon deactivation of BLOCK, all the 32 CMDBITxx outputs will be set by the DNP3 master again, momentarily. For AUTOBITS , the PSTO input determines the operator place. The command can be written to the block while in “Remote”. If PSTO is in “Local” then no change is applied to the outputs.

11.7.3 Function block

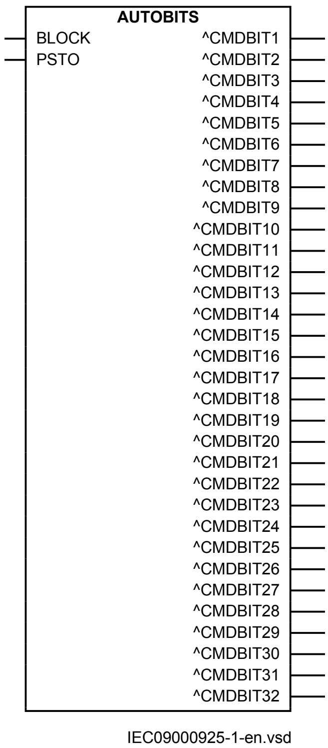

Figure 222: AUTOBITS function block

11.7.4 Input and output signals

Table 250: AUTOBITS Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of function
PSTO	INTEGER	0	Operator place selection

Table 251: AUTOBITS Output signals

Name	Type	Description
CMDBIT1	BOOLEAN	Command out bit 1
CMDBIT2	BOOLEAN	Command out bit 2
CMDBIT3	BOOLEAN	Command out bit 3
CMDBIT4	BOOLEAN	Command out bit 4
CMDBIT5	BOOLEAN	Command out bit 5
CMDBIT6	BOOLEAN	Command out bit 6
CMDBIT7	BOOLEAN	Command out bit 7
CMDBIT8	BOOLEAN	Command out bit 8
CMDBIT9	BOOLEAN	Command out bit 9
CMDBIT10	BOOLEAN	Command out bit 10
CMDBIT11	BOOLEAN	Command out bit 11
CMDBIT12	BOOLEAN	Command out bit 12
CMDBIT13	BOOLEAN	Command out bit 13
CMDBIT14	BOOLEAN	Command out bit 14
CMDBIT15	BOOLEAN	Command out bit 15
CMDBIT16	BOOLEAN	Command out bit 16
CMDBIT17	BOOLEAN	Command out bit 17
CMDBIT18	BOOLEAN	Command out bit 18
CMDBIT19	BOOLEAN	Command out bit 19
CMDBIT20	BOOLEAN	Command out bit 20
CMDBIT21	BOOLEAN	Command out bit 21
CMDBIT22	BOOLEAN	Command out bit 22
CMDBIT23	BOOLEAN	Command out bit 23
CMDBIT24	BOOLEAN	Command out bit 24
CMDBIT25	BOOLEAN	Command out bit 25
CMDBIT26	BOOLEAN	Command out bit 26
CMDBIT27	BOOLEAN	Command out bit 27
CMDBIT28	BOOLEAN	Command out bit 28
CMDBIT29	BOOLEAN	Command out bit 29
CMDBIT30	BOOLEAN	Command out bit 30
CMDBIT31	BOOLEAN	Command out bit 31
CMDBIT32	BOOLEAN	Command out bit 32

11.7.5 Setting parameters

Table 252: AUTOBITS Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On

Table 253: DNPGEN Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation mode Off / On

Table 254: CHSERRS485 Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off Serial-Mode	-	-	Off	Operation mode
BaudRate	300 Bd 600 Bd 1200 Bd 2400 Bd 4800 Bd 9600 Bd 19200 Bd	-	-	9600 Bd	Baud-rate for serial port
WireMode	Four-wire Two-wire	-	-	Two-wire	RS485 wire mode

Table 255: CHSERRS485 Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
DLinkConfirm	Never Sometimes Always	-	-	Never	Data-link confirm
tDLinkTimeout	0.000 - 60.000	s	0.001	2.000	Data-link confirm timeout in s
DLinkRetries	0 - 255	-	1	3	Data-link maximum retries
tRxToTxMinDel	0.000 - 60.000	s	0.001	0.000	Rx to Tx minimum delay in s
ApLayMaxRxSize	20 - 2048	-	1	2048	Application layer maximum Rx fragment size
ApLayMaxTxSize	20 - 2048	-	1	2048	Application layer maximum Tx fragment size
StopBits	1 - 2	-	1	1	Stop bits
Parity	No Even Odd	-	-	Even	Parity
tRTSWarmUp	0.000 - 60.000	s	0.001	0.000	RTS warm-up in s
tRTSWarmDown	0.000 - 60.000	s	0.001	0.000	RTS warm-down in s
tBackOffDelay	0.000 - 60.000	s	0.001	0.050	RS485 back-off delay in s
tMaxRndDelBkOf	0.000 - 60.000	s	0.001	0.100	RS485 maximum back-off random delay in s

Table 256: CH2TCP Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off TCP/IP UDP-Only	-	-	Off	Operation mode
TCPIPLisPort	1 - 65535	-	1	20000	TCP/IP listen port
UDPPortAccData	1 - 65535	-	1	20000	UDP port to accept UDP datagrams from master
UDPPortInitNUL	1 - 65535	-	1	20000	UDP port for initial NULL response
UDPPortCliMast	0 - 65535	-	1	0	UDP port to remote client/master

Table 257: CH2TCP Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
ApLayMaxRxSize	20 - 2048	-	1	2048	Application layer maximum Rx fragment size
ApLayMaxTxSize	20 - 2048	-	1	2048	Application layer maximum Tx fragment size

Table 258: CH3TCP Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off TCP/IP UDP-Only	-	-	Off	Operation mode
TCPIPLisPort	1 - 65535	-	1	20000	TCP/IP listen port
UDPPortAccData	1 - 65535	-	1	20000	UDP port to accept UDP datagrams from master
UDPPortInitNUL	1 - 65535	-	1	20000	UDP port for initial NULL response
UDPPortCliMast	0 - 65535	-	1	0	UDP port to remote client/master

Table 259: CH3TCP Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
ApLayMaxRxSize	20 - 2048	-	1	2048	Application layer maximum Rx fragment size
ApLayMaxTxSize	20 - 2048	-	1	2048	Application layer maximum Tx fragment size

Table 260: CH4TCP Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off TCP/IP UDP-Only	-	-	Off	Operation mode
TCPIPLisPort	1 - 65535	-	1	20000	TCP/IP listen port
UDPPortAccData	1 - 65535	-	1	20000	UDP port to accept UDP datagrams from master
UDPPortInitNUL	1 - 65535	-	1	20000	UDP port for initial NULL response
UDPPortCliMast	0 - 65535	-	1	0	UDP port to remote client/master

Table 261: CH4TCP Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
ApLayMaxRxSize	20 - 2048	-	1	2048	Application layer maximum Rx fragment size
ApLayMaxTxSize	20 - 2048	-	1	2048	Application layer maximum Tx fragment size

Table 262: CH5TCP Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off TCP/IP UDP-Only	-	-	Off	Operation mode
TCPIPLisPort	1 - 65535	-	1	20000	TCP/IP listen port
UDPPortAccData	1 - 65535	-	1	20000	UDP port to accept UDP datagrams from master
UDPPortInitNUL	1 - 65535	-	1	20000	UDP port for initial NULL response
UDPPortCliMast	0 - 65535	-	1	0	UDP port to remote client/master

Table 263: CH5TCP Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
ApLayMaxRxSize	20 - 2048	-	1	2048	Application layer maximum Rx fragment size
ApLayMaxTxSize	20 - 2048	-	1	2048	Application layer maximum Tx fragment size

Table 264: MSTRS485 Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
SlaveAddress	0 - 65519	-	1	1	Slave address
MasterAddres	0 - 65519	-	1	1	Master address
Table continues on next page					

Name	Values (Range)	Unit	Step	Default	Description
Obj1DefVar	1:BISingleBit 2:BIWithStatus	-	-	1:BISingleBit	Object 1, default variation
Obj2DefVar	1:BIChWithoutTim e 2:BIChWithTime 3:BIChWithRelTim e	-	-	3:BIChWithRelTim e	Object 2, default variation
Obj4DefVar	1:DIChWithoutTim e 2:DIChWithTime 3:DIChWithRelTim e	-	-	3:DIChWithRelTim e	Object 4, default variation
Obj10DefVar	1:BO 2:BOStatus	-	-	2:BOStatus	Object 10, default variation
Obj20DefVar	1:BinCnt32 2:BinCnt16 5:BinCnt32WoutF 6:BinCnt16WoutF	-	-	5:BinCnt32WoutF	Object 20, default variation
Obj22DefVar	1:BinCnt32EvWout T 2:BinCnt16EvWout T 5:BinCnt32EvWith T 6:BinCnt16EvWith T	-	-	1:BinCnt32EvWou tT	Object 22, default variation
Obj30DefVar	1:AI32Int 2:AI16Int 3:AI32IntWithoutF 4:AI16IntWithoutF 5:AI32FltWithF 6:AI64FltWithF	-	-	3:AI32IntWithoutF	Object 30, default variation
Obj32DefVar	1:AI32IntEvWoutF 2:AI16IntEvWoutF 3:AI32IntEvWithFT 4:AI16IntEvWithFT 5:AI32FltEvWithF 6:AI64FltEvWithF 7:AI32FltEvWithFT 8:AI64FltEvWithFT	-	-	1:AI32IntEvWoutF	Object 32, default variation

Table 265: MSTRS485 Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
ValMasterAddr	No Yes	-	-	Yes	Validate source (master) address
AddrQueryEnbl	No Yes	-	-	Yes	Address query enable
tApplConfTout	0.00 - 300.00	s	0.01	10.00	Application layer confim timeout
ApplMultFrgRes	No Yes	-	-	Yes	Enable application for multiple fragment response
ConfMultFrag	No Yes	-	-	Yes	Confirm each multiple fragment
Table continues on next page					

Name	Values (Range)	Unit	Step	Default	Description
UREnable	No Yes	-	-	Yes	Unsolicited response enabled
URSendOnline	No Yes	-	-	No	Unsolicited response sends when on-line
UREvClassMask	Off Class 1 Class 2 Class 1 and 2 Class 3 Class 1 and 3 Class 2 and 3 Class 1, 2 and 3	-	-	Off	Unsolicited response, event class mask
UROfflineRetry	0 - 10	-	1	5	Unsolicited response retries before off-line retry mode
tURRetryDelay	0.00 - 60.00	s	0.01	5.00	Unsolicited response retry delay in s
tUROfflRtryDel	0.00 - 60.00	s	0.01	30.00	Unsolicited response off-line retry delay in s
UREvCntThold1	1 - 100	-	1	5	Unsolicited response class 1 event count report treshold
tUREvBufTout1	0.00 - 60.00	s	0.01	5.00	Unsolicited response class 1 event buffer timeout
UREvCntThold2	1 - 100	-	1	5	Unsolicited response class 2 event count report treshold
tUREvBufTout2	0.00 - 60.00	s	0.01	5.00	Unsolicited response class 2 event buffer timeout
UREvCntThold3	1 - 100	-	1	5	Unsolicited response class 3 event count report treshold
tUREvBufTout3	0.00 - 60.00	s	0.01	5.00	Unsolicited response class 3 event buffer timeout
DelOldBufFull	No Yes	-	-	No	Delete oldest event when buffer is full
tSynchTimeout	30 - 3600	s	1	1800	Time synch timeout before error status is generated
TSyncReqAfTout	No Yes	-	-	No	Time synchronization request after timeout
DNPToSetTime	No Yes	-	-	Yes	Allow DNP to set time in IED
Averag3TimeReq	No Yes	-	-	No	Use average of 3 time requests
PairedPoint	No Yes	-	-	Yes	Enable paired point
tSelectTimeout	1.0 - 60.0	s	0.1	30.0	Select timeout

Table 266: MST1TCP Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
SlaveAddress	0 - 65519	-	1	1	Slave address
MasterAddres	0 - 65519	-	1	1	Master address
ValMasterAddr	No Yes	-	-	Yes	Validate source (master) address
MasterIP-Addr	0 - 18	IP Address	1	0.0.0.0	Master IP-address
MasterIPNetMsk	0 - 18	IP Address	1	255.255.255.255	Master IP net mask
Obj1DefVar	1:BISingleBit 2:BIWithStatus	-	-	1:BISingleBit	Object 1, default variation
Obj2DefVar	1:BIChWithoutTime 2:BIChWithTime 3:BIChWithRelTime	-	-	3:BIChWithRelTime	Object 2, default variation
Obj3DefVar	1:DIWithoutFlag 2:DIWithFlag	-	-	1:DIWithoutFlag	Object 3, default variation
Obj4DefVar	1:DIChWithoutTime 2:DIChWithTime 3:DIChWithRelTime	-	-	3:DIChWithRelTime	Object 4, default variation
Obj10DefVar	1:BO 2:BOStatus	-	-	2:BOStatus	Object 10, default variation
Obj20DefVar	1:BinCnt32 2:BinCnt16 5:BinCnt32WoutF 6:BinCnt16WoutF	-	-	5:BinCnt32WoutF	Object 20, default variation
Obj22DefVar	1:BinCnt32EvWoutT 2:BinCnt16EvWoutT 5:BinCnt32EvWithT 6:BinCnt16EvWithT	-	-	1:BinCnt32EvWoutT	Object 22, default variation
Obj30DefVar	1:AI32Int 2:AI16Int 3:AI32IntWithoutF 4:AI16IntWithoutF 5:AI32FltWithF 6:AI64FltWithF	-	-	3:AI32IntWithoutF	Object 30, default variation
Obj32DefVar	1:AI32IntEvWoutF 2:AI16IntEvWoutF 3:AI32IntEvWithFT 4:AI16IntEvWithFT 5:AI32FltEvWithF 6:AI64FltEvWithF 7:AI32FltEvWithFT 8:AI64FltEvWithFT	-	-	1:AI32IntEvWoutF	Object 32, default variation

Table 267: MST1TCP Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
AddrQueryEnbl	No Yes	-	-	Yes	Address query enable
tApplConfTout	0.00 - 300.00	s	0.01	10.00	Application layer confim timeout
ApplMultFrgRes	No Yes	-	-	Yes	Enable application for multiple fragment response
ConfMultFrag	No Yes	-	-	Yes	Confirm each multiple fragment
UREnable	No Yes	-	-	Yes	Unsolicited response enabled
UREvClassMask	Off Class 1 Class 2 Class 1 and 2 Class 3 Class 1 and 3 Class 2 and 3 Class 1, 2 and 3	-	-	Off	Unsolicited response, event class mask
UROfflineRetry	0 - 10	-	1	5	Unsolicited response retries before off-line retry mode
tURRetryDelay	0.00 - 60.00	s	0.01	5.00	Unsolicited response retry delay in s
tUROfflRtryDel	0.00 - 60.00	s	0.01	30.00	Unsolicited response off-line retry delay in s
UREvCntThold1	1 - 100	-	1	5	Unsolicited response class 1 event count report treshold
tUREvBufTout1	0.00 - 60.00	s	0.01	5.00	Unsolicited response class 1 event buffer timeout
UREvCntThold2	1 - 100	-	1	5	Unsolicited response class 2 event count report treshold
tUREvBufTout2	0.00 - 60.00	s	0.01	5.00	Unsolicited response class 2 event buffer timeout
UREvCntThold3	1 - 100	-	1	5	Unsolicited response class 3 event count report treshold
tUREvBufTout3	0.00 - 60.00	s	0.01	5.00	Unsolicited response class 3 event buffer timeout
DelOldBufFull	No Yes	-	-	No	Delete oldest event when buffer is full
ExtTimeFormat	LocalTime UTC	-	-	UTC	External time format
DNPToSetTime	No Yes	-	-	No	Allow DNP to set time in IED
tSynchTimeout	30 - 3600	s	1	1800	Time synch timeout before error status is generated
TSyncReqAfTout	No Yes	-	-	No	Time synchronization request after timeout
Averag3TimeReq	No Yes	-	-	No	Use average of 3 time requests
PairedPoint	No Yes	-	-	Yes	Enable paired point
Table continues on next page					

Name	Values (Range)	Unit	Step	Default	Description
tSelectTimeout	1.0 - 60.0	s	0.1	30.0	Select timeout
tBrokenConTout	0 - 3600	s	1	0	Broken connection timeout
tKeepAliveT	0 - 3600	s	1	10	Keep-Alive timer

Table 268: MST2TCP Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
SlaveAddress	0 - 65519	-	1	1	Slave address
MasterAddres	0 - 65519	-	1	1	Master address
ValMasterAddr	No Yes	-	-	Yes	Validate source (master) address
MasterIP-Addr	0 - 18	IP Address	1	0.0.0.0	Master IP-address
MasterIPNetMsk	0 - 18	IP Address	1	255.255.255.255	Master IP net mask
Obj1DefVar	1:BISingleBit 2:BIWithStatus	-	-	1:BISingleBit	Object 1, default variation
Obj2DefVar	1:BIChWithoutTime 2:BIChWithTime 3:BIChWithRelTime	-	-	3:BIChWithRelTime	Object 2, default variation
Obj3DefVar	1:DIWithoutFlag 2:DIWithFlag	-	-	1:DIWithoutFlag	Object 3, default variation
Obj4DefVar	1:DIChWithoutTime 2:DIChWithTime 3:DIChWithRelTime	-	-	3:DIChWithRelTime	Object 4, default variation
Obj10DefVar	1:BO 2:BOStatus	-	-	2:BOStatus	Object 10, default variation
Obj20DefVar	1:BinCnt32 2:BinCnt16 5:BinCnt32WoutF 6:BinCnt16WoutF	-	-	5:BinCnt32WoutF	Object 20, default variation

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
Obj22DefVar	1:BinCnt32EvWoutT 2:BinCnt16EvWoutT 5:BinCnt32EvWithT 6:BinCnt16EvWithT	-	-	1:BinCnt32EvWoutT	Object 22, default variation
Obj30DefVar	1:AI32Int 2:AI16Int 3:AI32IntWithoutF 4:AI16IntWithoutF 5:AI32FltWithF 6:AI64FltWithF	-	-	3:AI32IntWithoutF	Object 30, default variation
Obj32DefVar	1:AI32IntEvWoutF 2:AI16IntEvWoutF 3:AI32IntEvWithFT 4:AI16IntEvWithFT 5:AI32FltEvWithF 6:AI64FltEvWithF 7:AI32FltEvWithFT 8:AI64FltEvWithFT	-	-	1:AI32IntEvWoutF	Object 32, default variation

Table 269: MST2TCP Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
AddrQueryEnbl	No Yes	-	-	Yes	Address query enable
tApplConfTout	0.00 - 300.00	s	0.01	10.00	Application layer confim timeout
ApplMultFrgRes	No Yes	-	-	Yes	Enable application for multiple fragment response
ConfMultFrag	No Yes	-	-	Yes	Confirm each multiple fragment
UREnable	No Yes	-	-	Yes	Unsolicited response enabled
UREvClassMask	Off Class 1 Class 2 Class 1 and 2 Class 3 Class 1 and 3 Class 2 and 3 Class 1, 2 and 3	-	-	Off	Unsolicited response, event class mask
UROfflineRetry	0 - 10	-	1	5	Unsolicited response retries before off-line retry mode
tURRetryDelay	0.00 - 60.00	s	0.01	5.00	Unsolicited response retry delay in s
tUROfflRtryDel	0.00 - 60.00	s	0.01	30.00	Unsolicited response off-line retry delay in s
UREvCntThold1	1 - 100	-	1	5	Unsolicited response class 1 event count report treshold
tUREvBufTout1	0.00 - 60.00	s	0.01	5.00	Unsolicited response class 1 event buffer timeout
UREvCntThold2	1 - 100	-	1	5	Unsolicited response class 2 event count report treshold

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
tUREvBufTout2	0.00 - 60.00	s	0.01	5.00	Unsolicited response class 2 event buffer timeout
UREvCntThold3	1 - 100	-	1	5	Unsolicited response class 3 event count report treshold
tUREvBufTout3	0.00 - 60.00	s	0.01	5.00	Unsolicited response class 3 event buffer timeout
DelOldBufFull	No Yes	-	-	No	Delete oldest event when buffer is full
ExtTimeFormat	LocalTime UTC	-	-	UTC	External time format
DNPToSetTime	No Yes	-	-	No	Allow DNP to set time in IED
tSynchTimeout	30 - 3600	s	1	1800	Time synch timeout before error status is generated
TSyncReqAfTout	No Yes	-	-	No	Time synchronization request after timeout
Averag3TimeReq	No Yes	-	-	No	Use average of 3 time requests
PairedPoint	No Yes	-	-	Yes	Enable paired point
tSelectTimeout	1.0 - 60.0	s	0.1	30.0	Select timeout
tBrokenConTout	0 - 3600	s	1	0	Broken connection timeout
tKeepAliveT	0 - 3600	s	1	10	Keep-Alive timer

Table 270: MST3TCP Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
SlaveAddress	0 - 65519	-	1	1	Slave address
MasterAddres	0 - 65519	-	1	1	Master address
ValMasterAddr	No Yes	-	-	Yes	Validate source (master) address
MasterIP-Addr	0 - 18	IP Address	1	0.0.0.0	Master IP-address
MasterIPNetMsk	0 - 18	IP Address	1	255.255.255.255	Master IP net mask
Obj1DefVar	1:BISingleBit 2:BIWithStatus	-	-	1:BISingleBit	Object 1, default variation
Obj2DefVar	1:BIChWithoutTime 2:BIChWithTime 3:BIChWithRelTime	-	-	3:BIChWithRelTime	Object 2, default variation
Obj3DefVar	1:DIWithoutFlag 2:DIWithFlag	-	-	1:DIWithoutFlag	Object 3, default variation
Table continues on next page					

Name	Values (Range)	Unit	Step	Default	Description
Obj4DefVar	1:DIChWithoutTime 2:DIChWithTime 3:DIChWithRelTime	-	-	3:DIChWithRelTime	Object 4, default variation
Obj10DefVar	1:BO 2:BOStatus	-	-	2:BOStatus	Object 10, default variation
Obj20DefVar	1:BinCnt32 2:BinCnt16 5:BinCnt32WoutF 6:BinCnt16WoutF	-	-	5:BinCnt32WoutF	Object 20, default variation
Obj22DefVar	1:BinCnt32EvWoutT 2:BinCnt16EvWoutT 5:BinCnt32EvWithT 6:BinCnt16EvWithT	-	-	1:BinCnt32EvWoutT	Object 22, default variation
Obj30DefVar	1:AI32Int 2:AI16Int 3:AI32IntWithoutF 4:AI16IntWithoutF 5:AI32FltWithF 6:AI64FltWithF	-	-	3:AI32IntWithoutF	Object 30, default variation
Obj32DefVar	1:AI32IntEvWoutF 2:AI16IntEvWoutF 3:AI32IntEvWithFT 4:AI16IntEvWithFT 5:AI32FltEvWithF 6:AI64FltEvWithF 7:AI32FltEvWithFT 8:AI64FltEvWithFT	-	-	1:AI32IntEvWoutF	Object 32, default variation

Table 271: MST3TCP Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
AddrQueryEnbl	No Yes	-	-	Yes	Address query enable
tApplConfTout	0.00 - 300.00	s	0.01	10.00	Application layer confim timeout
ApplMultFrgRes	No Yes	-	-	Yes	Enable application for multiple fragment response
ConfMultFrag	No Yes	-	-	Yes	Confirm each multiple fragment
UREnable	No Yes	-	-	Yes	Unsolicited response enabled
UREvClassMask	Off Class 1 Class 2 Class 1 and 2 Class 3 Class 1 and 3 Class 2 and 3 Class 1, 2 and 3	-	-	Off	Unsolicited response, event class mask

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
UROfflineRetry	0 - 10	-	1	5	Unsolicited response retries before off-line retry mode
tURRetryDelay	0.00 - 60.00	s	0.01	5.00	Unsolicited response retry delay in s
tUROfflRtryDel	0.00 - 60.00	s	0.01	30.00	Unsolicited response off-line retry delay in s
UREvCntThold1	1 - 100	-	1	5	Unsolicited response class 1 event count report treshold
tUREvBufTout1	0.00 - 60.00	s	0.01	5.00	Unsolicited response class 1 event buffer timeout
UREvCntThold2	1 - 100	-	1	5	Unsolicited response class 2 event count report treshold
tUREvBufTout2	0.00 - 60.00	s	0.01	5.00	Unsolicited response class 2 event buffer timeout
UREvCntThold3	1 - 100	-	1	5	Unsolicited response class 3 event count report treshold
tUREvBufTout3	0.00 - 60.00	s	0.01	5.00	Unsolicited response class 3 event buffer timeout
DelOldBufFull	No Yes	-	-	No	Delete oldest event when buffer is full
ExtTimeFormat	LocalTime UTC	-	-	UTC	External time format
DNPToSetTime	No Yes	-	-	No	Allow DNP to set time in IED
tSynchTimeout	30 - 3600	s	1	1800	Time synch timeout before error status is generated
TSyncReqAfTout	No Yes	-	-	No	Time synchronization request after timeout
Averag3TimeReq	No Yes	-	-	No	Use average of 3 time requests
PairedPoint	No Yes	-	-	Yes	Enable paired point
tSelectTimeout	1.0 - 60.0	s	0.1	30.0	Select timeout
tBrokenConTout	0 - 3600	s	1	0	Broken connection timeout
tKeepAliveT	0 - 3600	s	1	10	Keep-Alive timer

Table 272: MST4TCP Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
SlaveAddress	0 - 65519	-	1	1	Slave address
MasterAddres	0 - 65519	-	1	1	Master address
ValMasterAddr	No Yes	-	-	Yes	Validate source (master) address
MasterIP-Addr	0 - 18	IP Address	1	0.0.0.0	Master IP-address

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
MasterIPNetMsk	0 - 18	IP Address	1	255.255.255.255	Master IP net mask
Obj1DefVar	1:BISingleBit 2:BIWithStatus	-	-	1:BISingleBit	Object 1, default variation
Obj2DefVar	1:BIChWithoutTime 2:BIChWithTime 3:BIChWithRelTime	-	-	3:BIChWithRelTime	Object 2, default variation
Obj3DefVar	1:DIWithoutFlag 2:DIWithFlag	-	-	1:DIWithoutFlag	Object 3, default variation
Obj4DefVar	1:DIChWithoutTime 2:DIChWithTime 3:DIChWithRelTime	-	-	3:DIChWithRelTime	Object 4, default variation
Obj10DefVar	1:BO 2:BOStatus	-	-	2:BOStatus	Object 10, default variation
Obj20DefVar	1:BinCnt32 2:BinCnt16 5:BinCnt32WoutF 6:BinCnt16WoutF	-	-	5:BinCnt32WoutF	Object 20, default variation
Obj22DefVar	1:BinCnt32EvWoutT 2:BinCnt16EvWoutT 5:BinCnt32EvWithT 6:BinCnt16EvWithT	-	-	1:BinCnt32EvWoutT	Object 22, default variation
Obj30DefVar	1:AI32Int 2:AI16Int 3:AI32IntWithoutF 4:AI16IntWithoutF 5:AI32FltWithF 6:AI64FltWithF	-	-	3:AI32IntWithoutF	Object 30, default variation
Obj32DefVar	1:AI32IntEvWoutF 2:AI16IntEvWoutF 3:AI32IntEvWithFT 4:AI16IntEvWithFT 5:AI32FltEvWithF 6:AI64FltEvWithF 7:AI32FltEvWithFT 8:AI64FltEvWithFT	-	-	1:AI32IntEvWoutF	Object 32, default variation

Table 273: MST4TCP Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
AddrQueryEnbl	No Yes	-	-	Yes	Address query enable
tApplConfTout	0.00 - 300.00	s	0.01	10.00	Application layer confim timeout
ApplMultFrgRes	No Yes	-	-	Yes	Enable application for multiple fragment response

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
ConfMultFrag	No Yes	-	-	Yes	Confirm each multiple fragment
UREnable	No Yes	-	-	Yes	Unsolicited response enabled
UREvClassMask	Off Class 1 Class 2 Class 1 and 2 Class 3 Class 1 and 3 Class 2 and 3 Class 1, 2 and 3	-	-	Off	Unsolicited response, event class mask
UROfflineRetry	0 - 10	-	1	5	Unsolicited response retries before off-line retry mode
tURRetryDelay	0.00 - 60.00	s	0.01	5.00	Unsolicited response retry delay in s
tUROfflRtryDel	0.00 - 60.00	s	0.01	30.00	Unsolicited response off-line retry delay in s
UREvCntThold1	1 - 100	-	1	5	Unsolicited response class 1 event count report treshold
tUREvBufTout1	0.00 - 60.00	s	0.01	5.00	Unsolicited response class 1 event buffer timeout
UREvCntThold2	1 - 100	-	1	5	Unsolicited response class 2 event count report treshold
tUREvBufTout2	0.00 - 60.00	s	0.01	5.00	Unsolicited response class 2 event buffer timeout
UREvCntThold3	1 - 100	-	1	5	Unsolicited response class 3 event count report treshold
tUREvBufTout3	0.00 - 60.00	s	0.01	5.00	Unsolicited response class 3 event buffer timeout
DelOldBufFull	No Yes	-	-	No	Delete oldest event when buffer is full
ExtTimeFormat	LocalTime UTC	-	-	UTC	External time format
DNPToSetTime	No Yes	-	-	No	Allow DNP to set time in IED
tSynchTimeout	30 - 3600	s	1	1800	Time synch timeout before error status is generated
TSyncReqAfTout	No Yes	-	-	No	Time synchronization request after timeout
Averag3TimeReq	No Yes	-	-	No	Use average of 3 time requests
PairedPoint	No Yes	-	-	Yes	Enable paired point
tSelectTimeout	1.0 - 60.0	s	0.1	30.0	Select timeout
tBrokenConTout	0 - 3600	s	1	0	Broken connection timeout
tKeepAliveT	0 - 3600	s	1	10	Keep-Alive timer

11.8 Single command, 16 signals SINGLECMD

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Single command, 16 signals	SINGLECMD	-	-

11.8.1 Introduction

The IEDs can receive commands either from a substation automation system or from the local HMI. The command function block has outputs that can be used, for example, to control high voltage apparatuses or for other user defined functionality.

11.8.2 Principle of operation

Single command, 16 signals (SINGLECMD) function has 16 binary output signals. The outputs can be individually controlled from a substation automation system or from the local HMI. Each output signal can be given a name with a maximum of 13 characters in PCM600.

The output signals can be of the types Off, Steady, or Pulse. This configuration setting is done via the local HMI or PCM600 and is common for the whole function block. The length of the output pulses are 100 ms. In steady mode, SINGLECMD function has a memory to remember the output values at power interruption of the IED. Also a BLOCK input is available used to block the updating of the outputs.

The output signals, OUT1 to OUT16, are available for configuration to built-in functions or via the configuration logic circuits to the binary outputs of the IED.

11.8.3 Function block

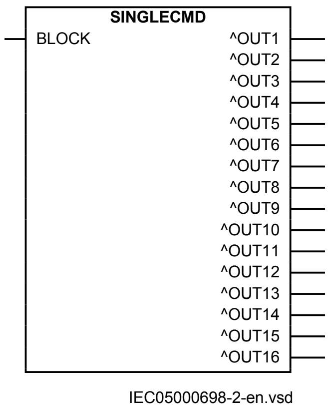

Figure 223: SINGLECMD function block

11.8.4 Input and output signals

Table 274: SINGLECMD Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block single command function

Table 275: SINGLECMD Output signals

Name	Type	Description
OUT1	BOOLEAN	Single command output 1
OUT2	BOOLEAN	Single command output 2
OUT3	BOOLEAN	Single command output 3
OUT4	BOOLEAN	Single command output 4
OUT5	BOOLEAN	Single command output 5
OUT6	BOOLEAN	Single command output 6
OUT7	BOOLEAN	Single command output 7
OUT8	BOOLEAN	Single command output 8
OUT9	BOOLEAN	Single command output 9
OUT10	BOOLEAN	Single command output 10
OUT11	BOOLEAN	Single command output 11
OUT12	BOOLEAN	Single command output 12
OUT13	BOOLEAN	Single command output 13
OUT14	BOOLEAN	Single command output 14
OUT15	BOOLEAN	Single command output 15
OUT16	BOOLEAN	Single command output 16

11.8.5 Setting parameters

Table 276: SINGLECMD Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Mode	Off Steady Pulsed	-	-	Off	Operation mode

Section 12 Logic

About this chapter

This chapter describes primarily tripping and trip logic functions. The way the functions work, their setting parameters, function blocks, input and output signals and technical data are included for each function.

12.1 Configurable logic blocks

12.1.1 Introduction

A number of logic blocks and timers are available for the user to adapt the configuration to the specific application needs.

- **OR** function block.
- **INVERTER** function blocks that inverts the input signal.
- **PULSETIMER** function block can be used, for example, for pulse extensions or limiting of operation of outputs.
- **GATE** function block is used for whether or not a signal should be able to pass from the input to the output.
- **XOR** function block.
- **LOOPDELAY** function block used to delay the output signal one execution cycle.
- **TIMERSET** function has pick-up and drop-out delayed outputs related to the input signal. The timer has a settable time delay.
- **AND** function block.
- **SRMEMORY** function block is a flip-flop that can set or reset an output from two inputs respectively. Each block has two outputs where one is inverted. The memory setting controls if the block's output should reset or return to the state it was, after a power interruption. Set input has priority.

- **RSMEMORY** function block is a flip-flop that can reset or set an output from two inputs respectively. Each block has two outputs where one is inverted. The memory setting controls if the block's output should reset or return to the state it was, after a power interruption. Reset input has priority.

12.1.2 Inverter function block INV

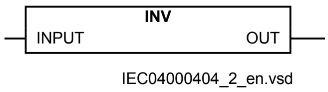

Figure 224: INV function block

Table 277: INV Input signals

Name	Type	Default	Description
INPUT	BOOLEAN	0	Input

Table 278: INV Output signals

Name	Type	Description
OUT	BOOLEAN	Output

12.1.3 OR function block OR

The OR function is used to form general combinatory expressions with boolean variables. The OR function block has six inputs and two outputs. One of the outputs is inverted.

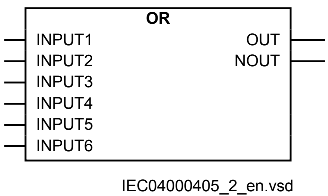

Figure 225: OR function block

Table 279: OR Input signals

Name	Type	Default	Description
INPUT1	BOOLEAN	0	Input 1 to OR gate
INPUT2	BOOLEAN	0	Input 2 to OR gate
INPUT3	BOOLEAN	0	Input 3 to OR gate
INPUT4	BOOLEAN	0	Input 4 to OR gate
INPUT5	BOOLEAN	0	Input 5 to OR gate
INPUT6	BOOLEAN	0	Input 6 to OR gate

Table 280: OR Output signals

Name	Type	Description
OUT	BOOLEAN	Output from OR gate
NOUT	BOOLEAN	Inverted output from OR gate

12.1.4 AND function block AND

The AND function is used to form general combinatory expressions with boolean variables. The AND function block has four inputs and two outputs. One of the outputs are inverted.

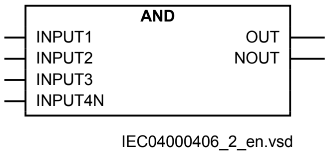

Figure 226: AND function block

Table 281: AND Input signals

Name	Type	Default	Description
INPUT1	BOOLEAN	1	Input 1
INPUT2	BOOLEAN	1	Input 2
INPUT3	BOOLEAN	1	Input 3
INPUT4N	BOOLEAN	0	Input 4 inverted

Table 282: AND Output signals

Name	Type	Description
OUT	BOOLEAN	Output
NOUT	BOOLEAN	Output inverted

12.1.5 Timer function block TIMER

The function block TIMER has drop-out and pick-up delayed outputs related to the input signal. The timer has a settable time delay (*T*).

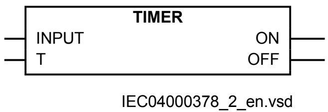

Figure 227: TIMER function block

Table 283: TIMER Input signals

Name	Type	Default	Description
INPUT	BOOLEAN	0	Input to timer

Table 284: TIMER Output signals

Name	Type	Description
ON	BOOLEAN	Output from timer , pick-up delayed
OFF	BOOLEAN	Output from timer, drop-out delayed

Table 285: TIMER Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
T	0.000 - 90000.000	s	0.001	0.000	Time delay of function

12.1.6 Pulse timer function block PULSETIMER

The pulse (PULSETIMER) function can be used, for example, for pulse extensions or limiting of operation of outputs. The pulse timer TP has a settable length.

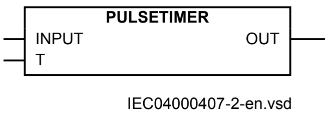

Figure 228: PULSETIMER function block

Table 286: PULSETIMER Input signals

Name	Type	Default	Description
INPUT	BOOLEAN	0	Input to pulse timer

Table 287: PULSETIMER Output signals

Name	Type	Description
OUT	BOOLEAN	Output from pulse timer

Table 288: PULSETIMER Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
T	0.000 - 90000.000	s	0.001	0.010	Time delay of function

12.1.7 Exclusive OR function block XOR

The exclusive OR function (XOR) is used to generate combinatory expressions with boolean variables. XOR has two inputs and two outputs. One of the outputs is inverted. The output signal is 1 if the input signals are different and 0 if they are equal.

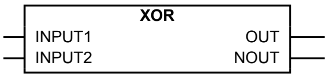

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Figure 229: XOR function block

Table 289: XOR Input signals

Name	Type	Default	Description
INPUT1	BOOLEAN	0	Input 1 to XOR gate
INPUT2	BOOLEAN	0	Input 2 to XOR gate

Table 290: XOR Output signals

Name	Type	Description
OUT	BOOLEAN	Output from XOR gate
NOUT	BOOLEAN	Inverted output from XOR gate

12.1.8 Loop delay function block LOOPDELAY

The Logic loop delay function block (LOOPDELAY) function is used to delay the output signal one execution cycle.

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Figure 230: LOOPDELAY function block

Table 291: LOOPDELAY Input signals

Name	Type	Default	Description
INPUT	BOOLEAN	0	Input signal

Table 292: LOOPDELAY Output signals

Name	Type	Description
OUT	BOOLEAN	Output signal, signal is delayed one execution cycle

12.1.9 Set-reset with memory function block SRMEMORY

The Set-reset with memory function block (SRMEMORY) is a flip-flop with memory that can set or reset an output from two inputs respectively. Each SRMEMORY function block has two outputs, where one is inverted. The memory setting controls if the flip-flop after a power interruption will return the state it had before or if it will be reset.

Table 293: Truth table for SRMEMORY function block

SET	RESET	OUT	NOUT
0	0	Last value	Inverted last value
0	1	0	1
1	0	1	0
1	1	1	0

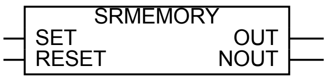

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Figure 231: SRMEMORY function block

Table 294: SRMEMORY Input signals

Name	Type	Default	Description
SET	BOOLEAN	0	Input signal to set
RESET	BOOLEAN	0	Input signal to reset

Table 295: SRMEMORY Output signals

Name	Type	Description
OUT	BOOLEAN	Output signal
NOUT	BOOLEAN	Inverted output signal

Table 296: SRMEMORY Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Memory	Off On	-	-	On	Operating mode of the memory function

12.1.10 Reset-set with memory function block RSMEMORY

The Reset-set with memory function block (RSMEMORY) is a flip-flop with memory that can reset or set an output from two inputs respectively. Each RSMEMORY function block has two outputs, where one is inverted. The memory setting controls if the flip-flop after a power interruption will return the state it had before or if it will be reset. For a Reset-Set flip-flop, RESET input has higher priority over SET input.

Table 297: Truth table for RSMEMORY function block

RESET	SET	OUT	NOUT
0	0	Last value	Inverted last value
0	1	0	1
1	0	1	0
1	1	0	1

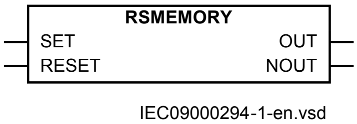

Figure 232: RSMEMORY function block

Table 298: RSMEMORY Input signals

Name	Type	Default	Description
SET	BOOLEAN	0	Input signal to set
RESET	BOOLEAN	0	Input signal to reset

Table 299: RSMEMORY Output signals

Name	Type	Description
OUT	BOOLEAN	Output signal
NOUT	BOOLEAN	Inverted output signal

Table 300: RSMEMORY Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Memory	Off On	-	-	On	Operating mode of the memory function

12.1.11 Controllable gate function block GATE

The Controllable gate function block (GATE) is used for controlling if a signal should be able to pass from the input to the output or not depending on a setting.

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Figure 233: GATE function block

Table 301: GATE Input signals

Name	Type	Default	Description
INPUT	BOOLEAN	0	Input to gate

Table 302: GATE Output signals

Name	Type	Description
OUT	BOOLEAN	Output from gate

Table 303: GATE Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off/On

12.1.12 Settable timer function block TIMERSET

The Settable timer function block (TIMERSET) timer has outputs for delayed input signal at drop-out and at pick-up. The timer has a settable time delay. It also has an *Operation* setting *On*/, *Off*/ that controls the operation of the timer.

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Figure 234: TIMERSET function block

Table 304: TIMERSET Input signals

Name	Type	Default	Description
INPUT	BOOLEAN	0	Input to timer

Table 305: TIMERSET Output signals

Name	Type	Description
ON	BOOLEAN	Output from timer, pick-up delayed
OFF	BOOLEAN	Output from timer, drop-out delayed

Table 306: TIMERSET Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off/On
t	0.000 - 90000.000	s	0.001	0.000	Delay for settable timer n

12.1.13 Technical data

Table 307: Configurable logic blocks

Logic block	Quantity with update rate			Range or value	Accuracy
	fast	medium	normal		
LogicAND	90	90	100	-	-
LogicOR	90	90	100	-	-
LogicXOR	15	15	10	-	-
LogicInverter	45	45	50	-	-
LogicSRMemory	15	15	10	-	-
LogicRSMemory	15	15	10	-	-
LogicGate	15	15	10	-	-
LogicTimer	15	15	10	(0.000–90000.000) s	± 0.5% ± 10 ms
LogicPulseTimer	15	15	10	(0.000–90000.000) s	± 0.5% ± 10 ms
LogicTimerSet	15	15	10	(0.000–90000.000) s	± 0.5% ± 10 ms
LogicLoopDelay	15	15	10	(0.000–90000.000) s	± 0.5% ± 10 ms
Boolean 16 to Integer	4	4	8	-	-
Boolean 16 to integer with Logic Node	4	4	8	-	-
Integer to Boolean 16	4	4	8	-	-
Integer to Boolean 16 with Logic Node	4	4	8	-	-

12.2 Fixed signal function block FXDSIGN

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Fixed signals	FXDSIGN	-	-

The Fixed signals function (FXDSIGN) generates a number of pre-set (fixed) signals that can be used in the configuration of an IED, either for forcing the unused inputs in other function blocks to a certain level/value, or for creating certain logic.

12.2.1 Principle of operation

There are eight outputs from FXDSIGN function block:

- OFF is a boolean signal, fixed to OFF (boolean 0) value
- ON is a boolean signal, fixed to ON (boolean 1) value
- INTZERO is an integer number, fixed to integer value 0
- INTONE is an integer number, fixed to integer value 1
- INTALONE is an integer value FFFF (hex)
- REALZERO is a floating point real number, fixed to 0.0 value
- STRNULL is a string, fixed to an empty string (null) value
- ZEROSMPL is a channel index, fixed to 0 value
- GRP_OFF is a group signal, fixed to 0 value

12.2.2 Function block

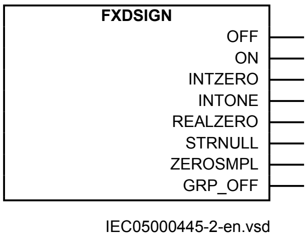


Figure 235: FXDSIGN function block

12.2.3 Input and output signals

Table 308: FXDSIGN Output signals

Name	Type	Description
OFF	BOOLEAN	Boolean signal fixed off
ON	BOOLEAN	Boolean signal fixed on
INTZERO	INTEGER	Integer signal fixed zero
INTONE	INTEGER	Integer signal fixed one
INTALONE	INTEGER	Integer signal fixed all ones
REALZERO	REAL	Real signal fixed zero
STRNULL	STRING	String signal with no characters
ZEROSMPL	GROUP SIGNAL	Channel id for zero sample
GRP_OFF	GROUP SIGNAL	Group signal fixed off

12.2.4 Setting parameters

The function does not have any parameters available in the local HMI or PCM600.

12.3 Boolean 16 to Integer conversion B16I

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Boolean 16 to integer conversion	B16I	-	-

12.3.1 Introduction

Boolean 16 to integer conversion function (B16I) is used to transform a set of 16 binary (logical) signals into an integer.

12.3.2 Principle of operation

Boolean 16 to integer conversion function (B16I) is used to transform a set of 16 binary (logical) signals into an integer. The BLOCK input will freeze the output at the last value.

12.3.3 Function block

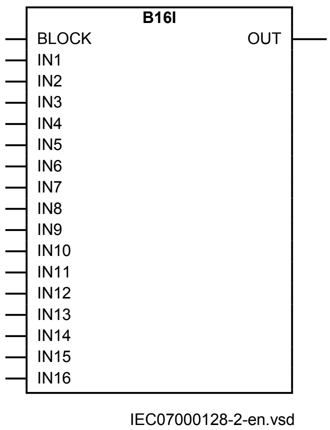


Figure 236: B16I function block

12.3.4 Input and output signals

Table 309: B16I Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of function
IN1	BOOLEAN	0	Input 1
IN2	BOOLEAN	0	Input 2
IN3	BOOLEAN	0	Input 3
IN4	BOOLEAN	0	Input 4
IN5	BOOLEAN	0	Input 5
IN6	BOOLEAN	0	Input 6
IN7	BOOLEAN	0	Input 7
IN8	BOOLEAN	0	Input 8
IN9	BOOLEAN	0	Input 9
IN10	BOOLEAN	0	Input 10
IN11	BOOLEAN	0	Input 11
IN12	BOOLEAN	0	Input 12
IN13	BOOLEAN	0	Input 13
IN14	BOOLEAN	0	Input 14
IN15	BOOLEAN	0	Input 15
IN16	BOOLEAN	0	Input 16

Table 310: B16I Output signals

Name	Type	Description
OUT	INTEGER	Output value

12.3.5 Setting parameters

The function does not have any parameters available in the local HMI or PCM600.

12.4 Boolean 16 to Integer conversion with logic node representation B16IFCVI

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Boolean 16 to integer conversion with logic node representation	B16IFCVI	-	-

12.4.1 Introduction

Boolean 16 to integer conversion with logic node representation function (B16IFCVI) is used to transform a set of 16 binary (logical) signals into an integer.

B16IFCVI can receive remote values via IEC 61850 depending on the operator position input (PSTO).

12.4.2 Principle of operation

Boolean 16 to integer conversion with logic node representation function (B16IFCVI) is used to transform a set of 16 binary (logical) signals into an integer. The BLOCK input will freeze the output at the last value.

12.4.3 Function block

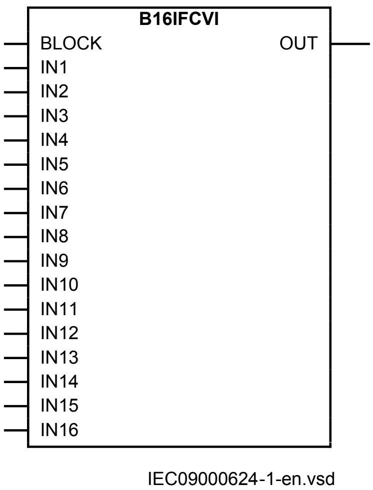


Figure 237: B16IFCVI function block

12.4.4 Input and output signals

Table 311: B16IFCVI Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of function
IN1	BOOLEAN	0	Input 1
IN2	BOOLEAN	0	Input 2
IN3	BOOLEAN	0	Input 3
IN4	BOOLEAN	0	Input 4
IN5	BOOLEAN	0	Input 5
IN6	BOOLEAN	0	Input 6
Table continues on next page			

Name	Type	Default	Description
IN7	BOOLEAN	0	Input 7
IN8	BOOLEAN	0	Input 8
IN9	BOOLEAN	0	Input 9
IN10	BOOLEAN	0	Input 10
IN11	BOOLEAN	0	Input 11
IN12	BOOLEAN	0	Input 12
IN13	BOOLEAN	0	Input 13
IN14	BOOLEAN	0	Input 14
IN15	BOOLEAN	0	Input 15
IN16	BOOLEAN	0	Input 16

Table 312: B16IFCVI Output signals

Name	Type	Description
OUT	INTEGER	Output value

12.4.5 Setting parameters

The function does not have any parameters available in the local HMI or PCM600.

12.5 Integer to Boolean 16 conversion IB16

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Integer to boolean 16 conversion	IB16	-	-

12.5.1 Introduction

Integer to boolean 16 conversion function (IB16) is used to transform an integer into a set of 16 binary (logical) signals.

12.5.2 Principle of operation

Integer to boolean 16 conversion function (IB16) is used to transform an integer into a set of 16 binary (logical) signals. IB16 function is designed for receiving the integer input locally. The BLOCK input will freeze the logical outputs at the last value.

12.5.3 Function block

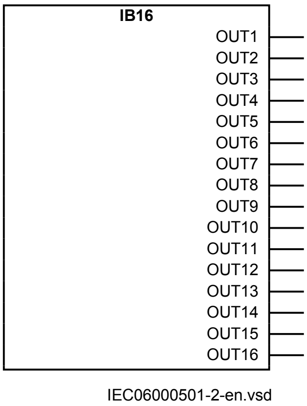


Figure 238: IB16 function block

12.5.4 Input and output signals

Table 313: IB16 Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of function
INP	INTEGER	0	Integer Input

Table 314: IB16 Output signals

Name	Type	Description
OUT1	BOOLEAN	Output 1
OUT2	BOOLEAN	Output 2
OUT3	BOOLEAN	Output 3
OUT4	BOOLEAN	Output 4
OUT5	BOOLEAN	Output 5
OUT6	BOOLEAN	Output 6
OUT7	BOOLEAN	Output 7
OUT8	BOOLEAN	Output 8
OUT9	BOOLEAN	Output 9
OUT10	BOOLEAN	Output 10
OUT11	BOOLEAN	Output 11
OUT12	BOOLEAN	Output 12
OUT13	BOOLEAN	Output 13
OUT14	BOOLEAN	Output 14
OUT15	BOOLEAN	Output 15
OUT16	BOOLEAN	Output 16

12.5.5 Setting parameters

The function does not have any parameters available in the local HMI or PCM600.

12.6 Integer to Boolean 16 conversion with logic node representation IB16FCVB

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Integer to boolean 16 conversion with logic node representation	IB16FCVB	-	-

12.6.1 Introduction

Integer to boolean conversion with logic node representation function (IB16FCVB) is used to transform an integer to 16 binary (logic) signals.

IB16FCVB function can receive remote values over IEC61850 depending on the operator position input (PSTO).

12.6.2 Principle of operation

Integer to boolean conversion with logic node representation function (IB16FCVB) is used to transform an integer into a set of 16 binary (logical) signals. IB16FCVB function can receive an integer from a station computer – for example, over IEC 61850. The BLOCK input will freeze the logical outputs at the last value.

The operator position input (PSTO) determines the operator place. The integer number can be written to the block while in “Remote”. If PSTO is in ”Off” or ”Local”, then no change is applied to the outputs.

12.6.3 Function block

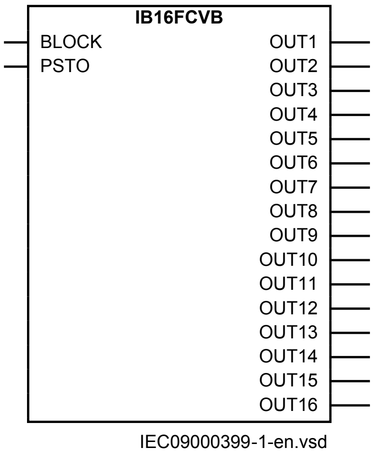


Figure 239: IB16FCVB function block

12.6.4 Input and output signals

Table 315: IB16FCVB Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of function
PSTO	INTEGER	1	Operator place selection

Table 316: IB16FCVB Output signals

Name	Type	Description
OUT1	BOOLEAN	Output 1
OUT2	BOOLEAN	Output 2
OUT3	BOOLEAN	Output 3
OUT4	BOOLEAN	Output 4
OUT5	BOOLEAN	Output 5
OUT6	BOOLEAN	Output 6
OUT7	BOOLEAN	Output 7
OUT8	BOOLEAN	Output 8
OUT9	BOOLEAN	Output 9
OUT10	BOOLEAN	Output 10
OUT11	BOOLEAN	Output 11
OUT12	BOOLEAN	Output 12
OUT13	BOOLEAN	Output 13
OUT14	BOOLEAN	Output 14
OUT15	BOOLEAN	Output 15
OUT16	BOOLEAN	Output 16

12.6.5 Setting parameters

This function does not have any setting parameters.

Section 13 Monitoring

About this chapter

This chapter describes the functions that handle measurements, events and disturbances. The way the functions work, their setting parameters, function blocks, input and output signals, and technical data are included for each function.

13.1 Measurements

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Measurements	CVMMXN	P, Q, S, I, U, f	-
Phase current measurement	CMMXU	I	-
Phase-phase voltage measurement	VMMXU	U	-
Current sequence component measurement	CMSQI	I1, I2, I0	-
Voltage sequence measurement	VMSQI	U1, U2, U0	-
Phase-neutral voltage measurement	VNMMXU	U	-

13.1.1 Introduction

Measurement functions is used for power system measurement, supervision and reporting to the local HMI, monitoring tool within PCM600 or to station level for example, via IEC 61850. The possibility to continuously monitor measured values of active power, reactive power, currents, voltages, frequency, power factor etc. is vital for efficient production, transmission and distribution of electrical energy. It provides to the system operator fast and easy overview of the present status of the power system. Additionally, it can be used during testing and commissioning of protection and control IEDs in order to verify proper operation and connection of instrument transformers (CTs and VTs). During normal service by periodic comparison of the measured value from the IED with other independent meters the proper operation of the IED analog measurement chain can be verified. Finally, it can be used to verify proper direction orientation for distance or directional overcurrent protection function.

The available measured values of an IED are depending on the actual hardware (TRM) and the logic configuration made in PCM600.

All measured values can be supervised with four settable limits that is, low-low limit, low limit, high limit and high-high limit. A zero clamping reduction is also supported, that is, the measured value below a settable limit is forced to zero which reduces the impact of noise in the inputs.

Dead-band supervision can be used to report measured signal value to station level when change in measured value is above set threshold limit or time integral of all changes since the last time value updating exceeds the threshold limit. Measure value can also be based on periodic reporting.

The measurement function, CVMMXN, provides the following power system quantities:

- P, Q and S: three phase active, reactive and apparent power
- PF: power factor
- U: phase-to-phase voltage amplitude
- I: phase current amplitude
- F: power system frequency

Main menu/Measurement/Monitoring/Service values/CVMMXN

The measuring functions CMMXU, VNMMXU and VMMXU provide physical quantities:

- I: phase currents (amplitude and angle) (CMMXU)
- U: voltages (phase-to-earth and phase-to-phase voltage, amplitude and angle) (VMMXU, VNMMXU)

It is possible to calibrate the measuring function above to get better then class 0.5 presentation. This is accomplished by angle and amplitude compensation at 5, 30 and 100% of rated current and at 100% of rated voltage.

The power system quantities provided, depends on the actual hardware, (TRM) and the logic configuration made in PCM600.

The measuring functions CMSQI and VMSQI provide sequential quantities:

- I: sequence currents (positive, zero, negative sequence, amplitude and angle)
- U: sequence voltages (positive, zero and negative sequence, amplitude and angle).

The CVMMXN function calculates three-phase power quantities by using fundamental frequency phasors (DFT values) of the measured current respectively voltage signals. The measured power quantities are available either, as instantaneously calculated quantities or, averaged values over a period of time (low pass filtered) depending on the selected settings.

13.1.2 Principle of operation

13.1.2.1 Measurement supervision

The protection, control, and monitoring IEDs have functionality to measure and further process information for currents and voltages obtained from the pre-processing blocks. The number of processed alternate measuring quantities depends on the type of IED and built-in options.

The information on measured quantities is available for the user at different locations:

- Locally by means of the local HMI
- Remotely using the monitoring tool within PCM600 or over the station bus
- Internally by connecting the analogue output signals to the Disturbance Report function

Phase angle reference

All phase angles are presented in relation to a defined reference channel. The General setting parameter *PhaseAngleRef* defines the reference.

Zero point clamping

Measured value below zero point clamping limit is forced to zero. This allows the noise in the input signal to be ignored. The zero point clamping limit is a general setting (*XZeroDb* where X equals S, P, Q, PF, U, I, F, IL1-3, UL1-3, UL12-31, I1, I2, 3I0, U1, U2 or 3U0). Observe that this measurement supervision zero point clamping might be overridden by the zero point clamping used for the measurement values within CVMMXU.

Continuous monitoring of the measured quantity

Users can continuously monitor the measured quantity available in each function block by means of four defined operating thresholds, see figure 240. The monitoring has two different modes of operating:

- Overfunction, when the measured current exceeds the High limit (*XHiLim*) or High-high limit (*XHiHiLim*) pre-set values
- Underfunction, when the measured current decreases under the Low limit (*XLowLim*) or Low-low limit (*XLowLowLim*) pre-set values.

X_RANGE is illustrated in figure 240.

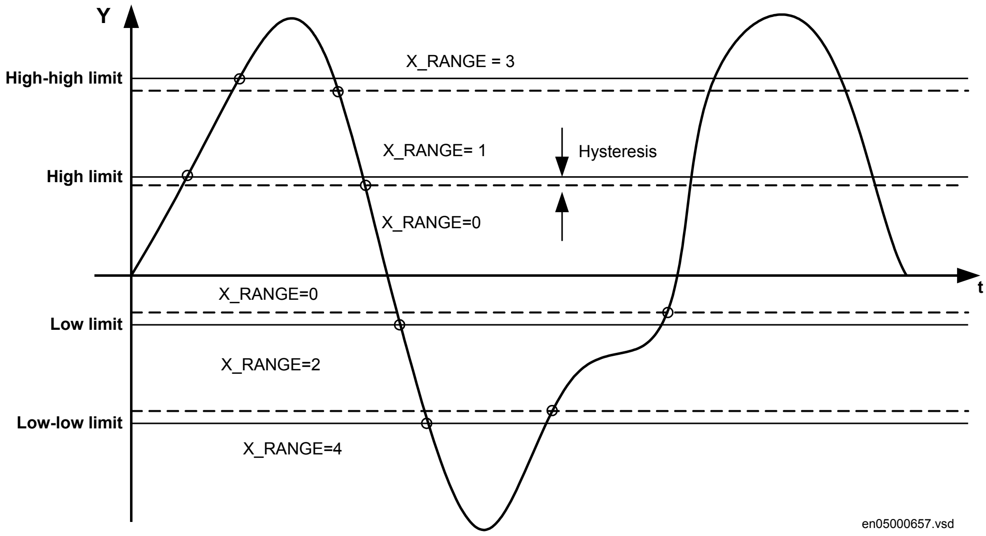


Figure 240: Presentation of operating limits

Each analogue output has one corresponding supervision level output (X_RANGE). The output signal is an integer in the interval 0-4 (0: Normal, 1: High limit exceeded, 3: High-high limit exceeded, 2: below Low limit and 4: below Low-low limit). The output may be connected to a measurement expander block (XP (RANGE_XP)) to get measurement supervision as binary signals.

The logical value of the functional output signals changes according to figure 240.

The user can set the hysteresis (*XLimHyst*), which determines the difference between the operating and reset value at each operating point, in wide range for each measuring channel separately. The hysteresis is common for all operating values within one channel.

Actual value of the measured quantity

The actual value of the measured quantity is available locally and remotely. The measurement is continuous for each measured quantity separately, but the reporting of the value to the higher levels depends on the selected reporting mode. The following basic reporting modes are available:

- Cyclic reporting (*Cyclic*)
- Amplitude dead-band supervision (*Dead band*)
- Integral dead-band supervision (*Int deadband*)

Cyclic reporting

The cyclic reporting of measured value is performed according to chosen setting (*XRepTyp*). The measuring channel reports the value independent of amplitude or integral dead-band reporting.

In addition to the normal cyclic reporting the IED also report spontaneously when measured value passes any of the defined threshold limits.

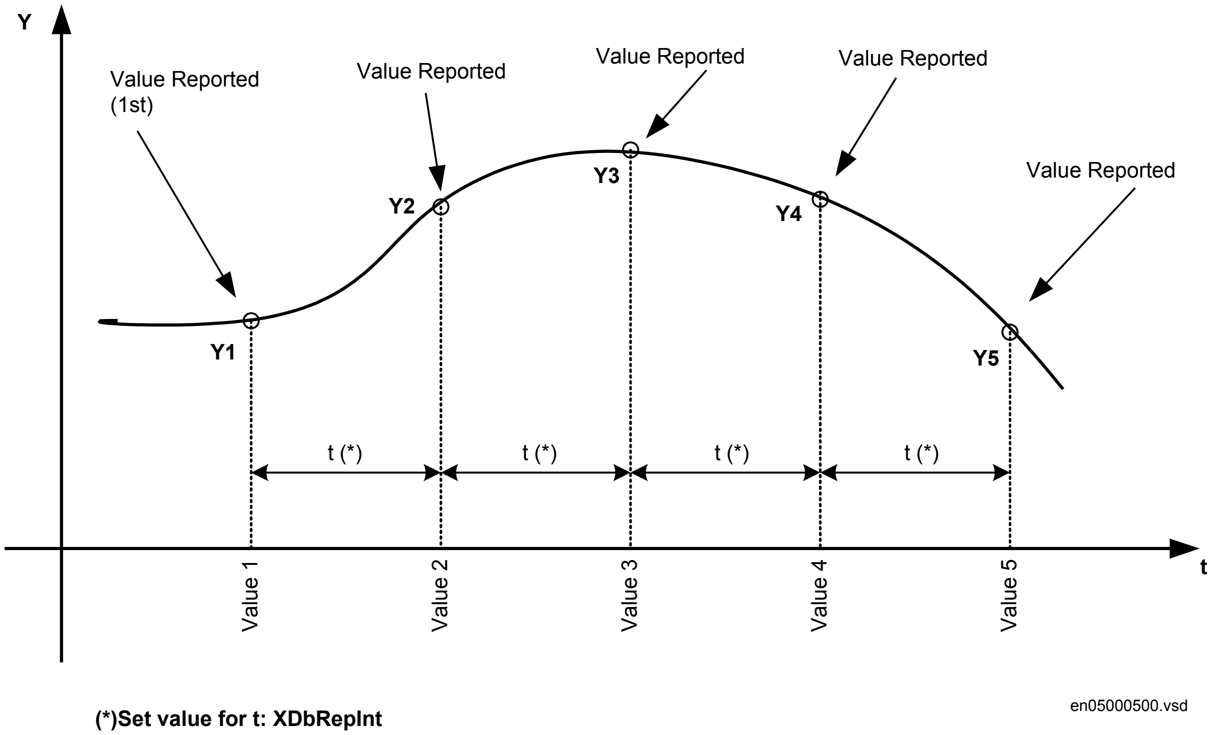


Figure 241: Periodic reporting

Amplitude dead-band supervision

If a measuring value is changed, compared to the last reported value, and the change is larger than the ±ΔY pre-defined limits that are set by user (*XZeroDb*), then the measuring channel reports the new value to a higher level, if this is detected by a new measured value. This limits the information flow to a minimum necessary. Figure 242 shows an example with the amplitude dead-band supervision. The picture is simplified: the process is not continuous but the values are evaluated with a time interval of one execution cycle from each other.

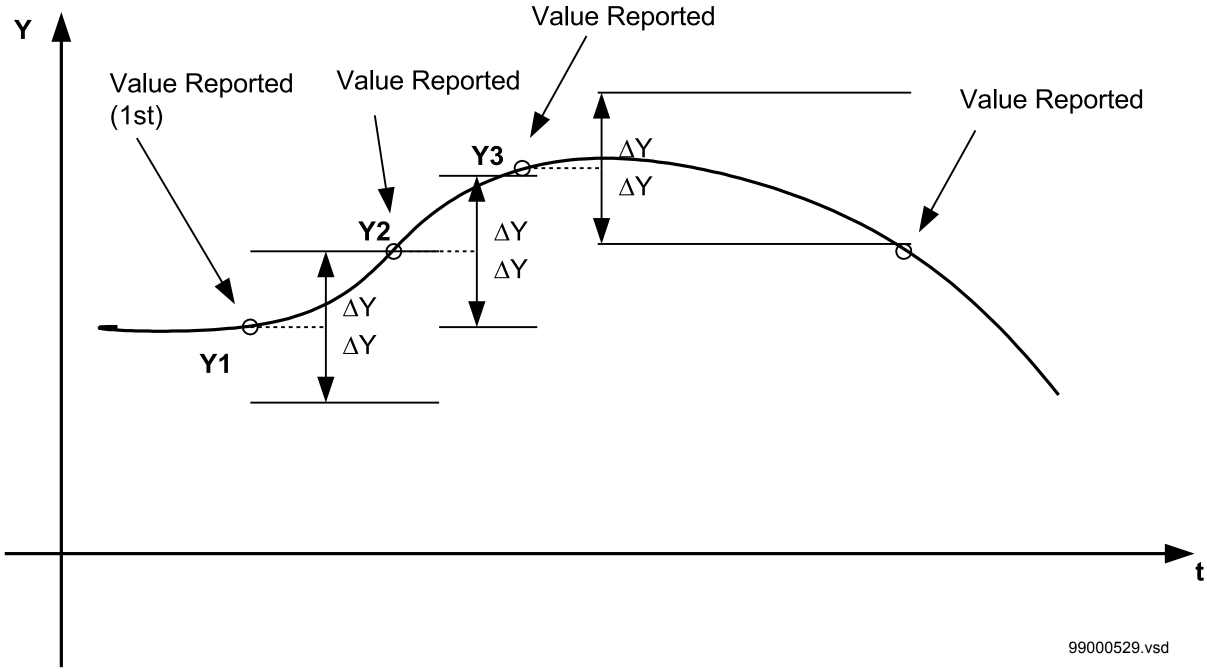


Figure 242: Amplitude dead-band supervision reporting

After the new value is reported, the ±ΔY limits for dead-band are automatically set around it. The new value is reported only if the measured quantity changes more than defined by the ±ΔY set limits. Even if amplitude dead-band reporting is selected, there will be a 30 s "back-ground" cyclic reporting as well.

Integral dead-band reporting

The measured value is reported if the time integral of all changes exceeds the pre-set limit (*XZeroDb*), figure 243, where an example of reporting with integral dead-band supervision is shown. The picture is simplified: the process is not continuous but the values are evaluated with a time interval of one execution cycle from each other.

The last value reported, Y1 in figure 243 serves as a basic value for further measurement. A difference is calculated between the last reported and the newly measured value and is multiplied by the time increment (discrete integral). The absolute values of these integral values are added until the pre-set value is exceeded. This occurs with the value Y2 that is reported and set as a new base for the following measurements (as well as for the values Y3, Y4 and Y5).

The integral dead-band supervision is particularly suitable for monitoring signals with small variations that can last for relatively long periods. Even if integral dead-band reporting is selected, there will be a 30 s "back-ground" cyclic reporting as well.

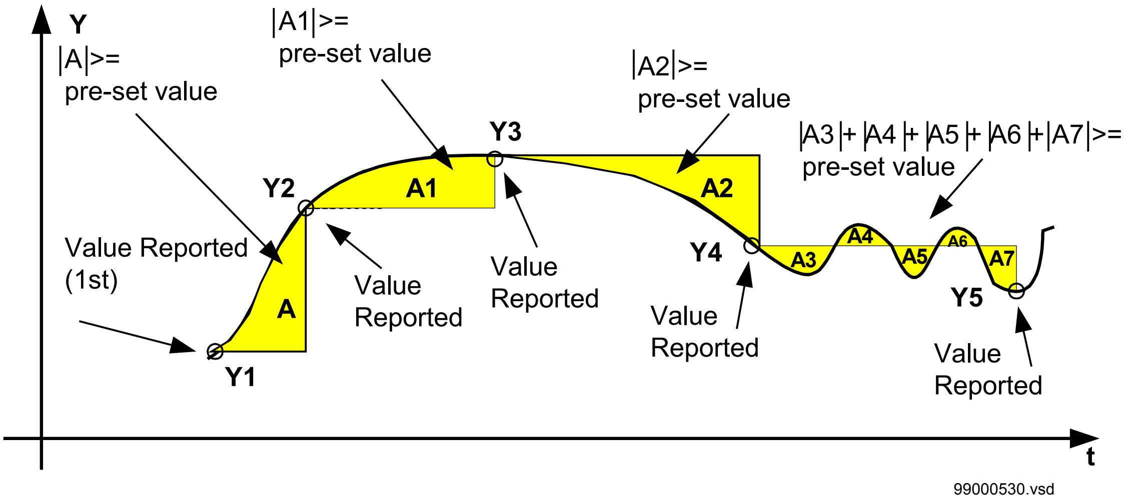


Figure 243: Reporting with integral dead-band supervision

13.1.2.2 Measurements CVMMXN

Mode of operation

The measurement function must be connected to three-phase current and three-phase voltage input in the configuration tool (group signals), but it is capable to measure and calculate above mentioned quantities in nine different ways depending on the available VT inputs connected to the IED. The end user can freely select by a parameter setting, which one of the nine available measuring modes shall be used within the function. Available options are summarized in the following table:

	Set value for parameter “Mode”	Formula used for complex, three-phase power calculation	Formula used for voltage and current magnitude calculation	Comment
1	L1, L2, L3	$\overline{S} = \overline{U_{L1}} \cdot \overline{I_{L1}^*} + \overline{U_{L2}} \cdot \overline{I_{L2}^*} + \overline{U_{L3}} \cdot \overline{I_{L3}^*}$	$U = (\lvert\overline{U_{L1}}\rvert + \lvert\overline{U_{L2}}\rvert + \lvert\overline{U_{L3}}\rvert) / \sqrt{3}$ $I = (\lvert\overline{I_{L1}}\rvert + \lvert\overline{I_{L2}}\rvert + \lvert\overline{I_{L3}}\rvert) / 3$	Used when three phase-to-earth voltages are available
2	Arone	$\overline{S} = \overline{U_{L1L2}} \cdot \overline{I_{L1}^*} - \overline{U_{L2L3}} \cdot \overline{I_{L3}^*}$ (Equation 63)	$U = (\lvert\overline{U_{L1L2}}\rvert + \lvert\overline{U_{L2L3}}\rvert) / 2$ $I = (\lvert\overline{I_{L1}}\rvert + \lvert\overline{I_{L3}}\rvert) / 2$ (Equation 64)	Used when three two phase-to-phase voltages are available
3	PosSeq	$\overline{S} = 3 \cdot \overline{U_{PosSeq}} \cdot \overline{I_{PosSeq}^*}$ (Equation 65)	$U = \sqrt{3} \cdot \lvert\overline{U_{PosSeq}}\rvert$ $I = \lvert\overline{I_{PosSeq}}\rvert$ (Equation 66)	Used when only symmetrical three phase power shall be measured

Table continues on next page

	Set value for parameter "Mode"	Formula used for complex, three-phase power calculation	Formula used for voltage and current magnitude calculation	Comment
4	L1L2	$\overline{S} = \overline{U_{L1L2}} \cdot (\overline{I_{L1}^{*}} - \overline{I_{L2}^{*}})$ (Equation 67)	$U = \left\|\overline{U_{L1L2}}\right\|$ $I = (\left\|\overline{I_{L1}}\right\| + \left\|\overline{I_{L2}}\right\|) / 2$ (Equation 68)	Used when only U_{L1L2} phase-to-phase voltage is available
5	L2L3	$\overline{S} = \overline{U_{L2L3}} \cdot (\overline{I_{L2}^{*}} - \overline{I_{L3}^{*}})$ (Equation 69)	$U = \left\|\overline{U_{L2L3}}\right\|$ $I = (\left\|\overline{I_{L2}}\right\| + \left\|\overline{I_{L3}}\right\|) / 2$ (Equation 70)	Used when only U_{L2L3} phase-to-phase voltage is available
6	L3L1	$\overline{S} = \overline{U_{L3L1}} \cdot (\overline{I_{L3}^{*}} - \overline{I_{L1}^{*}})$ (Equation 71)	$U = \left\|\overline{U_{L3L1}}\right\|$ $I = (\left\|\overline{I_{L3}}\right\| + \left\|\overline{I_{L1}}\right\|) / 2$ (Equation 72)	Used when only U_{L3L1} phase-to-phase voltage is available
7	L1	$\overline{S} = 3 \cdot \overline{U_{L1}} \cdot \overline{I_{L1}^{*}}$ (Equation 73)	$U = \sqrt{3} \cdot \left\|\overline{U_{L1}}\right\|$ $I = \left\|\overline{I_{L1}}\right\|$ (Equation 74)	Used when only U_{L1} phase-to-earth voltage is available
8	L2	$\overline{S} = 3 \cdot \overline{U_{L2}} \cdot \overline{I_{L2}^{*}}$ (Equation 75)	$U = \sqrt{3} \cdot \left\|\overline{U_{L2}}\right\|$ $I = \left\|\overline{I_{L2}}\right\|$ (Equation 76)	Used when only U_{L2} phase-to-earth voltage is available
9	L3	$\overline{S} = 3 \cdot \overline{U_{L3}} \cdot \overline{I_{L3}^{*}}$ (Equation 77)	$U = \sqrt{3} \cdot \left\|\overline{U_{L3}}\right\|$ $I = \left\|\overline{I_{L3}}\right\|$ (Equation 78)	Used when only U_{L3} phase-to-earth voltage is available
* means complex conjugated value				

It shall be noted that only in the first two operating modes that is, 1 & 2 the measurement function calculates exact three-phase power. In other operating modes that is, from 3 to 9 it calculates the three-phase power under assumption that the power system is fully symmetrical. Once the complex apparent power is calculated then the P, Q, S, & PF are calculated in accordance with the following formulas:

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

(Equation 79)

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

(Equation 80)

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

(Equation 81)

$$PF = \cos\varphi = \frac{P}{S}$$

(Equation 82)

Additionally to the power factor value the two binary output signals from the function are provided which indicates the angular relationship between current and voltage phasors. Binary output signal ILAG is set to one when current phasor is lagging behind voltage phasor. Binary output signal ILEAD is set to one when current phasor is leading the voltage phasor.

Each analogue output has a corresponding supervision level output (X_RANGE). The output signal is an integer in the interval 0-4, see section "Measurement supervision".

Calibration of analog inputs

Measured currents and voltages used in the CVMMXN function can be calibrated to get class 0.5 measuring accuracy. This is achieved by amplitude and angle compensation at 5, 30 and 100% of rated current and voltage. The compensation below 5% and above 100% is constant and linear in between, see example in figure 244.

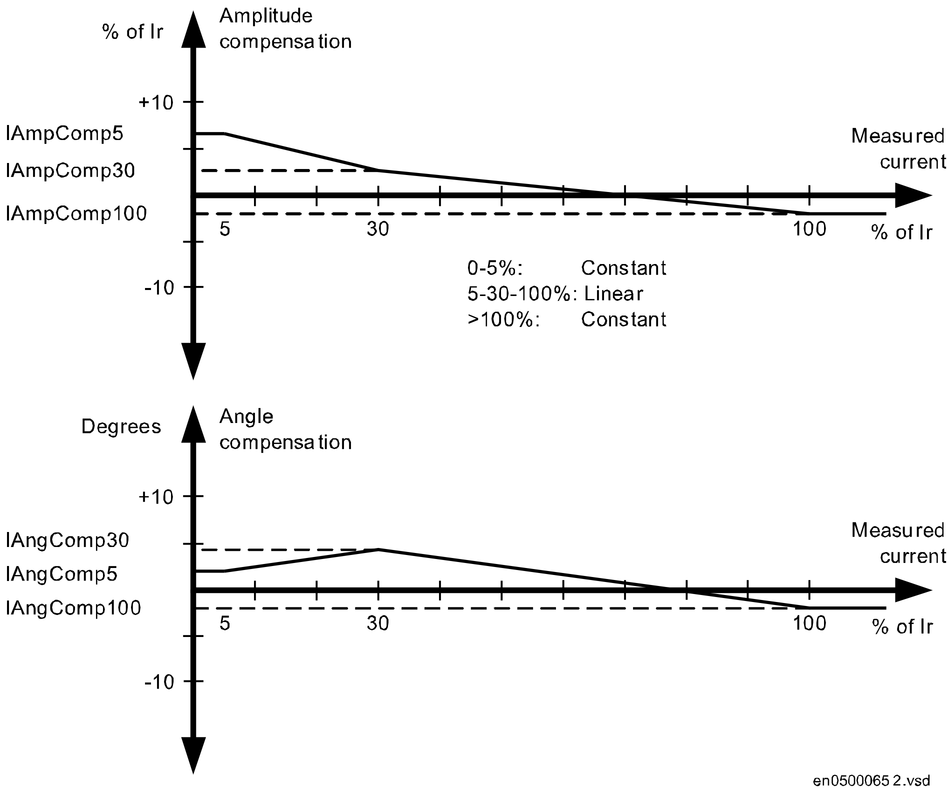


Figure 244: Calibration curves

The first current and voltage phase in the group signals will be used as reference and the amplitude and angle compensation will be used for related input signals.

Low pass filtering

In order to minimize the influence of the noise signal on the measurement it is possible to introduce the recursive, low pass filtering of the measured values for P, Q, S, U, I and power factor. This will make slower measurement response to the step changes in the measured quantity. Filtering is performed in accordance with the following recursive formula:

$$X = k \cdot X_{Old} + (1-k) \cdot X_{Calculated}$$

(Equation 83)

where:

X	is a new measured value (that is P, Q, S, U, I or PF) to be given out from the function
X_{Old}	is the measured value given from the measurement function in previous execution cycle
$X_{Calculated}$	is the new calculated value in the present execution cycle
k	is settable parameter by the end user which influence the filter properties

Default value for parameter *k* is 0.00. With this value the new calculated value is immediately given out without any filtering (that is, without any additional delay). When *k* is set to value bigger than 0, the filtering is enabled. Appropriate value of *k* shall be determined separately for every application. Some typical value for *k* =0.14.

Zero point clamping

In order to avoid erroneous measurements when either current or voltage signal is not present, it is possible for the end user to set the amplitude*IGenZeroDb* level for current and voltage measurement *UGenZeroDb* is forced to zero. When either current or voltage measurement is forced to zero automatically the measured values for power (P, Q and S) and power factor are forced to zero as well. Since the measurement supervision functionality, included in CVMMXN, is using these values the zero clamping will influence the subsequent supervision (observe the possibility to do zero point clamping within measurement supervision, see section "Measurement supervision").

Compensation facility

In order to compensate for small amplitude and angular errors in the complete measurement chain (CT error, VT error, IED input transformer errors and so on.) it is possible to perform on site calibration of the power measurement. This is achieved by setting the complex constant which is then internally used within the function to multiply the calculated complex apparent power S. This constant is set as amplitude (setting parameter *PowAmpFact*, default value 1.000) and angle (setting parameter *PowAngComp*, default value 0.0 degrees). Default values for these two parameters are done in such way that they do not influence internally calculated value (complex constant has default value 1). In this way calibration, for specific operating range (for example, around rated power) can be done at site. However, to perform this calibration it is necessary to have an external power meter with high accuracy class available.

Directionality

If CT earthing parameter is set as described in section "Analog inputs", active and reactive power will be measured always towards the protected object. This is shown in the following figure 245.

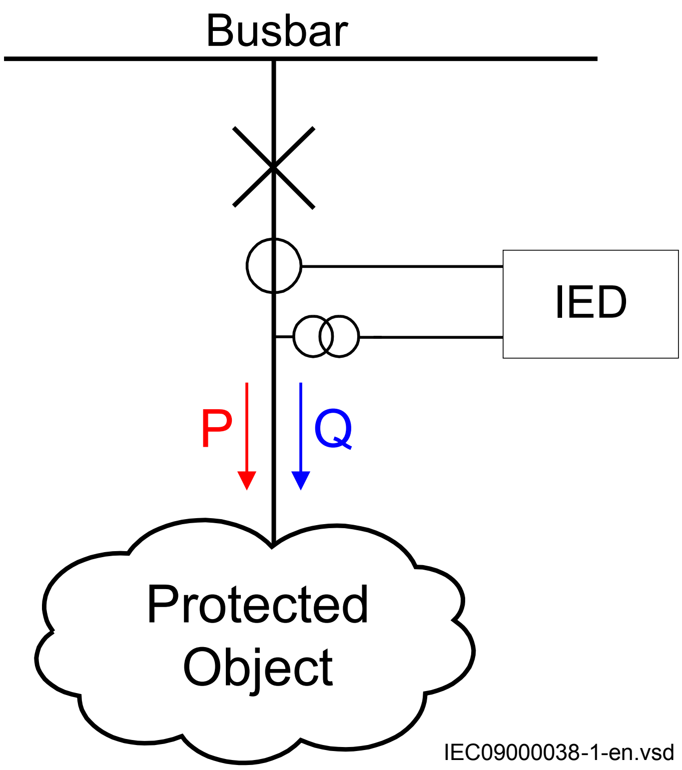


Figure 245: Internal IED directionality convention for P & Q measurements

Practically, it means that active and reactive power will have positive values when they flow from the busbar towards the protected object and they will have negative values when they flow from the protected object towards the busbar.

In some application, for example, when power is measured on the secondary side of the power transformer it might be desirable, from the end client point of view, to have actually opposite directional convention for active and reactive power measurements. This can be easily achieved by setting parameter *PowAngComp* to value of 180.0 degrees. With such setting the active and reactive power will have positive values when they flow from the protected object towards the busbar.

Frequency

Frequency is actually not calculated within measurement block. It is simply obtained from the pre-processing block and then just given out from the measurement block as an output.

13.1.2.3 Phase current measurement CMMXU

The Phase current measurement (CMMXU) function must be connected to three-phase current input in the configuration tool to be operable. Currents handled in the function can be calibrated to get better then class 0.5 measuring accuracy for internal use, on the outputs and IEC 61850. This is achieved by amplitude and angle compensation at 5, 30 and 100% of rated current. The compensation below 5% and above 100% is constant and linear in between, see figure 244.

Phase currents (amplitude and angle) are available on the outputs and each amplitude output has a corresponding supervision level output (ILx_RANG). The supervision output signal is an integer in the interval 0-4, see section "Measurement supervision".

13.1.2.4 Phase-phase and phase-neutral voltage measurements VMMXU, VNMMXU

The voltage function must be connected to three-phase voltage input in the configuration tool to be operable. Voltages are handled in the same way as currents when it comes to class 0.5 calibrations, see above.

The voltages (phase or phase-phase voltage, amplitude and angle) are available on the outputs and each amplitude output has a corresponding supervision level output (ULxy_RANG). The supervision output signal is an integer in the interval 0-4, see section "Measurement supervision".

13.1.2.5 Voltage and current sequence measurements VMSQI, CMSQI

The measurement functions must be connected to three-phase current (CMSQI) or voltage (VMSQI) input in the configuration tool to be operable. No outputs, but XRANG, are calculated within the measuring block and it is not possible to calibrate the signals. Input signals are obtained from the pre-processing block and transferred to corresponding output.

Positive, negative and three times zero sequence quantities are available on the outputs (voltage and current, amplitude and angle). Each amplitude output has a corresponding supervision level output (X_RANGE). The output signal is an integer in the interval 0-4, see section "Measurement supervision".

13.1.3 Function block

The available function blocks of an IED are depending on the actual hardware (TRM) and the logic configuration made in PCM600.

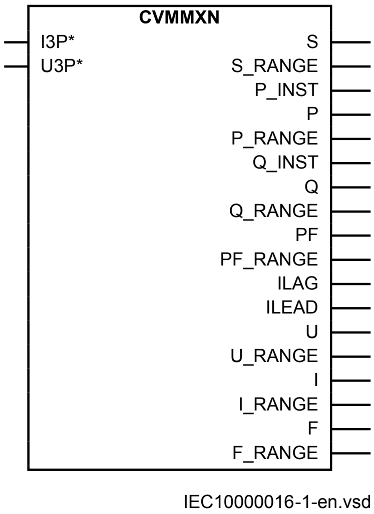


Figure 246: CVMMXN function block

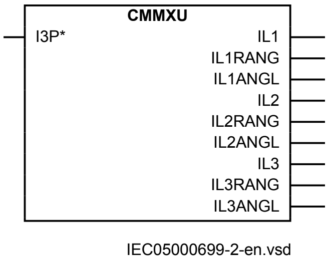


Figure 247: CMMXU function block

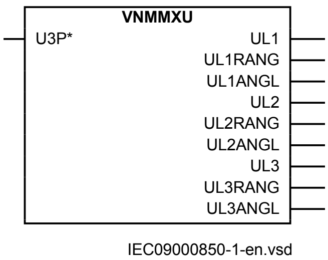


Figure 248: VNMMXU function block

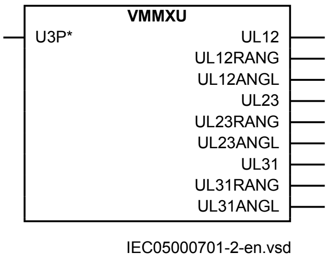


Figure 249: VMMXU function block

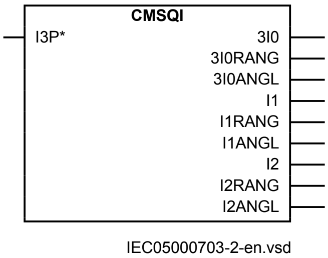


Figure 250: CMSQI function block

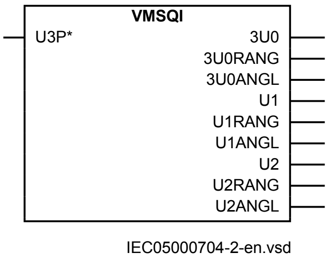


Figure 251: VMSQI function block

13.1.4 Input and output signals

Table 317: CVMMXN Input signals

Name	Type	Default	Description
I3P	GROUP SIGNAL	-	Group signal for current input
U3P	GROUP SIGNAL	-	Group signal for voltage input

Table 318: CVMMXN Output signals

Name	Type	Description
S	REAL	Apparent Power magnitude of deadband value
S_RANGE	INTEGER	Apparent Power range
P_INST	REAL	Active Power
P	REAL	Active Power magnitude of deadband value
P_RANGE	INTEGER	Active Power range
Q_INST	REAL	Reactive Power
Q	REAL	Reactive Power magnitude of deadband value
Q_RANGE	INTEGER	Reactive Power range
PF	REAL	Power Factor magnitude of deadband value
PF_RANGE	INTEGER	Power Factor range
ILAG	BOOLEAN	Current is lagging voltage
ILEAD	BOOLEAN	Current is leading voltage
U	REAL	Calculate voltage magnitude of deadband value
U_RANGE	INTEGER	Calcuate voltage range
I	REAL	Calculated current magnitude of deadband value
I_RANGE	INTEGER	Calculated current range
F	REAL	System frequency magnitude of deadband value
F_RANGE	INTEGER	System frequency range

Table 319: CMMXU Input signals

Name	Type	Default	Description
I3P	GROUP SIGNAL	-	Group connection abstract block 1

Table 320: CMMXU Output signals

Name	Type	Description
IL1	REAL	IL1 Amplitude, magnitude of reported value
IL1RANG	INTEGER	IL1 Amplitude range
IL1ANGL	REAL	IL1 Angle, magnitude of reported value
IL2	REAL	IL2 Amplitude, magnitude of reported value
IL2RANG	INTEGER	IL2 Amplitude range
IL2ANGL	REAL	IL2 Angle, magnitude of reported value
IL3	REAL	IL3 Amplitude, magnitude of reported value
IL3RANG	INTEGER	IL3 Amplitude range
IL3ANGL	REAL	IL3 Angle, magnitude of reported value

Table 321: VNMMXU Input signals

Name	Type	Default	Description
U3P	GROUP SIGNAL	-	Group connection abstract block 5

Table 322: VNMMXU Output signals

Name	Type	Description
UL1	REAL	UL1 Amplitude, magnitude of reported value
UL1RANG	INTEGER	UL1 Amplitude range
UL1ANGL	REAL	UL1 Angle, magnitude of reported value
UL2	REAL	UL2 Amplitude, magnitude of reported value
UL2RANG	INTEGER	UL2 Amplitude range
UL2ANGL	REAL	UL2 Angle, magnitude of reported value
UL3	REAL	UL3 Amplitude, magnitude of reported value
UL3RANG	INTEGER	UL3 Amplitude range
UL3ANGL	REAL	UL3 Angle, magnitude of reported value

Table 323: VMMXU Input signals

Name	Type	Default	Description
U3P	GROUP SIGNAL	-	Group connection abstract block 2

Table 324: VMMXU Output signals

Name	Type	Description
UL12	REAL	UL12 Amplitude, magnitude of reported value
UL12RANG	INTEGER	UL12 Amplitude range
UL12ANGL	REAL	UL12 Angle, magnitude of reported value
UL23	REAL	UL23 Amplitude, magnitude of reported value
UL23RANG	INTEGER	UL23 Amplitude range
UL23ANGL	REAL	UL23 Angle, magnitude of reported value
UL31	REAL	UL31 Amplitude, magnitude of reported value
UL31RANG	INTEGER	UL31 Amplitude range
UL31ANGL	REAL	UL31 Angle, magnitude of reported value

Table 325: CMSQI Input signals

Name	Type	Default	Description
I3P	GROUP SIGNAL	-	Group connection abstract block 3

Table 326: CMSQI Output signals

Name	Type	Description
3I0	REAL	3I0 Amplitude, magnitude of reported value
3I0RANG	INTEGER	3I0 Amplitude range
3I0ANGL	REAL	3I0 Angle, magnitude of reported value
I1	REAL	I1 Amplitude, magnitude of reported value
I1RANG	INTEGER	I1 Amplitude range
I1ANGL	REAL	I1 Angle, magnitude of reported value
I2	REAL	I2 Amplitude, magnitude of reported value
I2RANG	INTEGER	I2 Amplitude range
I2ANGL	REAL	I2 Angle, magnitude of reported value

Table 327: VMSQI Input signals

Name	Type	Default	Description
U3P	GROUP SIGNAL	-	Group connection abstract block 4

Table 328: VMSQI Output signals

Name	Type	Description
3U0	REAL	3U0 Amplitude, magnitude of reported value
3U0RANG	INTEGER	3U0 Amplitude range
3U0ANGL	REAL	3U0 Angle, magnitude of reported value
U1	REAL	U1 Amplitude, magnitude of reported value
U1RANG	INTEGER	U1 Amplitude range
U1ANGL	REAL	U1 Angle, magnitude of reported value
U2	REAL	U2 Amplitude, magnitude of reported value
U2RANG	INTEGER	U2 Amplitude range
U2ANGL	REAL	U2 Angle, magnitude of reported value

13.1.5 Setting parameters

The available setting parameters of the measurement function (MMXU, MSQI) are depending on the actual hardware (TRM) and the logic configuration made in PCM600.

Table 329: CVMMXN Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
SLowLim	0.0 - 2000.0	%SB	0.1	80.0	Low limit in % of SBase
SLowLowLim	0.0 - 2000.0	%SB	0.1	60.0	Low Low limit in % of SBase
SMin	0.0 - 2000.0	%SB	0.1	50.0	Minimum value in % of SBase

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
SMax	0.0 - 2000.0	%SB	0.1	200.0	Maximum value in % of SBase
SRepTyp	Cyclic Dead band Int deadband	-	-	Cyclic	Reporting type
PMin	-2000.0 - 2000.0	%SB	0.1	-200.0	Minimum value in % of SBase
PMax	-2000.0 - 2000.0	%SB	0.1	200.0	Maximum value in % of SBase
PRepTyp	Cyclic Dead band Int deadband	-	-	Cyclic	Reporting type
QMin	-2000.0 - 2000.0	%SB	0.1	-200.0	Minimum value in % of SBase
QMax	-2000.0 - 2000.0	%SB	0.1	200.0	Maximum value in % of SBase
QRepTyp	Cyclic Dead band Int deadband	-	-	Cyclic	Reporting type
PFMin	-1.000 - 1.000	-	0.001	-1.000	Minimum value
PFMax	-1.000 - 1.000	-	0.001	1.000	Maximum value
PFRepTyp	Cyclic Dead band Int deadband	-	-	Cyclic	Reporting type
UMin	0.0 - 200.0	%UB	0.1	50.0	Minimum value in % of UBase
UMax	0.0 - 200.0	%UB	0.1	200.0	Maximum value in % of UBase
URepTyp	Cyclic Dead band Int deadband	-	-	Cyclic	Reporting type
IMin	0.0 - 500.0	%IB	0.1	50.0	Minimum value in % of IBase
IMax	0.0 - 500.0	%IB	0.1	200.0	Maximum value in % of IBase
IRepTyp	Cyclic Dead band Int deadband	-	-	Cyclic	Reporting type
FrMin	0.000 - 100.000	Hz	0.001	0.000	Minimum value
FrMax	0.000 - 100.000	Hz	0.001	70.000	Maximum value
FrRepTyp	Cyclic Dead band Int deadband	-	-	Cyclic	Reporting type
Operation	Off On	-	-	Off	Operation Off / On
IBase	1 - 99999	A	1	3000	Base setting for current values in A
UBase	0.05 - 2000.00	kV	0.05	400.00	Base setting for voltage value in kV
SBase	0.05 - 200000.00	MVA	0.05	2080.00	Base setting for power values in MVA
Mode	L1, L2, L3 Arone Pos Seq L1L2 L2L3 L3L1 L1 L2 L3	-	-	L1, L2, L3	Selection of measured current and voltage

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
PowAmpFact	0.000 - 6.000	-	0.001	1.000	Amplitude factor to scale power calculations
PowAngComp	-180.0 - 180.0	Deg	0.1	0.0	Angle compensation for phase shift between measured I & U
k	0.000 - 1.000	-	0.001	0.000	Low pass filter coefficient for power measurement, U and I

Table 330: CVMMXN Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
SDbRepInt	1 - 300	Type	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s
SZeroDb	0 - 100000	m%	1	500	Zero point clamping in 0,001% of range
SHiHiLim	0.0 - 2000.0	%SB	0.1	150.0	High High limit in % of SBase
SHiLim	0.0 - 2000.0	%SB	0.1	120.0	High limit in % of SBase
SLimHyst	0.000 - 100.000	%	0.001	5.000	Hysteresis value in % of range (common for all limits)
PDbRepInt	1 - 300	Type	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s
PZeroDb	0 - 100000	m%	1	500	Zero point clamping in 0,001% of range
PHiHiLim	-2000.0 - 2000.0	%SB	0.1	150.0	High High limit in % of SBase
PHiLim	-2000.0 - 2000.0	%SB	0.1	120.0	High limit in % of SBase
PLowLim	-2000.0 - 2000.0	%SB	0.1	-120.0	Low limit in % of SBase
PLowLowLim	-2000.0 - 2000.0	%SB	0.1	-150.0	Low Low limit in % of SBase
PLimHyst	0.000 - 100.000	%	0.001	5.000	Hysteresis value in % of range (common for all limits)
QDbRepInt	1 - 300	Type	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s
QZeroDb	0 - 100000	m%	1	500	Zero point clamping in 0,001% of range
QHiHiLim	-2000.0 - 2000.0	%SB	0.1	150.0	High High limit in % of SBase
QHiLim	-2000.0 - 2000.0	%SB	0.1	120.0	High limit in % of SBase
QLowLim	-2000.0 - 2000.0	%SB	0.1	-120.0	Low limit in % of SBase
QLowLowLim	-2000.0 - 2000.0	%SB	0.1	-150.0	Low Low limit in % of SBase
QLimHyst	0.000 - 100.000	%	0.001	5.000	Hysteresis value in % of range (common for all limits)
PFDbRepInt	1 - 300	Type	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s
PFZeroDb	0 - 100000	m%	1	500	Zero point clamping in 0,001% of range
PFHiHiLim	-1.000 - 1.000	-	0.001	1.000	High High limit (physical value)
PFHiLim	-1.000 - 1.000	-	0.001	0.800	High limit (physical value)
PFLowLim	-1.000 - 1.000	-	0.001	-0.800	Low limit (physical value)
PFLowLowLim	-1.000 - 1.000	-	0.001	-1.000	Low Low limit (physical value)
PFLimHyst	0.000 - 100.000	%	0.001	5.000	Hysteresis value in % of range (common for all limits)
Table continues on next page					

Name	Values (Range)	Unit	Step	Default	Description
UDbRepInt	1 - 300	Type	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s
UZeroDb	0 - 100000	m%	1	500	Zero point clamping in 0,001% of range
UHiHiLim	0.0 - 200.0	%UB	0.1	150.0	High High limit in % of UBase
UHiLim	0.0 - 200.0	%UB	0.1	120.0	High limit in % of UBase
ULowLim	0.0 - 200.0	%UB	0.1	80.0	Low limit in % of UBase
ULowLowLim	0.0 - 200.0	%UB	0.1	60.0	Low Low limit in % of UBase
ULimHyst	0.000 - 100.000	%	0.001	5.000	Hysteresis value in % of range (common for all limits)
IDbRepInt	1 - 300	Type	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s
IZeroDb	0 - 100000	m%	1	500	Zero point clamping in 0,001% of range
IHiHiLim	0.0 - 500.0	%IB	0.1	150.0	High High limit in % of IBase
IHiLim	0.0 - 500.0	%IB	0.1	120.0	High limit in % of IBase
ILowLim	0.0 - 500.0	%IB	0.1	80.0	Low limit in % of IBase
ILowLowLim	0.0 - 500.0	%IB	0.1	60.0	Low Low limit in % of IBase
ILimHyst	0.000 - 100.000	%	0.001	5.000	Hysteresis value in % of range (common for all limits)
FrDbRepInt	1 - 300	Type	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s
FrZeroDb	0 - 100000	m%	1	500	Zero point clamping in 0,001% of range
FrHiHiLim	0.000 - 100.000	Hz	0.001	65.000	High High limit (physical value)
FrHiLim	0.000 - 100.000	Hz	0.001	63.000	High limit (physical value)
FrLowLim	0.000 - 100.000	Hz	0.001	47.000	Low limit (physical value)
FrLowLowLim	0.000 - 100.000	Hz	0.001	45.000	Low Low limit (physical value)
FrLimHyst	0.000 - 100.000	%	0.001	5.000	Hysteresis value in % of range (common for all limits)
UGenZeroDb	1 - 100	%UB	1	5	Zero point clamping in % of Ubase
IGenZeroDb	1 - 100	%IB	1	5	Zero point clamping in % of Ibase
UAmpComp5	-10.000 - 10.000	%	0.001	0.000	Amplitude factor to calibrate voltage at 5% of Ur
UAmpComp30	-10.000 - 10.000	%	0.001	0.000	Amplitude factor to calibrate voltage at 30% of Ur
UAmpComp100	-10.000 - 10.000	%	0.001	0.000	Amplitude factor to calibrate voltage at 100% of Ur
IAmpComp5	-10.000 - 10.000	%	0.001	0.000	Amplitude factor to calibrate current at 5% of Ir
IAmpComp30	-10.000 - 10.000	%	0.001	0.000	Amplitude factor to calibrate current at 30% of Ir
IAmpComp100	-10.000 - 10.000	%	0.001	0.000	Amplitude factor to calibrate current at 100% of Ir
IAngComp5	-10.000 - 10.000	Deg	0.001	0.000	Angle calibration for current at 5% of Ir
IAngComp30	-10.000 - 10.000	Deg	0.001	0.000	Angle calibration for current at 30% of Ir
IAngComp100	-10.000 - 10.000	Deg	0.001	0.000	Angle calibration for current at 100% of Ir

Table 331: CMMXU Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
IL1DbRepInt	1 - 300	Type	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s
Operation	Off On	-	-	Off	Operation Mode On / Off
IBase	1 - 99999	A	1	3000	Base setting for current level in A
IL1Max	0.000 - 10000000000.000	A	0.001	1000.000	Maximum value
IL1RepTyp	Cyclic Dead band Int deadband	-	-	Cyclic	Reporting type
IL1AngDbRepInt	1 - 300	Type	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s
IL2DbRepInt	1 - 300	Type	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s
IL2Max	0.000 - 10000000000.000	A	0.001	1000.000	Maximum value
IL2RepTyp	Cyclic Dead band Int deadband	-	-	Cyclic	Reporting type
IL2AngDbRepInt	1 - 300	Type	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s
IL3DbRepInt	1 - 300	Type	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s
IL3Max	0.000 - 10000000000.000	A	0.001	1000.000	Maximum value
IL3RepTyp	Cyclic Dead band Int deadband	-	-	Cyclic	Reporting type
IL3AngDbRepInt	1 - 300	Type	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s

Table 332: CMMXU Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
IL1ZeroDb	0 - 100000	m%	1	0	Zero point clamping in 0,001% of range
IL1HiHiLim	0.000 - 10000000000.000	A	0.001	900.000	High High limit (physical value)
IL1HiLim	0.000 - 10000000000.000	A	0.001	800.000	High limit (physical value)
IAmpComp5	-10.000 - 10.000	%	0.001	0.000	Amplitude factor to calibrate current at 5% of Ir
IAmpComp30	-10.000 - 10.000	%	0.001	0.000	Amplitude factor to calibrate current at 30% of Ir
IL1LowLim	0.000 - 10000000000.000	A	0.001	0.000	Low limit (physical value)
IL1LowLowLim	0.000 - 10000000000.000	A	0.001	0.000	Low Low limit (physical value)

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
IAmpComp100	-10.000 - 10.000	%	0.001	0.000	Amplitude factor to calibrate current at 100% of Ir
IAngComp5	-10.000 - 10.000	Deg	0.001	0.000	Angle calibration for current at 5% of Ir
IL1Min	0.000 - 10000000000.000	A	0.001	0.000	Minimum value
IAngComp30	-10.000 - 10.000	Deg	0.001	0.000	Angle calibration for current at 30% of Ir
IAngComp100	-10.000 - 10.000	Deg	0.001	0.000	Angle calibration for current at 100% of Ir
IL1LimHys	0.000 - 100.000	%	0.001	5.000	Hysteresis value in % of range and is common for all limits
IL2ZeroDb	0 - 100000	m%	1	0	Zero point clamping in 0,001% of range
IL2HiHiLim	0.000 - 10000000000.000	A	0.001	900.000	High High limit (physical value)
IL2HiLim	0.000 - 10000000000.000	A	0.001	800.000	High limit (physical value)
IL2LowLim	0.000 - 10000000000.000	A	0.001	0.000	Low limit (physical value)
IL2LowLowLim	0.000 - 10000000000.000	A	0.001	0.000	Low Low limit (physical value)
IL2Min	0.000 - 10000000000.000	A	0.001	0.000	Minimum value
IL2LimHys	0.000 - 100.000	%	0.001	5.000	Hysteresis value in % of range and is common for all limits
IL3ZeroDb	0 - 100000	m%	1	0	Zero point clamping in 0,001% of range
IL3HiHiLim	0.000 - 10000000000.000	A	0.001	900.000	High High limit (physical value)
IL3HiLim	0.000 - 10000000000.000	A	0.001	800.000	High limit (physical value)
IL3LowLim	0.000 - 10000000000.000	A	0.001	0.000	Low limit (physical value)
IL3LowLowLim	0.000 - 10000000000.000	A	0.001	0.000	Low Low limit (physical value)
IL3Min	0.000 - 10000000000.000	A	0.001	0.000	Minimum value
IL3LimHys	0.000 - 100.000	%	0.001	5.000	Hysteresis value in % of range and is common for all limits

Table 333: VNMMXU Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
UL1DbRepInt	1 - 300	Type	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s
Operation	Off On	-	-	Off	Operation Mode On / Off
UBase	0.05 - 2000.00	kV	0.05	400.00	Base setting for voltage level in kV
UL1Max	0.000 - 10000000000.000	V	0.001	300000.000	Maximum value
Table continues on next page					

Name	Values (Range)	Unit	Step	Default	Description
UL1RepTyp	Cyclic Dead band Int deadband	-	-	Cyclic	Reporting type
UL1LimHys	0.000 - 100.000	%	0.001	5.000	Hysteresis value in % of range and is common for all limits
UL1AnDbRepInt	1 - 300	Type	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s
UL2DbRepInt	1 - 300	Type	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s
UL2Max	0.000 - 10000000000.000	V	0.001	300000.000	Maximum value
UL2RepTyp	Cyclic Dead band Int deadband	-	-	Cyclic	Reporting type
UL2LimHys	0.000 - 100.000	%	0.001	5.000	Hysteresis value in % of range and is common for all limits
UL2AnDbRepInt	1 - 300	Type	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s
UL3DbRepInt	1 - 300	Type	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s
UL3Max	0.000 - 10000000000.000	V	0.001	300000.000	Maximum value
UL3RepTyp	Cyclic Dead band Int deadband	-	-	Cyclic	Reporting type
UL3LimHys	0.000 - 100.000	%	0.001	5.000	Hysteresis value in % of range and is common for all limits
UL3AnDbRepInt	1 - 300	Type	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s

Table 334: VNMMXU Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
UL1ZeroDb	0 - 100000	m%	1	0	Zero point clamping in 0,001% of range
UL1HiHiLim	0.000 - 10000000000.000	V	0.001	260000.000	High High limit (physical value)
UL1HiLim	0.000 - 10000000000.000	V	0.001	240000.000	High limit (physical value)
UL1LowLim	0.000 - 10000000000.000	V	0.001	220000.000	Low limit (physical value)
UL1LowLowLim	0.000 - 10000000000.000	V	0.001	200000.000	Low Low limit (physical value)
UAmpComp100	-10.000 - 10.000	%	0.001	0.000	Amplitude factor to calibrate voltage at 100% of Ur
UL1Min	0.000 - 10000000000.000	V	0.001	0.000	Minimum value
UL2ZeroDb	0 - 100000	m%	1	0	Zero point clamping in 0,001% of range
UL2HiHiLim	0.000 - 10000000000.000	V	0.001	260000.000	High High limit (physical value)

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
UL2HiLim	0.000 - 10000000000.000	V	0.001	240000.000	High limit (physical value)
UL2LowLim	0.000 - 10000000000.000	V	0.001	220000.000	Low limit (physical value)
UL2LowLowLim	0.000 - 10000000000.000	V	0.001	200000.000	Low Low limit (physical value)
UL2Min	0.000 - 10000000000.000	V	0.001	0.000	Minimum value
UL3ZeroDb	0 - 100000	m%	1	0	Zero point clamping in 0,001% of range
UL3HiHiLim	0.000 - 10000000000.000	V	0.001	260000.000	High High limit (physical value)
UL3HiLim	0.000 - 10000000000.000	V	0.001	240000.000	High limit (physical value)
UL3LowLim	0.000 - 10000000000.000	V	0.001	220000.000	Low limit (physical value)
UL3LowLowLim	0.000 - 10000000000.000	V	0.001	200000.000	Low Low limit (physical value)
UL3Min	0.000 - 10000000000.000	V	0.001	0.000	Minimum value

Table 335: VMMXU Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
UL12DbRepInt	1 - 300	Type	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s
Operation	Off On	-	-	Off	Operation Mode On / Off
UBase	0.05 - 2000.00	kV	0.05	400.00	Base setting for voltage level in kV
UL12Max	0.000 - 10000000000.000	V	0.001	500000.000	Maximum value
UL12RepTyp	Cyclic Dead band Int deadband	-	-	Cyclic	Reporting type
UL12AnDbRepInt	1 - 300	Type	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s
UL23DbRepInt	1 - 300	Type	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s
UL23Max	0.000 - 10000000000.000	V	0.001	500000.000	Maximum value
UL23RepTyp	Cyclic Dead band Int deadband	-	-	Cyclic	Reporting type
UL23AnDbRepInt	1 - 300	Type	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s
UL31DbRepInt	1 - 300	Type	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
UL31Max	0.000 - 10000000000.000	V	0.001	500000.000	Maximum value
UL31RepTyp	Cyclic Dead band Int deadband	-	-	Cyclic	Reporting type
UL31AnDbRepInt	1 - 300	Type	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s

Table 336: VMMXU Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
UL12ZeroDb	0 - 100000	m%	1	0	Zero point clamping in 0,001% of range
UL12HiHiLim	0.000 - 10000000000.000	V	0.001	450000.000	High High limit (physical value)
UL12HiLim	0.000 - 10000000000.000	V	0.001	420000.000	High limit (physical value)
UL12LowLim	0.000 - 10000000000.000	V	0.001	380000.000	Low limit (physical value)
UL12LowLowLim	0.000 - 10000000000.000	V	0.001	350000.000	Low Low limit (physical value)
UAmpComp100	-10.000 - 10.000	%	0.001	0.000	Amplitude factor to calibrate voltage at 100% of Ur
UL12Min	0.000 - 10000000000.000	V	0.001	0.000	Minimum value
UL12LimHys	0.000 - 100.000	%	0.001	5.000	Hysteresis value in % of range and is common for all limits
UL23ZeroDb	0 - 100000	m%	1	0	Zero point clamping in 0,001% of range
UL23HiHiLim	0.000 - 10000000000.000	V	0.001	450000.000	High High limit (physical value)
UL23HiLim	0.000 - 10000000000.000	V	0.001	420000.000	High limit (physical value)
UL23LowLim	0.000 - 10000000000.000	V	0.001	380000.000	Low limit (physical value)
UL23LowLowLim	0.000 - 10000000000.000	V	0.001	350000.000	Low Low limit (physical value)
UL23Min	0.000 - 10000000000.000	V	0.001	0.000	Minimum value
UL23LimHys	0.000 - 100.000	%	0.001	5.000	Hysteresis value in % of range and is common for all limits
UL31ZeroDb	0 - 100000	m%	1	0	Zero point clamping in 0,001% of range
UL31HiHiLim	0.000 - 10000000000.000	V	0.001	450000.000	High High limit (physical value)
UL31HiLim	0.000 - 10000000000.000	V	0.001	420000.000	High limit (physical value)
UL31LowLim	0.000 - 10000000000.000	V	0.001	380000.000	Low limit (physical value)

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
UL31LowLowLim	0.000 - 10000000000.000	V	0.001	350000.000	Low Low limit (physical value)
UL31Min	0.000 - 10000000000.000	V	0.001	0.000	Minimum value
UL31LimHys	0.000 - 100.000	%	0.001	5.000	Hysteresis value in % of range and is common for all limits

Table 337: CMSQI Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
3I0DbRepInt	1 - 300	Type	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s
3I0Min	0.000 - 10000000000.000	A	0.001	0.000	Minimum value
3I0Max	0.000 - 10000000000.000	A	0.001	1000.000	Maximum value
3I0RepTyp	Cyclic Dead band Int deadband	-	-	Cyclic	Reporting type
3I0LimHys	0.000 - 100.000	%	0.001	5.000	Hysteresis value in % of range and is common for all limits
3I0AngDbRepInt	1 - 300	Type	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s
Operation	Off On	-	-	Off	Operation Mode On / Off
3I0AngMin	-180.000 - 180.000	Deg	0.001	-180.000	Minimum value
3I0AngMax	-180.000 - 180.000	Deg	0.001	180.000	Maximum value
3I0AngRepTyp	Cyclic Dead band Int deadband	-	-	Cyclic	Reporting type
I1DbRepInt	1 - 300	Type	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s
I1Min	0.000 - 10000000000.000	A	0.001	0.000	Minimum value
I1Max	0.000 - 10000000000.000	A	0.001	1000.000	Maximum value
I1RepTyp	Cyclic Dead band Int deadband	-	-	Cyclic	Reporting type
I1AngDbRepInt	1 - 300	Type	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s
I1AngMax	-180.000 - 180.000	Deg	0.001	180.000	Maximum value
I1AngRepTyp	Cyclic Dead band Int deadband	-	-	Cyclic	Reporting type
I2DbRepInt	1 - 300	Type	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s
I2Min	0.000 - 10000000000.000	A	0.001	0.000	Minimum value
Table continues on next page					

Name	Values (Range)	Unit	Step	Default	Description
I2Max	0.000 - 10000000000.000	A	0.001	1000.000	Maximum value
I2RepTyp	Cyclic Dead band Int deadband	-	-	Cyclic	Reporting type
I2LimHys	0.000 - 100.000	%	0.001	5.000	Hysteresis value in % of range and is common for all limits
I2AngDbRepInt	1 - 300	Type	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s
I2AngMin	-180.000 - 180.000	Deg	0.001	-180.000	Minimum value
I2AngRepTyp	Cyclic Dead band Int deadband	-	-	Cyclic	Reporting type

Table 338: CMSQI Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
3I0ZeroDb	0 - 100000	m%	1	0	Zero point clamping in 0,001% of range
3I0HiHiLim	0.000 - 10000000000.000	A	0.001	900.000	High High limit (physical value)
3I0HiLim	0.000 - 10000000000.000	A	0.001	800.000	High limit (physical value)
3I0LowLim	0.000 - 10000000000.000	A	0.001	0.000	Low limit (physical value)
3I0LowLowLim	0.000 - 10000000000.000	A	0.001	0.000	Low Low limit (physical value)
3I0AngZeroDb	0 - 100000	m%	1	0	Zero point clamping in 0,001% of range
I1ZeroDb	0 - 100000	m%	1	0	Zero point clamping in 0,001% of range
I1HiHiLim	0.000 - 10000000000.000	A	0.001	900.000	High High limit (physical value)
I1HiLim	0.000 - 10000000000.000	A	0.001	800.000	High limit (physical value)
I1LowLim	0.000 - 10000000000.000	A	0.001	0.000	Low limit (physical value)
I1LowLowLim	0.000 - 10000000000.000	A	0.001	0.000	Low Low limit (physical value)
I1LimHys	0.000 - 100.000	%	0.001	5.000	Hysteresis value in % of range and is common for all limits
I1AngZeroDb	0 - 100000	m%	1	0	Zero point clamping in 0,001% of range
I1AngMin	-180.000 - 180.000	Deg	0.001	-180.000	Minimum value
I2ZeroDb	0 - 100000	m%	1	0	Zero point clamping in 0,001% of range
I2HiHiLim	0.000 - 10000000000.000	A	0.001	900.000	High High limit (physical value)
I2HiLim	0.000 - 10000000000.000	A	0.001	800.000	High limit (physical value)
I2LowLim	0.000 - 10000000000.000	A	0.001	0.000	Low limit (physical value)

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
I2LowLowLim	0.000 - 10000000000.000	A	0.001	0.000	Low Low limit (physical value)
I2AngZeroDb	0 - 100000	m%	1	0	Zero point clamping in 0,001% of range
I2AngMax	-180.000 - 180.000	Deg	0.001	180.000	Maximum value

Table 339: VMSQI Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
3U0DbRepInt	1 - 300	Type	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s
3U0Min	0.000 - 10000000000.000	V	0.001	0.000	Minimum value
3U0Max	0.000 - 10000000000.000	V	0.001	300000.000	Maximum value
3U0RepTyp	Cyclic Dead band Int deadband	-	-	Cyclic	Reporting type
3U0LimHys	0.000 - 100.000	%	0.001	5.000	Hysteresis value in % of range and is common for all limits
3U0AngDbRepInt	1 - 300	Type	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s
Operation	Off On	-	-	Off	Operation Mode On / Off
3U0AngZeroDb	0 - 100000	m%	1	0	Zero point clamping in 0,001% of range
3U0AngMin	-180.000 - 180.000	Deg	0.001	-180.000	Minimum value
3U0AngMax	-180.000 - 180.000	Deg	0.001	180.000	Maximum value
3U0AngRepTyp	Cyclic Dead band Int deadband	-	-	Cyclic	Reporting type
U1DbRepInt	1 - 300	Type	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s
U1Min	0.000 - 10000000000.000	V	0.001	0.000	Minimum value
U1Max	0.000 - 10000000000.000	V	0.001	300000.000	Maximum value
U1RepTyp	Cyclic Dead band Int deadband	-	-	Cyclic	Reporting type
U1LimHys	0.000 - 100.000	%	0.001	5.000	Hysteresis value in % of range and is common for all limits
U1AngDbRepInt	1 - 300	Type	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s
U2DbRepInt	1 - 300	Type	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s
U2Min	0.000 - 10000000000.000	V	0.001	0.000	Minimum value
U2Max	0.000 - 10000000000.000	V	0.001	300000.000	Maximum value
Table continues on next page					

Name	Values (Range)	Unit	Step	Default	Description
U2RepTyp	Cyclic Dead band Int deadband	-	-	Cyclic	Reporting type
U2LimHys	0.000 - 100.000	%	0.001	5.000	Hysteresis value in % of range and is common for all limits
U2AngDbRepInt	1 - 300	Type	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s
U2AngMin	-180.000 - 180.000	Deg	0.001	-180.000	Minimum value
U2AngMax	-180.000 - 180.000	Deg	0.001	180.000	Maximum value
U2AngRepTyp	Cyclic Dead band Int deadband	-	-	Cyclic	Reporting type
UAmpPreComp5	-10.000 - 10.000	%	0.001	0.000	Amplitude factor to pre-calibrate voltage at 5% of Ir
UAmpPreComp30	-10.000 - 10.000	%	0.001	0.000	Amplitude factor to pre-calibrate voltage at 30% of Ir
UAmpPreComp100	-10.000 - 10.000	%	0.001	0.000	Amplitude factor to pre-calibrate voltage at 100% of Ir

Table 340: VMSQI Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
3U0ZeroDb	0 - 100000	m%	1	0	Zero point clamping in 0,001% of range
3U0HiHiLim	0.000 - 10000000000.000	V	0.001	260000.000	High High limit (physical value)
3U0HiLim	0.000 - 10000000000.000	V	0.001	240000.000	High limit (physical value)
3U0LowLim	0.000 - 10000000000.000	V	0.001	220000.000	Low limit (physical value)
3U0LowLowLim	0.000 - 10000000000.000	V	0.001	200000.000	Low Low limit (physical value)
U1ZeroDb	0 - 100000	m%	1	0	Zero point clamping in 0,001% of range
U1HiHiLim	0.000 - 10000000000.000	V	0.001	260000.000	High High limit (physical value)
U1HiLim	0.000 - 10000000000.000	V	0.001	240000.000	High limit (physical value)
U1LowLim	0.000 - 10000000000.000	V	0.001	220000.000	Low limit (physical value)
U1LowLowLim	0.000 - 10000000000.000	V	0.001	200000.000	Low Low limit (physical value)
U1AngZeroDb	0 - 100000	m%	1	0	Zero point clamping in 0,001% of range
U1AngMin	-180.000 - 180.000	Deg	0.001	-180.000	Minimum value
U1AngMax	-180.000 - 180.000	Deg	0.001	180.000	Maximum value
U1AngRepTyp	Cyclic Dead band Int deadband	-	-	Cyclic	Reporting type
U2ZeroDb	0 - 100000	m%	1	0	Zero point clamping in 0,001% of range

Table continues on next page

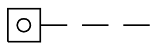
Name	Values (Range)	Unit	Step	Default	Description
U2HiHiLim	0.000 - 10000000000.000	V	0.001	260000.000	High High limit (physical value)
U2HiLim	0.000 - 10000000000.000	V	0.001	240000.000	High limit (physical value)
U2LowLim	0.000 - 10000000000.000	V	0.001	220000.000	Low limit (physical value)
U2LowLowLim	0.000 - 10000000000.000	V	0.001	200000.000	Low Low limit (physical value)
U2AngZeroDb	0 - 100000	m%	1	0	Zero point clamping in 0,001% of range

13.1.6 Technical data

Table 341: CVMMXN technical data

Function	Range or value	Accuracy
Frequency	$(0.95\text{-}1.05) \times f_r$	$\pm$ 2.0 mHz
Voltage	$(0.1\text{-}1.5) \times U_r$	$\pm$ 0.5% of U_r at $U \leq U_r$ $\pm$ 0.5% of U at $U > U_r$
Connected current	$(0.2\text{-}4.0) \times I_r$	$\pm$ 0.5% of I_r at $I \leq I_r$ $\pm$ 0.5% of I at $I > I_r$
Active power, P	$0.1 \times U_r < U < 1.5 \times U_r$ $0.2 \times I_r < I < 4.0 \times I_r$	$\pm$ 1.0% of S_r at $S \leq S_r$ $\pm$ 1.0% of S at $S > S_r$ Conditions: $0.8 \times U_r < U < 1.2 U_r$ $0.2 \times I_r < I < 1.2 I_r$
Reactive power, Q	$0.1 \times U_r < U < 1.5 \times U_r$ $0.2 \times I_r < I < 4.0 \times I_r$	
Apparent power, S	$0.1 \times U_r < U < 1.5 \times U_r$ $0.2 \times I_r < I < 4.0 \times I_r$	
Power factor, cos (φ)	$0.1 \times U_r < U < 1.5 \times U_r$ $0.2 \times I_r < I < 4.0 \times I_r$	$\pm$ 0.02

13.2 Event counter CNTGGIO

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Event counter	CNTGGIO		-

13.2.1 Introduction

Event counter (CNTGGIO) has six counters which are used for storing the number of times each counter input has been activated.

13.2.2 Principle of operation

Event counter (CNTGGIO) has six counter inputs. CNTGGIO stores how many times each of the inputs has been activated. The counter memory for each of the six inputs is updated, giving the total number of times the input has been activated, as soon as an input is activated. The maximum count up speed is 10 pulses per second. The maximum counter value is 10 000. For counts above 10 000 the counter will stop at 10 000 and no restart will take place.

To not risk that the flash memory is worn out due to too many writings, a mechanism for limiting the number of writings per time period is included in the product. This however gives as a result that it can take long time, up to several minutes, before a new value is stored in the flash memory. And if a new CNTGGIO value is not stored before auxiliary power interruption, it will be lost. CNTGGIO stored values in flash memory will however not be lost at an auxiliary power interruption.

The function block also has an input BLOCK. At activation of this input all six counters are blocked. The input can for example, be used for blocking the counters at testing.The function block has an input RESET. At activation of this input all six counters are set to 0.

All inputs are configured via PCM600.

13.2.2.1 Reporting

The content of the counters can be read in the local HMI.

Reset of counters can be performed in the local HMI and a binary input.

Reading of content can also be performed remotely, for example from a IEC 61850 client. The value can also be presented as a measuring value on the local HMI graphical display.

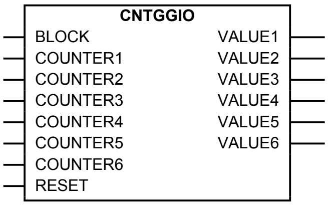
13.2.2.2 Design

The function block has six inputs for increasing the counter values for each of the six counters respectively. The content of the counters are stepped one step for each positive edge of the input respectively.

The function block also has an input BLOCK. At activation of this input all six counters are blocked and are not updated. Valid number is held.

The function block has an input RESET. At activation of this input all six counters are set to 0.

13.2.3 Function block



IEC05000345-2-en.vsd

Figure 252: CNTGGIO function block

13.2.4 Input signals

Table 342: CNTGGIO Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of function
COUNTER1	BOOLEAN	0	Input for counter1
COUNTER2	BOOLEAN	0	Input for counter2
COUNTER3	BOOLEAN	0	Input for counter3
COUNTER4	BOOLEAN	0	Input for counter4
COUNTER5	BOOLEAN	0	Input for counter5
COUNTER6	BOOLEAN	0	Input for counter6
RESET	BOOLEAN	0	Reset of function

Table 343: CNTGGIO Output signals

Name	Type	Description
VALUE1	INTEGER	Output of counter1
VALUE2	INTEGER	Output of counter2
VALUE3	INTEGER	Output of counter3
VALUE4	INTEGER	Output of counter4
VALUE5	INTEGER	Output of counter5
VALUE6	INTEGER	Output of counter6

13.2.5 Setting parameters

Table 344: CNTGGIO Group settings (basic)

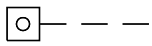
Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On

13.2.6 Technical data

Table 345: CNTGGIO technical data

Function	Range or value	Accuracy
Counter value	0-10000	-
Max. count up speed	10 pulses/s	-

13.3 Event function EVENT

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Event function	EVENT		-

13.3.1 Introduction

When using a Substation Automation system with LON or SPA communication, time-tagged events can be sent at change or cyclically from the IED to the station level. These events are created from any available signal in the IED that is connected to the Event function (EVENT). The event function block is used for LON and SPA communication.

Analog and double indication values are also transferred through EVENT function.

13.3.2 Principle of operation

The main purpose of the event function (EVENT) is to generate events when the state or value of any of the connected input signals is in a state, or is undergoing a state transition, for which event generation is enabled.

Each EVENT function has 16 inputs INPUT1 - INPUT16. Each input can be given a name from the Application Configuration tool. The inputs are normally used to create single events, but are also intended for double indication events.

EVENT function also has an input BLOCK to block the generation of events.

The events that are sent from the IED can originate from both internal logical signals and binary input channels. The internal signals are time-tagged in the main processing module, while the binary input channels are time-tagged directly on the input module. The time-tagging of the events that are originated from internal logical signals have a resolution corresponding to the execution cyclicity of EVENT function. The time-tagging of the events that are originated from binary input signals have a resolution of 1 ms.

The outputs from EVENT function are formed by the reading of status, events and alarms by the station level on every single input. The user-defined name for each input is intended to be used by the station level.

All events according to the event mask are stored in a buffer, which contains up to 1000 events. If new events appear before the oldest event in the buffer is read, the oldest event is overwritten and an overflow alarm appears.

The events are produced according to the set-event masks. The event masks are treated commonly for both the LON and SPA communication. The *EventMask* can be set individually for each input channel. These settings are available:

- *NoEvents*
- *OnSet*
- *OnReset*
- *OnChange*
- *AutoDetect*

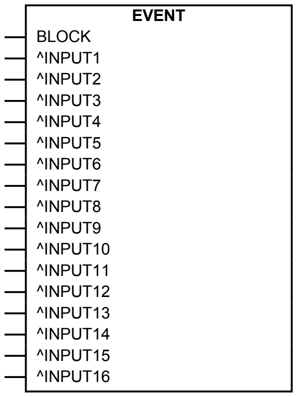
It is possible to define which part of EVENT function generates the events. This can be performed individually for the *SPAChannelMask* and *LONChannelMask* respectively. For each communication type these settings are available:

- *Off*
- *Channel 1-8*
- *Channel 9-16*
- *Channel 1-16*

For LON communication the events normally are sent to station level at change. It is possibly also to set a time for cyclic sending of the events individually for each input channel.

To protect the SA system from signals with a high change rate that can easily saturate the event system or the communication subsystems behind it, a quota limiter is implemented. If an input creates events at a rate that completely consume the granted quota then further events from the channel will be blocked. This block will be removed when the input calms down and the accumulated quota reach 66% of the maximum burst quota. The maximum burst quota per input channel is 45 events per second.

13.3.3 Function block



IEC05000697-2-en.vsd

Figure 253: EVENT function block

13.3.4 Input and output signals

Table 346: EVENT Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of function
INPUT1	GROUP SIGNAL	0	Input 1
INPUT2	GROUP SIGNAL	0	Input 2
INPUT3	GROUP SIGNAL	0	Input 3
INPUT4	GROUP SIGNAL	0	Input 4
INPUT5	GROUP SIGNAL	0	Input 5
INPUT6	GROUP SIGNAL	0	Input 6
INPUT7	GROUP SIGNAL	0	Input 7
INPUT8	GROUP SIGNAL	0	Input 8
INPUT9	GROUP SIGNAL	0	Input 9
INPUT10	GROUP SIGNAL	0	Input 10
INPUT11	GROUP SIGNAL	0	Input 11
INPUT12	GROUP SIGNAL	0	Input 12

Table continues on next page

Name	Type	Default	Description
INPUT13	GROUP SIGNAL	0	Input 13
INPUT14	GROUP SIGNAL	0	Input 14
INPUT15	GROUP SIGNAL	0	Input 15
INPUT16	GROUP SIGNAL	0	Input 16

13.3.5 Setting parameters

Table 347: EVENT Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
SPAChannelMask	Off Channel 1-8 Channel 9-16 Channel 1-16	-	-	Off	SPA channel mask
LONChannelMask	Off Channel 1-8 Channel 9-16 Channel 1-16	-	-	Off	LON channel mask
EventMask1	NoEvents OnSet OnReset OnChange AutoDetect	-	-	AutoDetect	Reporting criteria for input 1
EventMask2	NoEvents OnSet OnReset OnChange AutoDetect	-	-	AutoDetect	Reporting criteria for input 2
EventMask3	NoEvents OnSet OnReset OnChange AutoDetect	-	-	AutoDetect	Reporting criteria for input 3
EventMask4	NoEvents OnSet OnReset OnChange AutoDetect	-	-	AutoDetect	Reporting criteria for input 4
EventMask5	NoEvents OnSet OnReset OnChange AutoDetect	-	-	AutoDetect	Reporting criteria for input 5
EventMask6	NoEvents OnSet OnReset OnChange AutoDetect	-	-	AutoDetect	Reporting criteria for input 6

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
EventMask7	NoEvents OnSet OnReset OnChange AutoDetect	-	-	AutoDetect	Reporting criteria for input 7
EventMask8	NoEvents OnSet OnReset OnChange AutoDetect	-	-	AutoDetect	Reporting criteria for input 8
EventMask9	NoEvents OnSet OnReset OnChange AutoDetect	-	-	AutoDetect	Reporting criteria for input 9
EventMask10	NoEvents OnSet OnReset OnChange AutoDetect	-	-	AutoDetect	Reporting criteria for input 10
EventMask11	NoEvents OnSet OnReset OnChange AutoDetect	-	-	AutoDetect	Reporting criteria for input 11
EventMask12	NoEvents OnSet OnReset OnChange AutoDetect	-	-	AutoDetect	Reporting criteria for input 12
EventMask13	NoEvents OnSet OnReset OnChange AutoDetect	-	-	AutoDetect	Reporting criteria for input 13
EventMask14	NoEvents OnSet OnReset OnChange AutoDetect	-	-	AutoDetect	Reporting criteria for input 14
EventMask15	NoEvents OnSet OnReset OnChange AutoDetect	-	-	AutoDetect	Reporting criteria for input 15
EventMask16	NoEvents OnSet OnReset OnChange AutoDetect	-	-	AutoDetect	Reporting criteria for input 16
MinRepIntVal1	0 - 3600	s	1	2	Minimum reporting interval input 1
MinRepIntVal2	0 - 3600	s	1	2	Minimum reporting interval input 2
MinRepIntVal3	0 - 3600	s	1	2	Minimum reporting interval input 3
MinRepIntVal4	0 - 3600	s	1	2	Minimum reporting interval input 4
MinRepIntVal5	0 - 3600	s	1	2	Minimum reporting interval input 5

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
MinRepIntVal6	0 - 3600	s	1	2	Minimum reporting interval input 6
MinRepIntVal7	0 - 3600	s	1	2	Minimum reporting interval input 7
MinRepIntVal8	0 - 3600	s	1	2	Minimum reporting interval input 8
MinRepIntVal9	0 - 3600	s	1	2	Minimum reporting interval input 9
MinRepIntVal10	0 - 3600	s	1	2	Minimum reporting interval input 10
MinRepIntVal11	0 - 3600	s	1	2	Minimum reporting interval input 11
MinRepIntVal12	0 - 3600	s	1	2	Minimum reporting interval input 12
MinRepIntVal13	0 - 3600	s	1	2	Minimum reporting interval input 13
MinRepIntVal14	0 - 3600	s	1	2	Minimum reporting interval input 14
MinRepIntVal15	0 - 3600	s	1	2	Minimum reporting interval input 15
MinRepIntVal16	0 - 3600	s	1	2	Minimum reporting interval input 16

13.4 Logical signal status report BINSTATREP

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Logical signal status report	BINSTATREP	-	-

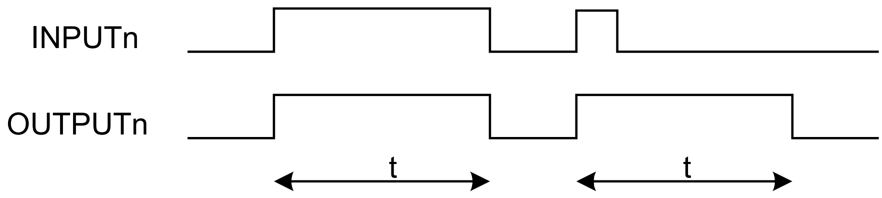
13.4.1 Introduction

The Logical signal status report (BINSTATREP) function makes it possible for a SPA master to poll signals from various other functions.

13.4.2 Principle of operation

The Logical signal status report (BINSTATREP) function has 16 inputs and 16 outputs. The output status follows the inputs and can be read from the local HMI or via SPA communication.

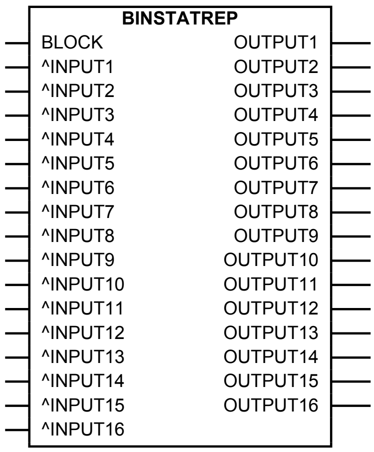
When an input is set, the respective output is set for a user defined time. If the input signal remains set for a longer period, the output will remain set until the input signal resets.



IEC09000732-1-en.vsd

Figure 254: BINSTATREP logical diagram

13.4.3 Function block



IEC09000730-1-en.vsd

Figure 255: BINSTATREP function block

13.4.4 Input and output signals

Table 348: BINSTATREP Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of function
INPUT1	BOOLEAN	0	Single status report input 1
INPUT2	BOOLEAN	0	Single status report input 2
INPUT3	BOOLEAN	0	Single status report input 3
INPUT4	BOOLEAN	0	Single status report input 4
INPUT5	BOOLEAN	0	Single status report input 5
INPUT6	BOOLEAN	0	Single status report input 6
INPUT7	BOOLEAN	0	Single status report input 7
INPUT8	BOOLEAN	0	Single status report input 8
INPUT9	BOOLEAN	0	Single status report input 9

Table continues on next page

Name	Type	Default	Description
INPUT10	BOOLEAN	0	Single status report input 10
INPUT11	BOOLEAN	0	Single status report input 11
INPUT12	BOOLEAN	0	Single status report input 12
INPUT13	BOOLEAN	0	Single status report input 13
INPUT14	BOOLEAN	0	Single status report input 14
INPUT15	BOOLEAN	0	Single status report input 15
INPUT16	BOOLEAN	0	Single status report input 16

Table 349: BINSTATREP Output signals

Name	Type	Description
OUTPUT1	BOOLEAN	Logical status report output 1
OUTPUT2	BOOLEAN	Logical status report output 2
OUTPUT3	BOOLEAN	Logical status report output 3
OUTPUT4	BOOLEAN	Logical status report output 4
OUTPUT5	BOOLEAN	Logical status report output 5
OUTPUT6	BOOLEAN	Logical status report output 6
OUTPUT7	BOOLEAN	Logical status report output 7
OUTPUT8	BOOLEAN	Logical status report output 8
OUTPUT9	BOOLEAN	Logical status report output 9
OUTPUT10	BOOLEAN	Logical status report output 10
OUTPUT11	BOOLEAN	Logical status report output 11
OUTPUT12	BOOLEAN	Logical status report output 12
OUTPUT13	BOOLEAN	Logical status report output 13
OUTPUT14	BOOLEAN	Logical status report output 14
OUTPUT15	BOOLEAN	Logical status report output 15
OUTPUT16	BOOLEAN	Logical status report output 16

13.4.5 Setting parameters

Table 350: BINSTATREP Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
t	0.000 - 60000.000	s	0.001	10.000	Time delay of function

13.5 Measured value expander block RANGE_XP

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Measured value expander block	RANGE_XP	-	-

13.5.1 Introduction

The current and voltage measurements functions (CVMMXN, CMMXU, VMMXU and VNMMXU), current and voltage sequence measurement functions (CMSQI and VMSQI) and IEC 61850 generic communication I/O functions (MVGGIO) are provided with measurement supervision functionality. All measured values can be supervised with four settable limits: low-low limit, low limit, high limit and high-high limit. The measure value expander block (RANGE_XP) has been introduced to enable translating the integer output signal from the measuring functions to 5 binary signals: below low-low limit, below low limit, normal, above high-high limit or above high limit. The output signals can be used as conditions in the configurable logic or for alarming purpose.

13.5.2 Principle of operation

The input signal must be connected to a range output of a measuring function block (CVMMXN, CMMXU, VMMXU, VNMMXU, CMSQI, VMSQ or MVGGIO). The function block converts the input integer value to five binary output signals according to table 351.

Table 351: Input integer value converted to binary output signals

Measured supervised value is: / Output:	below low-low limit	between low-low and low limit	between low and high limit	between high-high and high limit	above high-high limit
LOWLOW	High				
LOW		High			
NORMAL			High		
HIGH				High	
HIGHHIGH					High

13.5.3 Function block

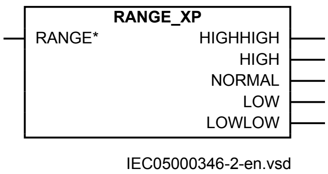


Figure 256: RANGE_XP function block

13.5.4 Input and output signals

Table 352: RANGE_XP Input signals

Name	Type	Default	Description
RANGE	INTEGER	0	Measured value range

Table 353: RANGE_XP Output signals

Name	Type	Description
HIGHHIGH	BOOLEAN	Measured value is above high-high limit
HIGH	BOOLEAN	Measured value is between high and high-high limit
NORMAL	BOOLEAN	Measured value is between high and low limit
LOW	BOOLEAN	Measured value is between low and low-low limit
LOWLOW	BOOLEAN	Measured value is below low-low limit

13.6 Disturbance report DRPRDRE

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Analog input signals	A41RADR	-	-
Disturbance report	DRPRDRE	-	-
Disturbance report	A1RADR	-	-
Disturbance report	A4RADR	-	-
Disturbance report	B1RBDR	-	-

13.6.1 Introduction

Complete and reliable information about disturbances in the primary and/or in the secondary system together with continuous event-logging is accomplished by the disturbance report functionality.

Disturbance report DRPRDRE, always included in the IED, acquires sampled data of all selected analog input and binary signals connected to the function block with a, maximum of 40 analog and 96 binary signals.

The Disturbance report functionality is a common name for several functions:

- Event list
- Indications
- Event recorder
- Trip value recorder
- Disturbance recorder

The Disturbance report function is characterized by great flexibility regarding configuration, starting conditions, recording times, and large storage capacity.

A disturbance is defined as an activation of an input to the AxRADR or BxRBDR function blocks, which are set to trigger the disturbance recorder. All signals from start of pre-fault time to the end of post-fault time will be included in the recording.

Every disturbance report recording is saved in the IED in the standard Comtrade format. The same applies to all events, which are continuously saved in a ring-buffer. The local HMI is used to get information about the recordings. The disturbance report files may be uploaded to PCM600 for further analysis using the disturbance handling tool.

13.6.2 Principle of operation

Disturbance report DRPRDRE is a common name for several functions to supply the operator, analysis engineer, and so on, with sufficient information about events in the system.

The functions included in the disturbance report are:

- Event list (EL)
- Indications (IND)
- Event recorder (ER)
- Trip value recorder(TVR)
- Disturbance recorder (DR)

Figure 257 shows the relations between Disturbance Report, included functions and function blocks. Event list (EL), Event recorder (ER) and Indications (IND) uses information from the binary input function blocks (BxRBDR). Trip value recorder (TVR) uses analog information from the analog input function blocks (AxRADR). Disturbance recorder DRPRDRE acquires information from both AxRADR and BxRBDR.

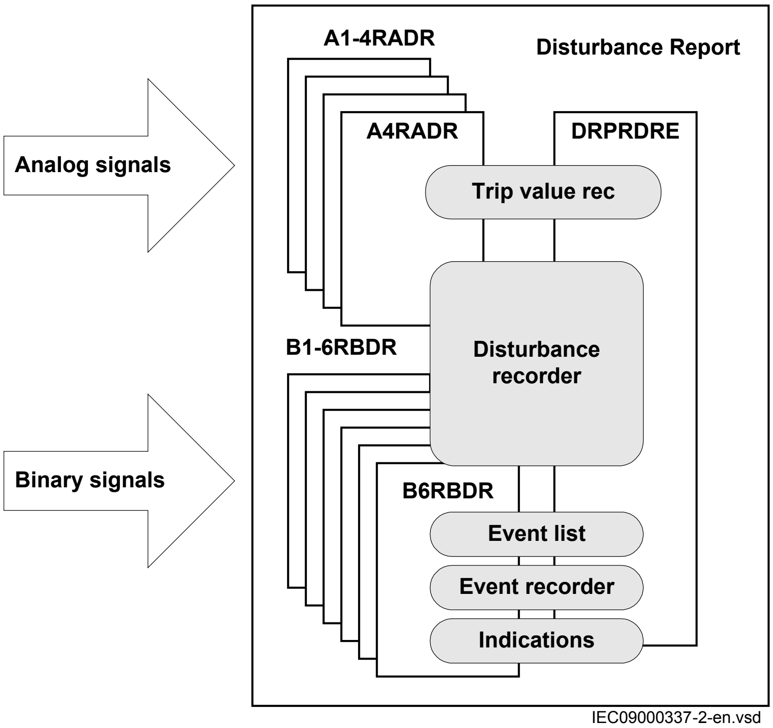


Figure 257: Disturbance report functions and related function blocks

The whole disturbance report can contain information for a number of recordings, each with the data coming from all the parts mentioned above. The event list function is working continuously, independent of disturbance triggering, recording time, and so on. All information in the disturbance report is stored in non-volatile flash memories. This implies that no information is lost in case of loss of auxiliary power. Each report will get an identification number in the interval from 0-999.

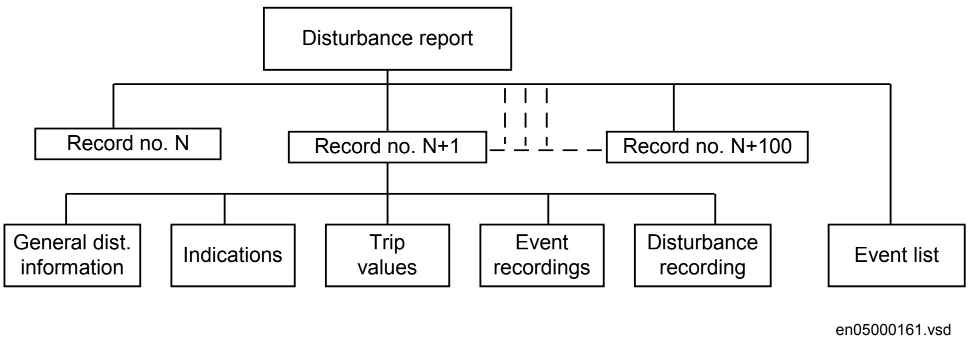


Figure 258: Disturbance report structure

Up to 100 disturbance reports can be stored. If a new disturbance is to be recorded when the memory is full, the oldest disturbance report is overwritten by the new one. The total recording capacity for the disturbance recorder is depending of sampling frequency, number of analog and binary channels and recording time. Figure 259 shows the number of recordings versus the total recording time tested for a typical configuration, that is, in a 50 Hz system it is possible to record 100 where the average recording time is 3.4 seconds. The memory limit does not affect the rest of the disturbance report (Event list (EL), Event recorder (ER), Indications (IND) and Trip value recorder (TVR)).

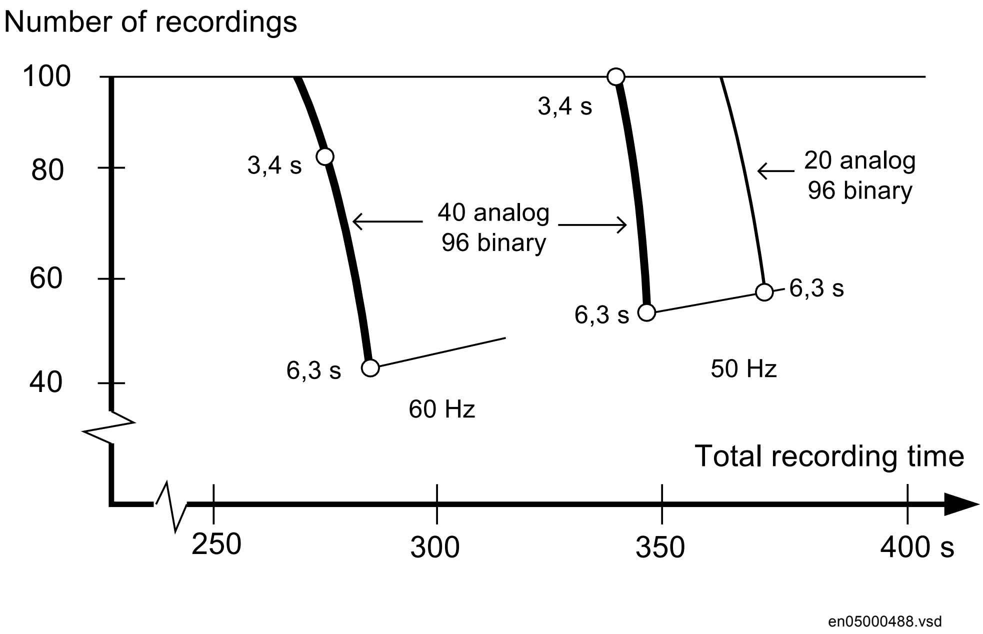


Figure 259: Number of recordings

Disturbance information

Date and time of the disturbance, the indications, events, fault location and the trip values are available on the local HMI. To acquire a complete disturbance report the user must use a PC and - either the PCM600 Disturbance handling tool - or a FTP or MMS (over 61850) client. The PC can be connected to the IED front, rear or remotely via the station bus (Ethernet ports).

Indications (IND)

Indications is a list of signals that were activated during the total recording time of the disturbance (not time-tagged), see section "Indications" for more detailed information.

Event recorder (ER)

The event recorder may contain a list of up to 150 time-tagged events, which have occurred during the disturbance. The information is available via the local HMI or PCM600, see section "Event recorder" for more detailed information.

Event list (EL)

The event list may contain a list of totally 1000 time-tagged events. The list information is continuously updated when selected binary signals change state. The oldest data is overwritten. The logged signals may be presented via local HMI or PCM600, see section "Event list" for more detailed information.

Trip value recorder (TVR)

The recorded trip values include phasors of selected analog signals before the fault and during the fault, see section "Trip value recorder" for more detailed information.

Disturbance recorder (DR)

Disturbance recorder records analog and binary signal data before, during and after the fault, see section "Disturbance recorder" for more detailed information.

Time tagging

The IED has a built-in real-time calendar and clock. This function is used for all time tagging within the disturbance report

Recording times

Disturbance report DRPRDRE records information about a disturbance during a settable time frame. The recording times are valid for the whole disturbance report. Disturbance recorder (DR), event recorder (ER) and indication function register disturbance data and events during tRecording, the total recording time.

The total recording time, tRecording, of a recorded disturbance is:

tRecording =	*PreFaultrecT* + tFault + *PostFaultrecT* or *PreFaultrecT* + *TimeLimit*, depending on which criterion stops the current disturbance recording

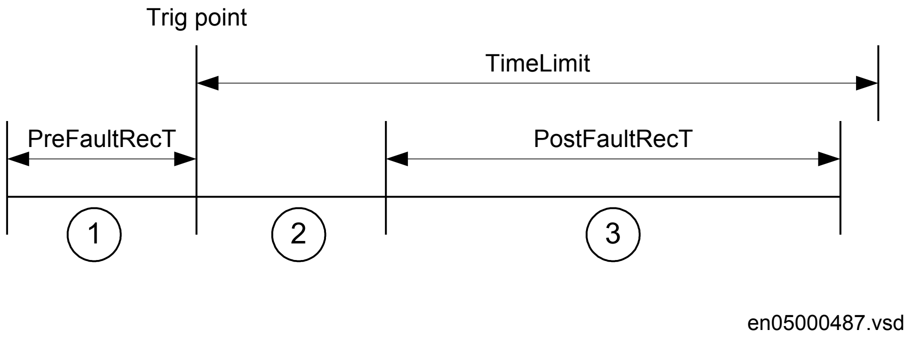


Figure 260: The recording times definition

PreFaultRecT, 1	Pre-fault or pre-trigger recording time. The time before the fault including the operate time of the trigger. Use the setting *PreFaultRecT* to set this time.
tFault, 2	Fault time of the recording. The fault time cannot be set. It continues as long as any valid trigger condition, binary or analog, persists (unless limited by *TimeLimit* the limit time).
PostFaultRecT, 3	Post fault recording time. The time the disturbance recording continues after all activated triggers are reset. Use the setting *PostFaultRecT* to set this time.
TimeLimit	Limit time. The maximum allowed recording time after the disturbance recording was triggered. The limit time is used to eliminate the consequences of a trigger that does not reset within a reasonable time interval. It limits the maximum recording time of a recording and prevents subsequent overwriting of already stored disturbances. Use the setting *TimeLimit* to set this time.

Analog signals

Up to 40 analog signals can be selected for recording by the Disturbance recorder and triggering of the Disturbance report function. Out of these 40, 30 are reserved for external analog signals from analog input modules (TRM) and line data communication module (LDCM) via preprocessing function blocks (SMAI) and summation block (3PHSUM). The last 10 channels may be connected to internally calculated analog signals available as function block output signals (mA input signals, phase differential currents, bias currents and so on).

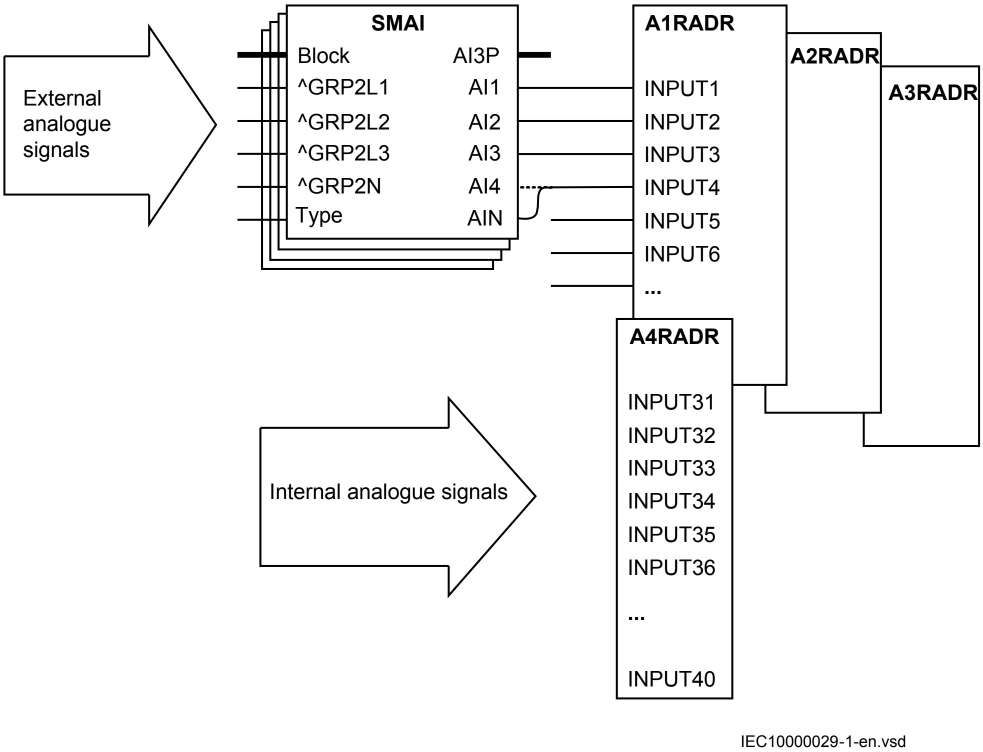


Figure 261: Analog input function blocks

The external input signals will be acquired, filtered and skewed and (after configuration) available as an input signal on the AxRADR function block via the SMAI function block. The information is saved at the Disturbance report base sampling rate (1000 or 1200 Hz). Internally calculated signals are updated according to the cycle time of the specific function. If a function is running at lower speed than the base sampling rate, Disturbance recorder will use the latest updated sample until a new updated sample is available.

If the IED is preconfigured the only tool needed for analog configuration of the Disturbance report is the Signal Matrix Tool (SMT, external signal configuration). In case of modification of a preconfigured IED or general internal configuration the Application Configuration tool within PCM600 is used.

The preprocessor function block (SMAI) calculates the residual quantities in cases where only the three phases are connected (AI4-input not used).SMAI makes the information available as a group signal output, phase outputs and calculated residual output (AIN-output). In situations where AI4-input is used as an input signal the corresponding information is available on the non-calculated output (AI4) on the SMAI function block. Connect the signals to the AxRADR accordingly.

For each of the analog signals, *Operation* = *On* means that it is recorded by the disturbance recorder. The trigger is independent of the setting of *Operation*, and triggers even if operation is set to *Off*. Both undervoltage and overvoltage can be used as trigger conditions. The same applies for the current signals.

If *Operation* = *Off*, no waveform (samples) will be recorded and reported in graph. However, Trip value, pre-fault and fault value will be recorded and reported. The input channel can still be used to trig the disturbance recorder.

If *Operation* = *On*, waveform (samples) will also be recorded and reported in graph.

The analog signals are presented only in the disturbance recording, but they affect the entire disturbance report when being used as triggers.

Binary signals

Up to 96 binary signals can be selected to be handled by disturbance report. The signals can be selected from internal logical and binary input signals. A binary signal is selected to be recorded when:

- the corresponding function block is included in the configuration
- the signal is connected to the input of the function block

Each of the 96 signals can be selected as a trigger of the disturbance report (*Operation* = *Off*). A binary signal can be selected to activate the red LED on the local HMI (*SetLED* = *On*/*Off*).

The selected signals are presented in the event recorder, event list and the disturbance recording. But they affect the whole disturbance report when they are used as triggers. The indications are also selected from these 96 signals with local HMI *IndicationMask=Show/Hide*.

Trigger signals

The trigger conditions affect the entire disturbance report, except the event list, which runs continuously. As soon as at least one trigger condition is fulfilled, a complete disturbance report is recorded. On the other hand, if no trigger condition is fulfilled, there is no disturbance report, no indications, and so on. This implies the importance of choosing the right signals as trigger conditions.

A trigger can be of type:

- Manual trigger
- Binary-signal trigger
- Analog-signal trigger (over/under function)

Manual trigger

A disturbance report can be manually triggered from the local HMI, PCM600 or via station bus (IEC 61850). When the trigger is activated, the manual trigger signal is generated. This feature is especially useful for testing. Refer to the operator's manual for procedure.

Binary-signal trigger

Any binary signal state (logic one or a logic zero) can be selected to generate a trigger (*Triglevel* = Trig on 0/Trig on 1). When a binary signal is selected to generate a trigger from a logic zero, the selected signal will not be listed in the indications list of the disturbance report.

Analog-signal trigger

All analog signals are available for trigger purposes, no matter if they are recorded in the disturbance recorder or not. The settings are *OverTrigOp*, *UnderTrigOp*, *OverTrigLe* and *UnderTrigLe*.

The check of the trigger condition is based on peak-to-peak values. When this is found, the absolute average value of these two peak values is calculated. If the average value is above the threshold level for an overvoltage or overcurrent trigger, this trigger is indicated with a greater than (>) sign with the user-defined name.

If the average value is below the set threshold level for an undervoltage or undercurrent trigger, this trigger is indicated with a less than (<) sign with its name. The procedure is separately performed for each channel.

This method of checking the analog start conditions gives a function which is insensitive to DC offset in the signal. The operate time for this start is typically in the range of one cycle, 20 ms for a 50 Hz network.

All under/over trig signal information is available on the local HMI and PCM600.

Post Retrigger

Disturbance report function does not respond to any new trig condition, during a recording. Under certain circumstances the fault condition may reoccur during the post-fault recording, for instance by automatic reclosing to a still faulty power line.

In order to capture the new disturbance it is possible to allow retriggering (*PostRetrig* = *On*) during the post-fault time. In this case a new, complete recording will start and, during a period, run in parallel with the initial recording.

When the retrig parameter is disabled (*PostRetrig* = *Off*), a new recording will not start until the post-fault (*PostFaultrecT* or *TimeLimit*) period is terminated. If a new trig occurs during the post-fault period and lasts longer than the proceeding recording a new complete recording will be fetched.

Disturbance report function can handle maximum 3 simultaneous disturbance recordings.

13.6.3 Function block

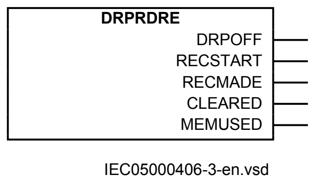


Figure 262: DRPRDRE function block

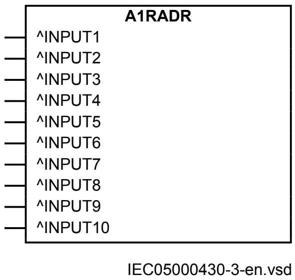


Figure 263: A1RADR function block

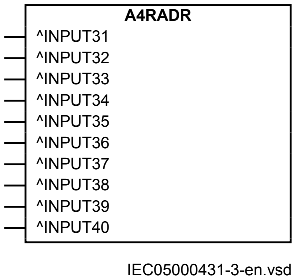


Figure 264: A4RADR function block, derived analog inputs

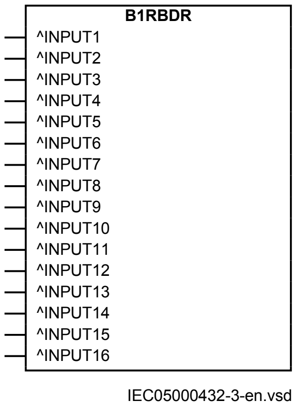


Figure 265: B1RBDR function block, binary inputs, example for B1RBDR - B6RBDR

13.6.4 Input and output signals

Table 354: DRPRDRE Output signals

Name	Type	Description
DRPOFF	BOOLEAN	Disturbance report function turned off
RECSTART	BOOLEAN	Disturbance recording started
RECMADE	BOOLEAN	Disturbance recording made
CLEARED	BOOLEAN	All disturbances in the disturbance report cleared
MEMUSED	BOOLEAN	More than 80% of memory used

Table 355: A1RADR Input signals

Name	Type	Default	Description
INPUT1	GROUP SIGNAL	-	Group signal for input 1
INPUT2	GROUP SIGNAL	-	Group signal for input 2
INPUT3	GROUP SIGNAL	-	Group signal for input 3
INPUT4	GROUP SIGNAL	-	Group signal for input 4
INPUT5	GROUP SIGNAL	-	Group signal for input 5
INPUT6	GROUP SIGNAL	-	Group signal for input 6
INPUT7	GROUP SIGNAL	-	Group signal for input 7
INPUT8	GROUP SIGNAL	-	Group signal for input 8
INPUT9	GROUP SIGNAL	-	Group signal for input 9
INPUT10	GROUP SIGNAL	-	Group signal for input 10

Table 356: A4RADR Input signals

Name	Type	Default	Description
INPUT31	REAL	0	Analogue channel 31
INPUT32	REAL	0	Analogue channel 32
INPUT33	REAL	0	Analogue channel 33
INPUT34	REAL	0	Analogue channel 34
INPUT35	REAL	0	Analogue channel 35
INPUT36	REAL	0	Analogue channel 36
INPUT37	REAL	0	Analogue channel 37

Table continues on next page

Name	Type	Default	Description
INPUT38	REAL	0	Analogue channel 38
INPUT39	REAL	0	Analogue channel 39
INPUT40	REAL	0	Analogue channel 40

Table 357: B1RBDR Input signals

Name	Type	Default	Description
INPUT1	BOOLEAN	0	Binary channel 1
INPUT2	BOOLEAN	0	Binary channel 2
INPUT3	BOOLEAN	0	Binary channel 3
INPUT4	BOOLEAN	0	Binary channel 4
INPUT5	BOOLEAN	0	Binary channel 5
INPUT6	BOOLEAN	0	Binary channel 6
INPUT7	BOOLEAN	0	Binary channel 7
INPUT8	BOOLEAN	0	Binary channel 8
INPUT9	BOOLEAN	0	Binary channel 9
INPUT10	BOOLEAN	0	Binary channel 10
INPUT11	BOOLEAN	0	Binary channel 11
INPUT12	BOOLEAN	0	Binary channel 12
INPUT13	BOOLEAN	0	Binary channel 13
INPUT14	BOOLEAN	0	Binary channel 14
INPUT15	BOOLEAN	0	Binary channel 15
INPUT16	BOOLEAN	0	Binary channel 16

13.6.5 Setting parameters

Table 358: DRPRDRE Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off/On
PreFaultRecT	0.05 - 9.90	s	0.01	0.10	Pre-fault recording time
PostFaultRecT	0.1 - 10.0	s	0.1	0.5	Post-fault recording time
TimeLimit	0.5 - 10.0	s	0.1	1.0	Fault recording time limit
PostRetrig	Off On	-	-	Off	Post-fault retrig enabled (On) or not (Off)
ZeroAngleRef	1 - 30	Ch	1	1	Reference channel (voltage), phasors, frequency measurement
OpModeTest	Off On	-	-	Off	Operation mode during test mode

Table 359: A1RADR Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation01	Off On	-	-	Off	Operation On/Off
NomValue01	0.0 - 999999.9	-	0.1	0.0	Nominal value for analogue channel 1
UnderTrigOp01	Off On	-	-	Off	Use under level trig for analogue cha 1 (on) or not (off)
UnderTrigLe01	0 - 200	%	1	50	Under trigger level for analogue cha 1 in % of signal
OverTrigOp01	Off On	-	-	Off	Use over level trig for analogue cha 1 (on) or not (off)
OverTrigLe01	0 - 5000	%	1	200	Over trigger level for analogue cha 1 in % of signal
Operation02	Off On	-	-	Off	Operation On/Off
NomValue02	0.0 - 999999.9	-	0.1	0.0	Nominal value for analogue channel 2
UnderTrigOp02	Off On	-	-	Off	Use under level trig for analogue cha 2 (on) or not (off)
UnderTrigLe02	0 - 200	%	1	50	Under trigger level for analogue cha 2 in % of signal
OverTrigOp02	Off On	-	-	Off	Use over level trig for analogue cha 2 (on) or not (off)
OverTrigLe02	0 - 5000	%	1	200	Over trigger level for analogue cha 2 in % of signal
Operation03	Off On	-	-	Off	Operation On/Off
NomValue03	0.0 - 999999.9	-	0.1	0.0	Nominal value for analogue channel 3
UnderTrigOp03	Off On	-	-	Off	Use under level trig for analogue cha 3 (on) or not (off)
UnderTrigLe03	0 - 200	%	1	50	Under trigger level for analogue cha 3 in % of signal
OverTrigOp03	Off On	-	-	Off	Use over level trig for analogue cha 3 (on) or not (off)
OverTrigLe03	0 - 5000	%	1	200	Overtrigger level for analogue cha 3 in % of signal
Operation04	Off On	-	-	Off	Operation On/Off
NomValue04	0.0 - 999999.9	-	0.1	0.0	Nominal value for analogue channel 4
UnderTrigOp04	Off On	-	-	Off	Use under level trig for analogue cha 4 (on) or not (off)
UnderTrigLe04	0 - 200	%	1	50	Under trigger level for analogue cha 4 in % of signal
OverTrigOp04	Off On	-	-	Off	Use over level trig for analogue cha 4 (on) or not (off)
OverTrigLe04	0 - 5000	%	1	200	Over trigger level for analogue cha 4 in % of signal
Operation05	Off On	-	-	Off	Operation On/Off

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
NomValue05	0.0 - 999999.9	-	0.1	0.0	Nominal value for analogue channel 5
UnderTrigOp05	Off On	-	-	Off	Use under level trig for analogue cha 5 (on) or not (off)
UnderTrigLe05	0 - 200	%	1	50	Under trigger level for analogue cha 5 in % of signal
OverTrigOp05	Off On	-	-	Off	Use over level trig for analogue cha 5 (on) or not (off)
OverTrigLe05	0 - 5000	%	1	200	Over trigger level for analogue cha 5 in % of signal
Operation06	Off On	-	-	Off	Operation On/Off
NomValue06	0.0 - 999999.9	-	0.1	0.0	Nominal value for analogue channel 6
UnderTrigOp06	Off On	-	-	Off	Use under level trig for analogue cha 6 (on) or not (off)
UnderTrigLe06	0 - 200	%	1	50	Under trigger level for analogue cha 6 in % of signal
OverTrigOp06	Off On	-	-	Off	Use over level trig for analogue cha 6 (on) or not (off)
OverTrigLe06	0 - 5000	%	1	200	Over trigger level for analogue cha 6 in % of signal
Operation07	Off On	-	-	Off	Operation On/Off
NomValue07	0.0 - 999999.9	-	0.1	0.0	Nominal value for analogue channel 7
UnderTrigOp07	Off On	-	-	Off	Use under level trig for analogue cha 7 (on) or not (off)
UnderTrigLe07	0 - 200	%	1	50	Under trigger level for analogue cha 7 in % of signal
OverTrigOp07	Off On	-	-	Off	Use over level trig for analogue cha 7 (on) or not (off)
OverTrigLe07	0 - 5000	%	1	200	Over trigger level for analogue cha 7 in % of signal
Operation08	Off On	-	-	Off	Operation On/Off
NomValue08	0.0 - 999999.9	-	0.1	0.0	Nominal value for analogue channel 8
UnderTrigOp08	Off On	-	-	Off	Use under level trig for analogue cha 8 (on) or not (off)
UnderTrigLe08	0 - 200	%	1	50	Under trigger level for analogue cha 8 in % of signal
OverTrigOp08	Off On	-	-	Off	Use over level trig for analogue cha 8 (on) or not (off)
OverTrigLe08	0 - 5000	%	1	200	Over trigger level for analogue cha 8 in % of signal
Operation09	Off On	-	-	Off	Operation On/Off
NomValue09	0.0 - 999999.9	-	0.1	0.0	Nominal value for analogue channel 9
UnderTrigOp09	Off On	-	-	Off	Use under level trig for analogue cha 9 (on) or not (off)

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
UnderTrigLe09	0 - 200	%	1	50	Under trigger level for analogue cha 9 in % of signal
OverTrigOp09	Off On	-	-	Off	Use over level trig for analogue cha 9 (on) or not (off)
OverTrigLe09	0 - 5000	%	1	200	Over trigger level for analogue cha 9 in % of signal
Operation10	Off On	-	-	Off	Operation On/Off
NomValue10	0.0 - 999999.9	-	0.1	0.0	Nominal value for analogue channel 10
UnderTrigOp10	Off On	-	-	Off	Use under level trig for analogue cha 10 (on) or not (off)
UnderTrigLe10	0 - 200	%	1	50	Under trigger level for analogue cha 10 in % of signal
OverTrigOp10	Off On	-	-	Off	Use over level trig for analogue cha 10 (on) or not (off)
OverTrigLe10	0 - 5000	%	1	200	Over trigger level for analogue cha 10 in % of signal

Table 360: A4RADR Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation31	Off On	-	-	Off	Operation On/off
NomValue31	0.0 - 999999.9	-	0.1	0.0	Nominal value for analogue channel 31
UnderTrigOp31	Off On	-	-	Off	Use under level trig for analogue cha 31 (on) or not (off)
UnderTrigLe31	0 - 200	%	1	50	Under trigger level for analogue cha 31 in % of signal
OverTrigOp31	Off On	-	-	Off	Use over level trig for analogue cha 31 (on) or not (off)
OverTrigLe31	0 - 5000	%	1	200	Over trigger level for analogue cha 31 in % of signal
Operation32	Off On	-	-	Off	Operation On/off
NomValue32	0.0 - 999999.9	-	0.1	0.0	Nominal value for analogue channel 32
UnderTrigOp32	Off On	-	-	Off	Use under level trig for analogue cha 32 (on) or not (off)
UnderTrigLe32	0 - 200	%	1	50	Under trigger level for analogue cha 32 in % of signal
OverTrigOp32	Off On	-	-	Off	Use over level trig for analogue cha 32 (on) or not (off)
OverTrigLe32	0 - 5000	%	1	200	Over trigger level for analogue cha 32 in % of signal
Operation33	Off On	-	-	Off	Operation On/off
NomValue33	0.0 - 999999.9	-	0.1	0.0	Nominal value for analogue channel 33
UnderTrigOp33	Off On	-	-	Off	Use under level trig for analogue cha 33 (on) or not (off)

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
UnderTrigLe33	0 - 200	%	1	50	Under trigger level for analogue cha 33 in % of signal
OverTrigOp33	Off On	-	-	Off	Use over level trig for analogue cha 33 (on) or not (off)
OverTrigLe33	0 - 5000	%	1	200	Overtrigger level for analogue cha 33 in % of signal
Operation34	Off On	-	-	Off	Operation On/off
NomValue34	0.0 - 999999.9	-	0.1	0.0	Nominal value for analogue channel 34
UnderTrigOp34	Off On	-	-	Off	Use under level trig for analogue cha 34 (on) or not (off)
UnderTrigLe34	0 - 200	%	1	50	Under trigger level for analogue cha 34 in % of signal
OverTrigOp34	Off On	-	-	Off	Use over level trig for analogue cha 34 (on) or not (off)
OverTrigLe34	0 - 5000	%	1	200	Over trigger level for analogue cha 34 in % of signal
Operation35	Off On	-	-	Off	Operation On/off
NomValue35	0.0 - 999999.9	-	0.1	0.0	Nominal value for analogue channel 35
UnderTrigOp35	Off On	-	-	Off	Use under level trig for analogue cha 35 (on) or not (off)
UnderTrigLe35	0 - 200	%	1	50	Under trigger level for analogue cha 35 in % of signal
OverTrigOp35	Off On	-	-	Off	Use over level trig for analogue cha 35 (on) or not (off)
OverTrigLe35	0 - 5000	%	1	200	Over trigger level for analogue cha 35 in % of signal
Operation36	Off On	-	-	Off	Operation On/off
NomValue36	0.0 - 999999.9	-	0.1	0.0	Nominal value for analogue channel 36
UnderTrigOp36	Off On	-	-	Off	Use under level trig for analogue cha 36 (on) or not (off)
UnderTrigLe36	0 - 200	%	1	50	Under trigger level for analogue cha 36 in % of signal
OverTrigOp36	Off On	-	-	Off	Use over level trig for analogue cha 36 (on) or not (off)
OverTrigLe36	0 - 5000	%	1	200	Over trigger level for analogue cha 36 in % of signal
Operation37	Off On	-	-	Off	Operation On/off
NomValue37	0.0 - 999999.9	-	0.1	0.0	Nominal value for analogue channel 37
UnderTrigOp37	Off On	-	-	Off	Use under level trig for analogue cha 37 (on) or not (off)
UnderTrigLe37	0 - 200	%	1	50	Under trigger level for analogue cha 37 in % of signal
OverTrigOp37	Off On	-	-	Off	Use over level trig for analogue cha 37 (on) or not (off)

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
OverTrigLe37	0 - 5000	%	1	200	Over trigger level for analogue cha 37 in % of signal
Operation38	Off On	-	-	Off	Operation On/off
NomValue38	0.0 - 999999.9	-	0.1	0.0	Nominal value for analogue channel 38
UnderTrigOp38	Off On	-	-	Off	Use under level trig for analogue cha 38 (on) or not (off)
UnderTrigLe38	0 - 200	%	1	50	Under trigger level for analogue cha 38 in % of signal
OverTrigOp38	Off On	-	-	Off	Use over level trig for analogue cha 38 (on) or not (off)
OverTrigLe38	0 - 5000	%	1	200	Over trigger level for analogue cha 38 in % of signal
Operation39	Off On	-	-	Off	Operation On/off
NomValue39	0.0 - 999999.9	-	0.1	0.0	Nominal value for analogue channel 39
UnderTrigOp39	Off On	-	-	Off	Use under level trig for analogue cha 39 (on) or not (off)
UnderTrigLe39	0 - 200	%	1	50	Under trigger level for analogue cha 39 in % of signal
OverTrigOp39	Off On	-	-	Off	Use over level trig for analogue cha 39 (on) or not (off)
OverTrigLe39	0 - 5000	%	1	200	Over trigger level for analogue cha 39 in % of signal
Operation40	Off On	-	-	Off	Operation On/off
NomValue40	0.0 - 999999.9	-	0.1	0.0	Nominal value for analogue channel 40
UnderTrigOp40	Off On	-	-	Off	Use under level trig for analogue cha 40 (on) or not (off)
UnderTrigLe40	0 - 200	%	1	50	Under trigger level for analogue cha 40 in % of signal
OverTrigOp40	Off On	-	-	Off	Use over level trig for analogue cha 40 (on) or not (off)
OverTrigLe40	0 - 5000	%	1	200	Over trigger level for analogue cha 40 in % of signal

Table 361: B1RBDR Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation01	Off On	-	-	Off	Trigger operation On/Off
TrigLevel01	Trig on 0 Trig on 1	-	-	Trig on 1	Trig on positiv (1) or negative (0) slope for binary inp 1
IndicationMa01	Hide Show	-	-	Hide	Indication mask for binary channel 1
SetLED01	Off On	-	-	Off	Set red-LED on HMI for binary channel 1

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
Operation02	Off On	-	-	Off	Trigger operation On/Off
TrigLevel02	Trig on 0 Trig on 1	-	-	Trig on 1	Trig on positiv (1) or negative (0) slope for binary inp 2
IndicationMa02	Hide Show	-	-	Hide	Indication mask for binary channel 2
SetLED02	Off On	-	-	Off	Set red-LED on HMI for binary channel 2
Operation03	Off On	-	-	Off	Trigger operation On/Off
TrigLevel03	Trig on 0 Trig on 1	-	-	Trig on 1	Trig on positiv (1) or negative (0) slope for binary inp 3
IndicationMa03	Hide Show	-	-	Hide	Indication mask for binary channel 3
SetLED03	Off On	-	-	Off	Set red-LED on HMI for binary channel 3
Operation04	Off On	-	-	Off	Trigger operation On/Off
TrigLevel04	Trig on 0 Trig on 1	-	-	Trig on 1	Trig on positiv (1) or negative (0) slope for binary inp 4
IndicationMa04	Hide Show	-	-	Hide	Indication mask for binary channel 4
SetLED04	Off On	-	-	Off	Set red-LED on HMI for binary channel 4
Operation05	Off On	-	-	Off	Trigger operation On/Off
TrigLevel05	Trig on 0 Trig on 1	-	-	Trig on 1	Trig on positiv (1) or negative (0) slope for binary inp 5
IndicationMa05	Hide Show	-	-	Hide	Indication mask for binary channel 5
SetLED05	Off On	-	-	Off	Set red-LED on HMI for binary channel 5
Operation06	Off On	-	-	Off	Trigger operation On/Off
TrigLevel06	Trig on 0 Trig on 1	-	-	Trig on 1	Trig on positiv (1) or negative (0) slope for binary inp 6
IndicationMa06	Hide Show	-	-	Hide	Indication mask for binary channel 6
SetLED06	Off On	-	-	Off	Set red-LED on HMI for binary channel 6
Operation07	Off On	-	-	Off	Trigger operation On/Off
TrigLevel07	Trig on 0 Trig on 1	-	-	Trig on 1	Trig on positiv (1) or negative (0) slope for binary inp 7
IndicationMa07	Hide Show	-	-	Hide	Indication mask for binary channel 7
SetLED07	Off On	-	-	Off	Set red-LED on HMI for binary channel 7

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
Operation08	Off On	-	-	Off	Trigger operation On/Off
TrigLevel08	Trig on 0 Trig on 1	-	-	Trig on 1	Trig on positiv (1) or negative (0) slope for binary inp 8
IndicationMa08	Hide Show	-	-	Hide	Indication mask for binary channel 8
SetLED08	Off On	-	-	Off	Set red-LED on HMI for binary channel 8
Operation09	Off On	-	-	Off	Trigger operation On/Off
TrigLevel09	Trig on 0 Trig on 1	-	-	Trig on 1	Trig on positiv (1) or negative (0) slope for binary inp 9
IndicationMa09	Hide Show	-	-	Hide	Indication mask for binary channel 9
SetLED09	Off On	-	-	Off	Set red-LED on HMI for binary channel 9
Operation10	Off On	-	-	Off	Trigger operation On/Off
TrigLevel10	Trig on 0 Trig on 1	-	-	Trig on 1	Trig on positiv (1) or negative (0) slope for binary inp 10
IndicationMa10	Hide Show	-	-	Hide	Indication mask for binary channel 10
SetLED10	Off On	-	-	Off	Set red-LED on HMI for binary channel 10
Operation11	Off On	-	-	Off	Trigger operation On/Off
TrigLevel11	Trig on 0 Trig on 1	-	-	Trig on 1	Trig on positiv (1) or negative (0) slope for binary inp 11
IndicationMa11	Hide Show	-	-	Hide	Indication mask for binary channel 11
SetLED11	Off On	-	-	Off	Set red-LED on HMI for binary channel 11
Operation12	Off On	-	-	Off	Trigger operation On/Off
TrigLevel12	Trig on 0 Trig on 1	-	-	Trig on 1	Trig on positiv (1) or negative (0) slope for binary inp 12
IndicationMa12	Hide Show	-	-	Hide	Indication mask for binary channel 12
SetLED12	Off On	-	-	Off	Set red-LED on HMI for binary input 12
Operation13	Off On	-	-	Off	Trigger operation On/Off
TrigLevel13	Trig on 0 Trig on 1	-	-	Trig on 1	Trig on positiv (1) or negative (0) slope for binary inp 13
IndicationMa13	Hide Show	-	-	Hide	Indication mask for binary channel 13
SetLED13	Off On	-	-	Off	Set red-LED on HMI for binary channel 13

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
Operation14	Off On	-	-	Off	Trigger operation On/Off
TrigLevel14	Trig on 0 Trig on 1	-	-	Trig on 1	Trig on positiv (1) or negative (0) slope for binary inp 14
IndicationMa14	Hide Show	-	-	Hide	Indication mask for binary channel 14
SetLED14	Off On	-	-	Off	Set red-LED on HMI for binary channel 14
Operation15	Off On	-	-	Off	Trigger operation On/Off
TrigLevel15	Trig on 0 Trig on 1	-	-	Trig on 1	Trig on positiv (1) or negative (0) slope for binary inp 15
IndicationMa15	Hide Show	-	-	Hide	Indication mask for binary channel 15
SetLED15	Off On	-	-	Off	Set red-LED on HMI for binary channel 15
Operation16	Off On	-	-	Off	Trigger operation On/Off
TrigLevel16	Trig on 0 Trig on 1	-	-	Trig on 1	Trig on positiv (1) or negative (0) slope for binary inp 16
IndicationMa16	Hide Show	-	-	Hide	Indication mask for binary channel 16
SetLED16	Off On	-	-	Off	Set red-LED on HMI for binary channel 16
FUNT1	0 - 255	FunT	1	0	Function type for binary channel 1 (IEC -60870-5-103)
FUNT2	0 - 255	FunT	1	0	Function type for binary channel 2 (IEC -60870-5-103)
FUNT3	0 - 255	FunT	1	0	Function type for binary channel 3 (IEC -60870-5-103)
FUNT4	0 - 255	FunT	1	0	Function type for binary channel 4 (IEC -60870-5-103)
FUNT5	0 - 255	FunT	1	0	Function type for binary channel 5 (IEC -60870-5-103)
FUNT6	0 - 255	FunT	1	0	Function type for binary channel 6 (IEC -60870-5-103)
FUNT7	0 - 255	FunT	1	0	Function type for binary channel 7 (IEC -60870-5-103)
FUNT8	0 - 255	FunT	1	0	Function type for binary channel 8 (IEC -60870-5-103)
FUNT9	0 - 255	FunT	1	0	Function type for binary channel 9 (IEC -60870-5-103)
FUNT10	0 - 255	FunT	1	0	Function type for binary channel 10 (IEC -60870-5-103)
FUNT11	0 - 255	FunT	1	0	Function type for binary channel 11 (IEC -60870-5-103)
FUNT12	0 - 255	FunT	1	0	Function type for binary channel 12 (IEC -60870-5-103)

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
FUNT13	0 - 255	FunT	1	0	Function type for binary channel 13 (IEC -60870-5-103)
FUNT14	0 - 255	FunT	1	0	Function type for binary channel 14 (IEC -60870-5-103)
FUNT15	0 - 255	FunT	1	0	Function type for binary channel 15 (IEC -60870-5-103)
FUNT16	0 - 255	FunT	1	0	Function type for binary channel 16 (IEC -60870-5-103)
INFNO1	0 - 255	InfNo	1	0	Information number for binary channel 1 (IEC -60870-5-103)
INFNO2	0 - 255	InfNo	1	0	Information number for binary channel 2 (IEC -60870-5-103)
INFNO3	0 - 255	InfNo	1	0	Information number for binary channel 3 (IEC -60870-5-103)
INFNO4	0 - 255	InfNo	1	0	Information number for binary channel 4 (IEC -60870-5-103)
INFNO5	0 - 255	InfNo	1	0	Information number for binary channel 5 (IEC -60870-5-103)
INFNO6	0 - 255	InfNo	1	0	Information number for binary channel 6 (IEC -60870-5-103)
INFNO7	0 - 255	InfNo	1	0	Information number for binary channel 7 (IEC -60870-5-103)
INFNO8	0 - 255	InfNo	1	0	Information number for binary channel 8 (IEC -60870-5-103)
INFNO9	0 - 255	InfNo	1	0	Information number for binary channel 9 (IEC -60870-5-103)
INFNO10	0 - 255	InfNo	1	0	Information number for binary channel 10 (IEC -60870-5-103)
INFNO11	0 - 255	InfNo	1	0	Information number for binary channel 11 (IEC -60870-5-103)
INFNO12	0 - 255	InfNo	1	0	Information number for binary channel 12 (IEC -60870-5-103)
INFNO13	0 - 255	InfNo	1	0	Information number for binary channel 13 (IEC -60870-5-103)
INFNO14	0 - 255	InfNo	1	0	Information number for binary channel 14 (IEC -60870-5-103)
INFNO15	0 - 255	InfNo	1	0	Information number for binary channel 15 (IEC -60870-5-103)
INFNO16	0 - 255	InfNo	1	0	Information number for binary channel 16 (IEC -60870-5-103)

13.6.6 Technical data

Table 362: DRPRDRE technical data

Function	Range or value	Accuracy
Pre-fault time	(0.05–9.90) s	-
Post-fault time	(0.1–10.0) s	-
Limit time	(0.5–10.0) s	-
Maximum number of recordings	100, first in - first out	-
Time tagging resolution	1 ms	See table 23
Maximum number of analog inputs	30 + 10 (external + internally derived)	-
Maximum number of binary inputs	96	-
Maximum number of phasors in the Trip Value recorder per recording	30	-
Maximum number of indications in a disturbance report	96	-
Maximum number of events in the Event recording per recording	150	-
Maximum number of events in the Event list	1000, first in - first out	-
Maximum total recording time (3.4 s recording time and maximum number of channels, typical value)	340 seconds (100 recordings) at 50 Hz, 280 seconds (80 recordings) at 60 Hz	-
Sampling rate	1 kHz at 50 Hz 1.2 kHz at 60 Hz	-
Recording bandwidth	(5-300) Hz	-

13.7 Event list

13.7.1 Introduction

Continuous event-logging is useful for monitoring the system from an overview perspective and is a complement to specific disturbance recorder functions.

The event list logs all binary input signals connected to the Disturbance report function. The list may contain up to 1000 time-tagged events stored in a ring-buffer.

13.7.2 Principle of operation

When a binary signal, connected to the disturbance report function, changes status, the event list function stores input name, status and time in the event list in chronological order. The list can contain up to 1000 events from both internal logic signals and binary input channels. If the list is full, the oldest event is overwritten when a new event arrives.

The list can be configured to show oldest or newest events first with a setting on the local HMI.

The event list function runs continuously, in contrast to the event recorder function, which is only active during a disturbance.

The name of the binary input signal that appears in the event recording is the user-defined name assigned when the IED is configured. The same name is used in the disturbance recorder function (DR), indications (IND)and the event recorder function (ER).

The event list is stored and managed separate from the disturbance report information (ER, DR, IND, TVR and FL).

13.7.3 Function block

The Event list has no function block of it’s own. It is included in the DRPRDRE block and uses information from the BxRBDR block.

13.7.4 Input signals

The Event list logs the same binary input signals as configured for the Disturbance report function.

13.7.5 Technical data

Table 363: technical data

Function		Value
Buffer capacity	Maximum number of events in the list	1000
Resolution Accuracy		1 ms Depending on time synchronizing

13.8 Indications

13.8.1 Introduction

To get fast, condensed and reliable information about disturbances in the primary and/or in the secondary system it is important to know, for example binary signals that have changed status during a disturbance. This information is used in the short perspective to get information via the local HMI in a straightforward way.

There are three LEDs on the local HMI (green, yellow and red), which will display status information about the IED and the Disturbance report function (trigged).

The Indication list function shows all selected binary input signals connected to the Disturbance report function that have changed status during a disturbance.

13.8.2 Principle of operation

The LED indications display this information:

Green LED:

Steady light	In Service
Flashing light	Internal fail
Dark	No power supply

Yellow LED:

Steady light	A disturbance report is triggered
Flashing light	The IED is in test mode or in configuration mode

Red LED:

Steady light	Trigged on binary signal N with SetLEDN=On

Indication list:

The possible indicated signals are the same as the ones chosen for the disturbance report function and disturbance recorder.

The indication function tracks 0 to 1 changes of binary signals during the recording period of the collection window. This means that constant logic zero, constant logic one or state changes from logic one to logic zero will not be visible in the list of indications. Signals are not time tagged. In order to be recorded in the list of indications the:

- the signal must be connected to binary input(DRB1-6)
- the DRPparameter *Operation* must be set *On*
- the DRP must be trigged (binary or analog)

Indications are selected with the indication mask (*IndicationMask*) when configuring the binary inputs.

The name of the binary input signal that appears in the Indication function is the user-defined name assigned at configuration of the IED. The same name is used in disturbance recorder function (DR), indications (IND) and event recorder function (ER).

13.8.3 Function block

The Indications function has no function block of it’s own. It is included in the DRPRDRE block and uses information from the BxRBDR block.

13.8.4 Input signals

The Indications function may log the same binary input signals as the Disturbance report function.

13.8.5 Technical data

Table 364: technical data

Function		Value
Buffer capacity	Maximum number of indications presented for single disturbance	96
	Maximum number of recorded disturbances	100

13.9 Event recorder

13.9.1 Introduction

Quick, complete and reliable information about disturbances in the primary and/or in the secondary system is vital, for example, time-tagged events logged during disturbances. This information is used for different purposes in the short term (for example corrective actions) and in the long term (for example functional analysis).

The event recorder logs all selected binary input signals connected to the Disturbance report function. Each recording can contain up to 150 time-tagged events.

The event recorder information is available for the disturbances locally in the IED.

The event recording information is an integrated part of the disturbance record (Comtrade file).

13.9.2 Principle of operation

When one of the trig conditions for the disturbance report is activated, the event recorder logs every status change in the 96 selected binary signals. The events can be generated by both internal logical signals and binary input channels. The internal signals are time-tagged in the main processor module, while the binary input channels are time-tagged directly in each I/O module. The events are collected during the total recording time (pre-, post-fault and limit time), and are stored in the disturbance report flash memory at the end of each recording.

In case of overlapping recordings, due to *PostRetrig* = *On* and a new trig signal appears during post-fault time, events will be saved in both recording files.

The name of the binary input signal that appears in the event recording is the user-defined name assigned when configuring the IED. The same name is used in the disturbance recorder function (DR), indications (IND) and event recorder function (ER).

The event record is stored as a part of the disturbance report information (ER, DR, IND, TVR and FL) and managed via the local HMI or PCM600.

13.9.3 Function block

The Event recorder has no function block of it’s own. It is included in the DRPRDRE block and uses information from the BxRBDR block.

13.9.4 Input signals

The Event recorder function logs the same binary input signals as the Disturbance report function.

13.9.5 Technical data

Table 365: technical data

Function		Value
Buffer capacity	Maximum number of events in disturbance report	150
	Maximum number of disturbance reports	100
Resolution		1 ms
Accuracy		Depending on time synchronizing

13.10 Trip value recorder

13.10.1 Introduction

Information about the pre-fault and fault values for currents and voltages are vital for the disturbance evaluation.

The Trip value recorder calculates the values of all selected analog input signals connected to the Disturbance report function. The result is magnitude and phase angle before and during the fault for each analog input signal.

The trip value recorder information is available for the disturbances locally in the IED.

The trip value recorder information is an integrated part of the disturbance record (Comtrade file).

13.10.2 Principle of operation

Trip value recorder (TVR)calculates and presents both fault and pre-fault amplitudes as well as the phase angles of all the selected analog input signals. The parameter *ZeroAngleRef* points out which input signal is used as the angle reference.

When the disturbance report function is triggered the sample for the fault interception is searched for, by checking the non-periodic changes in the analog input signals. The channel search order is consecutive, starting with the analog input with the lowest number.

When a starting point is found, the Fourier estimation of the pre-fault values of the complex values of the analog signals starts 1.5 cycle before the fault sample. The estimation uses samples during one period. The post-fault values are calculated using the Recursive Least Squares (RLS) method. The calculation starts a few samples after the fault sample and uses samples during 1/2 - 2 cycles depending on the shape of the signals.

If no starting point is found in the recording, the disturbance report trig sample is used as the start sample for the Fourier estimation. The estimation uses samples during one cycle before the trig sample. In this case the calculated values are used both as pre-fault and fault values.

The name of the analog input signal that appears in the Trip value recorder function is the user-defined name assigned when the IED is configured. The same name is used in the Disturbance recorder function (DR).

The trip value record is stored as a part of the disturbance report information (ER, DR, IND, TVR and fault locator) and managed in via the local HMI or PCM600.

13.10.3 Function block

The Trip value recorder has no function block of it’s own. It is included in the DRPRDRE block and uses information from the BxRBDR block.

13.10.4 Input signals

The trip value recorder function uses analog input signals connected to A1RADR to A3RADR (not A4RADR).

13.10.5 Technical data

Table 366: technical data

Function		Value
Buffer capacity	Maximum number of analog inputs	30
	Maximum number of disturbance reports	100

13.11 Disturbance recorder

13.11.1 Introduction

The Disturbance recorder function supplies fast, complete and reliable information about disturbances in the power system. It facilitates understanding system behavior and related primary and secondary equipment during and after a disturbance. Recorded information is used for different purposes in the short perspective (for example corrective actions) and long perspective (for example functional analysis).

The Disturbance recorder acquires sampled data from selected analog- and binary signals connected to the Disturbance report function (maximum 40 analog and 96 binary signals). The binary signals available are the same as for the event recorder function.

The function is characterized by great flexibility and is not dependent on the operation of protection functions. It can record disturbances not detected by protection functions. Up to ten seconds of data before the trigger instant can be saved in the disturbance file.

The disturbance recorder information for up to 100 disturbances are saved in the IED and the local HMI is used to view the list of recordings.

13.11.2 Principle of operation

Disturbance recording (DR) is based on the acquisition of binary and analog signals. The binary signals can be either true binary input signals or internal logical signals generated by the functions in the IED. The analog signals to be recorded are input channels from the Transformer Input Module (TRM), Line Differential communication Module (LDCM) through the Signal Matrix Analog Input (SMAI) and possible summation (Sum3Ph) function blocks and some internally derived analog signals. For details, refer to section "Disturbance report DRPRDRE".

Disturbance recorder collects analog values and binary signals continuously, in a cyclic buffer. The pre-fault buffer operates according to the FIFO principle; old data will continuously be overwritten as new data arrives when the buffer is full. The size of this buffer is determined by the set pre-fault recording time.

Upon detection of a fault condition (triggering), the disturbance is time tagged and the data storage continues in a post-fault buffer. The storage process continues as long as the fault condition prevails - plus a certain additional time. This is called the post-fault time and it can be set in the disturbance report.

The above mentioned two parts form a disturbance recording. The whole memory, intended for disturbance recordings, acts as a cyclic buffer and when it is full, the oldest recording is overwritten. The last 100 recordings are stored in the IED.

The time tagging refers to the activation of the trigger that starts the disturbance recording. A recording can be trigged by, manual start, binary input and/or from analog inputs (over-/underlevel trig).

A user-defined name for each of the signals can be set. These names are common for all functions within the disturbance report functionality.

13.11.2.1 Memory and storage

When a recording is completed, a post recording processing occurs.

This post-recording processing comprises:

- Saving the data for analog channels with corresponding data for binary signals
- Add relevant data to be used by the Disturbance handling tool (part of PCM 600)
- Compression of the data, which is performed without losing any data accuracy
- Storing the compressed data in a non-volatile memory (flash memory)

The recorded disturbance is now ready for retrieval and evaluation.

The recording files comply with the Comtrade standard IEC 60255-24 and are divided into three files; a header file (HDR), a configuration file (CFG) and a data file (DAT).

The header file (optional in the standard) contains basic information about the disturbance, that is, information from the Disturbance report sub-functions (ER, TVR). The Disturbance handling tool use this information and present the recording in a user-friendly way.

General:

- Station name, object name and unit name
- Date and time for the trig of the disturbance
- Record number
- Sampling rate
- Time synchronization source
- Recording times
- Activated trig signal
- Active setting group

Analog:

- Signal names for selected analog channels
- Information e.g. trig on analog inputs
- Primary and secondary instrument transformer rating
- Over- or Undertrig: level and operation
- Over- or Undertrig status at time of trig
- CT direction

Binary:

- Signal names
- Status of binary input signals

The configuration file is a mandatory file containing information needed to interpret the data file. For example sampling rate, number of channels, system frequency, channel info etc.

The data file, which also is mandatory, containing values for each input channel for each sample in the record (scaled value). The data file also contains a sequence number and time stamp for each set of samples.

13.11.2.2 IEC 60870-5-103

The communication protocol IEC 60870-5-103 may be used to poll disturbance recordings from the IED to a master (station HSI). The standard describes how to handle 8 disturbance recordings, 8 analog channels (4 currents and 4 voltages) using the public range and binary signals.

The last 8 recordings, out of maximum 100, are available for transfer to the master. When the last one is transferred and acknowledged new recordings in the IED will appear, in the master points of view (even if they already where stored in the IED).

To be able to report 40 analog channels from the IED using IEC 60870-5-103 the first 8 channels are placed in the public range and the next 32 are placed in the private range. To comply the standard the first 8 must be configured according to table 367.

Table 367: Configuration of analog channels

Signal	Disturbance recorder	
IL1	A1RADR	INPUT1
IL2	A1RADR	INPUT2
IL3	A1RADR	INPUT3
IN	A1RADR	INPUT4
UL1	A1RADR	INPUT5
UL2	A1RADR	INPUT6
UL3	A1RADR	INPUT7
UN	A1RADR	INPUT8

The binary signals connected to BxRBDR are reported by polling. The function blocks include function type and information number.

13.11.3 Function block

The Disturbance recorder has no function block of it’s own. It is included in the DRPRDRE, AxRADR and BxRBDR block.

13.11.4 Input and output signals

For signals see section, in Disturbance report, "Input and output signals".

13.11.5 Setting parameters

For Setting parameters see section "Disturbance report DRPRDRE".

13.11.6 Technical data

Table 368: technical data

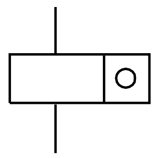
Function		Value
Buffer capacity	Maximum number of analog inputs	40
	Maximum number of binary inputs	96
	Maximum number of disturbance reports	100
Maximum total recording time (3.4 s recording time and maximum number of channels, typical value)		340 seconds (100 recordings) at 50 Hz 280 seconds (80 recordings) at 60 Hz

Section 14 Metering

About this chapter

This chapter describes among others, Pulse counter logic which is a function used to meter externally generated binary pulses. The way the functions work, their setting parameters, function blocks, input and output signals, and technical data are included for each function.

14.1 Pulse-counter logic PCGGIO

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Pulse-counter logic	PCGGIO		-

14.1.1 Introduction

Pulse counter (PCGGIO) function counts externally generated binary pulses, for instance pulses coming from an external energy meter, for calculation of energy consumption values. The pulses are captured by the binary input module and then read by the function. A scaled service value is available over the station bus. The special Binary input module with enhanced pulse counting capabilities must be ordered to achieve this functionality.

14.1.2 Principle of operation

The registration of pulses is done for positive transitions (0->1) on one of the 16 binary input channels located on the Binary Input Module (BIM). Pulse counter values are sent to the station HMI with predefined cyclicity without reset.

The reporting time period can be set in the range from 1 second to 60 minutes and is synchronized with absolute system time. Interrogation of additional pulse counter values can be done with a command (intermediate reading) for a single counter. All active counters can also be read by the LON General Interrogation command (GI) or IEC 61850.

Pulse counter (PCGGIO) function in the IED supports unidirectional incremental counters. That means only positive values are possible. The counter uses a 32 bit format, that is, the reported value is a 32-bit, signed integer with a range 0...+2147483647. The counter is reset at initialization of the IED.

The reported value to station HMI over the station bus contains Identity, Scaled Value (pulse count x scale), Time, and Pulse Counter Quality. The Pulse Counter Quality consists of:

- Invalid (board hardware error or configuration error)
- Wrapped around
- Blocked
- Adjusted

The transmission of the counter value by SPA can be done as a service value, that is, the value frozen in the last integration cycle is read by the station HMI from the database. PCGGIO updates the value in the database when an integration cycle is finished and activates the NEW_VAL signal in the function block. This signal can be connected to an Event function block, be time tagged, and transmitted to the station HMI. This time corresponds to the time when the value was frozen by the function.

The pulse counter function requires a binary input card, BIMp, that is specially adapted to the pulse counter function.

Figure 266 shows the pulse counter function block with connections of the inputs and outputs.

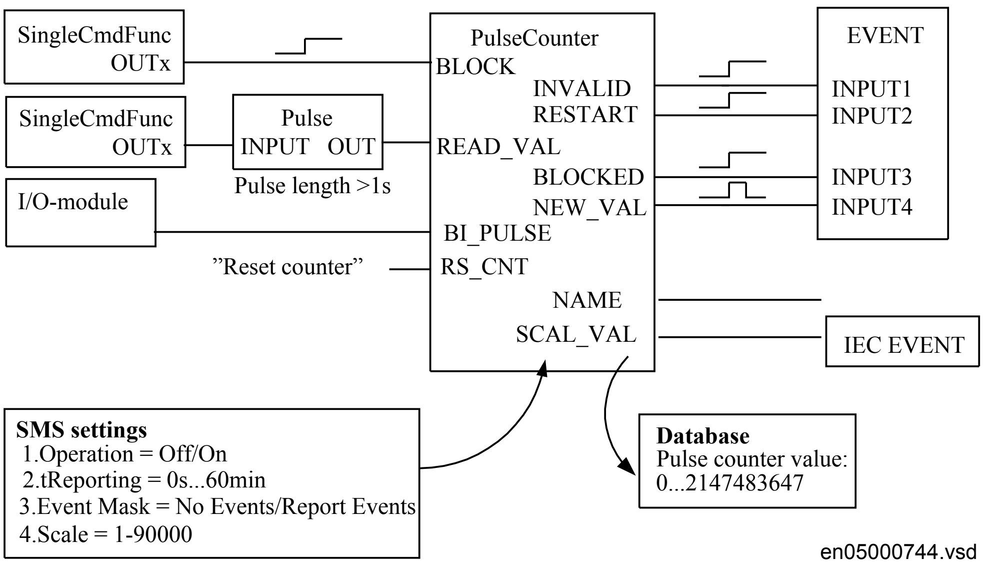


Figure 266: Overview of the pulse counter function

The BLOCK and READ_VAL inputs can be connected to Single Command blocks, which are intended to be controlled either from the station HMI or/and the local HMI. As long as the BLOCK signal is set, the pulse counter is blocked. The signal connected to READ_VAL performs one additional reading per positive flank. The signal must be a pulse with a length >1 second.

The BI_PULSE input is connected to the used input of the function block for the Binary Input Module (BIM).

The RS_CNT input is used for resetting the counter.

Each pulse counter function block has four binary output signals that can be connected to an Event function block for event recording: INVALID, RESTART, BLOCKED and NEW_VAL. The SCAL_VAL signal can be connected to the IEC Event function block.

The INVALID signal is a steady signal and is set if the Binary Input Module, where the pulse counter input is located, fails or has wrong configuration.

The RESTART signal is a steady signal and is set when the reported value does not comprise a complete integration cycle. That is, in the first message after IED start-up, in the first message after deblocking, and after the counter has wrapped around during last integration cycle.

The BLOCKED signal is a steady signal and is set when the counter is blocked. There are two reasons why the counter is blocked:

- The BLOCK input is set, or
- The Binary Input Module, where the counter input is situated, is inoperative.

The NEW_VAL signal is a pulse signal. The signal is set if the counter value was updated since last report.

The SCAL_VAL signal consists of scaled value (according to parameter *Scale*), time and status information.

14.1.3 Function block

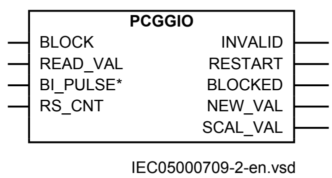


Figure 267: PCGGIO function block

14.1.4 Input and output signals

Table 369: PCGGIO Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of function
READ_VAL	BOOLEAN	0	Initiates an additional pulse counter reading
BI_PULSE	BOOLEAN	0	Connect binary input channel for metering
RS_CNT	BOOLEAN	0	Resets pulse counter value

Table 370: PCGGIO Output signals

Name	Type	Description
INVALID	BOOLEAN	The pulse counter value is invalid
RESTART	BOOLEAN	The reported value does not comprise a complete integration cycle
BLOCKED	BOOLEAN	The pulse counter function is blocked
NEW_VAL	BOOLEAN	A new pulse counter value is generated
SCAL_VAL	REAL	Scaled value with time and status information

14.1.5 Setting parameters

Table 371: PCGGIO Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off/On
EventMask	NoEvents ReportEvents	-	-	NoEvents	Report mask for analog events from pulse counter
CountCriteria	Off RisingEdge Falling edge OnChange	-	-	RisingEdge	Pulse counter criteria
Scale	1.000 - 90000.000	-	0.001	1.000	Scaling value for SCAL_VAL output to unit per counted value
Quantity	Count ActivePower ApparentPower ReactivePower ActiveEnergy ApparentEnergy ReactiveEnergy	-	-	Count	Measured quantity for SCAL_VAL output
tReporting	0 - 3600	s	1	60	Cycle time for reporting of counter value

14.1.6 Technical data

Table 372: PCGGIO technical data

Function	Setting range	Accuracy
Input frequency	See Binary Input Module (BIM)	-
Cycle time for report of counter value	(1–3600) s	-

14.2 Function for energy calculation and demand handling ETPMMTR

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Energy calculation and demand handling	ETPMMTR	-	-

14.2.1 Introduction

Outputs from the Measurements (CVMMXN) function can be used to calculate energy consumption. Active as well as reactive values are calculated in import and export direction. Values can be read or generated as pulses. Maximum demand power values are also calculated by the function.

14.2.2 Principle of operation

The instantaneous output values of active and reactive power from the Measurements (CVMMXN) function block are used and integrated over a selected time *tEnergy* to measure the integrated energy. The energy values (in MWh and MVarh) are available as output signals and also as pulsed output which can be connected to a pulse counter. Outputs are available for forward as well as reverse direction. The accumulated energy values can be reset from the local HMI reset menu or with input signal RSTACC.

The maximum demand values for active and reactive power are calculated for the set time *tEnergy* and the maximum value is stored in a register available over communication and from outputs MAXPAFD, MAXPARD, MAXPRFD, MAXPRRD for the active and reactive power forward and reverse direction until reset with input signal RSTDMD or from the local HMI reset menu.

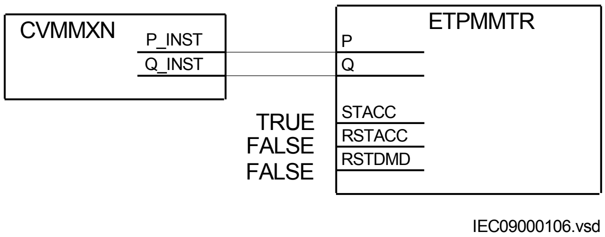


Figure 268: Connection of Energy calculation and demand handling function (ETPMMTR) to the Measurements function (CVMMXN)

14.2.3 Function block

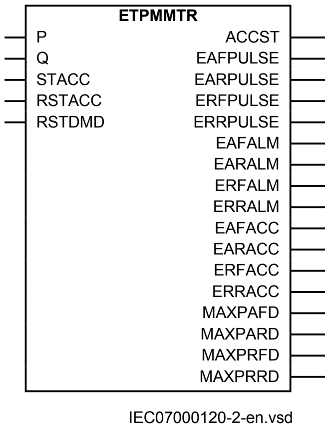


Figure 269: ETPMMTR function block

14.2.4 Input and output signals

Table 373: ETPMMTR Input signals

Name	Type	Default	Description
P	REAL	0	Measured active power
Q	REAL	0	Measured reactive power
STACC	BOOLEAN	0	Start to accumulate energy values
RSTACC	BOOLEAN	0	Reset of accumulated enery reading
RSTDMD	BOOLEAN	0	Reset of maximum demand reading

Table 374: ETPMMTR Output signals

Name	Type	Description
ACCST	BOOLEAN	Start of accumulating energy values.
EAFPULSE	BOOLEAN	Accumulated forward active energy pulse
EARPULSE	BOOLEAN	Accumulated reverse active energy pulse

Table continues on next page

Name	Type	Description
ERFPULSE	BOOLEAN	Accumulated forward reactive energy pulse
ERRPULSE	BOOLEAN	Accumulated reverse reactive energy pulse
EAFALM	BOOLEAN	Alarm for active forward energy exceed limit in set interval
EARALM	BOOLEAN	Alarm for active reverse energy exceed limit in set interval
ERFALM	BOOLEAN	Alarm for reactive forward energy exceed limit in set interval
ERRALM	BOOLEAN	Alarm for reactive reverse energy exceed limit in set interval
EAFACC	REAL	Accumulated forward active energy value in Ws
EARACC	REAL	Accumulated reverse active energy value in Ws
ERFACC	REAL	Accumulated forward reactive energy value in VArS
ERRACC	REAL	Accumulated reverse reactive energy value in VArS
MAXPAFD	REAL	Maximum forward active power demand value for set interval
MAXPARD	REAL	Maximum reverse active power demand value for set interval
MAXPRFD	REAL	Maximum forward reactive power demand value for set interval
MAXPRRD	REAL	Maximum reactive power demand value in reverse direction

14.2.5 Setting parameters

Table 375: ETPMMTR Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off/On
StartAcc	Off On	-	-	Off	Activate the accumulation of energy values
tEnergy	1 Minute 5 Minutes 10 Minutes 15 Minutes 30 Minutes 60 Minutes 180 Minutes	-	-	1 Minute	Time interval for energy calculation
tEnergyOnPls	0.000 - 60.000	s	0.001	1.000	Energy accumulated pulse ON time in secs
tEnergyOffPls	0.000 - 60.000	s	0.001	0.500	Energy accumulated pulse OFF time in secs
EAFAccPlsQty	0.001 - 10000.000	MWh	0.001	100.000	Pulse quantity for active forward accumulated energy value
Table continues on next page					

Name	Values (Range)	Unit	Step	Default	Description
EARAccPlsQty	0.001 - 10000.000	MWh	0.001	100.000	Pulse quantity for active reverse accumulated energy value
ERFAccPlsQty	0.001 - 10000.000	MVArh	0.001	100.000	Pulse quantity for reactive forward accumulated energy value
ERVAccPlsQty	0.001 - 10000.000	MVArh	0.001	100.000	Pulse quantity for reactive reverse accumulated energy value

Table 376: ETPMMTR Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
EALim	0.001 - 10000000000.000	MWh	0.001	1000000.000	Active energy limit
ERLim	0.001 - 10000000000.000	MVArh	0.001	1000.000	Reactive energy limit
DirEnergyAct	Forward Reverse	-	-	Forward	Direction of active energy flow Forward/ Reverse
DirEnergyReac	Forward Reverse	-	-	Forward	Direction of reactive energy flow Forward/ Reverse
EnZeroClamp	Off On	-	-	On	Enable of zero point clamping detection function
LevZeroClampP	0.001 - 10000.000	MW	0.001	10.000	Zero point clamping level at active Power
LevZeroClampQ	0.001 - 10000.000	MVAr	0.001	10.000	Zero point clamping level at reactive Power
EAFPrestVal	0.000 - 10000.000	MWh	0.001	0.000	Preset Initial value for forward active energy
EARPrestVal	0.000 - 10000.000	MWh	0.001	0.000	Preset Initial value for reverse active energy
ERFPresetVal	0.000 - 10000.000	MVArh	0.001	0.000	Preset Initial value for forward reactive energy
ERVPresetVal	0.000 - 10000.000	MVArh	0.001	0.000	Preset Initial value for reverse reactive energy

Section 15 Station communication

About this chapter

This chapter describes the functions and protocols used on the interfaces to the substation automation and substation monitoring buses. The way these work, their setting parameters, function blocks, input and output signals and technical data are included for each function.

15.1 Overview

Each IED is provided with a communication interface, enabling it to connect to one or many substation level systems or equipment, either on the Substation Automation (SA) bus or Substation Monitoring (SM) bus.

Following communication protocols are available:

- IEC 61850-8-1 communication protocol
- LON communication protocol
- SPA or IEC 60870-5-103 communication protocol
- DNP3.0 communication protocol

Theoretically, several protocols can be combined in the same IED.

15.2 IEC 61850-8-1 communication protocol

15.2.1 Introduction

The IED is equipped with single or double optical Ethernet rear ports (order dependent) for IEC 61850-8-1 station bus communication. The IEC 61850-8-1 communication is also possible from the optical Ethernet front port. IEC 61850-8-1 protocol allows intelligent electrical devices (IEDs) from different vendors to exchange information and simplifies system engineering. Peer-to-peer communication according to GOOSE is part of the standard. Disturbance files uploading is provided.

15.2.2 Setting parameters

Table 377: IEC61850-8-1 Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off/On
GOOSE	Front OEM311_AB OEM311_CD	-	-	OEM311_AB	Port for GOOSE communication

15.2.3 Technical data

Table 378: IEC 61850-8-1 communication protocol

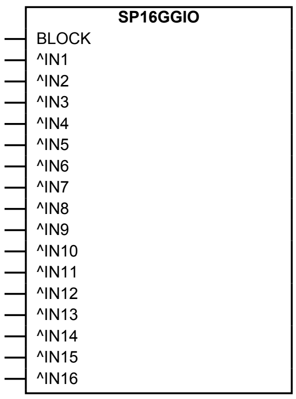
Function	Value
Protocol	IEC 61850-8-1
Communication speed for the IEDs	100BASE-FX

15.2.4 IEC 61850 generic communication I/O functions SPGGIO, SP16GGIO

15.2.4.1 Function block

IEC07000124-2-en.vsd

Figure 270: SPGGIO function block



IEC07000125-2-en.vsd

Figure 271: SP16GGIO function block

15.2.4.2 Input and output signals

Table 379: SPGGIO Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of function
IN	BOOLEAN	0	Input status

Table 380: SP16GGIO Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of function
IN1	BOOLEAN	0	Input 1 status
IN2	BOOLEAN	0	Input 2 status
IN3	BOOLEAN	0	Input 3 status
IN4	BOOLEAN	0	Input 4 status
IN5	BOOLEAN	0	Input 5 status
IN6	BOOLEAN	0	Input 6 status
IN7	BOOLEAN	0	Input 7 status
IN8	BOOLEAN	0	Input 8 status
IN9	BOOLEAN	0	Input 9 status
IN10	BOOLEAN	0	Input 10 status
IN11	BOOLEAN	0	Input 11 status
IN12	BOOLEAN	0	Input 12 status
IN13	BOOLEAN	0	Input 13 status
IN14	BOOLEAN	0	Input 14 status
IN15	BOOLEAN	0	Input 15 status
IN16	BOOLEAN	0	Input 16 status

15.2.4.3 Setting parameters

The function does not have any parameters available in the local HMI or PCM600.

15.2.5 IEC 61850 generic communication I/O functions MVGGIO

15.2.5.1 Principle of operation

Upon receiving an analog signal at its input, IEC61850 generic communication I/O functions (MVGGIO) will give the instantaneous value of the signal and the range, as output values. In the same time, it will send over IEC 61850-8-1 the value, to other IEC 61850 clients in the substation.

15.2.5.2 Function block

IEC05000408-2-en.vsd

Figure 272: MVGGIO function block

15.2.5.3 Setting parameters

Table 381: MVGGIO Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
MV db	1 - 300	Type	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s
MV zeroDb	0 - 100000	m%	1	500	Zero point clamping in 0,001% of range
MV hhLim	-10000000000.000 - 10000000000.000	-	0.001	90.000	High High limit
MV hLim	-10000000000.000 - 10000000000.000	-	0.001	80.000	High limit
MV lLim	-10000000000.000 - 10000000000.000	-	0.001	-80.000	Low limit
MV llLim	-10000000000.000 - 10000000000.000	-	0.001	-90.000	Low Low limit
MV min	-10000000000.000 - 10000000000.000	-	0.001	-100.000	Minimum value
MV max	-10000000000.000 - 10000000000.000	-	0.001	100.000	Maximum value
MV dbType	Cyclic Dead band Int deadband	-	-	Dead band	Reporting type
MV limHys	0.000 - 100.000	%	0.001	5.000	Hysteresis value in % of range (common for all limits)

15.2.6 IEC 61850-8-1 redundant station bus communication

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Parallel Redundancy Protocol Status	PRPSTATUS	-	-
Duo driver configuration	DUODRV	-	-

15.2.6.1 Introduction

Redundant station bus communication is used to assure communication, even though one communication channels might not be available for some reason.

Redundant communication over station bus running IEC 61850-8-1 use both port AB and CD on OEM module and IEC 62439-PRP protocol.

15.2.6.2 Principle of operation

The redundant station bus communication (DUODRV) is configured using the local HMI. The settings for DUODRV are also visible in PST in PCM600.

The communication is performed in parallel, that is the same data package is transmitted on both channels simultaneously. The received package identity from one channel is compared with data package identity from the other channel, if the same, the last package is discarded.

PRPSTATUS function block supervise the redundant communication on the two channels. If no data package has been received on one (or both) channels within the last 10 s, the output LAN-A-STATUS and/or LAN-B-STATUS is set to indicate error.

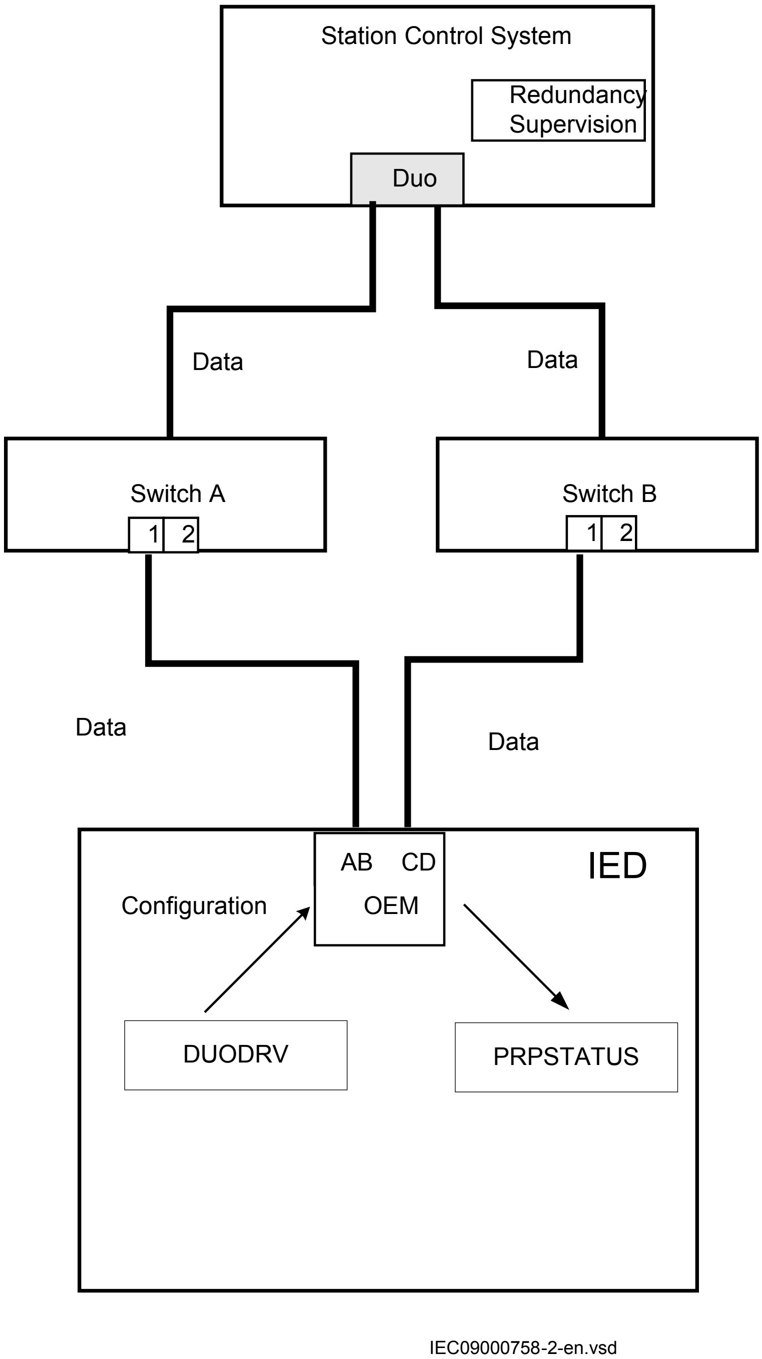
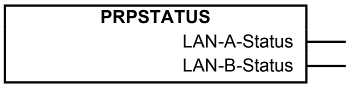


Figure 273: Redundant station bus

15.2.6.3 Function block



IEC09000757-1-en.vsd

Figure 274: PRPSTATUS function block

15.2.6.4 Output signals

Table 382: PRPSTATUS Output signals

Name	Type	Description
LAN-A-Status	BOOLEAN	Channel A status
LAN-B-Status	BOOLEAN	Channel B status

15.2.6.5 Setting parameters

Table 383: DUODRV Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
IPAddress	0 - 18	IP Address	1	192.168.7.10	IP-Address
IPMask	0 - 18	IP Address	1	255.255.255.0	IP-Mask

15.3 LON communication protocol

15.3.1 Introduction

An optical network can be used within the substation automation system. This enables communication with the IED through the LON bus from the operator’s workplace, from the control center and also from other terminals.

LON communication protocol is specified in LonTalkProtocol Specification Version 3 from Echelon Corporation and is designed for communication in control networks. These networks are characterized by high speed for data transfer, short messages (few bytes), peer-to-peer communication, multiple communication media, low maintenance, multivendor equipment, and low support costs. LonTalk supports the needs of applications that cover a range of requirements. The protocol follows the reference model for open system interconnection (OSI) designed by the International Standardization Organization (ISO).

In this document the most common addresses for commands and events are available. For other addresses, refer to section "".

It is assumed that the reader is familiar with LON communication protocol in general.

15.3.2 Principle of operation

The speed of the network depends on the medium and transceiver design. With protection and control devices, fibre optic media is used, which enables the use of the maximum speed of 1.25 Mbits/s. The protocol is a peer-to-peer protocol where all the devices connected to the network can communicate with each other. The own subnet and node number are identifying the nodes (max. 255 subnets, 127 nodes per one subnet).

The LON bus links the different parts of the protection and control system. The measured values, status information, and event information are spontaneously sent to the higher-level devices. The higher-level devices can read and write memorized values, setting values, and other parameter data when required. The LON bus also enables the bay level devices to communicate with each other to deliver, for example, interlocking information among the terminals without the need of a bus master.

The LonTalk protocol supports two types of application layer objects: network variables and explicit messages. Network variables are used to deliver short messages, such as measuring values, status information, and interlocking/blocking signals. Explicit messages are used to transfer longer pieces of information, such as events and explicit read and write messages to access device data.

The benefits achieved from using the LON bus in protection and control systems include direct communication among all terminals in the system and support for multi-master implementations. The LON bus also has an open concept, so that the terminals can communicate with external devices using the same standard of network variables.

Introduction of LON protocol

For more information, refer to LON bus, LonWorks Network in Protection and Control, User’s manual and Technical description.

LON protocol

Configuration of LON

Lon Network Tool (LNT 505) is a multi-purpose tool for LonWorks network configuration. All the functions required for setting up and configuring a LonWorks network, is easily accessible on a single tool program. For more information, refer to the operator's manual.

Activate LON Communication

Activate LON communication in the Parameter Setting tool under **Main menu/ Communication/ SLM configuration/ Rear optical LON port/ Horizontal communication**, where *Operation* must be set to *ON*.

Add LON Device Types LNT

A new device is added to LON Network Tool from the Device menu or by installing the device from the ABB LON Device Types package for LNT 505, with the SLDT 670 series package version 1p2 r03.

LON net address

To establish a LON connection with the 670 series IEDs, the IED has to be given a unique net address. The net address consists of a subnet and node number. This is accomplished with the LON Network Tool by creating one device for each IED.

Vertical communication

Vertical communication describes communication between the monitoring devices and protection and control IEDs. This communication includes sending of changed process data to monitoring devices as events and transfer of commands, parameter data and disturbance recorder files. This communication is implemented using explicit messages.

Events and indications

Events sent to the monitoring devices are using explicit messages (message code 44H) with unacknowledged transport service of the LonTalk protocol. When a signal is changed in the IED, one message with the value, quality and time is transmitted from terminal.

Binary events

Binary events are generated in event function blocks EVENT:1 to EVENT:20 in the 670 series IEDs. The event function blocks have predefined LON addresses. table 384 shows the LON addresses to the first input on the event function blocks. The addresses to the other inputs on the event function block are consecutive after the first input. For example, input 15 on event block EVENT:17 has the address 1280 + 14 (15-1) = 1294.

For double indications only the first eight inputs 1–8 must be used. Inputs 9–16 can be used for other type of events at the same event block.

As basic, three event function blocks EVENT:1 to EVENT:3 running with a fast loop time (3 ms) is available in the 670 series IEDs. The remaining event function blocks EVENT:4 to EVENT:9 runs with a loop time on 8 ms and EVENT:10 to EVENT:20 runs with a loop time on 100 ms. The event blocks are used to send binary signals, integers, real time values like analogue data from measuring functions and mA input modules as well as pulse counter signals.

16 pulse counter value function blocks PCGGIO:1 to PCGGIO:16 and 24 mA input service values function blocks SMMI1_In1 to 6 – SMMI4_In1 to 6 are available in the 670 series IEDs.

The first LON address in every event function block is found in table 384

Table 384: LON adresses for Event functions

Function block	First LON address in function block
EVENT:1	1024
EVENT:2	1040
EVENT:3	1056
EVENT:4	1072
EVENT:5	1088
EVENT:6	1104
EVENT:7	1120
EVENT:8	1136
EVENT:9	1152
EVENT:10	1168
EVENT:11	1184
EVENT:12	1200
EVENT:13	1216
EVENT:14	1232
EVENT:15	1248
EVENT:16	1264
EVENT:17	1280
EVENT:18	1296
EVENT:19	1312
EVENT:20	1328

Event masks

The event mask for each input can be set individually from Parameter Setting Tool (PST) under: **Settings/ General Settings/ Monitoring / EventFunction** as follows:

- No events
- OnSet, at pick-up of the signal
- OnReset, at drop-out of the signal
- OnChange, at both pick-up and drop-out of the signal
- AutoDetect, event system itself make the reporting decision, (reporting criteria for integers has no semantic, prefer to be set by the user)

The following type of signals from application functions can be connected to the event function block.

Single indication

Directly connected binary IO signal via binary input function block (SMBI) is always reported on change, no changed detection is done in the event function block. Other Boolean signals, for example a start or a trip signal from a protection function is event masked in the event function block.

Double indications

Double indications can only be reported via switch-control (SCSWI) functions, the event reporting is based on information from switch-control, no change detection is done in the event function block.

Directly connected binary IO signal via binary input function block (SMBI) is not possible to handle as double indication. Double indications can only be reported for the first 8 inputs on an event function block.

- 00 generates an intermediate event with the read status 0
- 01 generates an open event with the read status 1
- 10 generates a close event with the read status 2
- 11 generates an undefined event with the read status 3

Analog value

All analog values are reported cyclic, the reporting interval is taken from the connected function if there is a limit supervised signal, otherwise it is taken from the event function block.

Command handling

Commands are transferred using transparent SPA-bus messages. The transparent SPA-bus message is an explicit LON message, which contains an ASCII character message following the coding rules of the SPA-bus protocol. The message is sent using explicit messages with message code 41H and using acknowledged transport service.

Both the SPA-bus command messages (R or W) and the reply messages (D, A or N) are sent using the same message code. It is mandatory that one device sends out only one SPA-bus message at a time to one node and waits for the reply before sending the next message.

For commands from the operator workplace to the IED for apparatus control, That is, the function blocks type SCSWI 1 to 32, SXCBR 1 to 18 and SXSWI 1 to 28; the SPA addresses are according to table 385.

Horizontal communication

Network variables are used for communication between 500 series and 670 series IEDs. The supported network variable type is SNVT_state (NV type 83). SNVT_state is used to communicate the state of a set of 1 to 16 Boolean values.

Multiple command send function block (MULTICMDSND) is used to pack the information to one value. This value is transmitted to the receiving node and presented for the application by a multiple command function block (MULTICMDRCV). At horizontal communication the input BOUND on the event function block (MULTICMDSND) must be set to 1. There are 10 MULTICMDSND and 60 MULTICMDRCV function blocks available. The

MULTICMDSND and MULTICMDRCV function blocks are connected using Lon Network Tool (LNT 505). This tool also defines the service and addressing on LON.

This is an overview for configuring the network variables for 670 series IEDs.

Configuration of LON network variables

Configure the Network variables according to the specific application using the LON network Tool. For more information, refer to LNT 505 in Operation manual. The following is an example of how to configure network variables concerning, for example, interlocking between two IEDs.

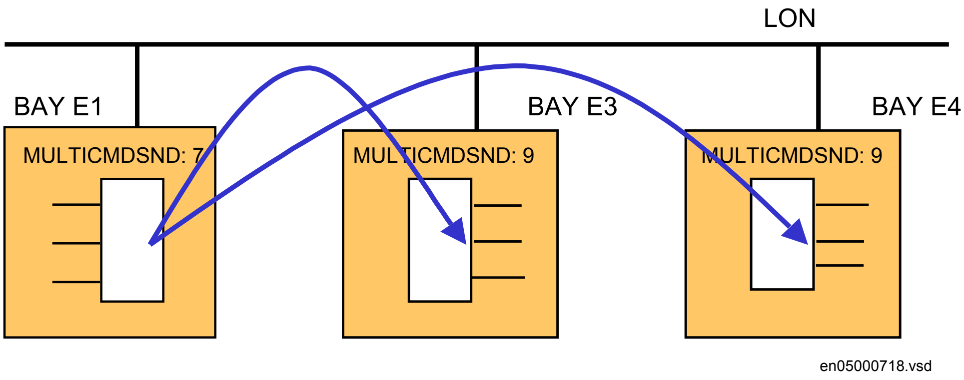
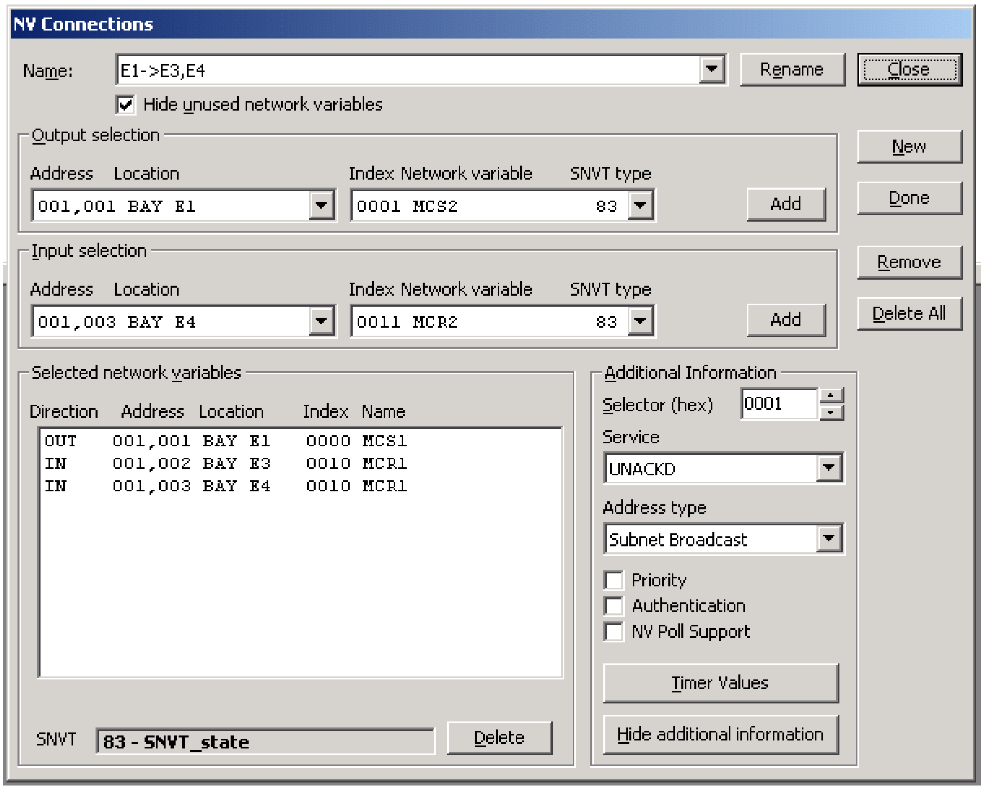


Figure 275: Examples connections between MULTICMDSND and MULTICMDRCV function blocks in three IEDs

The network variable connections are done from the NV Connection window. From LNT window select **Connections/ NVConnections/ New**.



en05000719.vsd

Figure 276: The network variables window in LNT

There are two ways of downloading NV connections. Either the users can use the drag-and-drop method where they can select all nodes in the device window, drag them to the Download area in the bottom of the program window and drop them there; or, they can perform it by selecting the traditional menu, **Configuration/ Download**.

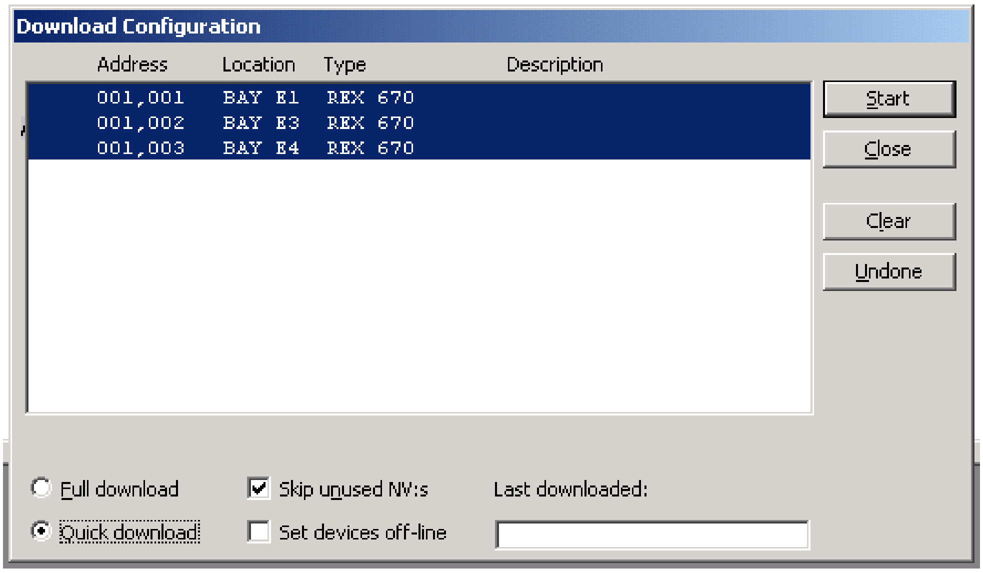


Figure 277: The download configuration window in LNT

Communication ports

The serial communication module (SLM) is used for SPA/IEC60870-5-103/DNP and LON communication. This module is a mezzanine module, and can be placed on the Main Processing Module (NUM). The serial communication module can have connectors for two plastic fibre cables (snap-in) or two glass fibre cables (ST, bayonet) or a combination of plastic and glass fibre. Three different types are available depending on type of fibre. The incoming optical fibre is connected to the RX receiver input, and the outgoing optical fibre to the TX transmitter output. When the fibre optic cables are laid out, pay special attention to the instructions concerning the handling and connection of the optical fibres. The module is identified with a number on the label on the module.

Table 385: SPA addresses for commands from the operator workplace to the IED for apparatus control

Name	Function block	SPA address	Description
BL_CMD	SCSWI01	1 I 5115	SPA parameters for block command
BL_CMD	SCSWI02	1 I 5139	SPA parameters for block command
BL_CMD	SCSWI02	1 I 5161	SPA parameters for block command
BL_CMD	SCSWI04	1 I 5186	SPA parameters for block command
BL_CMD	SCSWI05	1 I 5210	SPA parameters for block command
BL_CMD	SCSWI06	1 I 5234	SPA parameters for block command

Table continues on next page

Name	Function block	SPA address	Description
BL_CMD	SCSWI07	1 I 5258	SPA parameters for block command
BL_CMD	SCSWI08	1 I 5283	SPA parameters for block command
BL_CMD	SCSWI09	1 I 5307	SPA parameters for block command
BL_CMD	SCSWI10	1 I 5331	SPA parameters for block command
BL_CMD	SCSWI11	1 I 5355	SPA parameters for block command
BL_CMD	SCSWI12	1 I 5379	SPA parameters for block command
BL_CMD	SCSWI13	1 I 5403	SPA parameters for block command
BL_CMD	SCSWI14	1 I 5427	SPA parameters for block command
BL_CMD	SCSWI15	1 I 5451	SPA parameters for block command
BL_CMD	SCSWI16	1 I 5475	SPA parameters for block command
BL_CMD	SCSWI17	1 I 5499	SPA parameters for block command
BL_CMD	SCSWI18	1 I 5523	SPA parameters for block command
BL_CMD	SCSWI19	1 I 5545	SPA parameters for block command
BL_CMD	SCSWI20	1 I 5571	SPA parameters for block command
BL_CMD	SCSWI21	1 I 5594	SPA parameters for block command
BL_CMD	SCSWI22	1 I 5619	SPA parameters for block command
BL_CMD	SCSWI23	1 I 5643	SPA parameters for block command
BL_CMD	SCSWI24	1 I 5667	SPA parameters for block command
BL_CMD	SCSWI25	1 I 5691	SPA parameters for block command
BL_CMD	SCSWI26	1 I 5715	SPA parameters for block command
BL_CMD	SCSWI27	1 I 5739	SPA parameters for block command
BL_CMD	SCSWI28	1 I 5763	SPA parameters for block command
BL_CMD	SCSWI29	1 I 5787	SPA parameters for block command
BL_CMD	SCSWI30	1 I 5811	SPA parameters for block command

Table continues on next page

Name	Function block	SPA address	Description
BL_CMD	SCSWI31	1 I 5835	SPA parameters for block command
BL_CMD	SCSWI32	1 I 5859	SPA parameters for block command
CANCEL	SCSWI01	1 I 5107	SPA parameters for cancel command
CANCEL	SCSWI02	1 I 5131	SPA parameters for cancel command
CANCEL	SCSWI03	1 I 5153	SPA parameters for cancel command
CANCEL	SCSWI04	1 I 5178	SPA parameters for cancel command
CANCEL	SCSWI05	1 I 5202	SPA parameters for cancel command
CANCEL	SCSWI06	1 I 5226	SPA parameters for cancel command
CANCEL	SCSWI07	1 I 5250	SPA parameters for cancel command
CANCEL	SCSWI08	1 I 5275	SPA parameters for cancel command
CANCEL	SCSWI09	1 I 5299	SPA parameters for cancel command
CANCEL	SCSWI10	1 I 5323	SPA parameters for cancel command
CANCEL	SCSWI11	1 I 5347	SPA parameters for cancel command
CANCEL	SCSWI12	1 I 5371	SPA parameters for cancel command
CANCEL	SCSWI13	1 I 5395	SPA parameters for cancel command
CANCEL	SCSWI14	1 I 5419	SPA parameters for cancel command
CANCEL	SCSWI15	1 I 5443	SPA parameters for cancel command
CANCEL	SCSWI16	1 I 5467	SPA parameters for cancel command
CANCEL	SCSWI17	1 I 5491	SPA parameters for cancel command
CANCEL	SCSWI18	1 I 5515	SPA parameters for cancel command
CANCEL	SCSWI19	1 I 5537	SPA parameters for cancel command
CANCEL	SCSWI20	1 I 5563	SPA parameters for cancel command
CANCEL	SCSWI21	1 I 5586	SPA parameters for cancel command
CANCEL	SCSWI22	1 I 5611	SPA parameters for cancel command

Table continues on next page

Name	Function block	SPA address	Description
CANCEL	SCSWI23	1 I 5635	SPA parameters for cancel command
CANCEL	SCSWI24	1 I 5659	SPA parameters for cancel command
CANCEL	SCSWI25	1 I 5683	SPA parameters for cancel command
CANCEL	SCSWI26	1 I 5707	SPA parameters for cancel command
CANCEL	SCSWI27	1 I 5731	SPA parameters for cancel command
CANCEL	SCSWI28	1 I 5755	SPA parameters for cancel command
CANCEL	SCSWI29	1 I 5779	SPA parameters for cancel command
CANCEL	SCSWI30	1 I 5803	SPA parameters for cancel command
CANCEL	SCSWI31	1 I 5827	SPA parameters for cancel command
CANCEL	SCSWI32	1 I 5851	SPA parameters for cancel command
SELECTOpen=00, SELECTClose=01, SELOpen+ILO=10, SELClose+ILO=11, SELOpen+SCO=20, SELClose+SCO=21, SELOpen+ILO+SCO=30, SELClose+ILO+SCO=31	SCSWI01	1 I 5105	SPA parameters for select (Open/ Close) command Note: Send select command before operate command
SELECTOpen=00, SELECTClose=01, so on.	SCSWI02	1 I 5129	SPA parameters for select (Open/ Close) command
SELECTOpen=00, SELECTClose=01, so on.	SCSWI03	1 I 5151	SPA parameters for select (Open/ Close) command
SELECTOpen=00, SELECTClose=01, so on.	SCSWI04	1 I 5176	SPA parameters for select (Open/ Close) command
SELECTOpen=00, SELECTClose=01, so on.	SCSWI05	1 I 5200	SPA parameters for select (Open/ Close) command
SELECTOpen=00, SELECTClose=01, so on.	SCSWI06	1 I 5224	SPA parameters for select (Open/ Close) command
SELECTOpen=00, SELECTClose=01, so on.	SCSWI07	1 I 5248	SPA parameters for select (Open/ Close) command
SELECTOpen=00, SELECTClose=01, so on.	SCSWI08	1 I 5273	SPA parameters for select (Open/ Close) command
SELECTOpen=00, SELECTClose=01, so on.	SCSWI09	1 I 5297	SPA parameters for select (Open/ Close) command
SELECTOpen=00, SELECTClose=01, so on.	SCSWI10	1 I 5321	SPA parameters for select (Open/ Close) command
SELECTOpen=00, SELECTClose=01, so on.	SCSWI11	1 I 5345	SPA parameters for select (Open/ Close) command
SELECTOpen=00, SELECTClose=01, so on.	SCSWI12	1 I 5369	SPA parameters for select (Open/ Close) command

Table continues on next page

Name	Function block	SPA address	Description
SELECTOpen=00, SELECTClose=01, so on.	SCSWI13	1 I 5393	SPA parameters for select (Open/ Close) command
SELECTOpen=00, SELECTClose=01, so on.	SCSWI14	1 I 5417	SPA parameters for select (Open/ Close) command
SELECTOpen=00, SELECTClose=01, so on.	SCSWI15	1 I 5441	SPA parameters for select (Open/ Close) command
SELECTOpen=00, SELECTClose=01, so on.	SCSWI16	1 I 5465	SPA parameters for select (Open/ Close) command
SELECTOpen=00, SELECTClose=01, so on.	SCSWI17	1 I 5489	SPA parameters for select (Open/ Close) command
SELECTOpen=00, SELECTClose=01, so on.	SCSWI18	1 I 5513	SPA parameters for select (Open/ Close) command
SELECTOpen=00, SELECTClose=01, so on.	SCSWI19	1 I 5535	SPA parameters for select (Open/ Close) command
SELECTOpen=00, SELECTClose=01, so on.	SCSWI20	1 I 5561	SPA parameters for select (Open/ Close) command
SELECTOpen=00, SELECTClose=01, so on.	SCSWI21	1 I 5584	SPA parameters for select (Open/ Close) command
SELECTOpen=00, SELECTClose=01, so on.	SCSWI22	1 I 5609	SPA parameters for select (Open/ Close) command
SELECTOpen=00, SELECTClose=01, so on.	SCSWI23	1 I 5633	SPA parameters for select (Open/ Close) command
SELECTOpen=00, SELECTClose=01, so on.	SCSWI24	1 I 5657	SPA parameters for select (Open/ Close) command
SELECTOpen=00, SELECTClose=01, so on.	SCSWI25	1 I 5681	SPA parameters for select (Open/ Close) command
SELECTOpen=00, SELECTClose=01, so on.	SCSWI26	1 I 5705	SPA parameters for select (Open/ Close) command
SELECTOpen=00, SELECTClose=01, so on.	SCSWI27	1 I 5729	SPA parameters for select (Open/ Close) command
SELECTOpen=00, SELECTClose=01, so on.	SCSWI28	1 I 5753	SPA parameters for select (Open/ Close) command
SELECTOpen=00, SELECTClose=01, so on.	SCSWI29	1 I 5777	SPA parameters for select (Open/ Close) command
SELECTOpen=00, SELECTClose=01, so on.	SCSWI30	1 I 5801	SPA parameters for select (Open/ Close) command
SELECTOpen=00, SELECTClose=01, so on.	SCSWI31	1 I 5825	SPA parameters for select (Open/ Close) command
SELECTOpen=00, SELECTClose=01, so on.	SCSWI32	1 I 5849	SPA parameters for select (Open/ Close) command
ExcOpen=00, ExcClose=01, ExcOpen+ILO=10, ExcClose+ILO=11, ExcOpen+SCO=20, ExcClose+SCO=21, ExcOpen+ILO+SCO=30, ExcClose+ILO+SCO=31	SCSWI01	1 I 5106	SPA parameters for operate (Open/ Close) command Note: Send select command before operate command
ExcOpen=00, ExcClose=01, so on.	SCSWI02	1 I 5130	SPA parameters for operate (Open/ Close) command
Table continues on next page			

Name	Function block	SPA address	Description
ExcOpen=00, ExcClose=01, so on.	SCSWI02	1 I 5152	SPA parameters for operate (Open/ Close) command
ExcOpen=00, ExcClose=01, so on.	SCSWI04	1 I 5177	SPA parameters for operate (Open/ Close) command
ExcOpen=00, ExcClose=01, so on.	SCSWI05	1 I 5201	SPA parameters for operate (Open/ Close) command
ExcOpen=00, ExcClose=01, so on.	SCSWI06	1 I 5225	SPA parameters for operate (Open/ Close) command
ExcOpen=00, ExcClose=01, so on.	SCSWI07	1 I 5249	SPA parameters for operate (Open/ Close) command
ExcOpen=00, ExcClose=01, so on.	SCSWI08	1 I 5274	SPA parameters for operate (Open/ Close) command
ExcOpen=00, ExcClose=01, so on.	SCSWI09	1 I 5298	SPA parameters for operate (Open/ Close) command
ExcOpen=00, ExcClose=01, so on.	SCSWI10	1 I 5322	SPA parameters for operate (Open/ Close) command
ExcOpen=00, ExcClose=01, so on.	SCSWI11	1 I 5346	SPA parameters for operate (Open/ Close) command
ExcOpen=00, ExcClose=01, so on.	SCSWI12	1 I 5370	SPA parameters for operate (Open/ Close) command
ExcOpen=00, ExcClose=01, so on.	SCSWI13	1 I 5394	SPA parameters for operate (Open/ Close) command
ExcOpen=00, ExcClose=01, so on.	SCSWI14	1 I 5418	SPA parameters for operate (Open/ Close) command
ExcOpen=00, ExcClose=01, so on.	SCSWI15	1 I 5442	SPA parameters for operate (Open/ Close) command
ExcOpen=00, ExcClose=01, so on.	SCSWI16	1 I 5466	SPA parameters for operate (Open/ Close) command
ExcOpen=00, ExcClose=01, so on.	SCSWI17	1 I 5490	SPA parameters for operate (Open/ Close) command
ExcOpen=00, ExcClose=01, so on.	SCSWI18	1 I 5514	SPA parameters for operate (Open/ Close) command
ExcOpen=00, ExcClose=01, so on.	SCSWI19	1 I 5536	SPA parameters for operate (Open/ Close) command
ExcOpen=00, ExcClose=01, so on.	SCSWI20	1 I 5562	SPA parameters for operate (Open/ Close) command
ExcOpen=00, ExcClose=01, so on.	SCSWI21	1 I 5585	SPA parameters for operate (Open/ Close) command
ExcOpen=00, ExcClose=01, so on.	SCSWI22	1 I 5610	SPA parameters for operate (Open/ Close) command
ExcOpen=00, ExcClose=01, so on.	SCSWI23	1 I 5634	SPA parameters for operate (Open/ Close) command
ExcOpen=00, ExcClose=01, so on.	SCSWI24	1 I 5658	SPA parameters for operate (Open/ Close) command
ExcOpen=00, ExcClose=01, so on.	SCSWI25	1 I 5682	SPA parameters for operate (Open/ Close) command
ExcOpen=00, ExcClose=01, so on.	SCSWI26	1 I 5706	SPA parameters for operate (Open/ Close) command

Table continues on next page

Name	Function block	SPA address	Description
ExcOpen=00, ExcClose=01, so on.	SCSWI27	1 I 5730	SPA parameters for operate (Open/ Close) command
ExcOpen=00, ExcClose=01, so on.	SCSWI28	1 I 5754	SPA parameters for operate (Open/ Close) command
ExcOpen=00, ExcClose=01, so on.	SCSWI29	1 I 5778	SPA parameters for operate (Open/ Close) command
ExcOpen=00, ExcClose=01, so on.	SCSWI30	1 I 5802	SPA parameters for operate (Open/ Close) command
ExcOpen=00, ExcClose=01, so on.	SCSWI31	1 I 5826	SPA parameters for operate (Open/ Close) command
ExcOpen=00, ExcClose=01, so on.	SCSWI32	1 I 5850	SPA parameters for operate (Open/ Close) command
Sub Value	SXCBR01	2 I 7854	SPA parameter for position to be substituted Note: Send the value before Enable
Sub Value	SXCBR02	2 I 7866	SPA parameter for position to be substituted
Sub Value	SXCBR03	2 I 7884	SPA parameter for position to be substituted
Sub Value	SXCBR04	2 I 7904	SPA parameter for position to be substituted
Sub Value	SXCBR05	2 I 7923	SPA parameter for position to be substituted
Sub Value	SXCBR06	2 I 7942	SPA parameter for position to be substituted
Sub Value	SXCBR07	2 I 7961	SPA parameter for position to be substituted
Sub Value	SXCBR08	2 I 7980	SPA parameter for position to be substituted
Sub Value	SXCBR09	3 I 7	SPA parameter for position to be substituted
Sub Value	SXCBR10	3 I 26	SPA parameter for position to be substituted
Sub Value	SXCBR11	3 I 45	SPA parameter for position to be substituted
Sub Value	SXCBR12	3 I 56	SPA parameter for position to be substituted
Sub Value	SXCBR13	3 I 74	SPA parameter for position to be substituted
Sub Value	SXCBR14	3 I 94	SPA parameter for position to be substituted
Sub Value	SXCBR15	3 I 120	SPA parameter for position to be substituted
Sub Value	SXCBR16	3 I 133	SPA parameter for position to be substituted
Sub Value	SXCBR17	3 I 158	SPA parameter for position to be substituted
Sub Value	SXCBR18	3 I 179	SPA parameter for position to be substituted

Table continues on next page

Name	Function block	SPA address	Description
Sub Value	SXSWI01	3 I 196	SPA parameter for position to be substituted
Sub Value	SXSWI02	3 I 216	SPA parameter for position to be substituted
Sub Value	SXSWI03	3 I 235	SPA parameter for position to be substituted
Sub Value	SXSWI04	3 I 254	SPA parameter for position to be substituted
Sub Value	SXSWI05	3 I 272	SPA parameter for position to be substituted
Sub Value	SXSWI06	3 I 292	SPA parameter for position to be substituted
Sub Value	SXSWI07	3 I 310	SPA parameter for position to be substituted
Sub Value	SXSWI08	3 I 330	SPA parameter for position to be substituted
Sub Value	SXSWI09	3 I 348	SPA parameter for position to be substituted
Sub Value	SXSWI10	3 I 359	SPA parameter for position to be substituted
Sub Value	SXSWI11	3 I 378	SPA parameter for position to be substituted
Sub Value	SXSWI12	3 I 397	SPA parameter for position to be substituted
Sub Value	SXSWI13	3 I 416	SPA parameter for position to be substituted
Sub Value	SXSWI14	3 I 435	SPA parameter for position to be substituted
Sub Value	SXSWI15	3 I 454	SPA parameter for position to be substituted
Sub Value	SXSWI16	3 I 473	SPA parameter for position to be substituted
Sub Value	SXSWI17	3 I 492	SPA parameter for position to be substituted
Sub Value	SXSWI18	3 I 511	SPA parameter for position to be substituted
Sub Value	SXSWI19	3 I 530	SPA parameter for position to be substituted
Sub Value	SXSWI20	3 I 549	SPA parameter for position to be substituted
Sub Value	SXSWI21	3 I 568	SPA parameter for position to be substituted
Sub Value	SXSWI22	3 I 587	SPA parameter for position to be substituted
Sub Value	SXSWI23	3 I 606	SPA parameter for position to be substituted
Sub Value	SXSWI24	3 I 625	SPA parameter for position to be substituted

Table continues on next page

Name	Function block	SPA address	Description
Sub Value	SXSWI25	3 I 644	SPA parameter for position to be substituted
Sub Value	SXSWI26	3 I 663	SPA parameter for position to be substituted
Sub Value	SXSWI27	3 I 682	SPA parameter for position to be substituted
Sub Value	SXSWI28	3 I 701	SPA parameter for position to be substituted
Sub Enable	SXCBR01	2 I 7855	SPA parameter for substitute enable command Note: Send the Value before Enable
Sub Enable	SXCBR02	2 I 7865	SPA parameter for substitute enable command
Sub Enable	SXCBR03	2 I 7885	SPA parameter for substitute enable command
Sub Enable	SXCBR04	2 I 7903	SPA parameter for substitute enable command
Sub Enable	SXCBR05	2 I 7924	SPA parameter for substitute enable command
Sub Enable	SXCBR06	2 I 7941	SPA parameter for substitute enable command
Sub Enable	SXCBR07	2 I 7962	SPA parameter for substitute enable command
Sub Enable	SXCBR08	2 I 7979	SPA parameter for substitute enable command
Sub Enable	SXCBR09	3 I 8	SPA parameter for substitute enable command
Sub Enable	SXCBR10	3 I 25	SPA parameter for substitute enable command
Sub Enable	SXCBR11	3 I 46	SPA parameter for substitute enable command
Sub Enable	SXCBR12	3 I 55	SPA parameter for substitute enable command
Sub Enable	SXCBR13	3 I 75	SPA parameter for substitute enable command
Sub Enable	SXCBR14	3 I 93	SPA parameter for substitute enable command
Sub Enable	SXCBR15	3 I 121	SPA parameter for substitute enable command
Sub Enable	SXCBR16	3 I 132	SPA parameter for substitute enable command
Sub Enable	SXCBR17	3 I 159	SPA parameter for substitute enable command
Sub Enable	SXCBR18	3 I 178	SPA parameter for substitute enable command
Sub Enable	SXSWI01	3 I 197	SPA parameter for substitute enable command

Table continues on next page

Name	Function block	SPA address	Description
Sub Enable	SXSWI02	3 I 215	SPA parameter for substitute enable command
Sub Enable	SXSWI03	3 I 234	SPA parameter for substitute enable command
Sub Enable	SXSWI04	3 I 252	SPA parameter for substitute enable command
Sub Enable	SXSWI05	3 I 271	SPA parameter for substitute enable command
Sub Enable	SXSWI06	3 I 290	SPA parameter for substitute enable command
Sub Enable	SXSWI07	3 I 309	SPA parameter for substitute enable command
Sub Enable	SXSWI08	3 I 328	SPA parameter for substitute enable command
Sub Enable	SXSWI09	3 I 347	SPA parameter for substitute enable command
Sub Enable	SXSWI10	3 I 360	SPA parameter for substitute enable command
Sub Enable	SXSWI11	3I 379	SPA parameter for substitute enable command
Sub Enable	SXSWI12	3 I 398	SPA parameter for substitute enable command
Sub Enable	SXSWI13	3 I 417	SPA parameter for substitute enable command
Sub Enable	SXSWI14	3 I 436	SPA parameter for substitute enable command
Sub Enable	SXSWI15	3 I 455	SPA parameter for substitute enable command
Sub Enable	SXSWI16	3 I 474	SPA parameter for substitute enable command
Sub Enable	SXSWI17	3 I 493	SPA parameter for substitute enable command
Sub Enable	SXSWI18	3 I 512	SPA parameter for substitute enable command
Sub Enable	SXSWI19	3 I 531	SPA parameter for substitute enable command
Sub Enable	SXSWI20	3 I 550	SPA parameter for substitute enable command
Sub Enable	SXSWI21	3 I 569	SPA parameter for substitute enable command
Sub Enable	SXSWI22	3 I 588	SPA parameter for substitute enable command
Sub Enable	SXSWI23	3 I 607	SPA parameter for substitute enable command
Sub Enable	SXSWI24	3 I 626	SPA parameter for substitute enable command
Sub Enable	SXSWI25	3 I 645	SPA parameter for substitute enable command

Table continues on next page

Name	Function block	SPA address	Description
Sub Enable	SXSWI26	3 I 664	SPA parameter for substitute enable command
Sub Enable	SXSWI27	3 I 683	SPA parameter for substitute enable command
Sub Enable	SXSWI28	3 I 702	SPA parameter for substitute enable command
Update Block	SXCBR01	2 I 7853	SPA parameter for update block command
Update Block	SXCBR02	2 I 7864	SPA parameter for update block command
Update Block	SXCBR03	2 I 7883	SPA parameter for update block command
Update Block	SXCBR04	2 I 7905	SPA parameter for update block command
Update Block	SXCBR05	2 I 7922	SPA parameter for update block command
Update Block	SXCBR06	2 I 7943	SPA parameter for update block command
Update Block	SXCBR07	2 I 7960	SPA parameter for update block command
Update Block	SXCBR08	2 I 7981	SPA parameter for update block command
Update Block	SXCBR09	3 I 6	SPA parameter for update block command
Update Block	SXCBR10	3 I 27	SPA parameter for update block command
Update Block	SXCBR11	3 I 44	SPA parameter for update block command
Update Block	SXCBR12	3 I 57	SPA parameter for update block command
Update Block	SXCBR13	3 I 73	SPA parameter for update block command
Update Block	SXCBR14	3 I 92	SPA parameter for update block command
Update Block	SXCBR15	3 I 122	SPA parameter for update block command
Update Block	SXCBR16	3 I 131	SPA parameter for update block command
Update Block	SXCBR17	3 I 160	SPA parameter for update block command
Update Block	SXCBR18	3 I 177	SPA parameter for update block command
Update Block	SXSWI01	3 I 198	SPA parameter for update block command
Update Block	SXSWI02	3 I 214	SPA parameter for update block command
Update Block	SXSWI03	3 I 236	SPA parameter for update block command

Table continues on next page

Name	Function block	SPA address	Description
Update Block	SXSWI04	3 I 253	SPA parameter for update block command
Update Block	SXSWI05	3 I 273	SPA parameter for update block command
Update Block	SXSWI06	3 I 291	SPA parameter for update block command
Update Block	SXSWI07	3 I 311	SPA parameter for update block command
Update Block	SXSWI08	3 I 329	SPA parameter for update block command
Update Block	SXSWI09	3 I 349	SPA parameter for update block command
Update Block	SXSWI10	3 I 358	SPA parameter for update block command
Update Block	SXSWI11	3 I 377	SPA parameter for update block command
Update Block	SXSWI12	3 I 396	SPA parameter for update block command
Update Block	SXSWI13	3 I 415	SPA parameter for update block command
Update Block	SXSWI14	3 I 434	SPA parameter for update block command
Update Block	SXSWI15	3 I 453	SPA parameter for update block command
Update Block	SXSWI16	3 I 472	SPA parameter for update block command
Update Block	SXSWI17	3 I 491	SPA parameter for update block command
Update Block	SXSWI18	3 I 510	SPA parameter for update block command
Update Block	SXSWI19	3 I 529	SPA parameter for update block command
Update Block	SXSWI20	3 I 548	SPA parameter for update block command
Update Block	SXSWI21	3 I 567	SPA parameter for update block command
Update Block	SXSWI22	3 I 586	SPA parameter for update block command
Update Block	SXSWI23	3 I 605	SPA parameter for update block command
Update Block	SXSWI24	3 I 624	SPA parameter for update block command
Update Block	SXSWI25	3 I 643	SPA parameter for update block command

Table continues on next page

Name	Function block	SPA address	Description
Update Block	SXSWI26	3 I 662	SPA parameter for update block command
Update Block	SXSWI27	3 I 681	SPA parameter for update block command
Update Block	SXSWI28	3 I 700	SPA parameter for update block command

15.3.3 Setting parameters

Table 386: HORZCOMM Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation

Table 387: ADE Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation
TimerClass	Slow Normal Fast	-	-	Slow	Timer class

15.3.4 Technical data

Table 388: LON communication protocol

Function	Value
Protocol	LON
Communication speed	1.25 Mbit/s

15.4 SPA communication protocol

15.4.1 Introduction

In this section the most common addresses for commands and events are available. For other addresses, refer to section "".

It is assumed that the reader is familiar with the SPA communication protocol in general.

15.4.2 Principle of operation

The SPA bus uses an asynchronous serial communications protocol (1 start bit, 7 data bits + even parity, 1 stop bit) with data transfer rate up to 38400 bit/s. For more information on recommended baud rate for each type of IED, refer to Technical reference manual. Messages on the bus consist of ASCII characters.

Introduction of SPA protocol

The basic construction of the protocol assumes that the slave has no self-initiated need to talk to the master but the master is aware of the data contained in the slaves and, consequently, can request required data. In addition, the master can send data to the slave. Requesting by the master can be performed either by sequenced polling (for example, for event information) or only on demand.

The master requests slave information using request messages and sends information to the slave in write messages. Furthermore, the master can send all slaves in common a broadcast message containing time or other data. The inactive state of bus transmit and receive lines is a logical "1".

SPA protocol

The tables below specify the SPA addresses for reading data from and writing data to an IED with the SPA communication protocol implemented.

The SPA addresses for the mA input service values (MIM3 to MIM16) are found in table 389.

Table 389: SPA addresses for the MIM function

Function block	SPA address
MIM3-CH1	4-O-6508
MIM3-CH2	4-O-6511
MIM3-CH3	4-O-6512
MIM3-CH4	4-O-6515
MIM3-CH5	4-O-6516
MIM3-CH6	4-O-6519
MIM4-CH1	4-O-6527
MIM4-CH2	4-O-6530
MIM4-CH3	4-O-6531
MIM4-CH4	4-O-6534
MIM4-CH5	4-O-6535
MIM4-CH6	4-O-6538
MIM5-CH1	4-O-6546
MIM5-CH2	4-O-6549
MIM5-CH3	4-O-6550
MIM5-CH4	4-O-6553
MIM5-CH5	4-O-6554

Table continues on next page

Function block	SPA address
MIM5-CH6	4-O-6557
MIM6-CH1	4-O-6565
MIM6-CH2	4-O-6568
MIM6-CH3	4-O-6569
MIM6-CH4	4-O-6572
MIM6-CH5	4-O-6573
MIM6-CH6	4-O-6576
MIM7-CH1	4-O-6584
MIM7-CH2	4-O-6587
MIM7-CH3	4-O-6588
MIM7-CH4	4-O-6591
MIM7-CH5	4-O-6592
MIM7-CH6	4-O-6595
MIM8-CH1	4-O-6603
MIM8-CH2	4-O-6606
MIM8-CH3	4-O-6607
MIM8-CH4	4-O-6610
MIM8-CH5	4-O-6611
MIM8-CH6	4-O-6614
MIM9-CH1	4-O-6622
MIM9-CH2	4-O-6625
MIM9-CH3	4-O-6626
MIM9-CH4	4-O-6629
MIM9-CH5	4-O-6630
MIM9-CH6	4-O-6633
MIM10-CH1	4-O-6641
MIM10-CH2	4-O-6644
MIM10-CH3	4-O-6645
MIM10-CH4	4-O-6648
MIM10-CH5	4-O-6649
MIM10-CH6	4-O-6652
MIM11-CH1	4-O-6660
MIM11-CH2	4-O-6663
MIM11-CH3	4-O-6664
MIM11-CH4	4-O-6667
MIM11-CH5	4-O-6668
MIM11-CH6	4-O-6671
MIM12-CH1	4-O-6679
MIM12-CH2	4-O-6682
Table continues on next page	

Function block	SPA address
MIM12-CH3	4-O-6683
MIM12-CH4	4-O-6686
MIM12-CH5	4-O-6687
MIM12-CH6	4-O-6690
MIM13-CH1	4-O-6698
MIM13-CH2	4-O-6701
MIM13-CH3	4-O-6702
MIM13-CH4	4-O-6705
MIM13-CH5	4-O-6706
MIM13-CH6	4-O-6709
MIM14-CH1	4-O-6717
MIM14-CH2	4-O-6720
MIM14-CH3	4-O-6721
MIM14-CH4	4-O-6724
MIM14-CH5	4-O-6725
MIM14-CH6	4-O-6728
MIM15-CH1	4-O-6736
MIM15-CH2	4-O-6739
MIM15-CH3	4-O-6740
MIM15-CH4	4-O-6743
MIM15-CH5	4-O-6744
MIM15-CH6	4-O-6747
MIM16-CH1	4-O-6755
MIM16-CH2	4-O-6758
MIM16-CH3	4-O-6759
MIM16-CH4	4-O-6762
MIM16-CH5	4-O-6763
MIM16-CH6	4-O-6766

The SPA addresses for the pulse counter values PCGGIO:1 to PCGGIO:16 are found in table 390.

Table 390: SPA addresses for the PCGGIO function

Function block	SPA address CNT_VAL	SPA address NEW_VAL
PCGGIO:1	3-O-5834	3-O-5833
PCGGIO:2	3-O-5840	3-O-5839
PCGGIO:3	3-O-5846	3-O-5845
PCGGIO:4	3-O-5852	3-O-5851
PCGGIO:5	3-O-5858	3-O-5857
PCGGIO:6	3-O-5864	3-O-5863

Table continues on next page

Function block	SPA address CNT_VAL	SPA address NEW_VAL
PCGGIO:7	3-O-5870	3-O-5869
PCGGIO:8	3-O-5876	3-O-5875
PCGGIO:9	3-O-5882	3-O-5881
PCGGIO:10	3-O-5888	3-O-5887
PCGGIO:11	3-O-5894	3-O-5893
PCGGIO:12	3-O-5900	3-O-5899
PCGGIO:13	3-O-5906	3-O-5905
PCGGIO:14	3-O-5912	3-O-5911
PCGGIO:15	3-O-5918	3-O-5917
PCGGIO:16	3-O-5924	3-O-5923

I/O modules

To read binary inputs, the SPA-addresses for the outputs of the I/O-module function block are used, that is, the addresses for BI1 – BI16. For SPA addresses, refer to section "".

Single command, 16 signals

The IEDs can be provided with a function to receive signals either from a substation automation system or from the local HMI. That receiving function block has 16 outputs that can be used, for example, to control high voltage apparatuses in switchyards. For local control functions, the local HMI can also be used.

Single command, 16 signals function consists of three function blocks; SINGLECMD:1 to SINGLECMD:3 for 16 binary output signals each.

The signals can be individually controlled from the operator station, remote-control gateway, or from the local HMI on the IED. For Single command, 16 signals function block, SINGLECMD:1 to SINGLECMD:3, the address is for the first output. The other outputs follow consecutively after the first one. For example, output 7 on the SINGLECMD:2 function block has the 5O533 address.

The SPA addresses for Single command, 16 signals functions SINGLECMD:1 to SINGLECMD:3 are found in table 391.

Table 391: SPA addresses for SINGLECMD function

Function block	SPA address CMD Input	SPA address CMD output
SINGLECMD1-Cmd1	4-S-4639	5-O-511
SINGLECMD1-Cmd2	4-S-4640	5-O-512
SINGLECMD1-Cmd3	4-S-4641	5-O-513
SINGLECMD1-Cmd4	4-S-4642	5-O-514
SINGLECMD1-Cmd5	4-S-4643	5-O-515
SINGLECMD1-Cmd6	4-S-4644	5-O-516
SINGLECMD1-Cmd7	4-S-4645	5-O-517

Table continues on next page

Function block	SPA address CMD Input	SPA address CMD output
SINGLECMD1-Cmd8	4-S-4646	5-O-518
SINGLECMD1-Cmd9	4-S-4647	5-O-519
SINGLECMD1-Cmd10	4-S-4648	5-O-520
SINGLECMD1-Cmd11	4-S-4649	5-O-521
SINGLECMD1-Cmd12	4-S-4650	5-O-522
SINGLECMD1-Cmdt13	4-S-4651	5-O-523
SINGLECMD1-Cmd14	4-S-4652	5-O-524
SINGLECMD1-Cmd15	4-S-4653	5-O-525
SINGLECMD1-Cmd16	4-S-4654	5-O-526
SINGLECMD2-Cmd1	4-S-4672	5-O-527
SINGLECMD2-Cmd2	4-S-4673	5-O-528
SINGLECMD2-Cmdt3	4-S-4674	5-O-529
SINGLECMD2-Cmd4	4-S-4675	5-O-530
SINGLECMD2-Cmd5	4-S-4676	5-O-531
SINGLECMD2-Cmd6	4-S-4677	5-O-532
SINGLECMD2-Cmd7	4-S-4678	5-O-533
SINGLECMD2-Cmd8	4-S-4679	5-O-534
SINGLECMD2-Cmd9	4-S-4680	5-O-535
SINGLECMD2-Cmd10	4-S-4681	5-O-536
SINGLECMD2-Cmd11	4-S-4682	5-O-537
SINGLECMD2-Cmd12	4-S-4683	5-O-538
SINGLECMD2-Cmd13	4-S-4684	5-O-539
SINGLECMD2-Cmd14	4-S-4685	5-O-540
SINGLECMD2-Cmd15	4-S-4686	5-O-541
SINGLECMD2-Cmd16	4-S-4687	5-O-542
SINGLECMD3-Cmd1	4-S-4705	5-O-543
SINGLECMD3-Cmd2	4-S-4706	5-O-544
SINGLECMD3-Cmd3	4-S-4707	5-O-545
SINGLECMD3-Cmd4	4-S-4708	5-O-546
SINGLECMD3-Cmd5	4-S-4709	5-O-547
SINGLECMD3-Cmd6	4-S-4710	5-O-548
SINGLECMD3-Cmd7	4-S-4711	5-O-549
SINGLECMD3-Cmd8	4-S-4712	5-O-550
SINGLECMD3-Cmd9	4-S-4713	5-O-551
SINGLECMD3-Cmd10	4-S-4714	5-O-552
SINGLECMD3-Cmd11	4-S-4715	5-O-553
SINGLECMD3-Cmd12	4-S-4716	5-O-554
SINGLECMD3-Cmd13	4-S-4717	5-O-555

Table continues on next page

Function block	SPA address CMD Input	SPA address CMD output
SINGLECMD3-Cmd14	4-S-4718	5-O-556
SINGLECMD3-Cmd15	4-S-4719	5-O-557
SINGLECMD3-Cmd16	4-S-4720	5-O-558

Figure 278 shows an application example of how the user can, in a simplified way, connect the command function via the configuration logic circuit in a protection IED for control of a circuit breaker.

A pulse via the binary outputs of the IED normally performs this type of command control. The SPA addresses to control the outputs OUT1 – OUT16 in SINGLECMD: 1 are shown in table 391.

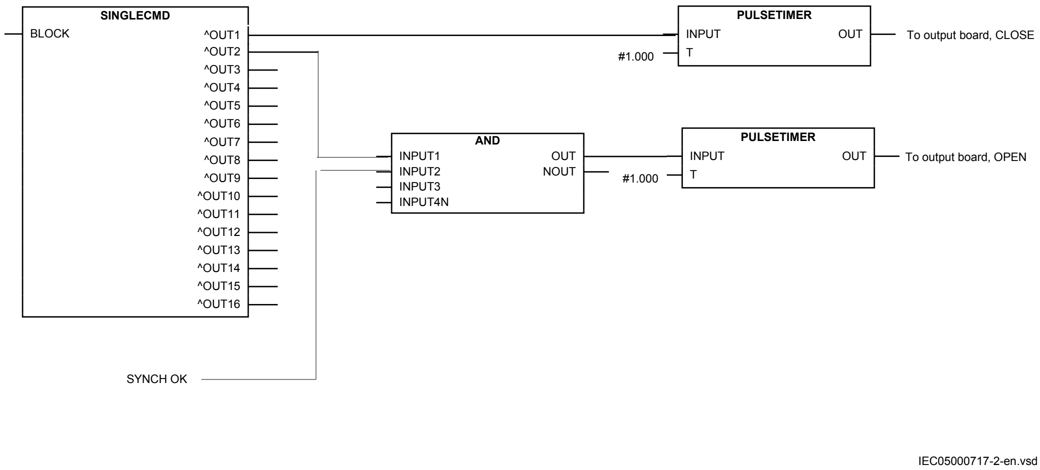


Figure 278: Application example showing a simplified logic diagram for control of a circuit breaker

The MODE input defines if the output signals from SINGLECMD:1 is off, steady or pulsed signals. This is set in Parameter Setting Tool (PST) under: **Setting / General Settings / Control / Commands / Single Command**.

Event function

Event function is intended to send time-tagged events to the station level (for example, operator workplace) over the station bus. The events are there presented in an event list. The events can be created from both internal logical signals and binary input channels. All the internal signals are time tagged in the main processing module, while the binary input channels are time tagged directly on each I/O module. The events are produced according to the set event masks. The event masks are treated commonly for both the LON and SPA channels. All events according to the event mask are stored in a buffer, which contains up to 1000 events. If new events appear before the oldest event in the buffer is read, the oldest event is overwritten and an overflow alarm appears.

Two special signals for event registration purposes are available in the IED, Terminal Restarted (0E50) and Event buffer overflow (0E51).

The input parameters can be set individually from the Parameter Setting Tool (PST) under: **Setting / General Setting / Monitoring / Event Function** as follows:

- No events
- OnSet, at pick-up of the signal
- OnReset, at drop-out of the signal
- OnChange, at both pick-up and drop-out of the signal
- AutoDetect, event system itself make the reporting decision, (reporting criteria for integers has no semantic, prefer to be set by the user)

The Status and event codes for the Event functions are found in table 392.

Table 392: Status and event codes

Event block	Status	Single indication[1)]		Double indication			
		Set event	Reset event	Intermediate 00	Closed 10	Open 01	Undefined 11
EVENT:1							
Input 1	22O1	22E33	22E32	22E0	22E1	22E2	22E3
Input 2	22O2	22E35	22E34	22E4	22E5	22E6	22E7
Input 3	22O3	22E37	22E36	22E8	22E9	22E10	22E11
Input 4	22O4	22E39	22E38	22E12	22E13	22E14	22E15
Input 5	22O5	22E41	22E40	22E16	22E17	22E18	22E19
Input 6	22O6	22E43	22E42	22E20	22E21	22E22	22E23
Input 7	22O7	22E45	22E44	22E24	22E25	22E26	22E27
Input 8	22O8	22E47	22E46	22E28	22E29	22E30	22E31
Input 9	22O9	22E49	22E48	-	-	-	-
Input 10	22O10	22E51	22E50	-	-	-	-
Input 11	22O11	22E53	22E52	-	-	-	-
Input 12	22O12	22E55	22E54	-	-	-	-
Input 13	22O13	22E57	22E56	-	-	-	-
Input 14	22O14	22E59	22E58	-	-	-	-
Input 15	22O15	22E61	22E60	-	-	-	-
Input 16	22O16	22E63	22E62	-	-	-	-
EVENT:2	230..	23E..	23E..	23E..	23E..	23E..	23E..
EVENT:3	240..	24E..	24E..	24E..	23E..	24E..	24E..
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
EVENT:20	410..	41E..	41E..	41E..	41E..	41E..	41E..

These values are only applicable if the Event mask is masked ≠ OFF.

Connection of signals as events

Signals coming from different protection and control functions and must be sent as events to the station level over the SPA-bus (or LON-bus) are connected to the Event function block according to figure 279.

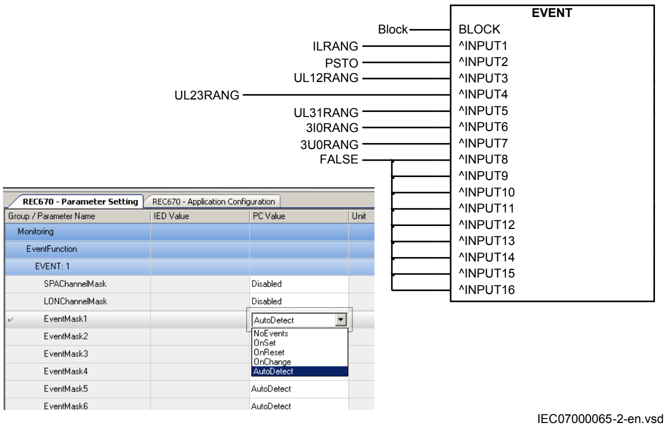


Figure 279: Connection of protection signals for event handling

15.4.2.1 Communication ports

The serial communication module (SLM) is used for SPA /IEC 60870-5-103/DNP and LON communication. This module is a mezzanine module, and can be placed on the Analog/Digital conversion module (ADM). The serial communication module can have connectors for two plastic fibre cables (snap-in) or two glass fibre cables (ST, bayonet) or a combination of plastic and glass fibre. Three different types are available depending on type of fibre.

The incoming optical fibre is connected to the RX receiver input, and the outgoing optical fibre to the TX transmitter output. When the fibre optic cables are laid out, pay special attention to the instructions concerning the handling and connection of the optical fibres. The module is identified with a number on the label on the module.

The procedure to set the transfer rate and slave number can be found in the Installation and commissioning manual for respective IEDs.

15.4.3 Design

When communicating locally with a computer (PC) in the station, using the rear SPA port, the only hardware needed for a station monitoring system is:

- Optical fibres
- Opto/electrical converter for the PC
- PC

When communicating remotely with a PC using the rear SPA port, the same hardware and telephone modems are needed.

The software needed in the PC, either local or remote, is PCM600.

When communicating between the local HMI and a PC, the only hardware required is a front-connection cable.

15.4.4 Setting parameters

Table 393: SPA Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
SlaveAddress	1 - 899	-	1	30	Slave address
BaudRate	300 Bd 1200 Bd 2400 Bd 4800 Bd 9600 Bd 19200 Bd 38400 Bd	-	-	9600 Bd	Baudrate on serial line

Table 394: LONSPA Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation
SlaveAddress	1 - 899	-	1	30	Slave address

15.4.5 Technical data

Table 395: SPA communication protocol

Function	Value
Protocol	SPA
Communication speed	300, 1200, 2400, 4800, 9600, 19200 or 38400 Bd
Slave number	1 to 899

15.5 IEC 60870-5-103 communication protocol

15.5.1 Introduction

IEC 60870-5-103 communication protocol is mainly used when a protection IED communicates with a third party control or monitoring system. This system must have software that can interpret the IEC 60870-5-103 communication messages.

15.5.2 Principle of operation

15.5.2.1 General

IEC 60870-5-103 is an unbalanced (master-slave) protocol for coded-bit serial communication exchanging information with a control system, and with a data transfer rate up to 38400 bit/s. In IEC terminology, a primary station is a master and a secondary station is a slave. The communication is based on a point-to-point principle. The master must have software that can interpret IEC 60870-5-103 communication messages.

Introduction to IEC 60870–5–103 protocol

IEC 60870-5-103 protocol functionality consists of the following functions:

- Event handling
- Report of analog service values (measurements)
- Fault location
- Command handling
    - Autorecloser ON/OFF
    - Teleprotection ON/OFF
    - Protection ON/OFF
    - LED reset
    - Characteristics 1 - 4 (Setting groups)
- File transfer (disturbance files)
- Time synchronization

For detailed information about IEC 60870-5-103, refer to the IEC 60870 standard part 5: Transmission protocols, and to the section 103: Companion standard for the informative interface of protection equipment.

IEC 60870-5-103

The tables in the following sections specify the information types supported by the IEDs with the communication protocol IEC 60870-5-103 implemented.

To support the information, corresponding functions must be included in the protection and control IED.

Commands in control direction

Commands in control direction, I103IEDCMD

Command block in control direction with defined output signals.

Number of instances: 1

Command block use PARAMETER as FUNCTION TYPE.

INFORMATION NUMBER is defined for each output signals.

Info. no	Message	Supported
19	LED Reset	Yes
23	Activate setting group 1	Yes
24	Activate setting group 2	Yes
25	Activate setting group 3	Yes
26	Activate setting group 4	Yes

Function commands in control direction, pre-defined I103CMD

Function command block in control direction with defined output signals.

Number of instances: 1

FUNCTION TYPE parameter for each block.

INFORMATION NUMBER is defined for each output signals.

Info. no.	Message	Supported
16	Auto-recloser on/off	Yes
17	Teleprotection on/off	Yes
18	Protection on/off	Yes

Function commands in control direction, user-defined, I103UserCMD

Function command blocks in control direction with user-defined output signals.

Number of instances: 4

FUNCTION TYPE parameter for each block in private range. Default values are defined in private range 1 - 4. One for each instance.

INFORMATION NUMBER is required for each output signal. Default values are 1 - 8.

Info. no.	Message	Supported
1	Output signal 01	Yes
2	Output signal 02	Yes
3	Output signal 03	Yes
4	Output signal 04	Yes
5	Output signal 05	Yes
6	Output signal 06	Yes
7	Output signal 07	Yes
8	Output signal 08	Yes

Status

Terminal status indications in monitor direction, I103IED

Indication block for status in monitor direction with defined IED functions.

Number of instances: 1

Indication block use PARAMETER as FUNCTION TYPE.

INFORMATION NUMBER is defined for each input signals.

Info. no.	Message	Supported
19	LED reset	Yes
23	Setting group 1 active	Yes
24	Setting group 2 active	Yes
25	Setting group 3 active	Yes
26	Setting group 4 active	Yes
21	Test mode active	Yes

Function status indications in monitor direction, user-defined, I103UserDef

Function indication blocks in monitor direction with user-defined input signals.

Number of instances: 20

FUNCTION TYPE parameter for each block in private range. Default values are defined in private range 5 - 24. One for each instance.

INFORMATION NUMBER is required for each input signal. Default values are defined in range 1 - 8.

Info. no.	Message	Supported
1	Input signal 01	Yes
2	Input signal 02	Yes
3	Input signal 03	Yes
4	Input signal 04	Yes
5	Input signal 05	Yes
6	Input signal 06	Yes
7	Input signal 07	Yes
8	Input signal 08	Yes

Supervision indications in monitor direction, I103Superv

Indication block for supervision in monitor direction with defined functions.

Number of instances: 1

FUNCTION TYPE parameter for each block.

INFORMATION NUMBER is defined for output signals.

Info. no.	Message	Supported
32	Measurand supervision I	Yes
33	Measurand supervision U	Yes
37	I>>back-up operation	Yes
38	VT fuse failure	Yes
46	Group warning	Yes
47	Group alarm	Yes

Earth fault indications in monitor direction, I103EF

Indication block for earth fault in monitor direction with defined functions.

Number of instances: 1

FUNCTION TYPE parameter for each block.

INFORMATION NUMBER is defined for each output signal.

Info. no.	Message	Supported
51	Earth fault forward	Yes
52	Earth fault reverse	Yes

Fault indications in monitor direction, type 1, I103FltDis

Fault indication block for faults in monitor direction with defined functions.

The instance type is suitable for distance protection function.

FUNCTION TYPE parameter for each block.

INFORMATION NUMBER is defined for each input signal.

Number of instances: 1

Info. no.	Message	Supported
64	Start L1	Yes
65	Start L2	Yes
66	Start L3	Yes
67	Start IN	Yes
84	General start	Yes
69	Trip L1	Yes
70	Trip L2	Yes
71	Trip L3	Yes
68	General trip	Yes
74	Fault forward/line	Yes
75	Fault reverse/busbar	Yes
78	Zone 1	Yes
79	Zone 2	Yes
80	Zone 3	Yes
81	Zone 4	Yes
82	Zone 5	Yes
76	Signal transmitted	Yes
77	Signal received	Yes
73	SCL, Fault location in ohm	Yes

Fault indications in monitor direction, type 2, I103FltStd

Fault indication block for faults in monitor direction with defined functions.

The instance type is suitable for line differential, transformer differential, overcurrent and earth fault protection functions.

FUNCTION TYPE setting for each block.

INFORMATION NUMBER is defined for each input signal.

Number of instances: 1

Info. no.	Message	Supported
64	Start L1	Yes
65	Start L2	Yes
66	Start L3	Yes
67	Start IN	Yes
84	General start	Yes
69	Trip L1	Yes
70	Trip L2	Yes
71	Trip L3	Yes
68	General trip	Yes
74	Fault forward/line	Yes
75	Fault reverse/busbar	Yes
85	Breaker failure	Yes
86	Trip measuring system L1	Yes
87	Trip measuring system L2	Yes
88	Trip measuring system L3	Yes
89	Trip measuring system N	Yes
90	Over current trip I>	Yes
91	Over current trip I>>	Yes
92	Earth fault trip IN>	Yes
93	Earth fault trip IN>>	Yes

Autorecloser indications in monitor direction, I103AR

Indication block for autorecloser in monitor direction with defined functions.

Number of instances: 1

FUNCTION TYPE parameter for each block.

INFORMATION NUMBER is defined for each output signal.

Info. no.	Message	Supported
16	Autorecloser active	Yes
128	CB on by Autorecloser	Yes
130	Autorecloser blocked	Yes

Measurands
Function blocks in monitor direction for input measurands. Typically connected to monitoring function, for example to power measurement CVMMXN.

Measurands in public range, I103Meas
Number of instances: 1

The IED reports all valid measuring types depending on connected signals.

Upper limit for measured currents, active/reactive-power is 2.4 times rated value.

Upper limit for measured voltages and frequency is 1.2 times rated value.

Info. no.	Message	Supported
148	IL1	Yes
144, 145, 148	IL2	Yes
148	IL3	Yes
147	IN, Neutral current	Yes
148	UL1	Yes
148	UL2	Yes
148	UL3	Yes
145, 146	UL1-UL2	Yes
147	UN, Neutral voltage	Yes
146, 148	P, active power	Yes
146, 148	Q, reactive power	Yes
148	f, frequency	Yes

Measurands in private range, I103MeasUsr
Number of instances: 3

FUNCTION TYPE parameter for each block in private range. Default values are defined in private range 25 – 27. One for each instance.

INFORMATION NUMBER parameter for each block. Default value 1.

Info. no.	Message	Supported
-	Meas1	Yes
-	Meas2	Yes
-	Meas3	Yes
Table continues on next page		

Info. no.	Message	Supported
-	Meas4	Yes
-	Meas5	Yes
-	Meas6	Yes
-	Meas7	Yes
-	Meas8	Yes
-	Meas9	Yes

Disturbance recordings

The following elements are used in the ASDUs (Application Service Data Units) defined in the standard.

Analog signals, 40-channels: the channel number for each channel has to be specified. Channels used in the public range are 1 to 8 and with:

- I_{L1} connected to channel 1 on disturbance function block A1RADR
- I_{L2} connected to channel 2 on disturbance function block A1RADR
- I_{L3} connected to channel 3 on disturbance function block A1RADR
- I_N connected to channel 4 on disturbance function block A1RADR
- V_{L1E} connected to channel 5 on disturbance function block A1RADR
- V_{L2E} connected to channel 6 on disturbance function block A1RADR
- V_{L3E} connected to channel 7 on disturbance function block A1RADR
- V_{EN} connected to channel 8 on disturbance function block A1RADR

Channel number used for the remaining 32 analog signals are numbers in the private range 64 to 95.

Binary signals, 96-channels: for each channel the user can specify a FUNCTION TYPE and an INFORMATION NUMBER.

Disturbance upload

All analog and binary signals that are recorded with disturbance recorder can be reported to the master. The last eight disturbances that are recorded are available for transfer to the master. A successfully transferred disturbance (acknowledged by the master) will not be reported to the master again.

When a new disturbance is recorded by the IED a list of available recorded disturbances will be sent to the master, an updated list of available disturbances can be sent whenever something has happened to disturbances in this list. For example, when a disturbance is deteceted (by other client, for example, SPA) or when a new disturbance has been recorded or when the master has uploaded a disturbance.

Deviations from the standard

Information sent in the disturbance upload is specified by the standard; however, some of the information are adapted to information available in disturbance recorder in 670 series.

This section describes all data that is not exactly as specified in the standard.

ASDU23

In ‘list of recorded disturbances’ (ASDU23) an information element named SOF (status of fault) exists. This information element consists of 4 bits and indicates whether:

- Bit TP: the protection equipment has tripped during the fault
- Bit TM: the disturbance data are currently being transmitted
- Bit TEST: the disturbance data have been recorded during normal operation or test mode.
- Bit OTEV: the disturbance data recording has been initiated by another event than start

The only information that is easily available is test-mode status. The other information is always set (hard coded) to:

TP	Recorded fault with trip. [1]
TM	Disturbance data waiting for transmission [0]
OTEV	Disturbance data initiated by other events [1]

Another information element in ASDU23 is the FAN (fault number). According to the standard this is a number that is incremented when a protection function takes action. In 670 series FAN is equal to disturbance number, which is incremented for each disturbance.

ASDU26

When a disturbance has been selected by the master; (by sending ASDU24), the protection equipment answers by sending ASDU26, which contains an information element named NOF (number of grid faults). This number must indicate fault number in the power system,that is, a fault in the power system with several trip and auto-reclosing has the same NOF (while the FAN must be incremented). NOF is in 670 series, just as FAN, equal to disturbance number.

To get INF and FUN for the recorded binary signals there are parameters on the disturbance recorder for each input. The user must set these parameters to whatever he connects to the corresponding input.

Interoperability, physical layer

	Supported
Electrical Interface	
EIA RS-485	No
number of loads	No
Optical interface	
glass fibre	Yes
plastic fibre	Yes
Transmission speed	
96000 bit/s	Yes
19200 bit/s	Yes
Link Layer	
DFC-bit used	Yes
Connectors	
connector F-SMA	No
connector BFOC/2.5	Yes

Interoperability, application layer

		Supported
Selection of standard ASDUs in monitoring direction		
ASDU		Yes
1	Time-tagged message	Yes
2	Time-tagged message with rel. time	Yes
3	Measurands I	Yes
4	Time-tagged message with rel. time	Yes
5	Identification	Yes
6	Time synchronization	Yes
8	End of general interrogation	Yes
9	Measurands II	Yes
10	Generic data	No
11	Generic identification	No
23	List of recorded disturbances	Yes
26	Ready for transm. of disturbance data	Yes
27	Ready for transm. of a channel	Yes
28	Ready for transm of tags	Yes
29	Transmission of tags	Yes
30	Transmission fo disturbance data	Yes
31	End of transmission	Yes
Selection of standard ASDUs in control direction		
Table continues on next page		

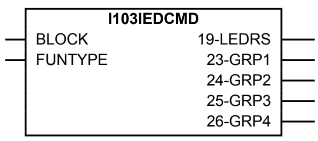
		Supported
ASDU		Yes
6	Time synchronization	Yes
7	General interrogation	Yes
10	Generic data	No
20	General command	Yes
21	Generic command	No
24	Order for disturbance data transmission	Yes
25	Acknowledgement for distance data transmission	Yes
Selection of basic application functions		
	Test mode	No
	Blocking of monitoring direction	Yes
	Disturbance data	Yes
	Private data	Yes
	Generic services	No

15.5.2.2 Communication ports

The serial communication module (SLM) is used for SPA/IEC 60870-5-103/DNP and LON communication. This module is a mezzanine module, and can be placed on the Analog/Digital conversion module (ADM). The serial communication module can have connectors for two plastic fibre cables (snap-in) or two glass fibre cables (ST, bayonet) or a combination of plastic and glass fibre. Three different types are available depending on type of fibre.

The incoming optical fibre is connected to the RX receiver input, and the outgoing optical fibre to the TX transmitter output. When the fibre optic cables are laid out, pay special attention to the instructions concerning the handling and connection of the optical fibres. The module is identified with a number on the label on the module.

15.5.3 Function block



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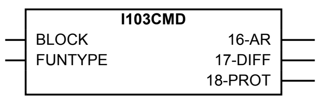

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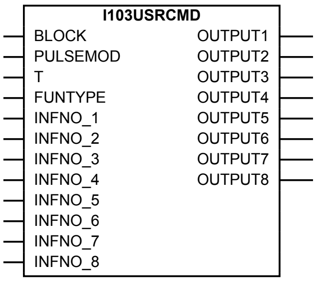

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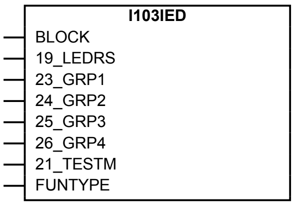

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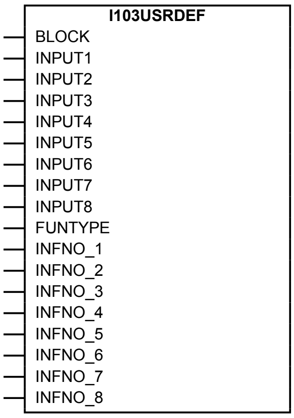

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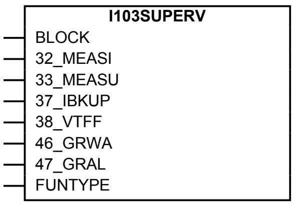

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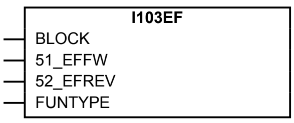

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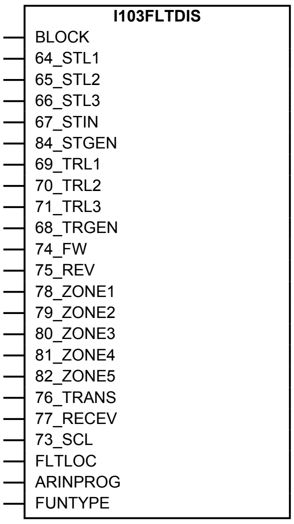

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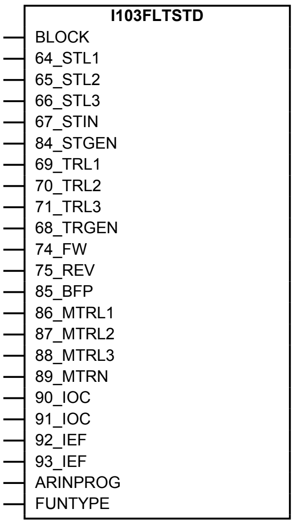

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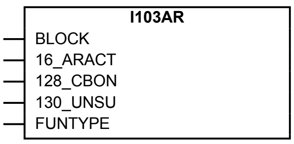

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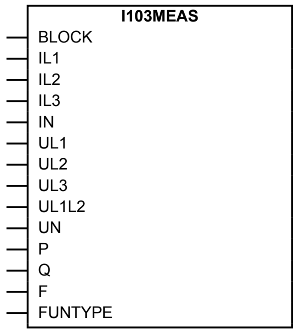

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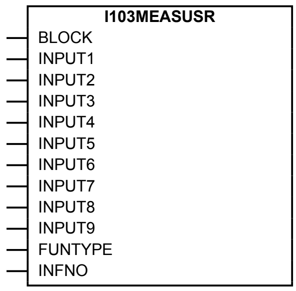


IEC05000691-2-en.vsd

15.5.4 Input and output signals

Table 396: I103IEDCMD Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of commands

Table 397: I103IEDCMD Output signals

Name	Type	Description
19-LEDRS	BOOLEAN	Information number 19, reset LEDs
23-GRP1	BOOLEAN	Information number 23, activate setting group 1
24-GRP2	BOOLEAN	Information number 24, activate setting group 2
25-GRP3	BOOLEAN	Information number 25, activate setting group 3
26-GRP4	BOOLEAN	Information number 26, activate setting group 4

Table 398: I103CMD Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of commands

Table 399: I103CMD Output signals

Name	Type	Description
16-AR	BOOLEAN	Information number 16, block of autorecloser
17-DIFF	BOOLEAN	Information number 17, block of differential protection
18-PROT	BOOLEAN	Information number 18, block of protection

Table 400: I103USRCMD Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of commands

Table 401: I103USRCMD Output signals

Name	Type	Description
OUTPUT1	BOOLEAN	Command output 1
OUTPUT2	BOOLEAN	Command output 2
OUTPUT3	BOOLEAN	Command output 3
OUTPUT4	BOOLEAN	Command output 4
OUTPUT5	BOOLEAN	Command output 5
OUTPUT6	BOOLEAN	Command output 6
OUTPUT7	BOOLEAN	Command output 7
OUTPUT8	BOOLEAN	Command output 8

Table 402: I103IED Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of status reporting
19_LEDRS	BOOLEAN	0	Information number 19, reset LEDs
23_GRP1	BOOLEAN	0	Information number 23, setting group 1 is active
24_GRP2	BOOLEAN	0	Information number 24, setting group 2 is active
25_GRP3	BOOLEAN	0	Information number 25, setting group 3 is active
26_GRP4	BOOLEAN	0	Information number 26, setting group 4 is active
21_TESTM	BOOLEAN	0	Information number 21, test mode is active

Table 403: I103USRDEF Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of status reporting
INPUT1	BOOLEAN	0	Binary signal Input 1
INPUT2	BOOLEAN	0	Binary signal input 2
INPUT3	BOOLEAN	0	Binary signal input 3

Table continues on next page

Name	Type	Default	Description
INPUT4	BOOLEAN	0	Binary signal input 4
INPUT5	BOOLEAN	0	Binary signal input 5
INPUT6	BOOLEAN	0	Binary signal input 6
INPUT7	BOOLEAN	0	Binary signal input 7
INPUT8	BOOLEAN	0	Binary signal input 8

Table 404: I103SUPERV Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of status reporting
32_MEASI	BOOLEAN	0	Information number 32, measurand supervision of I
33_MEASU	BOOLEAN	0	Information number 33, measurand supervision of U
37_IBKUP	BOOLEAN	0	Information number 37, I high-high back-up protection
38_VTFF	BOOLEAN	0	Information number 38, fuse failure VT
46_GRWA	BOOLEAN	0	Information number 46, group warning
47_GRAL	BOOLEAN	0	Information number 47, group alarm

Table 405: I103EF Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of status reporting
51_EFFW	BOOLEAN	0	Information number 51, earth-fault forward
52_EFREV	BOOLEAN	0	Information number 52, earth-fault reverse

Table 406: I103FLTDIS Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of status reporting
64_STL1	BOOLEAN	0	Information number 64, start phase L1
65_STL2	BOOLEAN	0	Information number 65, start phase L2
66_STL3	BOOLEAN	0	Information number 66, start phase L3
67_STIN	BOOLEAN	0	Information number 67, start residual current IN
84_STGEN	BOOLEAN	0	Information number 84, start general
69_TRL1	BOOLEAN	0	Information number 69, trip phase L1
70_TRL2	BOOLEAN	0	Information number 70, trip phase L2
71_TRL3	BOOLEAN	0	Information number 71, trip phase L3
68_TRGEN	BOOLEAN	0	Information number 68, trip general
74_FW	BOOLEAN	0	Information number 74, forward/line
75_REV	BOOLEAN	0	Information number 75, reverse/bus

Table continues on next page

Name	Type	Default	Description
78_ZONE1	BOOLEAN	0	Information number 78, zone 1
79_ZONE2	BOOLEAN	0	Information number 79, zone 2
80_ZONE3	BOOLEAN	0	Information number 79, zone 3
81_ZONE4	BOOLEAN	0	Information number 79, zone 4
82_ZONE5	BOOLEAN	0	Information number 79, zone 5
76_TRANS	BOOLEAN	0	Information number 76, signal transmitted
77_RECEV	BOOLEAN	0	Information number 77, signal recevied
73_SCL	REAL	0	Information number 73, fault location in ohm
FLTLOC	BOOLEAN	0	Faultlocator faultlocation valid (LMBRFLO-CALCMADE)
ARINPROG	BOOLEAN	0	Autorecloser in progress (SMBRREC- INPROGR)

Table 407: I103FLTSTD Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of status reporting
64_STL1	BOOLEAN	0	Information number 64, start phase L1
65_STL2	BOOLEAN	0	Information number 65, start phase L2
66_STL3	BOOLEAN	0	Information number 66, start phase L3
67_STIN	BOOLEAN	0	Information number 67, start residual curent IN
84_STGEN	BOOLEAN	0	Information number 84, start general
69_TRL1	BOOLEAN	0	Information number 69, trip phase L1
70_TRL2	BOOLEAN	0	Information number 70, trip phase L2
71_TRL3	BOOLEAN	0	Information number 71, trip phase L3
68_TRGEN	BOOLEAN	0	Information number 68, trip general
74_FW	BOOLEAN	0	Information number 74, forward/line
75_REV	BOOLEAN	0	Information number 75, reverse/bus
85_BFP	BOOLEAN	0	Information number 85, breaker failure
86_MTRL1	BOOLEAN	0	Information number 86, trip measuring system phase L1
87_MTRL2	BOOLEAN	0	Information number 87, trip measuring system phase L2
88_MTRL3	BOOLEAN	0	Information number 88, trip measuring system phase L3
89_MTRN	BOOLEAN	0	Information number 89, trip measuring system neutral N
90_IOC	BOOLEAN	0	Information number 90, over current trip, stage low
91_IOC	BOOLEAN	0	Information number 91, over current trip, stage high
92_IEF	BOOLEAN	0	Information number 92, earth-fault trip, stage low
93_IEF	BOOLEAN	0	Information number 93, earth-fault trip, stage high
ARINPROG	BOOLEAN	0	Autorecloser in progress (SMBRREC- INPROGR)

Table 408: I103AR Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of status reporting
16_ARACT	BOOLEAN	0	Information number 16, auto-recloser active
128_CBON	BOOLEAN	0	Information number 128, circuit breaker on by auto-recloser
130_UNSU	BOOLEAN	0	Information number 130, unsuccessful reclosing

Table 409: I103MEAS Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of service value reporting
IL1	REAL	0.0	Service value for current phase L1
IL2	REAL	0.0	Service value for current phase L2
IL3	REAL	0.0	Service value for current phase L3
IN	REAL	0.0	Service value for residual current IN
UL1	REAL	0.0	Service value for voltage phase L1
UL2	REAL	0.0	Service value for voltage phase L2
UL3	REAL	0.0	Service value for voltage phase L3
UL1L2	REAL	0.0	Service value for voltage phase-phase L1-L2
UN	REAL	0.0	Service value for residual voltage UN
P	REAL	0.0	Service value for active power
Q	REAL	0.0	Service value for reactive power
F	REAL	0.0	Service value for system frequency

Table 410: I103MEASUSR Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of service value reporting
INPUT1	REAL	0.0	Service value for measurement on input 1
INPUT2	REAL	0.0	Service value for measurement on input 2
INPUT3	REAL	0.0	Service value for measurement on input 3
INPUT4	REAL	0.0	Service value for measurement on input 4
INPUT5	REAL	0.0	Service value for measurement on input 5
INPUT6	REAL	0.0	Service value for measurement on input 6
INPUT7	REAL	0.0	Service value for measurement on input 7
INPUT8	REAL	0.0	Service value for measurement on input 8
INPUT9	REAL	0.0	Service value for measurement on input 9

15.5.5 Setting parameters

Table 411: IEC60870-5-103 Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
SlaveAddress	0 - 255	-	1	30	Slave address
BaudRate	9600 Bd 19200 Bd	-	-	9600 Bd	Baudrate on serial line
RevPolarity	Off On	-	-	On	Invert polarity
CycMeasRepTime	1.0 - 3600.0	-	0.1	5.0	Cyclic reporting time of measurments

Table 412: I103IEDCMD Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
FUNTYPE	1 - 255	FunT	1	255	Function type (1-255)

Table 413: I103CMD Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
FUNTYPE	1 - 255	FunT	1	1	Function type (1-255)

Table 414: I103USRCMD Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
PULSEMOD	0 - 1	Mode	1	1	Pulse mode 0=Steady, 1=Pulsed
T	0.200 - 60.000	s	0.001	0.400	Pulse length
FUNTYPE	1 - 255	FunT	1	1	Function type (1-255)
INFNO_1	1 - 255	InfNo	1	1	Information number for output 1 (1-255)
INFNO_2	1 - 255	InfNo	1	2	Information number for output 2 (1-255)
INFNO_3	1 - 255	InfNo	1	3	Information number for output 3 (1-255)
INFNO_4	1 - 255	InfNo	1	4	Information number for output 4 (1-255)
INFNO_5	1 - 255	InfNo	1	5	Information number for output 5 (1-255)
INFNO_6	1 - 255	InfNo	1	6	Information number for output 6 (1-255)
INFNO_7	1 - 255	InfNo	1	7	Information number for output 7 (1-255)
INFNO_8	1 - 255	InfNo	1	8	Information number for output 8 (1-255)

Table 415: I103IED Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
FUNTYPE	1 - 255	FunT	1	1	Function type (1-255)

Table 416: I103USRDEF Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
FUNTYPE	1 - 255	FunT	1	5	Function type (1-255)
INFNO_1	1 - 255	InfNo	1	1	Information number for binary input 1 (1-255)
INFNO_2	1 - 255	InfNo	1	2	Information number for binary input 2 (1-255)
INFNO_3	1 - 255	InfNo	1	3	Information number for binary input 3 (1-255)
INFNO_4	1 - 255	InfNo	1	4	Information number for binary input 4 (1-255)
INFNO_5	1 - 255	InfNo	1	5	Information number for binary input 5 (1-255)
INFNO_6	1 - 255	InfNo	1	6	Information number for binary input 6 (1-255)
INFNO_7	1 - 255	InfNo	1	7	Information number for binary input 7 (1-255)
INFNO_8	1 - 255	InfNo	1	8	Information number for binary input 8 (1-255)

Table 417: I103SUPERV Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
FUNTYPE	1 - 255	FunT	1	1	Function type (1-255)

Table 418: I103EF Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
FUNTYPE	1 - 255	FunT	1	160	Function type (1-255)

Table 419: I103FLTDIS Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
FUNTYPE	1 - 255	FunT	1	128	Function type (1-255)

Table 420: I103FLTSTD Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
FUNTYPE	1 - 255	FunT	1	1	Function type (1-255)

Table 421: I103AR Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
FUNTYPE	1 - 255	FunT	1	1	Function type (1-255)

Table 422: I103MEAS Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
RatedIL1	1 - 99999	A	1	3000	Rated current phase L1
RatedIL2	1 - 99999	A	1	3000	Rated current phase L2
RatedIL3	1 - 99999	A	1	3000	Rated current phase L3
RatedIN	1 - 99999	A	1	3000	Rated residual current IN
RatedUL1	0.05 - 2000.00	kV	0.05	230.00	Rated voltage for phase L1
RatedUL2	0.05 - 2000.00	kV	0.05	230.00	Rated voltage for phase L2
RatedUL3	0.05 - 2000.00	kV	0.05	230.00	Rated voltage for phase L3
RatedUL1-UL2	0.05 - 2000.00	kV	0.05	400.00	Rated voltage for phase-phase L1-L2
RatedUN	0.05 - 2000.00	kV	0.05	230.00	Rated residual voltage UN
RatedP	0.00 - 2000.00	MW	0.05	1200.00	Rated value for active power
RatedQ	0.00 - 2000.00	MVA	0.05	1200.00	Rated value for reactive power
RatedF	50.0 - 60.0	Hz	10.0	50.0	Rated system frequency
FUNTYPE	1 - 255	FunT	1	1	Function type (1-255)

Table 423: I103MEASUSR Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
FUNTYPE	1 - 255	FunT	1	25	Function type (1-255)
INFNO	1 - 255	InfNo	1	1	Information number for measurands (1-255)
RatedMeasur1	0.05 - 10000000000.00	-	0.05	1000.00	Rated value for measurement on input 1
RatedMeasur2	0.05 - 10000000000.00	-	0.05	1000.00	Rated value for measurement on input 2
RatedMeasur3	0.05 - 10000000000.00	-	0.05	1000.00	Rated value for measurement on input 3
RatedMeasur4	0.05 - 10000000000.00	-	0.05	1000.00	Rated value for measurement on input 4
RatedMeasur5	0.05 - 10000000000.00	-	0.05	1000.00	Rated value for measurement on input 5
RatedMeasur6	0.05 - 10000000000.00	-	0.05	1000.00	Rated value for measurement on input 6
RatedMeasur7	0.05 - 10000000000.00	-	0.05	1000.00	Rated value for measurement on input 7
RatedMeasur8	0.05 - 10000000000.00	-	0.05	1000.00	Rated value for measurement on input 8
RatedMeasur9	0.05 - 10000000000.00	-	0.05	1000.00	Rated value for measurement on input 9

15.5.6 Technical data

Table 424: IEC60870-5-103 communication protocol

Function	Value
Protocol	IEC 60870-5-103
Communication speed	9600, 19200 Bd

15.6 Horizontal communication via GOOSE for interlocking GOOSEINTLKRCV

15.6.1 Function block

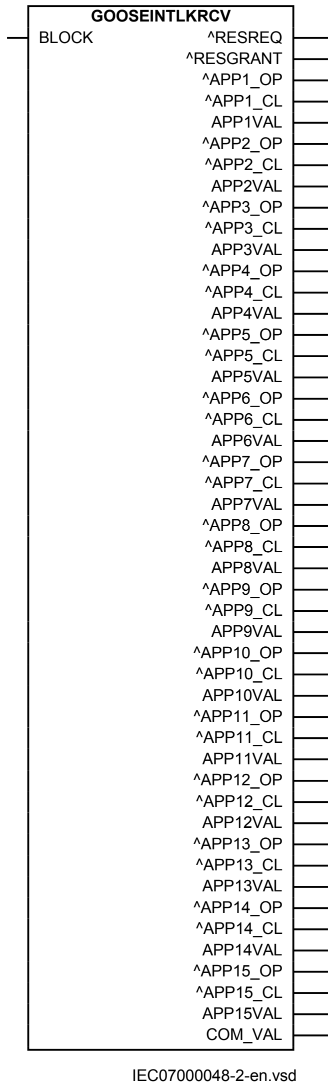


Figure 280: GOOSEINTLKRCV function block

15.6.2 Input and output signals

Table 425: GOOSEINTLKRCV Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of output signals

Table 426: GOOSEINTLKRCV Output signals

Name	Type	Description
RESREQ	BOOLEAN	Reservation request
RESGRANT	BOOLEAN	Reservation granted
APP1_OP	BOOLEAN	Apparatus 1 position is open
APP1_CL	BOOLEAN	Apparatus 1 position is closed
APP1VAL	BOOLEAN	Apparatus 1 position is valid
APP2_OP	BOOLEAN	Apparatus 2 position is open
APP2_CL	BOOLEAN	Apparatus 2 position is closed
APP2VAL	BOOLEAN	Apparatus 2 position is valid
APP3_OP	BOOLEAN	Apparatus 3 position is open
APP3_CL	BOOLEAN	Apparatus 3 position is closed
APP3VAL	BOOLEAN	Apparatus 3 position is valid
APP4_OP	BOOLEAN	Apparatus 4 position is open
APP4_CL	BOOLEAN	Apparatus 4 position is closed
APP4VAL	BOOLEAN	Apparatus 4 position is valid
APP5_OP	BOOLEAN	Apparatus 5 position is open
APP5_CL	BOOLEAN	Apparatus 5 position is closed
APP5VAL	BOOLEAN	Apparatus 5 position is valid
APP6_OP	BOOLEAN	Apparatus 6 position is open
APP6_CL	BOOLEAN	Apparatus 6 position is closed
APP6VAL	BOOLEAN	Apparatus 6 position is valid
APP7_OP	BOOLEAN	Apparatus 7 position is open
APP7_CL	BOOLEAN	Apparatus 7 position is closed
APP7VAL	BOOLEAN	Apparatus 7 position is valid
APP8_OP	BOOLEAN	Apparatus 8 position is open
APP8_CL	BOOLEAN	Apparatus 8 position is closed
APP8VAL	BOOLEAN	Apparatus 8 position is valid
APP9_OP	BOOLEAN	Apparatus 9 position is open
APP9_CL	BOOLEAN	Apparatus 9 position is closed
APP9VAL	BOOLEAN	Apparatus 9 position is valid
APP10_OP	BOOLEAN	Apparatus 10 position is open
APP10_CL	BOOLEAN	Apparatus 10 position is closed
APP10VAL	BOOLEAN	Apparatus 10 position is valid
Table continues on next page		

Name	Type	Description
APP11_OP	BOOLEAN	Apparatus 11 position is open
APP11_CL	BOOLEAN	Apparatus 11 position is closed
APP11VAL	BOOLEAN	Apparatus 11 position is valid
APP12_OP	BOOLEAN	Apparatus 12 position is open
APP12_CL	BOOLEAN	Apparatus 12 position is closed
APP12VAL	BOOLEAN	Apparatus 12 position is valid
APP13_OP	BOOLEAN	Apparatus 13 position is open
APP13_CL	BOOLEAN	Apparatus 13 position is closed
APP13VAL	BOOLEAN	Apparatus 13 position is valid
APP14_OP	BOOLEAN	Apparatus 14 position is open
APP14_CL	BOOLEAN	Apparatus 14 position is closed
APP14VAL	BOOLEAN	Apparatus 14 position is valid
APP15_OP	BOOLEAN	Apparatus 15 position is open
APP15_CL	BOOLEAN	Apparatus 15 position is closed
APP15VAL	BOOLEAN	Apparatus 15 position is valid
COM_VAL	BOOLEAN	Receive communication status is valid

15.6.3 Setting parameters

Table 427: GOOSEINTLKRCV Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off/On

15.7 Goose binary receive GOOSEBINRCV

15.7.1 Function block

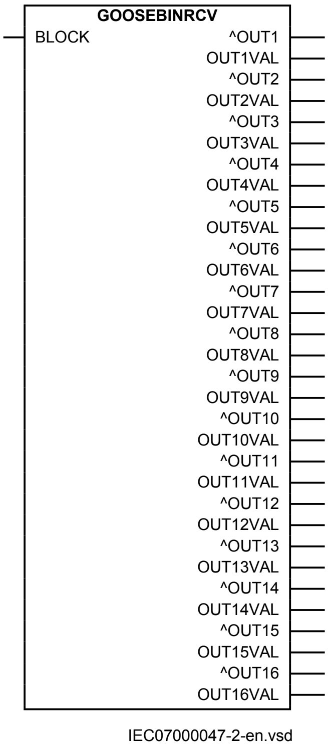


Figure 281: GOOSEBINRCV function block

15.7.2 Input and output signals

Table 428: GOOSEBINRCV Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of output signals

Table 429: GOOSEBINRCV Output signals

Name	Type	Description
OUT1	BOOLEAN	Binary output 1
OUT1VAL	BOOLEAN	Valid data on binary output 1
OUT2	BOOLEAN	Binary output 2
OUT2VAL	BOOLEAN	Valid data on binary output 2
OUT3	BOOLEAN	Binary output 3
OUT3VAL	BOOLEAN	Valid data on binary output 3
Table continues on next page		

Name	Type	Description
OUT4	BOOLEAN	Binary output 4
OUT4VAL	BOOLEAN	Valid data on binary output 4
OUT5	BOOLEAN	Binary output 5
OUT5VAL	BOOLEAN	Valid data on binary output 5
OUT6	BOOLEAN	Binary output 6
OUT6VAL	BOOLEAN	Valid data on binary output 6
OUT7	BOOLEAN	Binary output 7
OUT7VAL	BOOLEAN	Valid data on binary output 7
OUT8	BOOLEAN	Binary output 8
OUT8VAL	BOOLEAN	Valid data on binary output 8
OUT9	BOOLEAN	Binary output 9
OUT9VAL	BOOLEAN	Valid data on binary output 9
OUT10	BOOLEAN	Binary output 10
OUT10VAL	BOOLEAN	Valid data on binary output 10
OUT11	BOOLEAN	Binary output 11
OUT11VAL	BOOLEAN	Valid data on binary output 11
OUT12	BOOLEAN	Binary output 12
OUT12VAL	BOOLEAN	Valid data on binary output 12
OUT13	BOOLEAN	Binary output 13
OUT13VAL	BOOLEAN	Valid data on binary output 13
OUT14	BOOLEAN	Binary output 14
OUT14VAL	BOOLEAN	Valid data on binary output 14
OUT15	BOOLEAN	Binary output 15
OUT15VAL	BOOLEAN	Valid data on binary output 15
OUT16	BOOLEAN	Binary output 16
OUT16VAL	BOOLEAN	Valid data on binary output 16

15.7.3 Setting parameters

Table 430: GOOSEBINRCV Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off/On

15.8 Multiple command and transmit MULTICMDRCV, MULTICMDSND

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Multiple command and transmit	MULTICMDRCV	-	-
Multiple command and transmit	MULTICMDSND	-	-

15.8.1 Introduction

The IED can be provided with a function to send and receive signals to and from other IEDs via the interbay bus. The send and receive function blocks has 16 outputs/inputs that can be used, together with the configuration logic circuits, for control purposes within the IED or via binary outputs. When it is used to communicate with other IEDs, these IEDs have a corresponding Multiple transmit function block with 16 outputs to send the information received by the command block.

15.8.2 Principle of operation

Two multiple transmit function blocks MULTICMDSND:1 and MULTICMDSND:2 and 8 slow multiple transmit function blocks MULTICMDSND:3 to MULTICMDSND:10 are available in the IED.

Sixteen signals can be connected and they will then be sent to the multiple command block in the other IED. The connections are set with the LON Network Tool (LNT).

Twelve multiple command function blocks MULTICMDRCV:1 to MULTICMDRCV:12 with fast execution time and 48 multiple command function blocks MULTICMDRCV:13 to MULTICMDRCV:60 with slower execution time are available in the IED.

Multiple command function block MULTICMDRCV has 16 outputs combined in one block, which can be controlled from other IEDs.

The output signals, here OUTPUT1 to OUTPUT16, are then available for configuration to built-in functions or via the configuration logic circuits to the binary outputs of the IED.

MULTICMDRCV also has a supervision function, which sets the output VALID to 0 if the block does not receive data within set maximum time.

15.8.3 Design

15.8.3.1 General

The output signals can be of the types Off, Steady, or Pulse. The setting is done on the MODE settings, common for the whole block, from PCM600.

- 0 = Off sets all outputs to 0, independent of the values sent from the station level, that is, the operator station or remote-control gateway.
- 1 = Steady sets the outputs to a steady signal 0 or 1, depending on the values sent from the station level.
- 2 = Pulse gives a pulse with one execution cycle duration, if a value sent from the station level is changed from 0 to 1. That means that the configured logic connected to the command function blocks may not have a cycle time longer than the execution cycle time for the command function block.

15.8.4 Function block

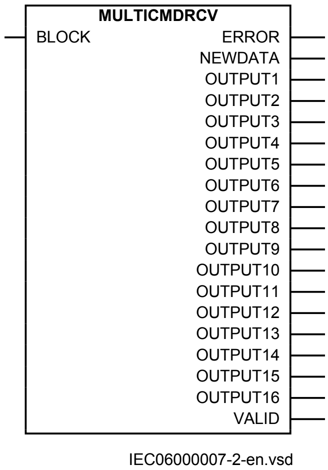


Figure 282: MULTICMDRCV function block

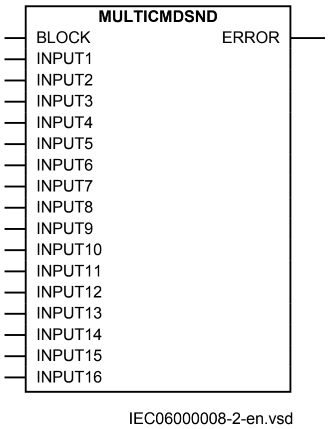


Figure 283: MULTICMDSND function block

15.8.5 Input and output signals

Table 431: MULTICMDRCV Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of function

Table 432: MULTICMDSND Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of function
INPUT1	BOOLEAN	0	Input 1
INPUT2	BOOLEAN	0	Input 2
INPUT3	BOOLEAN	0	Input 3
INPUT4	BOOLEAN	0	Input 4
INPUT5	BOOLEAN	0	Input 5
INPUT6	BOOLEAN	0	Input 6
INPUT7	BOOLEAN	0	Input 7
INPUT8	BOOLEAN	0	Input 8
INPUT9	BOOLEAN	0	Input 9
INPUT10	BOOLEAN	0	Input 10
INPUT11	BOOLEAN	0	Input 11
INPUT12	BOOLEAN	0	Input 12
INPUT13	BOOLEAN	0	Input 13
INPUT14	BOOLEAN	0	Input 14
INPUT15	BOOLEAN	0	Input 15
INPUT16	BOOLEAN	0	Input 16

Table 433: MULTICMDRCV Output signals

Name	Type	Description
ERROR	BOOLEAN	MultiReceive error
NEWDATA	BOOLEAN	New data is received
OUTPUT1	BOOLEAN	Output 1
OUTPUT2	BOOLEAN	Output 2
OUTPUT3	BOOLEAN	Output 3
OUTPUT4	BOOLEAN	Output 4
OUTPUT5	BOOLEAN	Output 5
OUTPUT6	BOOLEAN	Output 6
OUTPUT7	BOOLEAN	Output 7
OUTPUT8	BOOLEAN	Output 8
OUTPUT9	BOOLEAN	Output 9

Table continues on next page

Name	Type	Description
OUTPUT10	BOOLEAN	Output 10
OUTPUT11	BOOLEAN	Output 11
OUTPUT12	BOOLEAN	Output 12
OUTPUT13	BOOLEAN	Output 13
OUTPUT14	BOOLEAN	Output 14
OUTPUT15	BOOLEAN	Output 15
OUTPUT16	BOOLEAN	Output 16
VALID	BOOLEAN	Output data is valid

Table 434: MULTICMDSND Output signals

Name	Type	Description
ERROR	BOOLEAN	MultiSend error

15.8.6 Setting parameters

Table 435: MULTICMDRCV Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
tMaxCycleTime	0.050 - 200.000	s	0.001	11.000	Maximum cycle time between receptions of input data
tMinCycleTime	0.000 - 200.000	s	0.001	0.000	Minimum cycle time between receptions of input data
Mode	Steady Pulsed	-	-	Steady	Mode for output signals
tPulseTime	0.000 - 60.000	s	0.001	0.200	Pulse length for multi command outputs

Table 436: MULTICMDSND Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
tMaxCycleTime	0.000 - 200.000	s	0.001	5.000	Maximum time interval between transmission of output data
tMinCycleTime	0.000 - 200.000	s	0.001	0.000	Minimum time interval between transmission of output data

Section 16 Remote communication

About this chapter

This chapter describes the Binary signal transfer function and associated hardware functionality. The way the functions work, their setting parameters, function blocks, input and output signals, and technical data are included for each function.

16.1 Binary signal transfer

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Binary signal transfer	BinSignReceive	-	-
Binary signal transfer	BinSignTransm	-	-

16.1.1 Introduction

The remote end data communication is used either for the transmission of current values together with maximum 8 binary signals in the line differential protection, or for transmission of only binary signals, up to 192 signals, in the other 670 series IEDs. The binary signals are freely configurable and can, thus, be used for any purpose, for example, communication scheme related signals, transfer trip and/or other binary signals between IEDs.

Communication between two IEDs requires that each IED is equipped with an LDCM (Line Data Communication Module). The LDCMs are then interfaces to a 64 kbit/s communication channel for duplex communication between the IEDs.

The IED can be equipped with up to two short range LDCM.

16.1.2 Principle of operation

The communication is made on standard ITU (CCITT) PCM digital 64 kbit/s channels. It is a two-way communication where telegrams are sent every 5 ms (same in 50 Hz and 60 Hz), exchanging information between two IEDs. The format used is C37.94 and one telegram consists of start and stop flags, address, data to be transmitted, Cyclic Redundancy Check (CRC) and Yellow bit (which is associated with C37.94).

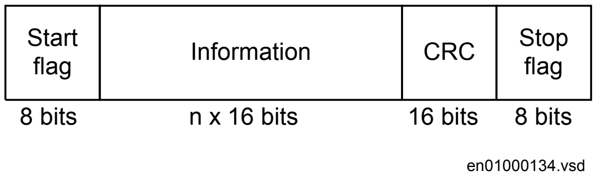


Figure 284: Data message structure

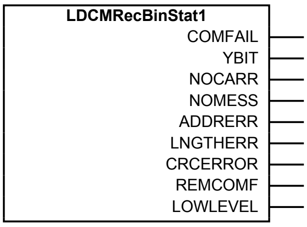
The start and stop flags are the 0111 1110 sequence (7E hexadecimal), defined in the HDLC standard. The CRC is designed according to the standard CRC16 definition. The optional address field in the HDLC frame is not used instead a separate addressing is included in the data field.

The address field is used for checking that the received message originates from the correct equipment. There is always a risk that multiplexers occasionally mix the messages up. Each terminal in the system is given a number. The terminal is then programmed to accept messages from a specific terminal number. If the CRC function detects a faulty message, the message is thrown away and not used in the evaluation.

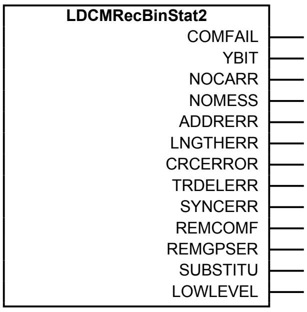
When the communication is used for line differential purpose, the transmitted data consists of three currents, clock information, trip-, block- and alarm-signals and eight binary signals which can be used for any purpose. The three currents are represented as sampled values.

When the communication is used exclusively for binary signals, the full data capacity of the communication channel is used for the binary signal purpose which gives the capacity of 192 signals.

16.1.3 Function block

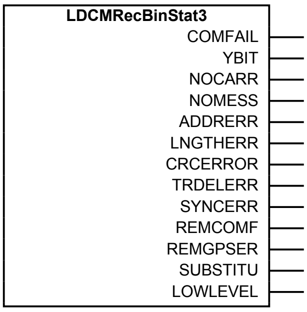


IEC07000043-2-en.vsd



IEC07000044-2-en.vsd

Figure 285: LDCMRecBinStat function blocks



IEC05000451-2-en.vsd

Figure 286: LDCMRecBinStat function block

16.1.4 Input and output signals

Table 437: LDCMRecBinStat1 Output signals

Name	Type	Description
COMFAIL	BOOLEAN	Detected error in the differential communication
YBIT	BOOLEAN	Detected error in remote end with incoming message
NOCARR	BOOLEAN	No carrier is detected in the incoming message
Table continues on next page		

Name	Type	Description
NOMESS	BOOLEAN	No start and stop flags identified for the incoming message
ADDRERR	BOOLEAN	Incoming message from a wrong terminal
LNGTHERR	BOOLEAN	Wrong length of the incoming message
CRCERROR	BOOLEAN	Identified error by CRC check in incoming message
REMCOMF	BOOLEAN	Remote terminal indicates problem with received message
LOWLEVEL	BOOLEAN	Low signal level on the receive link

Table 438: LDCMRecBinStat2 Output signals

Name	Type	Description
COMFAIL	BOOLEAN	Detected error in the differential communication
YBIT	BOOLEAN	Detected error in remote end with incoming message
NOCARR	BOOLEAN	No carrier is detected in the incoming message
NOMESS	BOOLEAN	No start and stop flags identified for the incoming message
ADDRERR	BOOLEAN	Incoming message from a wrong terminal
LNGTHERR	BOOLEAN	Wrong length of the incoming message
CRCERROR	BOOLEAN	Identified error by CRC check in incoming message
TRDELERR	BOOLEAN	Transmission time is longer than permitted
SYNCERR	BOOLEAN	Indicates when echo synchronication is used
REMCOMF	BOOLEAN	Remote terminal indicates problem with received message
REMGPSER	BOOLEAN	Remote terminal indicates problem with GPS synchronization
SUBSTITU	BOOLEAN	Link error, values are substituted
LOWLEVEL	BOOLEAN	Low signal level on the receive link

Table 439: LDCMRecBinStat3 Output signals

Name	Type	Description
COMFAIL	BOOLEAN	Detected error in the differential communication
YBIT	BOOLEAN	Detected error in remote end with incoming message
NOCARR	BOOLEAN	No carrier is detected in the incoming message
NOMESS	BOOLEAN	No start and stop flags identified for the incoming message
ADDRERR	BOOLEAN	Incoming message from a wrong terminal
LNGTHERR	BOOLEAN	Wrong length of the incoming message
CRCERROR	BOOLEAN	Identified error by CRC check in incoming message
TRDELERR	BOOLEAN	Transmission time is longer than permitted

Table continues on next page

Name	Type	Description
SYNCERR	BOOLEAN	Indicates when echo synchronication is used
REMCOMF	BOOLEAN	Remote terminal indicates problem with received message
REMGPSER	BOOLEAN	Remote terminal indicates problem with GPS synchronization
SUBSTITU	BOOLEAN	Link error, values are substituted
LOWLEVEL	BOOLEAN	Low signal level on the receive link

16.1.5 Setting parameters

Table 440: LDCMRecBinStat1 Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
ChannelMode	Off On OutOfService	-	-	On	Channel mode of LDCM, 0=OFF, 1=ON, 2=OutOfService
TerminalNo	0 - 255	-	1	0	Terminal number used for line differential communication
RemoteTermNo	0 - 255	-	1	0	Terminal number on remote terminal
CommSync	Slave Master	-	-	Slave	Com Synchronization mode of LDCM, 0=Slave, 1=Master
OptoPower	LowPower HighPower	-	-	LowPower	Transmission power for LDCM, 0=Low, 1=High
ComFailAlrmDel	5 - 500	ms	5	100	Time delay before communication error signal is activated
ComFailResDel	5 - 500	ms	5	100	Reset delay before communication error signal is reset
InvertPolX21	Off On	-	-	Off	Invert polarization for X21 communication

Table 441: LDCMRecBinStat2 Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
ChannelMode	Off On OutOfService	-	-	On	Channel mode of LDCM, 0=OFF, 1=ON, 2=OutOfService
NAMECH1	0 - 13	-	1	LDCM#-CH1	User define string for analogue input 1
TerminalNo	0 - 255	-	1	0	Terminal number used for line differential communication
RemoteTermNo	0 - 255	-	1	0	Terminal number on remote terminal
NAMECH2	0 - 13	-	1	LDCM#-CH2	User define string for analogue input 2
DiffSync	Echo GPS	-	-	Echo	Diff Synchronization mode of LDCM, 0=ECHO, 1=GPS
GPSSyncErr	Block Echo	-	-	Block	Operation mode when GPS synchroniation signal is lost
CommSync	Slave Master	-	-	Slave	Com Synchronization mode of LDCM, 0=Slave, 1=Master

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
NAMECH3	0 - 13	-	1	LDCM#-CH3	User define string for analogue input 3
OptoPower	LowPower HighPower	-	-	LowPower	Transmission power for LDCM, 0=Low, 1=High
NAMECH4	0 - 13	-	1	LDCM#-CH4	User define string for analogue input 4
TransmCurr	CT-GRP1 CT-GRP2 CT-SUM CT-DIFF1 CT-DIFF2	-	-	CT-GRP1	Summation mode for transmitted current values
ComFailAlrmDel	5 - 500	ms	5	100	Time delay before communication error signal is activated
ComFailResDel	5 - 500	ms	5	100	Reset delay before communication error signal is reset
RedChSwTime	5 - 500	ms	5	5	Time delay before switching in redundant channel
RedChRturnTime	5 - 500	ms	5	100	Time delay before switching back from redundant channel
AsymDelay	-20.00 - 20.00	ms	0.01	0.00	Asymmetric delay when communication use echo synch.
AnalogLatency	2 - 20	-	1	2	Latency between local analogue data and transmitted
remAinLatency	2 - 20	-	1	2	Analog latency of remote terminal
MaxTransmDelay	0 - 40	ms	1	20	Max allowed transmission delay
CompRange	0-10kA 0-25kA 0-50kA 0-150kA	-	-	0-25kA	Compression range
MaxtDiffLevel	200 - 2000	us	1	600	Maximum time diff for ECHO back-up
DeadbandtDiff	200 - 1000	us	1	300	Deadband for t Diff
InvertPolX21	Off On	-	-	Off	Invert polarization for X21 communication

Table 442: LDCMRecBinStat3 Non group settings (basic)

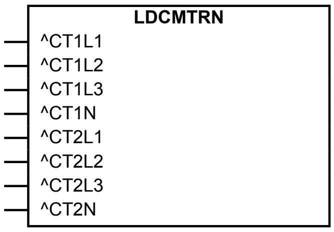
Name	Values (Range)	Unit	Step	Default	Description
ChannelMode	Off On OutOfService	-	-	On	Channel mode of LDCM, 0=OFF, 1=ON, 2=OutOfService
NAMECH1	0 - 13	-	1	LDCM#-CH1	User define string for analogue input 1
TerminalNo	0 - 255	-	1	0	Terminal number used for line differential communication
RemoteTermNo	0 - 255	-	1	0	Terminal number on remote terminal
NAMECH2	0 - 13	-	1	LDCM#-CH2	User define string for analogue input 2
DiffSync	Echo GPS	-	-	Echo	Diff Synchronization mode of LDCM, 0=ECHO, 1=GPS
GPSSyncErr	Block Echo	-	-	Block	Operation mode when GPS synchroniation signal is lost

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
CommSync	Slave Master	-	-	Slave	Com Synchronization mode of LDCM, 0=Slave, 1=Master
NAMECH3	0 - 13	-	1	LDCM#-CH3	User define string for analogue input 3
OptoPower	LowPower HighPower	-	-	LowPower	Transmission power for LDCM, 0=Low, 1=High
NAMECH4	0 - 13	-	1	LDCM#-CH4	User define string for analogue input 4
TransmCurr	CT-GRP1 CT-GRP2 CT-SUM CT-DIFF1 CT-DIFF2 RedundantChannel	-	-	CT-GRP1	Summation mode for transmitted current values
ComFailAlrmDel	5 - 500	ms	5	100	Time delay before communication error signal is activated
ComFailResDel	5 - 500	ms	5	100	Reset delay before communication error signal is reset
RedChSwTime	5 - 500	ms	5	5	Time delay before switching in redundant channel
RedChRturnTime	5 - 500	ms	5	100	Time delay before switching back from redundant channel
AsymDelay	-20.00 - 20.00	ms	0.01	0.00	Asymmetric delay when communication use echo synch.
AnalogLatency	2 - 20	-	1	2	Latency between local analogue data and transmitted
remAinLatency	2 - 20	-	1	2	Analog latency of remote terminal
MaxTransmDelay	0 - 40	ms	1	20	Max allowed transmission delay
CompRange	0-10kA 0-25kA 0-50kA 0-150kA	-	-	0-25kA	Compression range
MaxtDiffLevel	200 - 2000	us	1	600	Maximum time diff for ECHO back-up
DeadbandtDiff	200 - 1000	us	1	300	Deadband for t Diff
InvertPolX21	Off On	-	-	Off	Invert polarization for X21 communication

16.2 Transmission of analog data from LDCM LDCMTransmit

16.2.1 Function block



IEC10000017-1-en.vsd

Figure 287: LDCMTransmit function block

The function blocks are not represented in the Application Configuration tool except for the LDCMTRN function block that is visible in ACT. The signals appear only in the Signal Matrix tool when a LDCM is included in the configuration with the function selector tool.

16.2.2 Input and output signals

Table 443: LDCMTRN Input signals

Name	Type	Default	Description
CT1L1	STRING	0	Input to be used for transmit CT-group1 line L1 to remote end
CT1L2	STRING	0	Input to be used for transmit CT-group1 line L2 to remote end
CT1L3	STRING	0	Input to be used for transmit CT-group1 line L3 to remote end
CT1N	STRING	0	Input to be used for transmit CT-group1 neutral N to remote end
CT2L1	STRING	0	Input to be used for transmit CT-group2 line L1 to remote end
CT2L2	STRING	0	Input to be used for transmit CT-group2 line L2 to remote end
CT2L3	STRING	0	Input to be used for transmit CT-group2 line L3 to remote end
CT2N	STRING	0	Input to be used for transmit CT-group2 neutral N to remote end

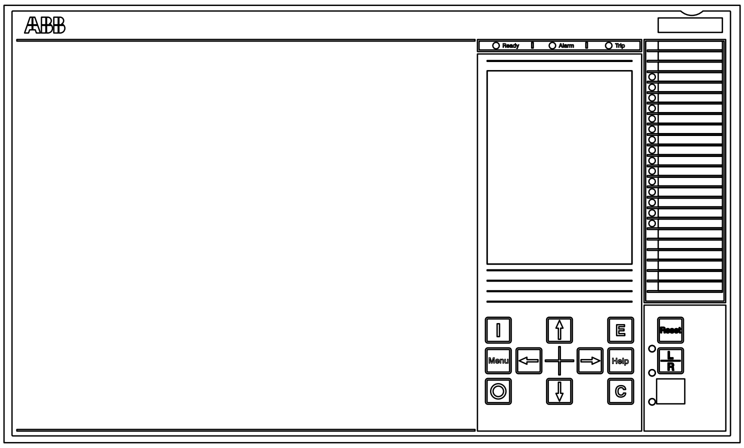
Section 17 IED hardware

About this chapter

This chapter describes the different hardware modules available in the IED. The descriptions includes diagrams from different elevations indicating the location of connection terminals and modules.

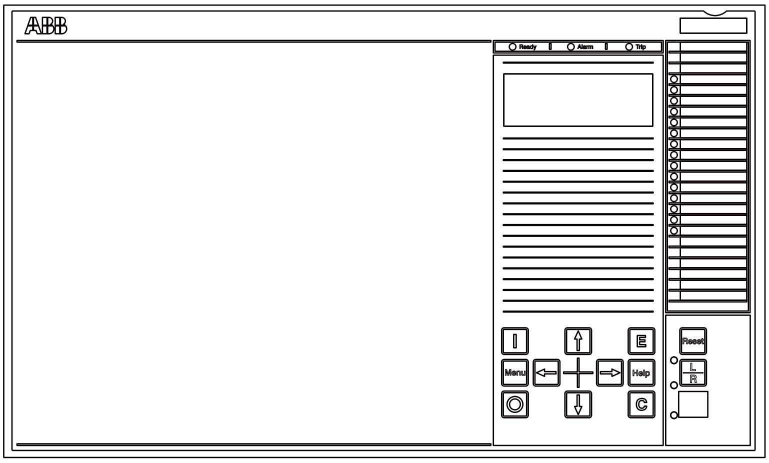
17.1 Overview

17.1.1 Variants of case and local HMI display size



xx04000460.ep

Figure 288: 1/1 19” case with medium local HMI display.

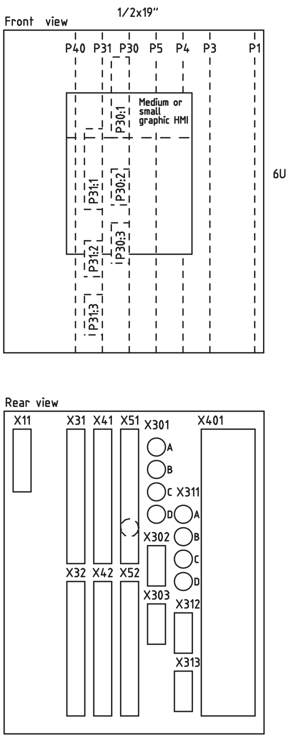


xx04000461.eps

Figure 289: 1/1 19" case with small local HMI display.

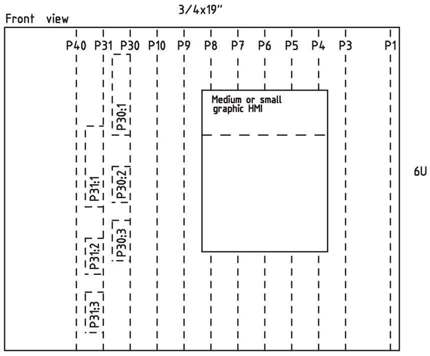
17.1.2 Case from the rear side

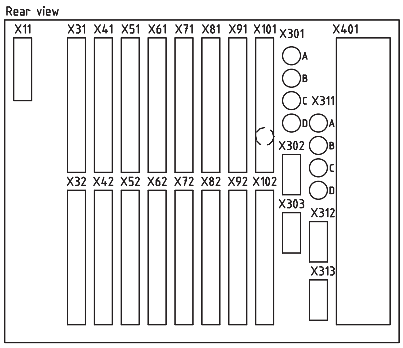
Table 444: Designations for 1/2 x 19" casing with 1 TRM slot



Module	Rear Positions
PSM	X11
BIM, BOM, SOM, IOM or MIM	X31 and X32 etc. to X51 and X52
SLM	X301:A, B, C, D
LDCM, IRIG-B or RS485	X302
LDCM or RS485	X303
OEM	X311:A, B, C, D
LDCM, RS485 or GTM	X312, 313
TRM	X401

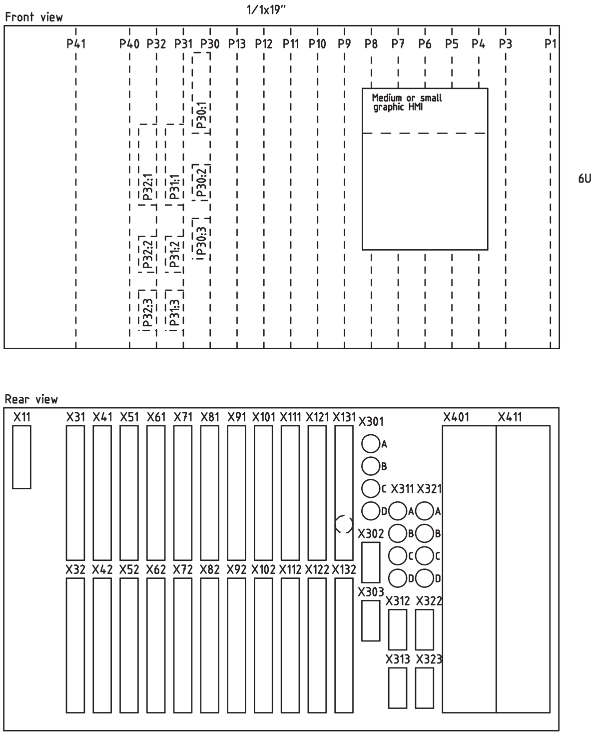
Table 445: Designations for 3/4 x 19” casing with 1 TRM slot





Module	Rear Positions
PSM	X11
BIM, BOM, SOM, IOM or MIM	X31 and X32 etc. to X101 and X102
SLM	X301:A, B, C, D
LDCM, IRIG-B or RS485	X302
LDCM or RS485	X303
OEM	X311:A, B, C, D
LDCM, RS485 or GTM	X312, X313
TRM	X401

Table 446: Designations for 1/1 x 19” casing with 2 TRM slots



Module	Rear Positions
PSM	X11
BIM, BOM, SOM, IOM or MIM	X31 and X32 etc. to X131 and X132
SLM	X301:A, B, C, D
LDCM, IRIG-B or RS485	X302
LDCM or RS485	X303
OEM	X311:A, B, C, D
LDCM, RS485 or GTM	X312, X313, X322, X323
TRM 1	X401
TRM 2	X411

17.2 Hardware modules

17.2.1 Overview

Table 447: Basic modules

Module	Description
Combined backplane module (CBM)	A backplane PCB that carries all internal signals between modules in an IED. Only the TRM (when included) is not connected directly to this board.
Universal backplane module (UBM)	A backplane PCB that forms part of the IED backplane with connectors for TRM (when included), ADM etc.
Power supply module (PSM)	Including a regulated DC/DC converter that supplies auxiliary voltage to all static circuits. • An internal fail alarm output is available.
Numerical module (NUM)	Module for overall application control. All information is processed or passed through this module, such as configuration, settings and communication.

Table continues on next page

Module	Description
Local Human machine interface (LHMI)	The module consists of LED:s, an LCD, a push button keyboard and an ethernet connector used to connect a PC to the IED.
Transformer input module (TRM)	Transformer module that galvanically separates the internal circuits from the VT and CT circuits. It has 12 analog inputs.
Analog digital conversion module (ADM)	Slot mounted PCB with A/D conversion.

Table 448: Application specific modules

Module	Description
Binary input module (BIM)	Module with 16 optically isolated binary inputs
Binary output module (BOM)	Module with 24 single outputs or 12 double-pole command outputs including supervision function
Binary I/O module (IOM)	Module with 8 optically isolated binary inputs, 10 outputs and 2 fast signalling outputs.
Line data communication modules (LDCM), short range, medium range, long range, X21	Modules used for digital communication to remote terminal.
Serial SPA/LON/IEC 60870-5-103/DNP3 communication modules (SLM)	Used for SPA/LON/IEC 60870–5–103/DNP3 communication
Optical ethernet module (OEM)	PMC board for IEC 61850 based communication.
mA input module (MIM)	Analog input module with 6 independent, galvanically separated channels.
GPS time synchronization module (GTM)	Used to provide the IED with GPS time synchronization.
Static output module (SOM)	Module with 6 fast static outputs and 6 change over output relays.
IRIG-B Time synchronization module (IRIG-B)	Module with 2 inputs. One is used for handling both pulse-width modulated signals and amplitude modulated signals and one is used for optical input type ST for PPS time synchronization.

17.2.2 Combined backplane module (CBM)

17.2.2.1 Introduction

The combined backplane module (CBM) carries signals between modules in an IED.

17.2.2.2 Functionality

The Compact PCI makes 3.3V or 5V signaling in the backplane possible. The CBM backplane and connected modules are 5V PCI-compatible.

Some pins on the Compact PCI connector are connected to the CAN bus, to be able to communicate with CAN based modules.

If a modules self test discovers an error it informs other modules using the Internal Fail signal IRF.

17.2.2.3 Design

There are two basic versions of the CBM:

- with 3 Compact PCI connectors and a number of euro connectors depending on the IED case size. One Compact PCI connector is used by NUM and two are used by other PCI modules, for example two ADMs in IEDs with two TRMs. See figure 291
- with 2 Compact PCI connectors and a number of euro connectors depending on the IED case size. One Compact PCI connector is used by NUM and one is used by for example an ADM in IEDs with one TRM. See figure 290

Each PCI connector consists of 2 compact PCI receptacles. The euro connectors are connected to the CAN bus and used for I/O modules and power supply.

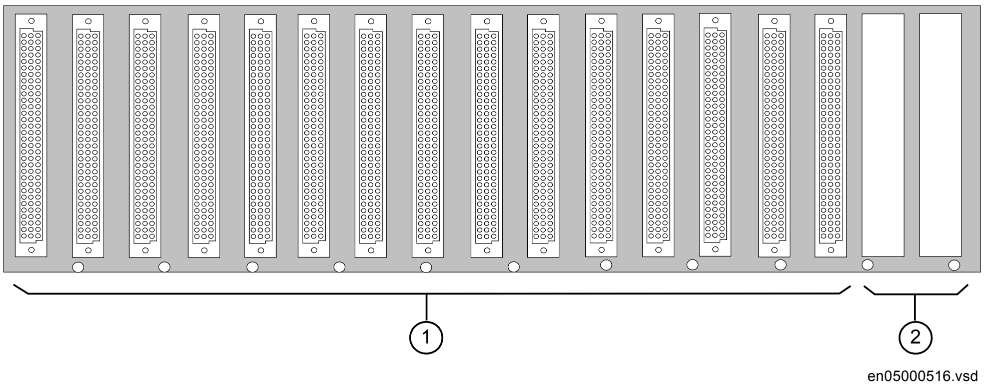


Figure 290: CBM for 1 TRM.

Pos	Description
1	CAN slots
2	CPCI slots

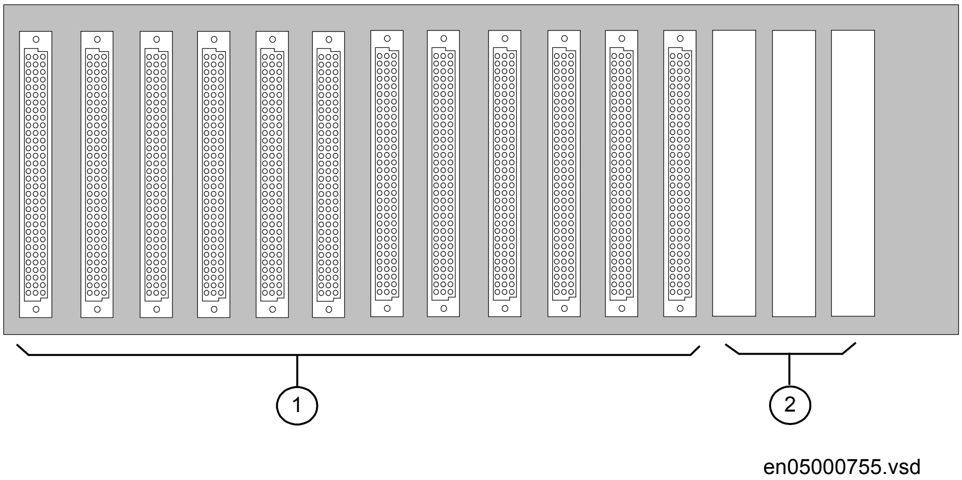


Figure 291: CBM for 2 TRM.

Pos	Description
1	CAN slots
2	CPCI slots

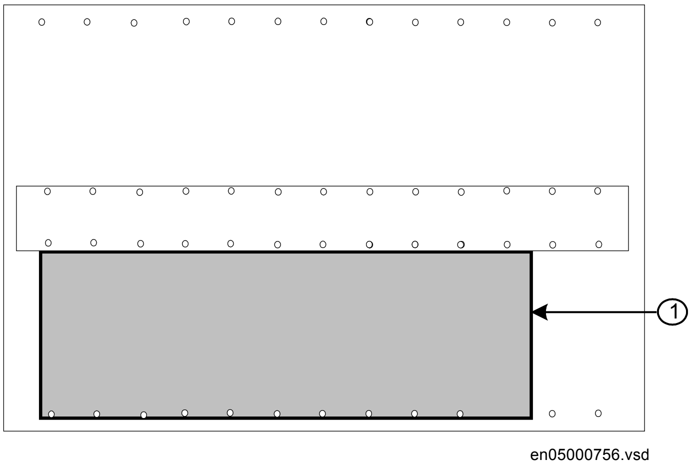


Figure 292: CBM position, rear view.

Pos	Description
1	CBM

17.2.3 Universal backplane module (UBM)

17.2.3.1 Introduction

The Universal Backplane Module (UBM) is part of the IED backplane and is mounted above the CBM. It connects the Transformer input module (TRM) to the Analog digital conversion module (ADM) and the Numerical module (NUM).

17.2.3.2 Functionality

The Universal Backplane Module connects the CT and VT analog signals from the transformer input module to the analog digital converter module. The Numerical processing module (NUM) is also connected to the UBM. The ethernet contact on the front panel as well as the internal ethernet contacts are connected to the UBM which provides the signal path to the NUM board.

17.2.3.3 Design

It connects the Transformer input module (TRM) to the Analog digital conversion module (ADM) and the Numerical module (NUM).

The UBM exists in 2 versions.

- for IEDs with two TRM and two ADM. It has four 48 pin euro connectors and one 96 pin euro connector, see figure 294
- for IEDs with one TRM and one ADM. It has two 48 pin euro connectors and one 96 pin euro connector, see figure 295.

The 96 pin euro connector is used to connect the NUM board to the backplane. The 48 pin connectors are used to connect the TRM and ADM.

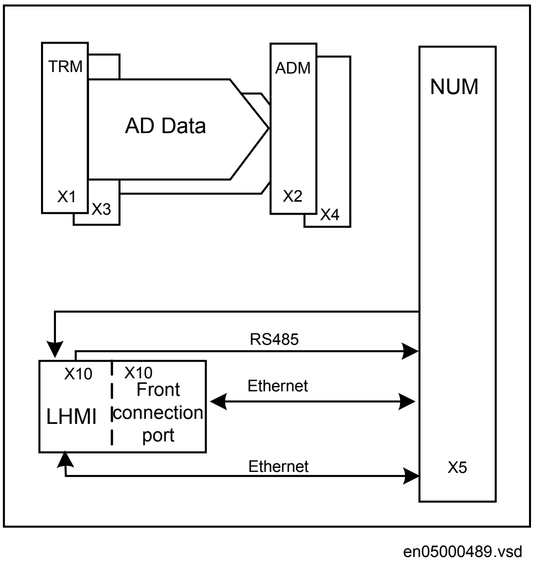


Figure 293: UBM block diagram.

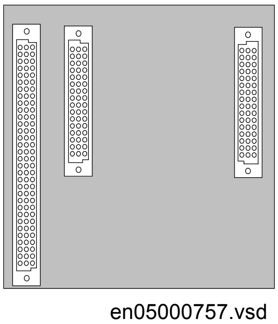


Figure 294: UBM for 1 TRM.

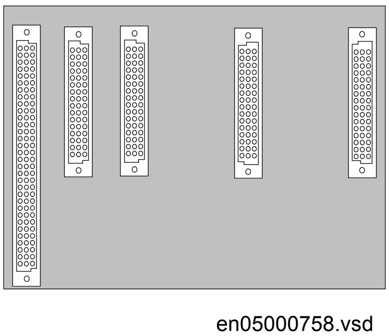


Figure 295: UBM for 2 TRM.

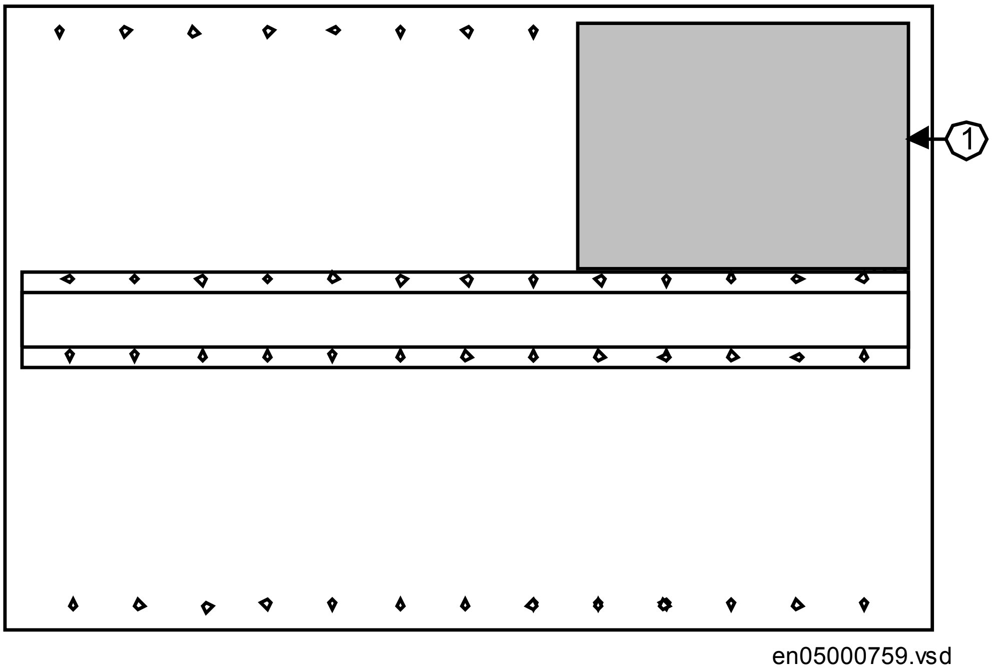


Figure 296: UBM position, rear view.

Pos	Description
1	UBM

17.2.4 Numeric processing module (NUM)

17.2.4.1 Introduction

The Numeric processing module (NUM), is a CPU-module that handles all protection functions and logic.

For communication with high speed modules, e.g. analog input modules and high speed serial interfaces, the NUM is equipped with a Compact PCI bus. The NUM is the compact PCI system card i.e. it controls bus mastering, clock distribution and receives interrupts.

17.2.4.2 Functionality

The NUM, Numeric processing module is a high performance, standard off-the-shelf compact-PCI CPU module. It is 6U high and occupies one slot. Contact with the backplane is via two compact PCI connectors and an euro connector.

The NUM has one PMC slot (32-bit IEEE P1386.1 compliant) and two PC-MIP slots onto which mezzanine cards such as SLM or LDCM can be mounted.

To reduce bus loading of the compact PCI bus in the backplane the NUM has one internal PCI bus for internal resources and the PMC/PC-MIP slots and external PCI accesses through the backplane are buffered in a PCI/PCI bridge.

The application code and configuration data are stored in flash memory using a flash file system.

The NUM is equipped with a real time clock. It uses a capacitor for power backup of the real time clock.

No forced cooling is used on this standard module because of the low power dissipation.

17.2.4.3 Block diagram

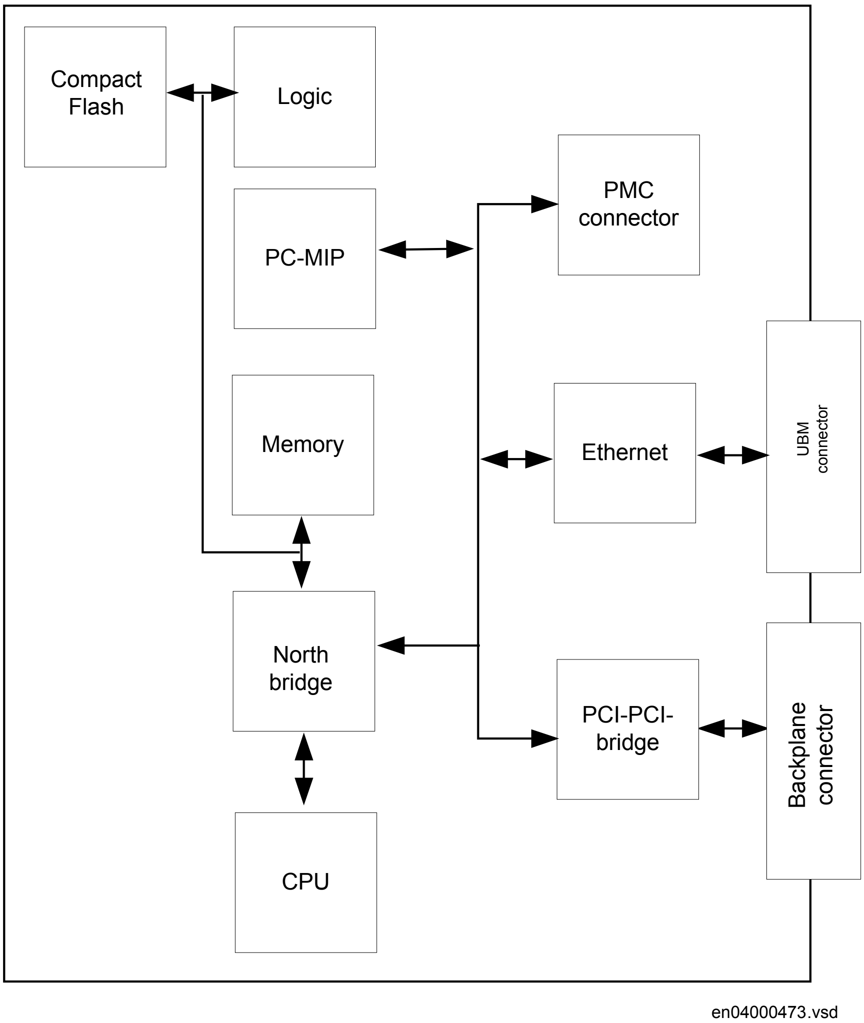


Figure 297: Numeric processing module block diagram

17.2.5 Power supply module (PSM)

17.2.5.1 Introduction

The power supply module is used to provide the correct internal voltages and full isolation between the terminal and the battery system. An internal fail alarm output is available.

17.2.5.2 Design

There are two types of the power supply module. They are designed for different DC input voltage ranges see table 449. The power supply module contains a built-in, self-regulated DC/DC converter that provides full isolation between the terminal and the external battery system.

Block diagram

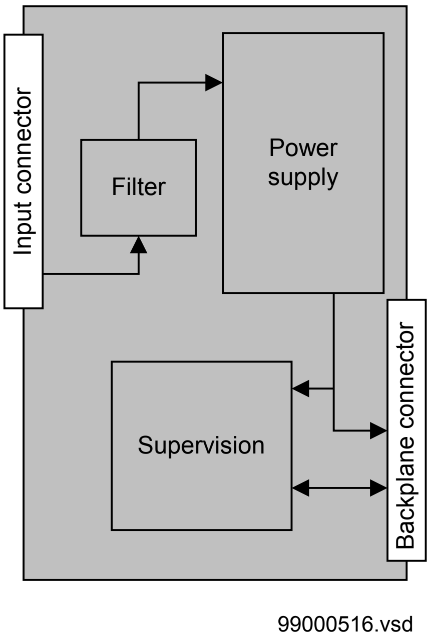


Figure 298: PSM Block diagram.

17.2.5.3 Technical data

Table 449: PSM - Power supply module

Quantity	Rated value	Nominal range
Auxiliary dc voltage, EL (input)	EL = (24 - 60) V EL = (90 - 250) V	EL ± 20% EL ± 20%
Power consumption	50 W typically	-
Auxiliary DC power in-rush	< 5 A during 0.1 s	-

17.2.6 Local human-machine interface (Local HMI)

Refer to section "Local HMI" for information.

17.2.7 Transformer input module (TRM)

17.2.7.1 Introduction

The transformer input module is used to galvanically separate and transform the secondary currents and voltages generated by the measuring transformers. The module has twelve inputs in different combinations of currents and voltage inputs.

Alternative connectors of Ring lug or Compression type can be ordered.

17.2.7.2 Design

The transformer module has 12 input transformers. There are several versions of the module, each with a different combination of voltage and current input transformers.

Basic versions:

- 6 current channels and 6 voltage channels
- 7 current channels and 5 voltage channels
- 9 current channels and 3 voltage channels
- 12 current channels
- 6 current channels

The rated values and channel type, measurement or protection, of the current inputs are selected at order.

Transformer input module for measuring should not be used with current transformers intended for protection purposes, due to limitations in overload characteristics.

The TRM is connected to the ADM and NUM via the UBM.

For configuration of the input and output signals, refer to section "Signal matrix for analog inputs SMAI".

17.2.7.3 Technical data

Table 450: TRM - Energizing quantities, rated values and limits for protection transformer modules

Quantity	Rated value	Nominal range
Current	I_r = 1 or 5 A	(0.2-40) × I_r
Operative range	(0-100) x I_r	
Permissive overload	4 × I_r cont. 100 × I_r for 1 s *)	
Burden	< 150 mVA at I_r = 5 A < 20 mVA at I_r = 1 A	
Ac voltage	U_r = 110 V	0.5–288 V
Operative range	(0–340) V	
Permissive overload	420 V cont. 450 V 10 s	
Burden	< 20 mVA at 110 V	
Frequency	f_r = 50/60 Hz	± 5%
*) max. 350 A for 1 s when COMBITEST test switch is included.		

17.2.8 Analog digital conversion module, with time synchronization (ADM)

17.2.8.1 Introduction

The Analog/Digital module has twelve analog inputs, 2 PC-MIP slots and 1 PMC slot. The PC-MIP slot is used for PC-MIP cards and the PMC slot for PMC cards according to table 451. The OEM card should always be mounted on the ADM board. The UBM connects the ADM to the transformer input module (TRM).

Table 451: PC-MIP cards and PMC cards

PC-MIP cards	PMC cards
LDCM	SLM
LR-LDCM	OEM 1 ch
MR-LDCM	OEM 2 ch
X21-LDCM	
IRIG-B	
RS485	

17.2.8.2 Design

The Analog digital conversion module input signals are voltage and current from the transformer module. Shunts are used to adapt the current signals to the electronic voltage level. To gain dynamic range for the current inputs, two shunts with separate A\D channels are used for each input current. In this way a 20 bit dynamic range is obtained with a 16 bit A\D converter.

Input signals are sampled with a sampling freqency of 5 kHz at 50 Hz system frequency and 6 kHz at 60 Hz system frequency.

The A\D converted signals goes through a filter with a cut off frequency of 500 Hz and are reported to the numerical module (NUM) with 1 kHz at 50 Hz system frequency and 1,2 kHz at 60 Hz system frequency.

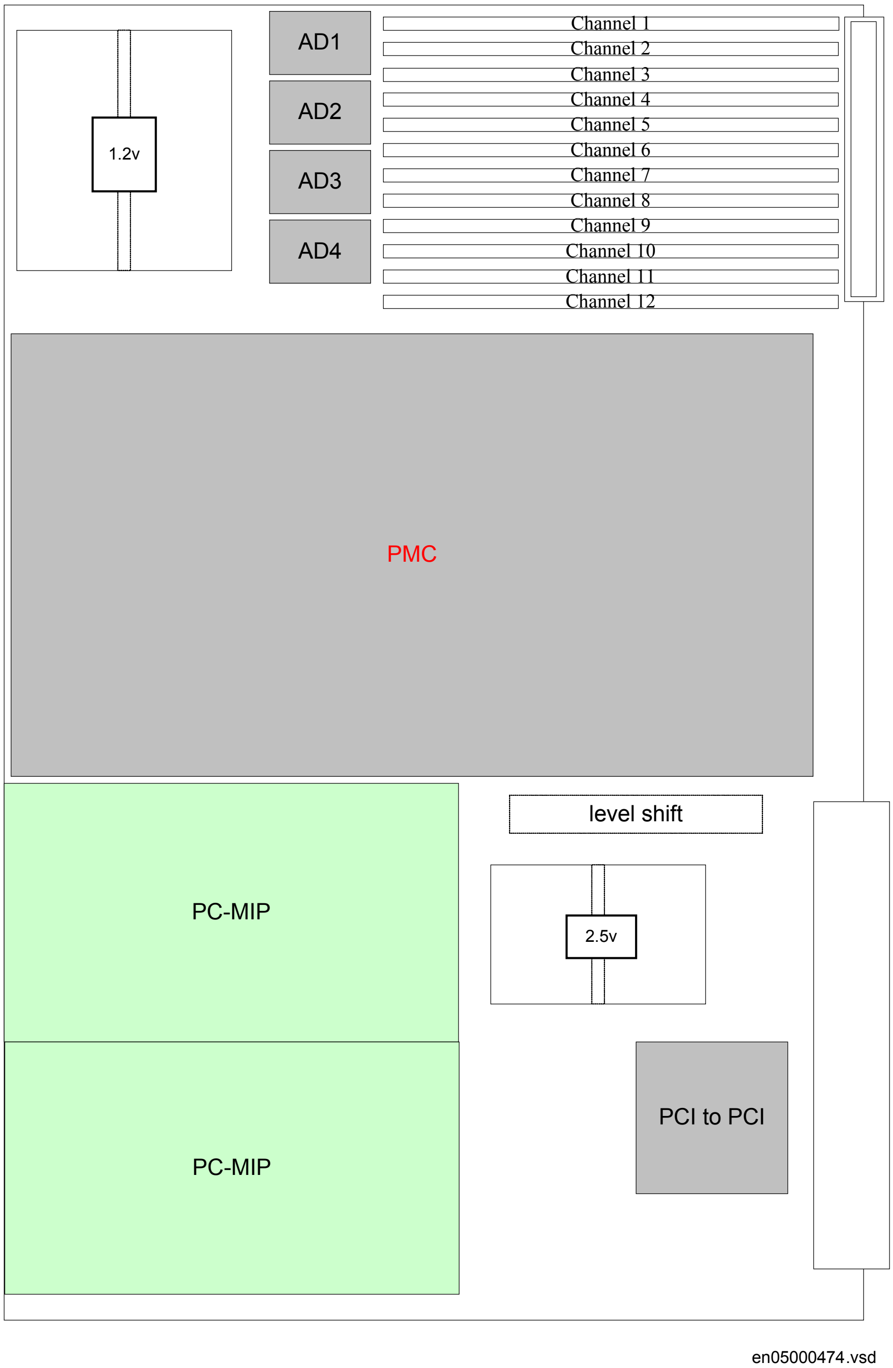


Figure 299: The ADM layout

17.2.9 Binary input module (BIM)

17.2.9.1 Introduction

The binary input module has 16 optically isolated inputs and is available in two versions, one standard and one with enhanced pulse counting capabilities on the inputs to be used with the pulse counter function. The binary inputs are freely programmable and can be used for the input of logical signals to any of the functions. They can also be included in the disturbance recording and event-recording functions. This enables extensive monitoring and evaluation of operation of the IED and for all associated electrical circuits.

17.2.9.2 Design

The Binary input module contains 16 optical isolated binary inputs. The voltage level of the binary input is selected at order.

For configuration of the input signals, refer to section "Signal matrix for binary inputs SMBI".

A signal discriminator detects and blocks oscillating signals. When blocked, a hysteresis function may be set to release the input at a chosen frequency, making it possible to use the input for pulse counting. The blocking frequency may also be set.

Figure 300 shows the operating characteristics of the binary inputs of the four voltage levels.

The standard version of binary inputs gives an improved capability to withstand disturbances and should generally be used when pulse counting is not required.

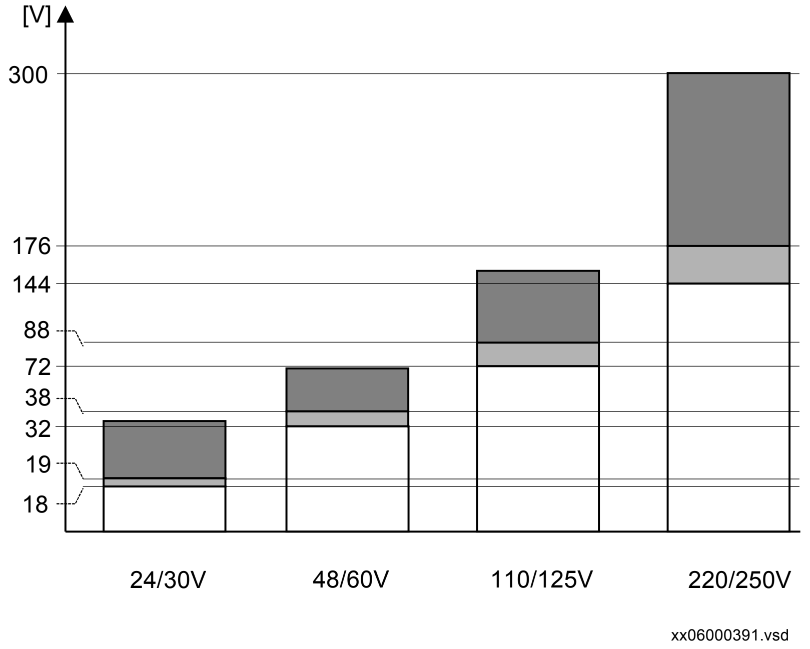
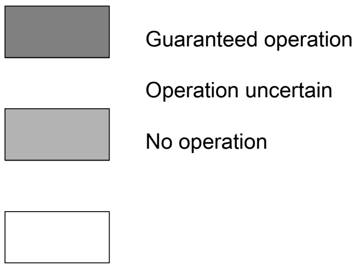


Figure 300: Voltage dependence for the binary inputs



This binary input module communicates with the Numerical module (NUM) via the CAN-bus on the backplane.

The design of all binary inputs enables the burn off of the oxide of the relay contact connected to the input, despite the low, steady-state power consumption, which is shown in figure 301 and 302.

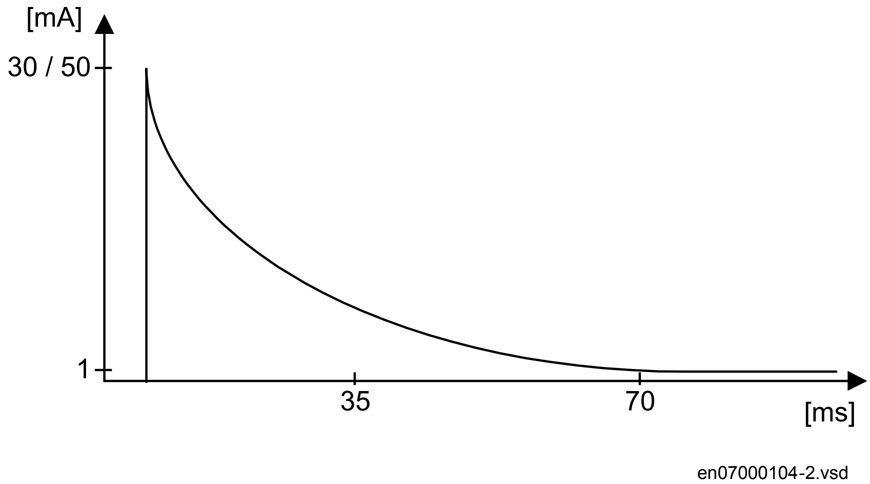


Figure 301: Approximate binary input inrush current for the two standard versions of BIM.

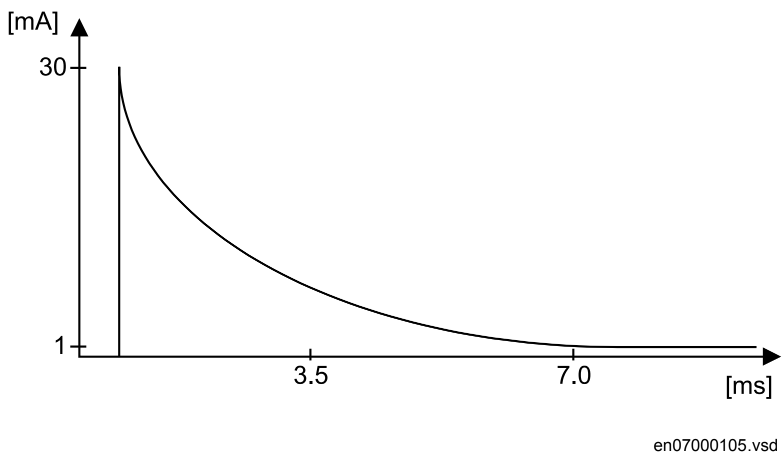


Figure 302: Approximate binary input inrush current for the BIM version with enhanced pulse counting capabilities.

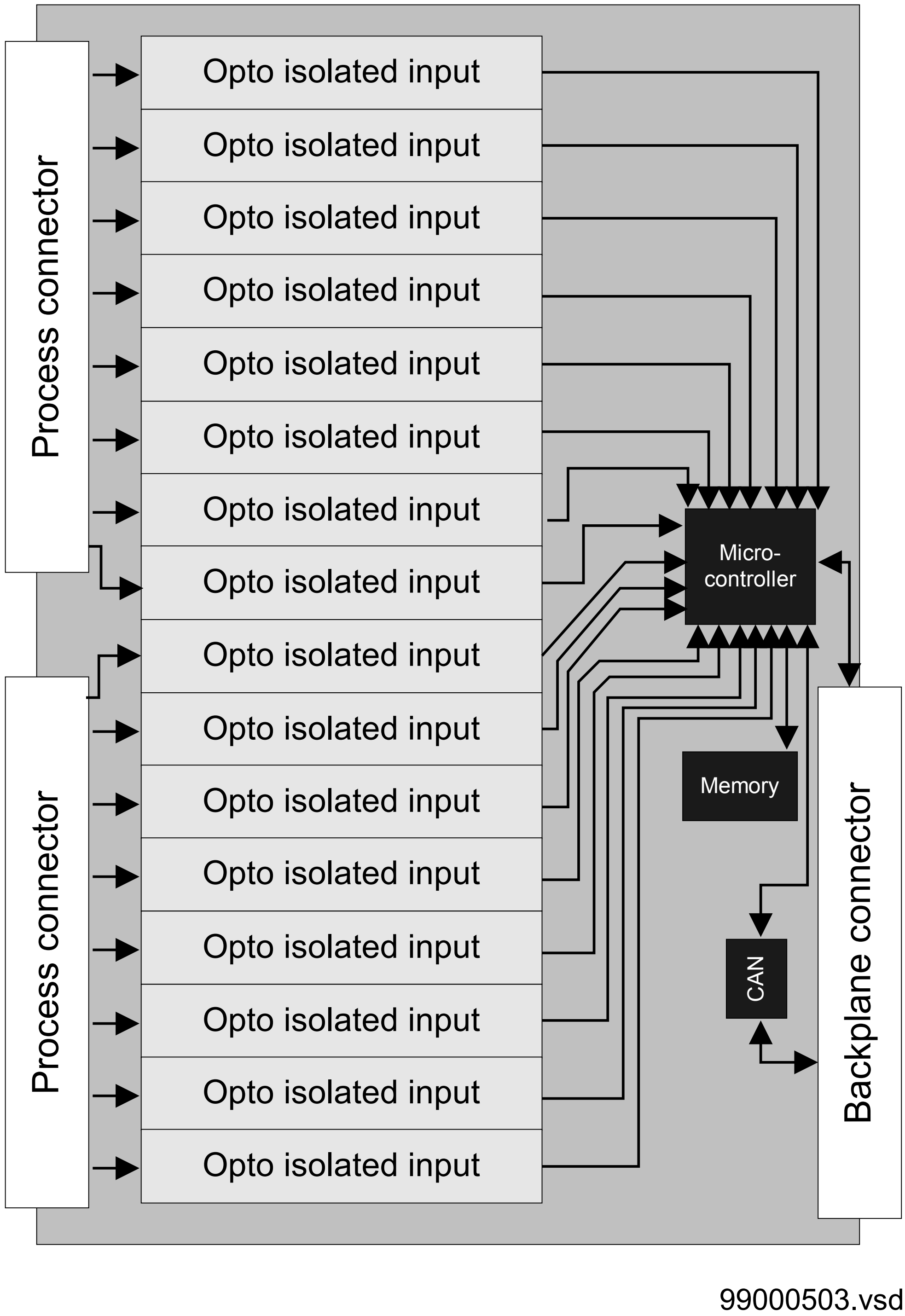


Figure 303: Block diagram of the Binary input module.

17.2.9.3 Technical data

Table 452: BIM - Binary input module

Quantity	Rated value	Nominal range
Binary inputs	16	-
DC voltage, RL	24/30 V 48/60 V 110/125 V 220/250 V	RL ± 20% RL ± 20% RL ± 20% RL ± 20%
Power consumption 24/30 V 48/60 V 110/125 V 220/250 V	 max. 0.05 W/input max. 0.1 W/input max. 0.2 W/input max. 0.4 W/input	-
Counter input frequency	10 pulses/s max	-
Oscillating signal discriminator	Blocking settable 1–40 Hz Release settable 1–30 Hz	

Table 453: BIM - Binary input module with enhanced pulse counting capabilities

Quantity	Rated value	Nominal range
Binary inputs	16	-
DC voltage, RL	24/30 V 48/60 V 110/125 V 220/250 V	RL ± 20% RL ± 20% RL ± 20% RL ± 20%
Power consumption 24/30 V 48/60 V 110/125 V 220/250 V	 max. 0.05 W/input max. 0.1 W/input max. 0.2 W/input max. 0.4 W/input	-
Counter input frequency	10 pulses/s max	-
Balanced counter input frequency	40 pulses/s max	-
Oscillating signal discriminator	Blocking settable 1–40 Hz Release settable 1–30 Hz	

17.2.10 Binary output modules (BOM)

17.2.10.1 Introduction

The binary output module has 24 independent output relays and is used for trip output or any signaling purpose.

17.2.10.2 Design

The binary output module (BOM) has 24 software supervised output relays. Each pair of relays have a common power source input to the contacts, see figure 304.

This should be considered when connecting the wiring to the connection terminal on the back of the IED.

The high closing and carrying current capability allows connection directly to breaker trip and closing coils. If breaking capability is required to manage fail of the breaker auxiliary contacts normally breaking the trip coil current, a parallel reinforcement is required.

For configuration of the output signals, refer to section "Signal matrix for binary outputs SMBO".

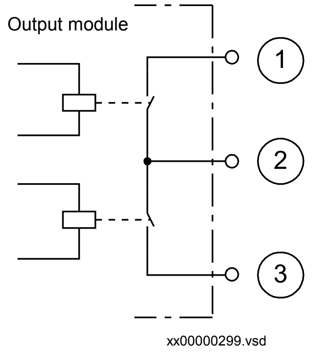


Figure 304: Relay pair example

1 Output connection from relay 1

2 Output signal power source connection

3 Output connection from relay 2

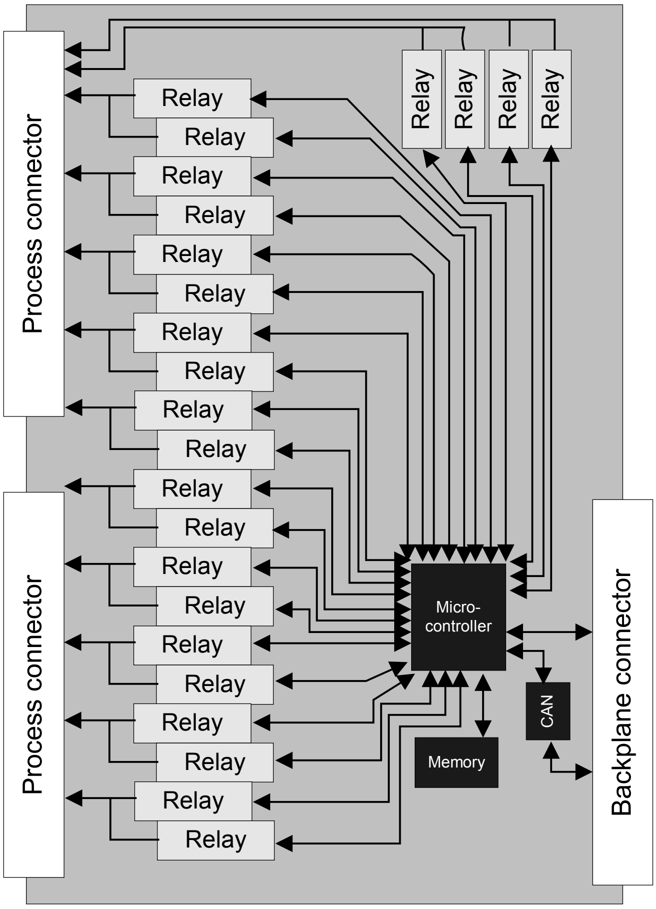


Figure 305: Block diagram of the Binary Output Module

17.2.10.3 Technical data

Table 454: BOM - Binary output module contact data (reference standard: IEC 61810-2)

Function or quantity	Trip and Signal relays
Binary outputs	24
Max system voltage	250 V AC, DC
Test voltage across open contact, 1 min	1000 V rms
Current carrying capacity Continuous 1 s	 8 A 10 A
Table continues on next page	

Function or quantity	Trip and Signal relays
Making capacity at inductive load with L/R>10 ms 0.2 s 1.0 s	 30 A 10 A
Breaking capacity for AC, cos φ>0.4	250 V/8.0 A
Breaking capacity for DC with L/R < 40 ms	48 V/1 A 110 V/0.4 A 125 V/0.35 A 220 V/0.2 A 250 V/0.15 A

17.2.11 Static binary output module (SOM)

17.2.11.1 Introduction

The static binary output module has six fast static outputs and six change over output relays for use in applications with high speed requirements.

17.2.11.2 Design

The Static output module (SOM) have 6 normally open (NO) static outputs and 6 electromechanical relay outputs with change over contacts.

The SOM consists mainly of:

- An MCU
- A CAN-driver
- 6 static relays outputs
- 6 electromechanical relay outputs
- A DC/DC converter
- Connectors interfacing
    - CAN-bus to backplane CBM
    - IO-connectors to binary outputs (2 pcs.)

The following parts are supervised:

- Interruption in relay coil
- Short circuit of relay coil
- Driver failure

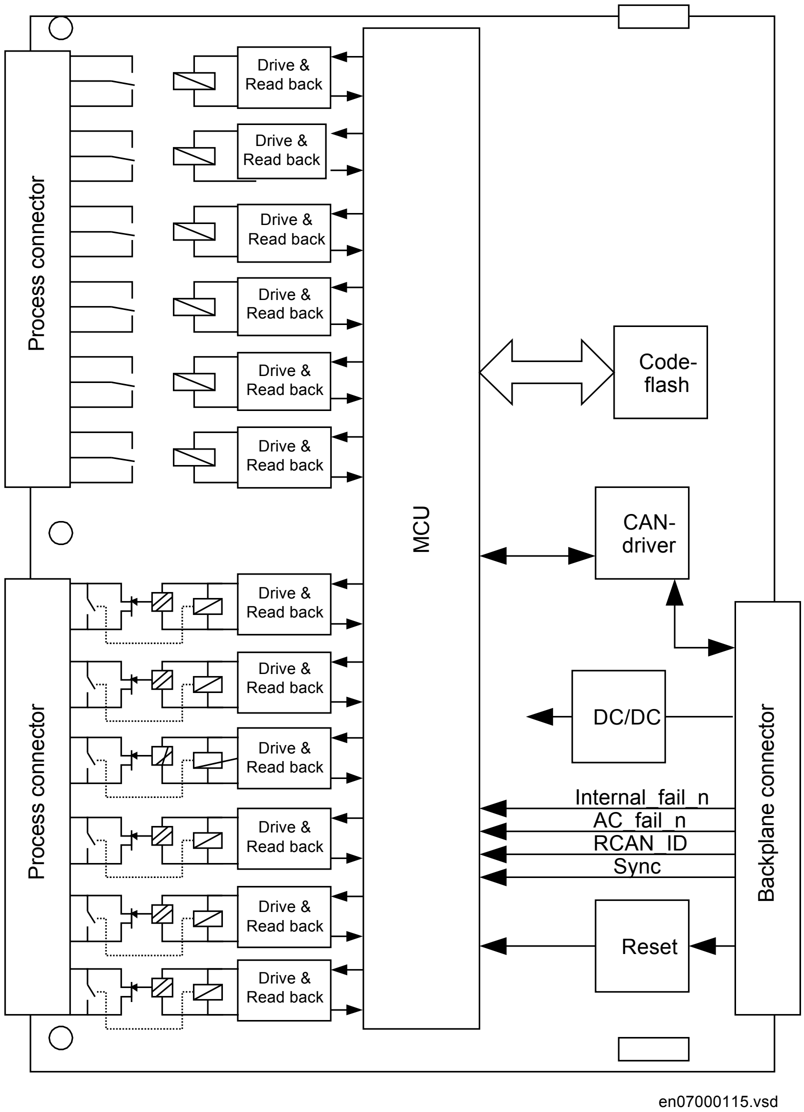


Figure 306: Block diagram of the static output module

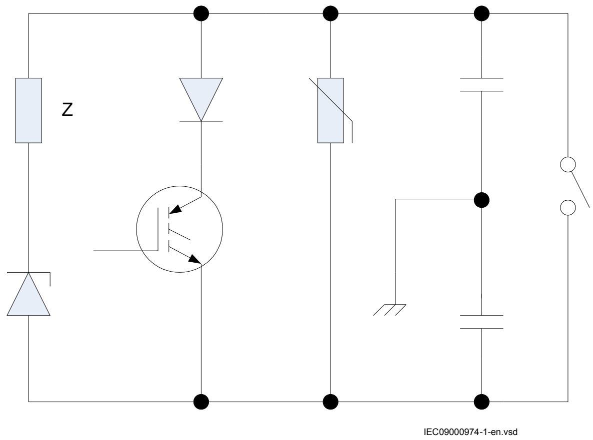


Figure 307: SOM Static output principle

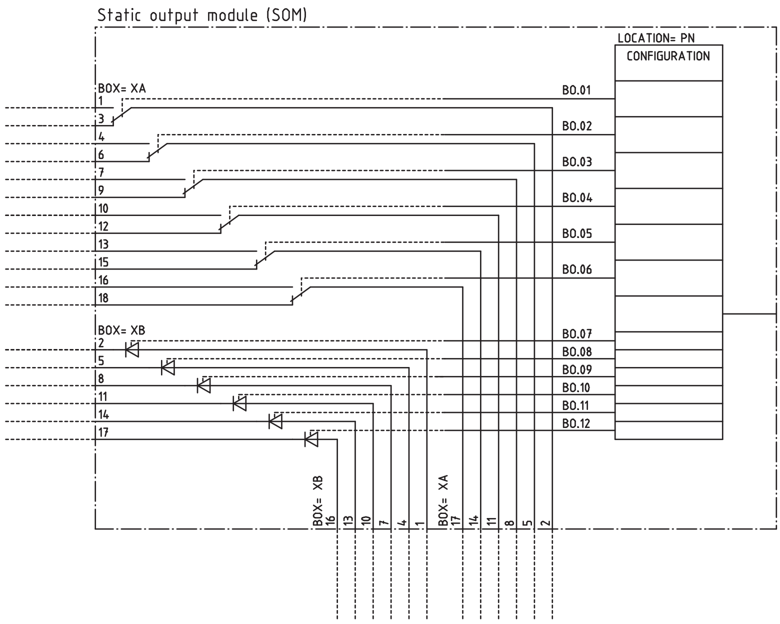


Figure 308: Connection diagram of the static output module

17.2.11.3 Technical data

Table 455: SOM - Static Output Module (reference standard: IEC 61810-2): Static binary outputs

Function of quantity	Static binary output trip	
Rated voltage	48 - 60 VDC	110 - 250 VDC
Number of outputs	6	6
Impedance open state	~300 kΩ	~810 kΩ
Test voltage across open contact, 1 min	No galvanic separation	No galvanic separation
Current carrying capacity:		

Table continues on next page

Function of quantity	Static binary output trip	
Continuous 1.0s	5A 10A	5A 10A
Making capacity at capacitive load with the maximum capacitance of 0.2 μF : 0.2s 1.0s	 30A 10A	 30A 10A
Breaking capacity for DC with L/R ≤ 40ms	48V / 1A 60V / 0,75A	110V / 0.4A 125V / 0.35A 220V / 0.2A 250V / 0.15A
Operating time	<1ms	<1ms

Table 456: SOM - Static Output module data (reference standard: IEC 61810-2): Electromechanical relay outputs

Function of quantity	Trip and signal relays
Max system voltage	250V AC/DC
Number of outputs	6
Test voltage across open contact, 1 min	1000V rms
Current carrying capacity: Continuous 1.0s	 8A 10A
Making capacity at capacitive load with the maximum capacitance of 0.2 μF: 0.2s 1.0s	 30A 10A
Breaking capacity for DC with L/R ≤ 40ms	48V / 1A 110V / 0.4A 125V / 0,35A 220V / 0,2A 250V / 0.15A

17.2.12 Binary input/output module (IOM)

17.2.12.1 Introduction

The binary input/output module is used when only a few input and output channels are needed. The ten standard output channels are used for trip output or any signaling purpose. The two high speed signal output channels are used for applications where short operating time is essential. Eight optically isolated binary inputs cater for required binary input information.

17.2.12.2 Design

The binary input/output module is available in two basic versions, one with unprotected contacts and one with MOV (Metal Oxide Varistor) protected contacts.

Inputs are designed to allow oxide burn-off from connected contacts, and increase the disturbance immunity during normal protection operate times. This is achieved with a high peak inrush current while having a low steady-state current, see figure 301. Inputs are debounced by software.

Well defined input high and input low voltages ensures normal operation at battery supply earth faults, see figure 300.

The voltage level of the inputs is selected when ordering.

I/O events are time stamped locally on each module for minimum time deviance and stored by the event recorder if present.

The binary I/O module, IOM, has eight optically isolated inputs and ten output relays. One of the outputs has a change-over contact. The nine remaining output contacts are connected in two groups. One group has five contacts with a common and the other group has four contacts with a common, to be used as single-output channels, see figure 309.

The binary I/O module also has two high speed output channels where a reed relay is connected in parallel to the standard output relay.

For configuration of the input and output signals, refer to sections "Signal matrix for binary inputs SMBI" and "Signal matrix for binary outputs SMBO".

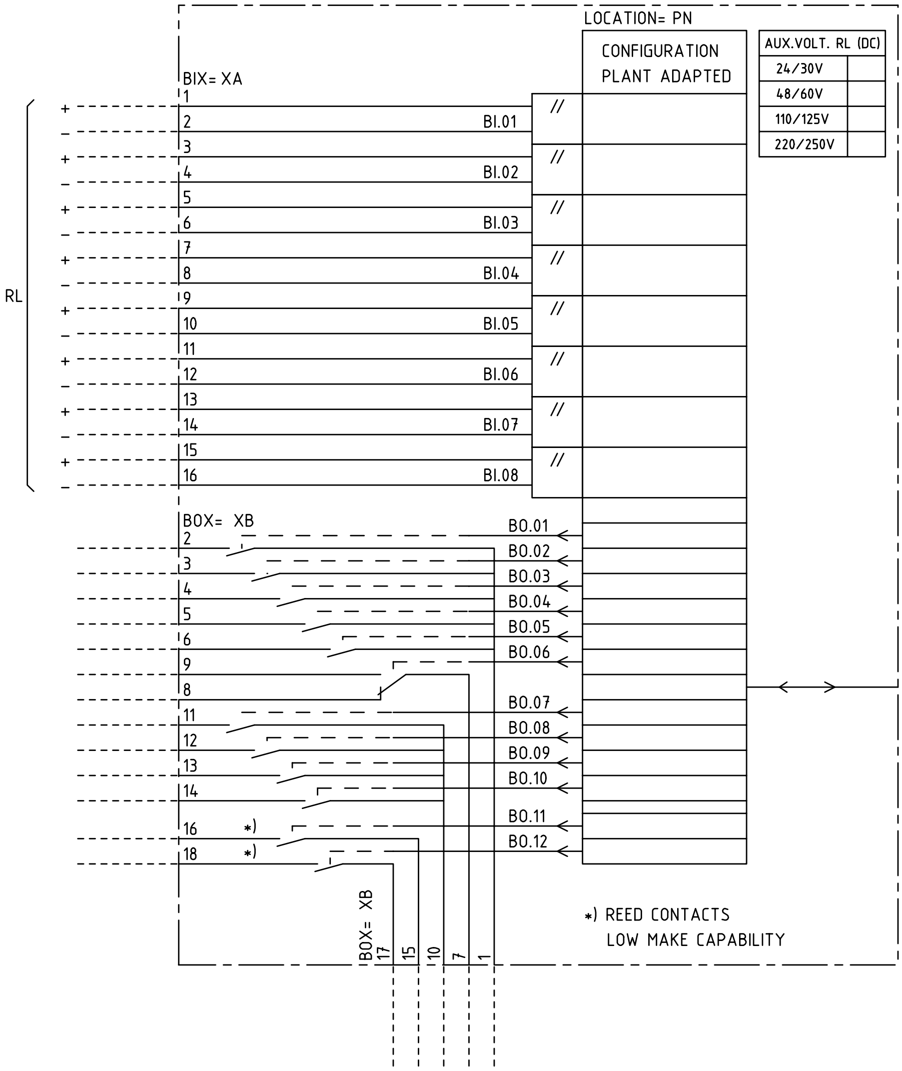


Figure 309: Binary in/out module (IOM), input contacts named XA corresponds to rear position X31, X41, and so on, and output contacts named XB to rear position X32, X42, and so on

The binary input/output module version with MOV protected contacts can for example be used in applications where breaking high inductive load would cause excessive wear of the contacts.

The test voltage across open contact is lower for this version of the binary input/output module.

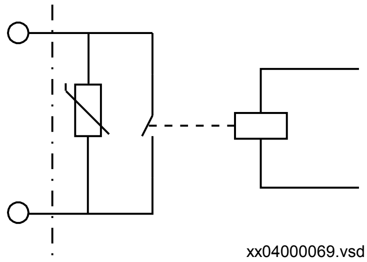


Figure 310: IOM with MOV protection, relay example

17.2.12.3 Technical data

Table 457: IOM - Binary input/output module

Quantity	Rated value	Nominal range
Binary inputs	8	-
DC voltage, RL	24/30 V 48/60 V 110/125 V 220/250 V	RL ± 20% RL ± 20% RL ± 20% RL ± 20%
Power consumption 24/30 V 48/60 V 110/125 V 220/250 V	 max. 0.05 W/input max. 0.1 W/input max. 0.2 W/input max. 0.4 W/input	-

Table 458: IOM - Binary input/output module contact data (reference standard: IEC 61810-2)

Function or quantity	Trip and signal relays	Fast signal relays (parallel reed relay)
Binary outputs	10	2
Max system voltage	250 V AC, DC	250 V AC, DC
Test voltage across open contact, 1 min	1000 V rms	800 V DC
Current carrying capacity Continuous 1 s	 8 A 10 A	 8 A 10 A
Making capacity at inductive load with L/R>10 ms 0.2 s 1.0 s	 30 A 10 A	 0.4 A 0.4 A
Breaking capacity for AC, cos φ > 0.4	250 V/8.0 A	250 V/8.0 A
Breaking capacity for DC with L/R < 40 ms	48 V/1 A 110 V/0.4 A 125 V/0.35 A 220 V/0.2 A 250 V/0.15 A	48 V/1 A 110 V/0.4 A 125 V/0.35 A 220 V/0.2 A 250 V/0.15 A
Maximum capacitive load	-	10 nF

Table 459: IOM with MOV - contact data (reference standard: IEC 60255-23)

Function or quantity	Trip and Signal relays	Fast signal relays (parallel reed relay)
Binary outputs	IOM: 10	IOM: 2
Max system voltage	250 V AC, DC	250 V AC, DC
Test voltage across open contact, 1 min	250 V rms	250 V DC
Current carrying capacity Continuous 1 s	 8 A 10 A	 8 A 10 A
Making capacity at inductive loadwith L/R>10 ms 0.2 s 1.0 s	 30 A 10 A	 0.4 A 0.4 A
Breaking capacity for AC, cos φ>0.4	250 V/8.0 A	250 V/8.0 A
Breaking capacity for DC with L/R < 40 ms	48 V/1 A 110 V/0.4 A 220 V/0.2 A 250 V/0.15 A	48 V/1 A 110 V/0.4 A 220 V/0.2 A 250 V/0.15 A
Maximum capacitive load	-	10 nF

17.2.13 mA input module (MIM)

17.2.13.1 Introduction

The milli-ampere input module is used to interface transducer signals in the –20 to +20 mA range from for example OLTC position, temperature or pressure transducers. The module has six independent, galvanically separated channels.

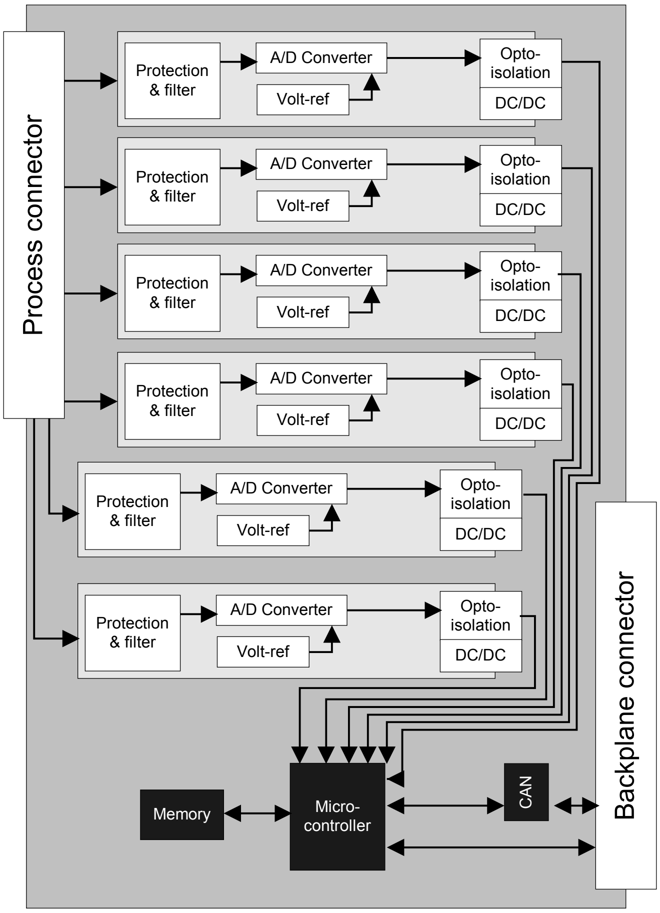
17.2.13.2 Design

The Milliampere Input Module has six independent analog channels with separated protection, filtering, reference, A/D-conversion and optical isolation for each input making them galvanically isolated from each other and from the rest of the module.

For configuration of the input signals, refer to section "Signal matrix for mA inputs SMMI".

The analog inputs measure DC current in the range of +/- 20 mA. The A/D converter has a digital filter with selectable filter frequency. All inputs are calibrated separately The filter parameters and the calibration factors are stored in a non-volatile memory on the module.

The calibration circuitry monitors the module temperature and starts an automatical calibration procedure if the temperature drift is outside the allowed range. The module communicates, like the other I/O-modules on the serial CAN-bus.



99000504.vsd

Figure 311: MIM block diagram

17.2.13.3 Technical data

Table 460: MIM - mA input module

Quantity:	Rated value:	Nominal range:
Input resistance	R_{in} = 194 Ohm	-
Input range	± 5, ± 10, ± 20mA 0-5, 0-10, 0-20, 4-20mA	-
Power consumption each mA-board each mA input	 ≤ 2 W ≤ 0.1 W	-

17.2.14 Serial and LON communication module (SLM)

17.2.14.1 Introduction

The serial and LON communication module (SLM) is used for SPA, IEC 60870-5-103, DNP3 and LON communication. The module has two optical communication ports for plastic/plastic, plastic/glass or glass/glass. One port is used for serial communication (SPA, IEC 60870-5-103 and DNP3 port or dedicated IEC 60870-5-103 port depending on ordered SLM module) and one port is dedicated for LON communication.

17.2.14.2 Design

The SLM is a PMC card and it is factory mounted as a mezzanine card on the NUM module. Three variants of the SLM is available with different combinations of optical fiber connectors, see figure 312. The plastic fiber connectors are of snap-in type and the glass fiber connectors are of ST type.

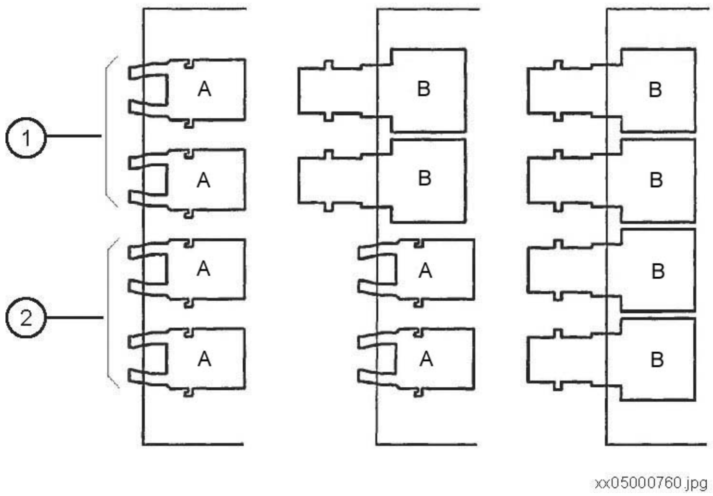


Figure 312: The SLM variants, component side view

A	Snap in connector for plastic fiber
B	ST connector for glass fiber
1	LON port
2	SPA/IEC 60870-5-103/DNP3 port or dedicated IEC 60870-5-103 port depending on ordered SLM module

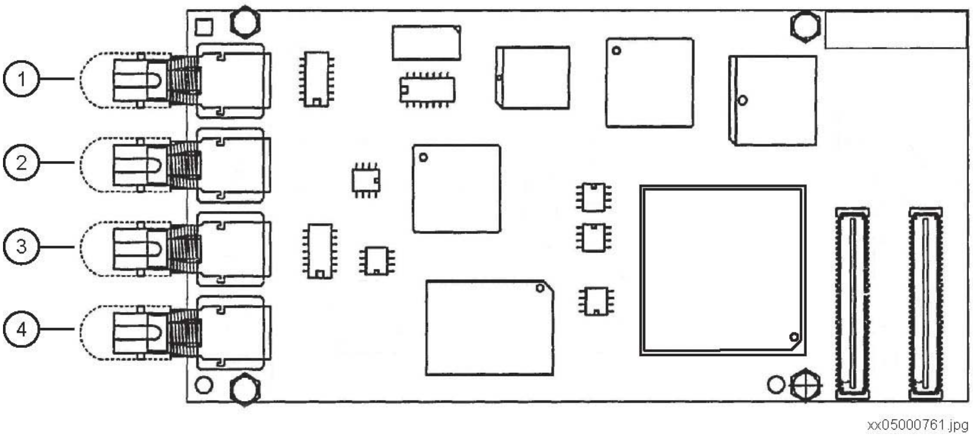


Figure 313: The SLM layout overview, component side view

1	Receiver, LON
2	Transmitter, LON
3	Receiver, SPA/IEC 60870-5-103/DNP3
4	Transmitter, SPA/IEC 60870-5-103/DNP3

Observe that when the SLM connectors are viewed from the rear side of the IED, contact 4 above is in the uppermost position and contact 1 in the lowest position.

17.2.14.3 Technical data

Table 461: SLM – LON port

Quantity	Range or value
Optical connector	Glass fibre: type ST Plastic fibre: type HFBR snap-in
Fibre, optical budget	Glass fibre: 11 dB (1000 m typically *) Plastic fibre: 7 dB (10 m typically *)
Fibre diameter	Glass fibre: 62.5/125 µm Plastic fibre: 1 mm
*) depending on optical budget calculation	

Table 462: SLM – SPA/IEC 60870-5-103/DNP3 port

Quantity	Range or value
Optical connector	Glass fibre: type ST Plastic fibre: type HFBR snap-in
Fibre, optical budget	Glass fibre: 11 dB (3000ft/1000 m typically *) Plastic fibre: 7 dB (80ft/25 m typically *)
Fibre diameter	Glass fibre: 62.5/125 μm Plastic fibre: 1 mm
*) depending on optical budget calculation	

17.2.15 Galvanic RS485 communication module

17.2.15.1 Introduction

The Galvanic RS485 communication module (RS485) is used for DNP3.0 communication. The module has one RS485 communication port. The RS485 is a balanced serial communication that can be used either in 2-wire or 4-wire connections. A 2-wire connection uses the same signal for RX and TX and is a multidrop communication with no dedicated Master or slave. This variant requires however a control of the output. The 4-wire connection has separated signals for RX and TX multidrop communication with a dedicated Master and the rest are slaves. No special control signal is needed in this case.

17.2.15.2 Design

The RS485 is a PMC card and it is factory mounted as a mezzanine card on the NUM module. The internal structure of the RS485 can be seen in figure 314:

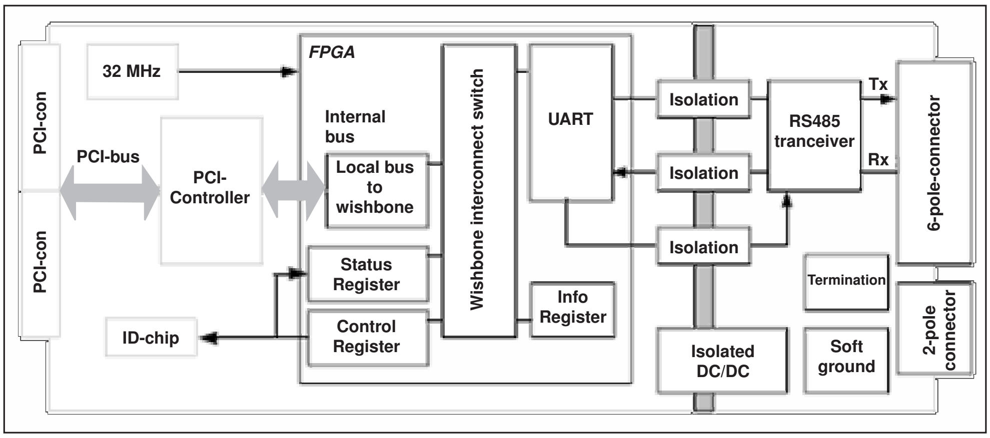


Figure 314: The internal structure of the RS485 card

RS485 connector pinouts

The arrangement for the pins in the RS485 connector (figure 315) are presented in table 463:

Table 463: The arrangement for the pins

Pin	Name 2-wire	Name 4-wire	Description
1	RS485+	TX+	Receive/transmit high or transmit high
2	RS485–	TX–	Receive/transmit
3	Term	T-Term	Termination resistor for transmitter (and receiver in 2–wir case) (connect to TX+)
4	N.A.	R-Term	Termination resistor for receiver (connect to RX +)
5	N.A.	RX–	Receive low
6	N.A.	RX+	Receive high

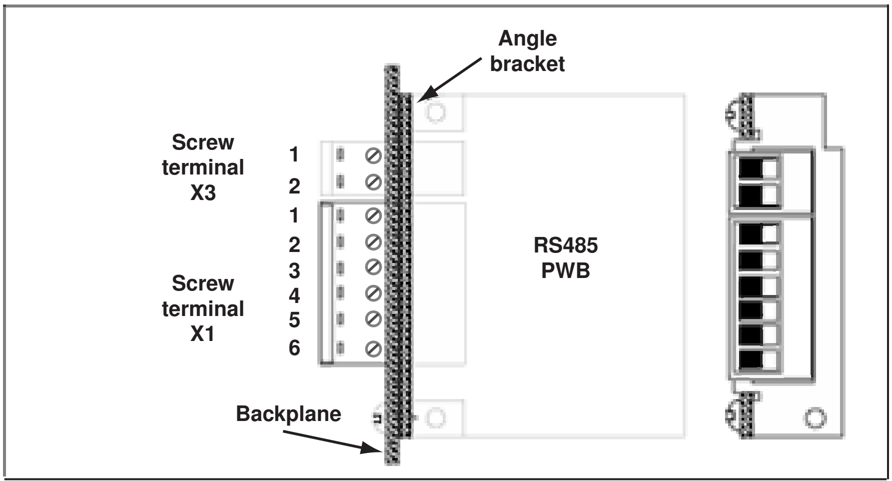


Figure 315: RS485 connector

- 2-wire: Connect pin 1 to pin 6 and pin 2 to pin 5
- Termination (2-wire): Connect pin 1 to pin 3
- Termination (4-wire): Connect pin 1 to pin 3 and pin 4 to pin 6

Soft ground connector pinouts

A second 2-pole screw connector is used for the connection of IO-ground. It can be used in two combinations like:

- Unconnected: No ground of the IO-part · .
- Soft grounded: The IO is connected to the GND with an RC net parallel with a MOV

17.2.15.3 Technical data

Table 464: Galvanic RS485 communication module

Quantity	Range or value
Communication speed	2400–19200 bauds
External connectors	RS-485 6-pole connector Soft ground 2-pole connector

17.2.16 Optical ethernet module (OEM)

17.2.16.1 Introduction

The optical fast-ethernet module is used to connect an IED to the communication buses (like the station bus) that use the IEC 61850-8-1 protocol (port A, B). The module has one or two optical ports with ST connectors.

17.2.16.2 Functionality

The Optical Ethernet module (OEM) is used when communication systems according to IEC61850–8–1 have been implemented.

17.2.16.3 Design

The Optical Ethernet module (OEM) is a PMC card and mounted as a mezzanine card on the ADM. The OEM is a 100base Fx module and available as a single channel or double channel unit.

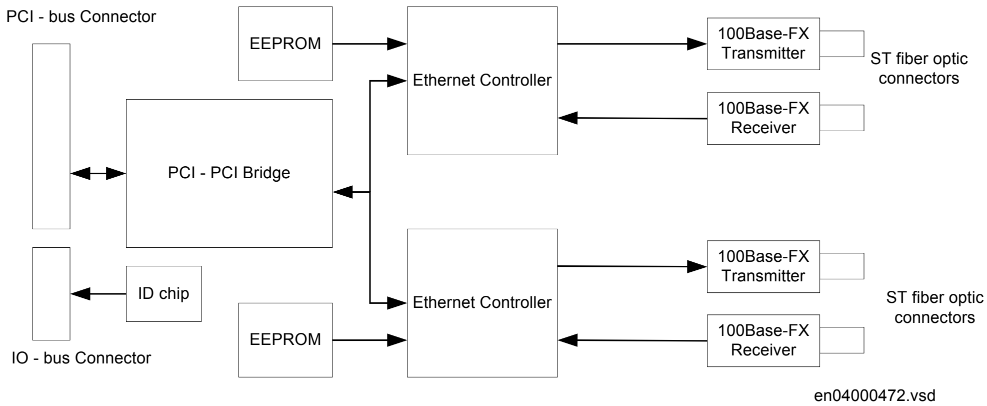


Figure 316: OEM block diagram.

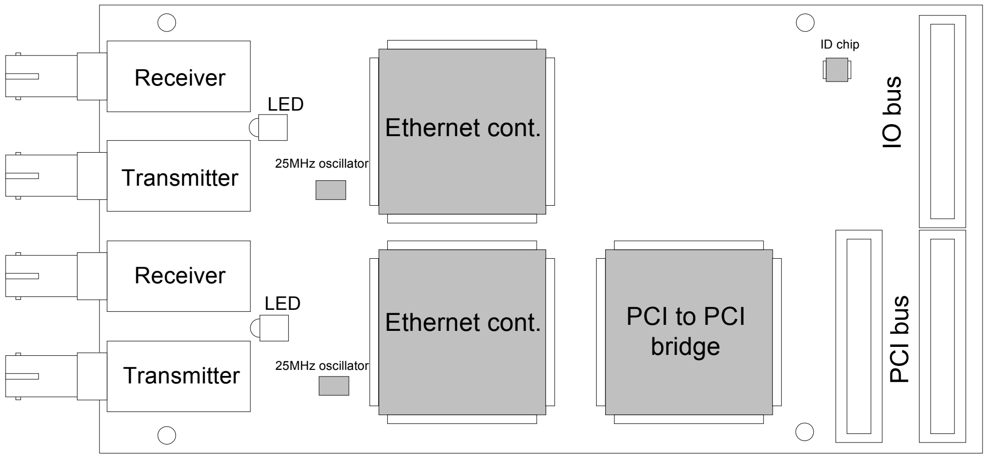


Figure 317: OEM layout, standard PMC format 2 channels

17.2.16.4 Technical data

Table 465: OEM - Optical ethernet module

Quantity	Rated value
Number of channels	1 or 2
Standard	IEEE 802.3u 100BASE-FX
Type of fiber	62.5/125 μm multimode fibre
Wave length	1300 nm
Optical connector	Type ST
Communication speed	Fast Ethernet 100 MB

17.2.17 Line data communication module (LDCM)

17.2.17.1 Introduction

The line data communication module (LDCM) is used for communication between the IEDs situated at distances <110 km or from the IED to optical to electrical converter with G.703 interface located on a distances <3 km away. The LDCM module sends and rereceives data, to and from another LDCM module. The IEEE/ ANSI standard format is used.

The line data communication module is used for binary signal transfer. The module has one optical port with ST connectors see figure 318.

Line data communication module LDCM

Each module has one optical port, one for each remote end to which the IED communicates.

Alternative cards for Short range (850 nm multi mode) are available.

Class 1 laser product. Take adequate measures to protect the eyes. Never look into the laser beam.

17.2.17.2 Design

The LDCM is a PCMIP type II single width format module. The LDCM can be mounted on:

- the ADM
- the NUM

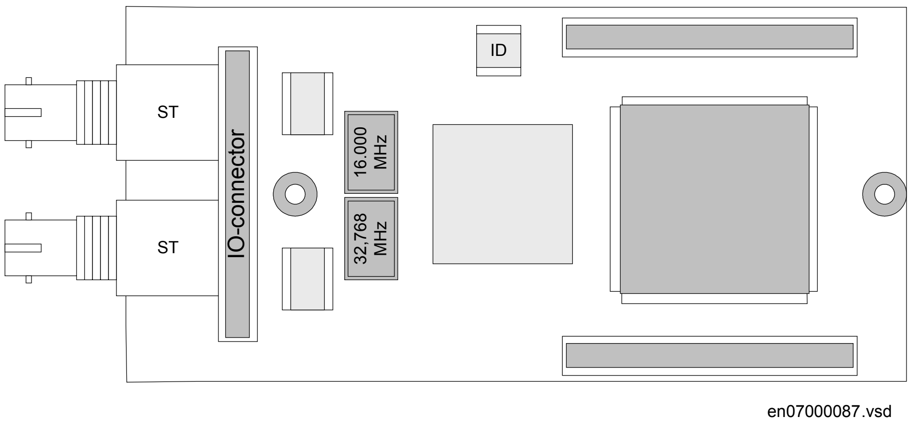


Figure 318: The SR-LDCM layout. PCMIP type II single width format with two PCI connectors and one I/O ST type connector

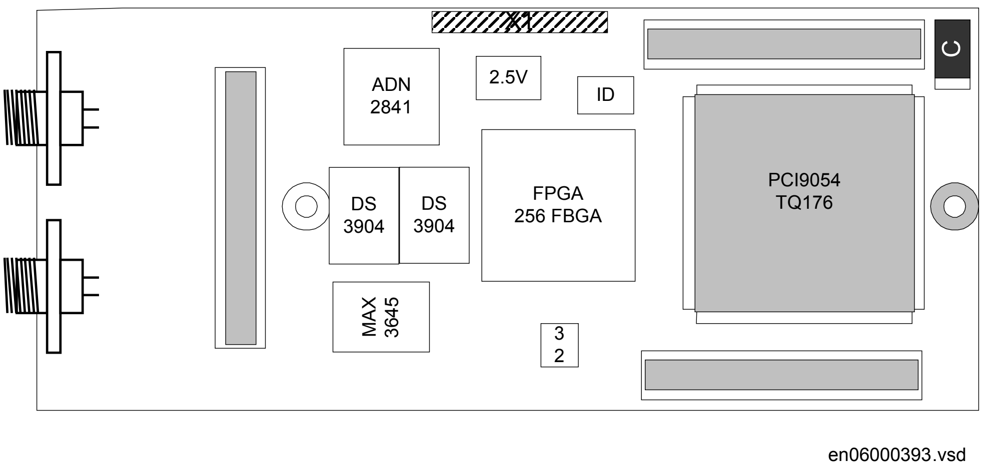


Figure 319: The MR-LDCM and LR-LDCM layout. PCMIP type II single width format with two PCI connectors and one I/O FC/PC type connector

17.2.17.3 Technical data

Table 466: Line data communication module

Characteristic	Range or value		
Type of LDCM	Short range (SR)	Medium range (MR)	Long range (LR)
Type of fibre	Graded-index multimode 62.5/125 µm or 50/125 µm	Singlemode 9/125 µm	Singlemode 9/125 µm
Wave length	850 nm	1310 nm	1550 nm
Optical budget Graded-index multimode 62.5/125 µm, Graded-index multimode 50/125 µm	13 dB (typical distance about 3 km *) 9 dB (typical distance about 2 km *)	22 dB (typical distance 80 km *)	26 dB (typical distance 110 km *)
Optical connector	Type ST	Type FC/PC	Type FC/PC
Protocol	C37.94	C37.94 implementation **)	C37.94 implementation **)
Data transmission	Synchronous	Synchronous	Synchronous
Transmission rate / Data rate	2 Mb/s / 64 kbit/s	2 Mb/s / 64 kbit/s	2 Mb/s / 64 kbit/s
Clock source	Internal or derived from received signal	Internal or derived from received signal	Internal or derived from received signal
*) depending on optical budget calculation **) C37.94 originally defined just for multimode; using same header, configuration and data format as C37.94			

17.2.18 GPS time synchronization module (GTM)

17.2.18.1 Introduction

This module includes a GPS receiver used for time synchronization. The GPS has one SMA contact for connection to an antenna. It also includes an optical PPS ST-connector output.

17.2.18.2 Design

The GTM is a PCMIP-format card and is placed only on one of the ADM slots. The antenna input connector is shielded and directly attached to a grounded plate to eliminate the risk of electromagnetic interference.

All communication between the GCM and the NUM is via the PCI-bus. PPS time data is sent from the GCM to the rest of the time system to provide 1μs accuracy at sampling level. An optical transmitter for PPS output is available for time synchronization of another relay with an optical PPS input. The PPS output connector is of ST-type for multimode fibre and could be used up to 1 km.

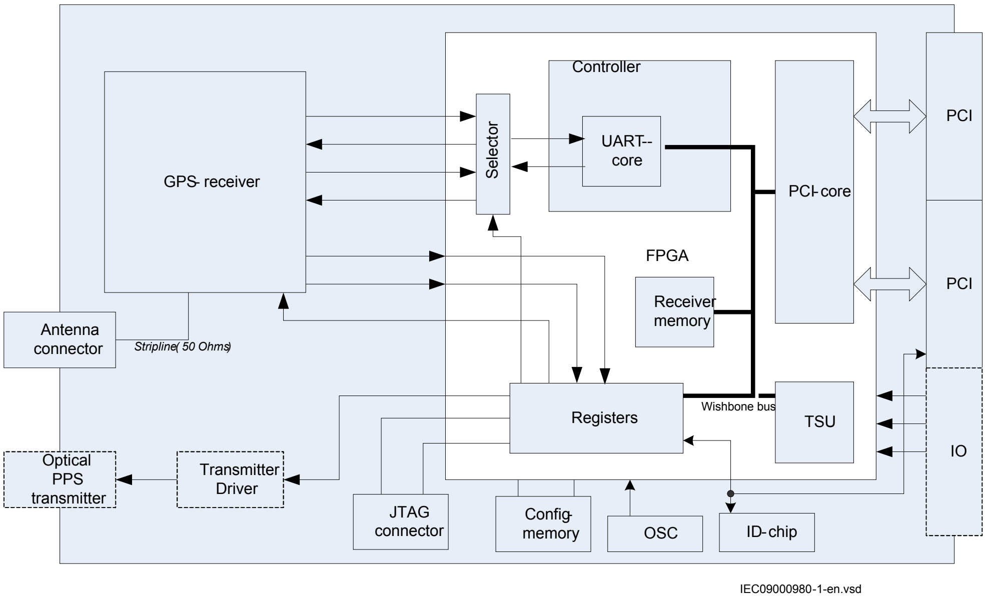


Figure 320: Block diagram of the GCM

17.2.18.3 Technical data

Table 467: GPS time synchronization module (GTM)

Function	Range or value	Accuracy
Receiver	–	±1μs relative UTC
Time to reliable time reference with antenna in new position or after power loss longer than 1 month	<30 minutes	–
Time to reliable time reference after a power loss longer than 48 hours	<15 minutes	–
Time to reliable time reference after a power loss shorter than 48 hours	<5 minutes	–

17.2.19 GPS antenna

17.2.19.1 Introduction

In order to receive GPS signals from the satellites orbiting the earth a GPS antenna with applicable cable must be used.

17.2.19.2 Design

The antenna with a console for mounting on a horizontal or vertical flat surface or on an antenna mast. See figure 321

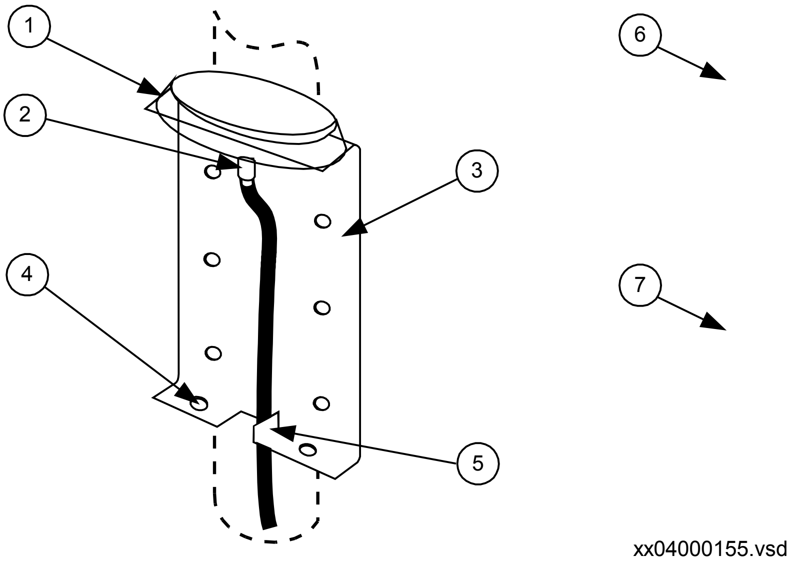


Figure 321: Antenna with console

where:

1	GPS antenna
2	TNC connector
3	Console, 78x150 mm
4	Mounting holes 5.5 mm
5	Tab for securing of antenna cable
6	Vertical mounting position
7	Horizontal mounting position

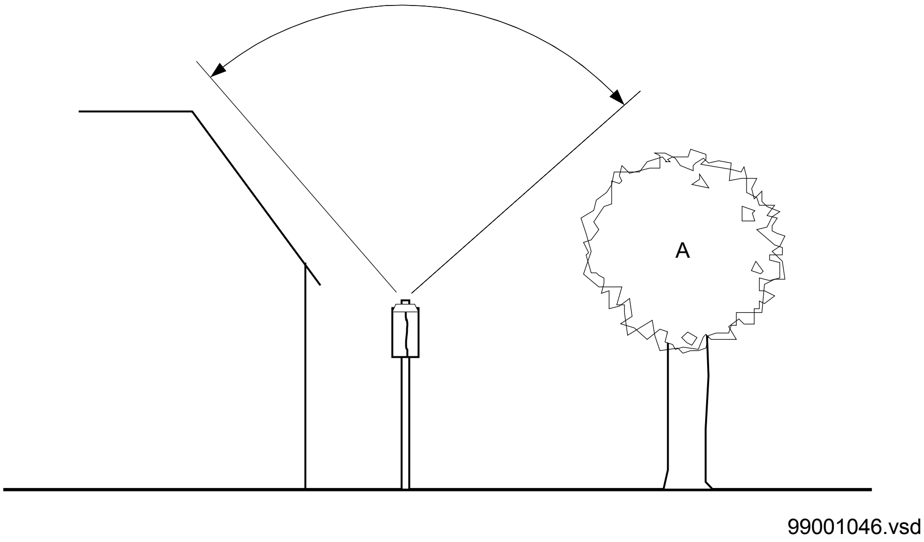


Figure 322: Antenna line-of-sight

Antenna cable

Use a 50 ohm coaxial cable with a male TNC connector in the antenna end and a male SMA connector in the receiver end to connect the antenna to GTM. Choose cable type and length so that the total attenuation is max. 26 dB at 1.6 GHz.

Make sure that the antenna cable is not charged when connected to the antenna or to the receiver. Short-circuit the end of the antenna cable with some metal device, when first connected to the antenna. When the antenna is connected to the cable, connect the cable to the receiver. REx670 must be switched off when the antenna cable is connected.

17.2.19.3 Technical data

Table 468: GPS – Antenna and cable

Function	Value
Max antenna cable attenuation	26 db @ 1.6 GHz
Antenna cable impedance	50 ohm
Lightning protection	Must be provided externally
Antenna cable connector	SMA in receiver end TNC in antenna end

17.2.20 IRIG-B time synchronization module IRIG-B

17.2.20.1 Introduction

The IRIG-B time synchronizing module is used for accurate time synchronizing of the IED from a station clock.

Electrical (BNC) and optical connection (ST) for 0XX and 12X IRIG-B support.

17.2.20.2 Design

The IRIG-B module have two inputs. One input is for the IRIG-B that can handle both a pulse-width modulated signal (also called unmodulated) and an amplitude modulated signal (also called sine wave modulated). The other is an optical input type ST for PPS to synchronize the time between several protections.

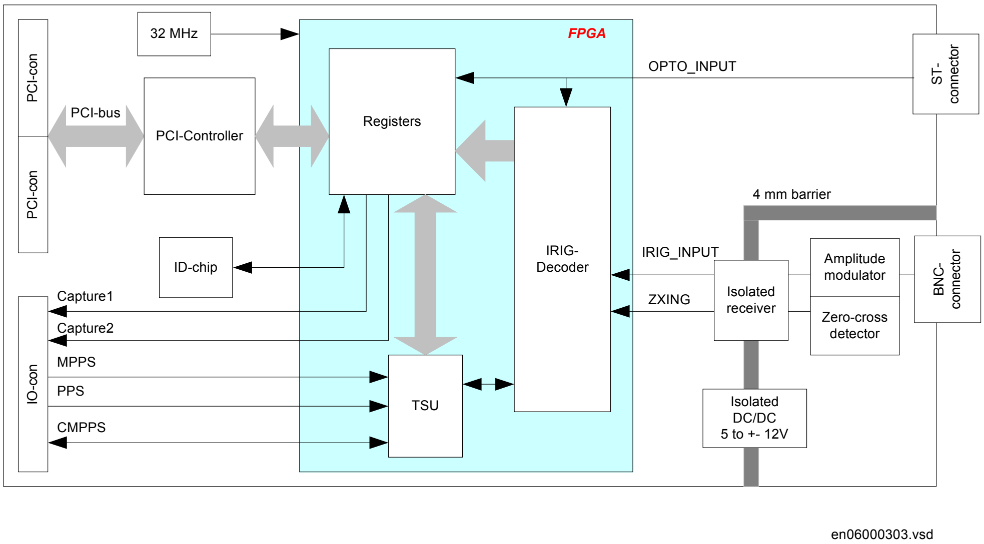


Figure 323: IRIG-B block diagram

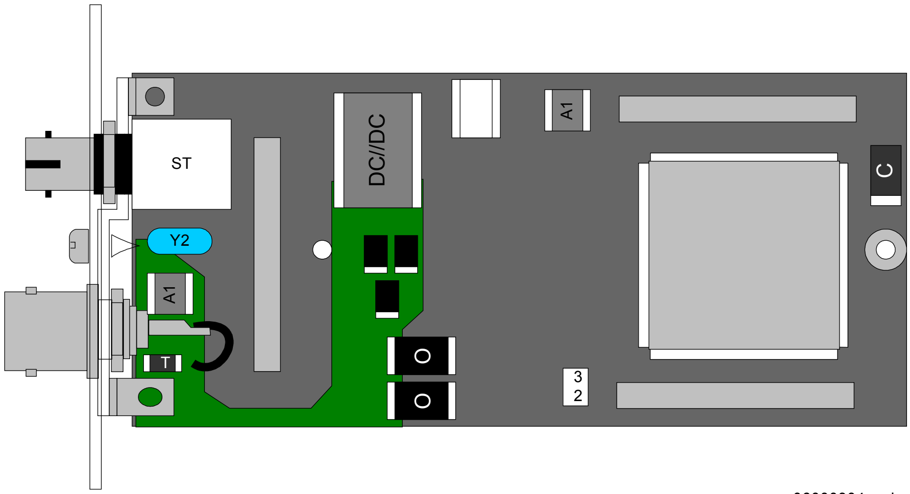


Figure 324: IRIG-B PC-MIP board with top left ST connector for PPS 820 nm multimode fibre optic signal input and lower left BNC connector for IRIG-B signal input

17.2.20.3 Technical data

Table 469: IRIG-B

Quantity	Rated value
Number of channels IRIG-B	1
Number of channels PPS	1
Electrical connector IRIG-B	BNC
Optical connector PPS and IRIG-B	Type ST
Type of fibre	62.5/125 μm multimode fibre

17.3 Dimensions

17.3.1 Case without rear cover

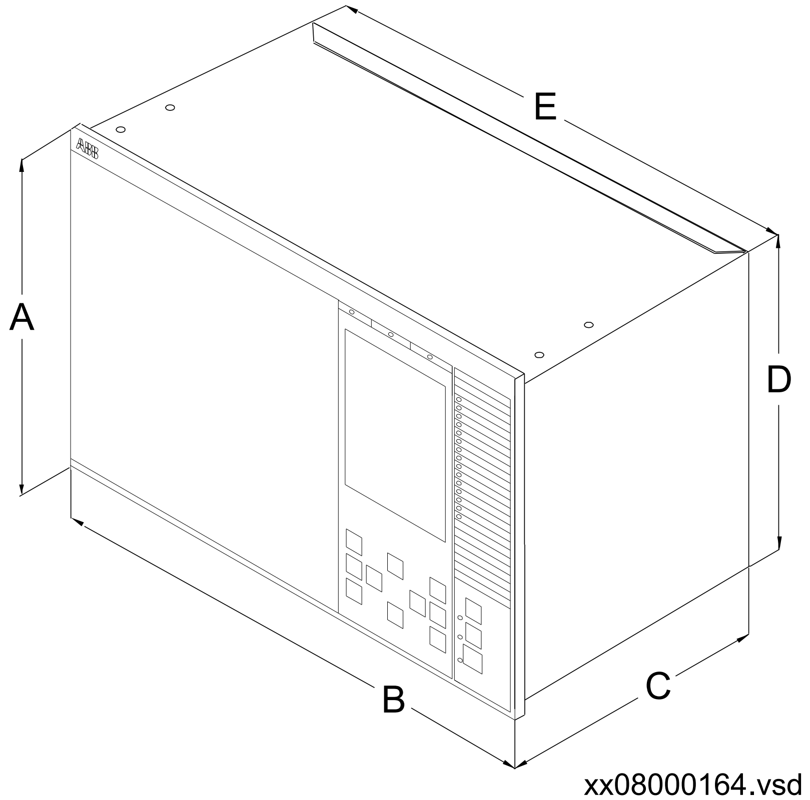


Figure 325: Case without rear cover

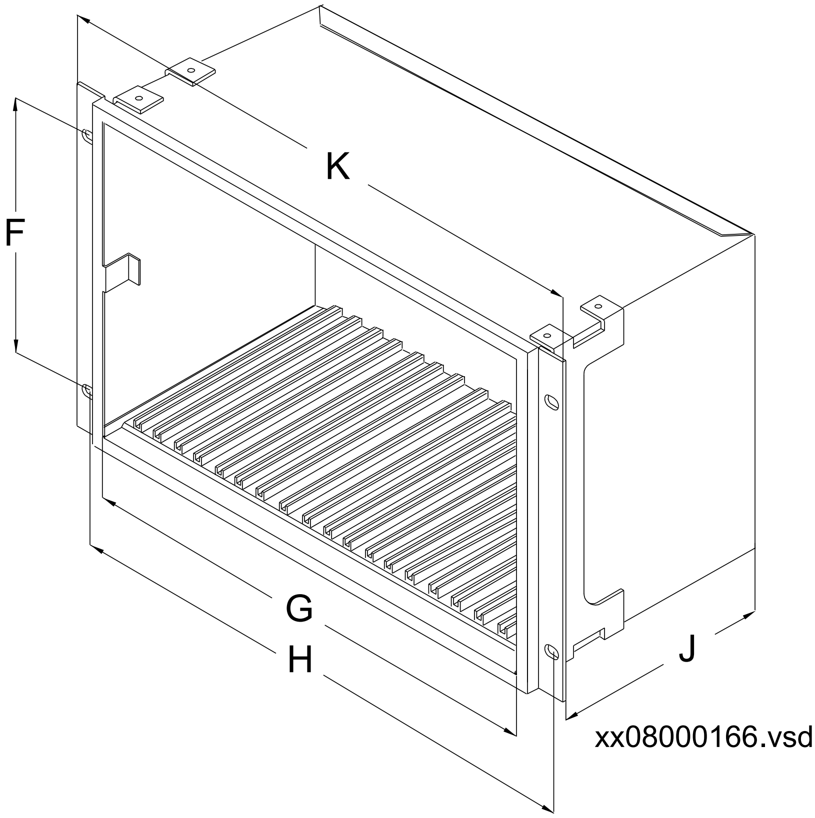


Figure 326: Case without rear cover with 19” rack mounting kit

Case size (mm)	A	B	C	D	E	F	G	H	J	K
6U, 1/2 x 19”	265.9	223.7	201.1	252.9	205.7	190.5	203.7	-	187.6	-
6U, 3/4 x 19”	265.9	336.0	201.1	252.9	318.0	190.5	316.0	-	187.6	-
6U, 1/1 x 19”	265.9	448.3	201.1	252.9	430.3	190.5	428.3	465.1	187.6	482.6
The H and K dimensions are defined by the 19” rack mounting kit										

17.3.2 Case with rear cover

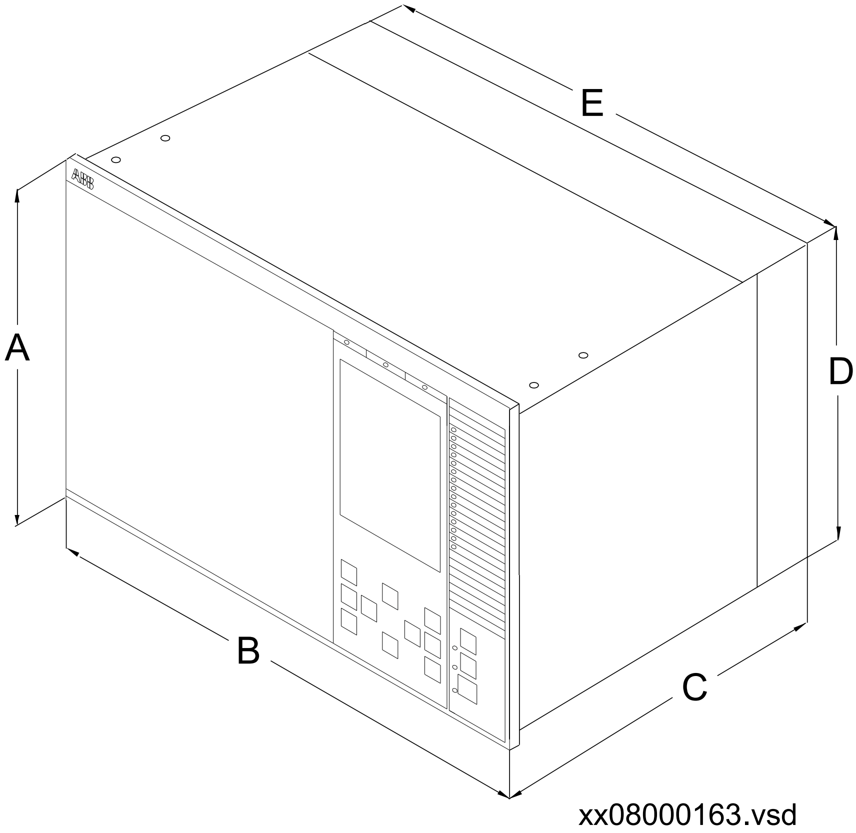


Figure 327: Case with rear cover

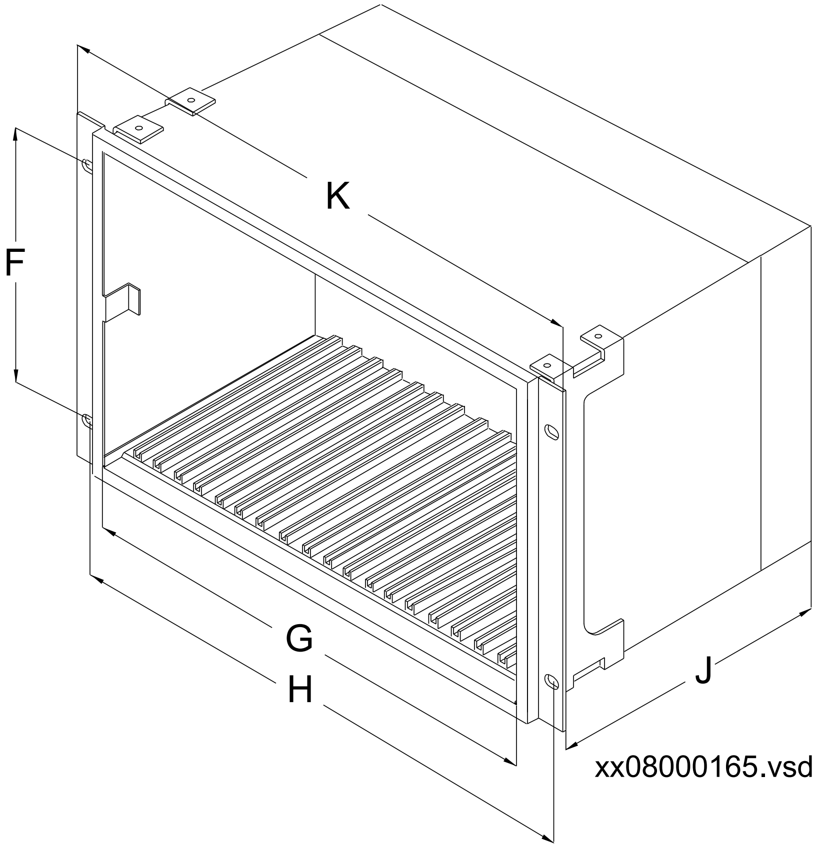


Figure 328: Case with rear cover and 19” rack mounting kit

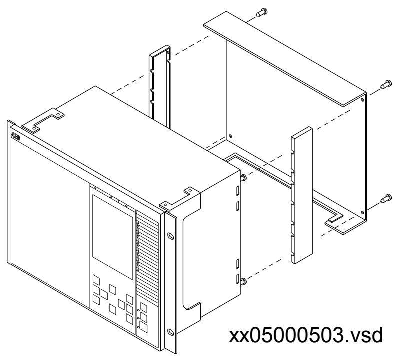


Figure 329: Rear cover case with details

Case size (mm)	A	B	C	D	E	F	G	H	J	K
6U, 1/2 x 19”	265.9	223.7	242.1	255.8	205.7	190.5	203.7	-	228.6	-
6U, 3/4 x 19”	265.9	336.0	242.1	255.8	318.0	190.5	316.0	-	228.6	-
6U, 1/1 x 19”	265.9	448.3	242.1	255.8	430.3	190.5	428.3	465.1	228.6	482.6
The H and K dimensions are defined by the 19” rack mounting kit.										

17.3.3 Flush mounting dimensions

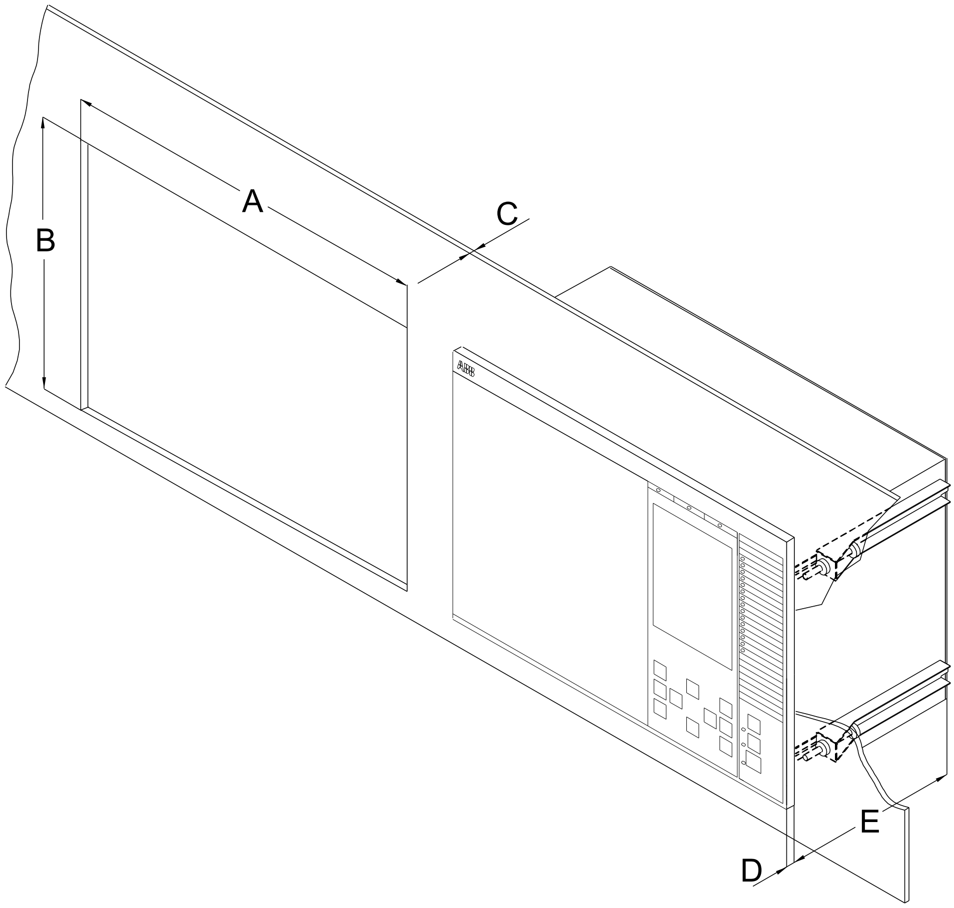


Figure 330: Flush mounting

Case size Tolerance	Cut-out dimensions (mm)			
	A +/-1	B +/-1	C	D
6U, 1/2 x 19"	210.1	254.3	4.0-10.0	12.5
6U, 3/4 x 19"	322.4	254.3	4.0-10.0	12.5
6U, 1/1 x 19"	434.7	254.3	4.0-10.0	12.5
E = 188.6 mm without rear protection cover, 229.6 mm with rear protection cover				

17.3.4 Side-by-side flush mounting dimensions

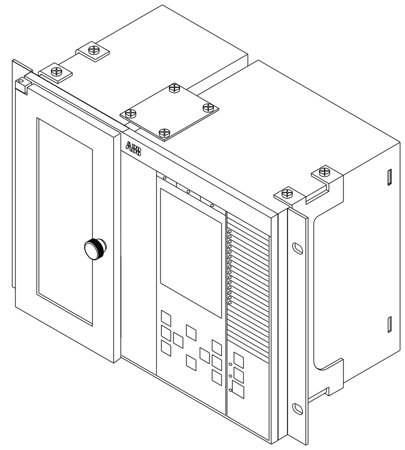


Figure 331: A 1/2 x 19” size 670 series IED side-by-side with RHGS6.

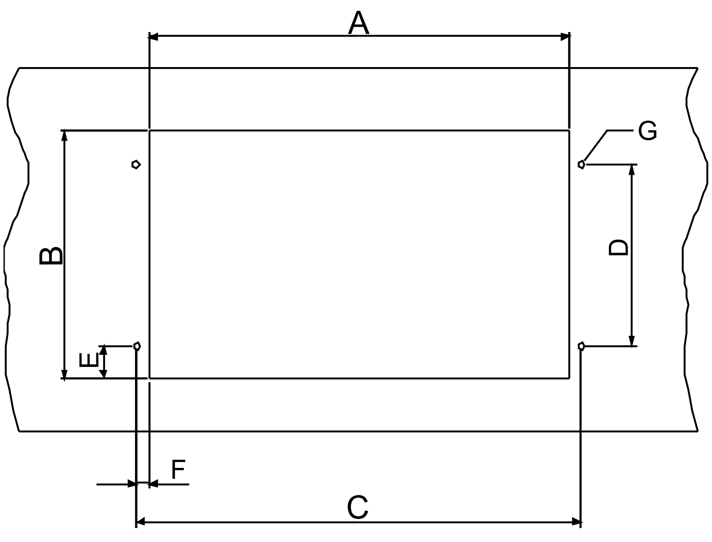


Figure 332: Panel-cut out dimensions for side-by-side flush mounting

Case size (mm) Tolerance	A ±1	B ±1	C ±1	D ±1	E ±1	F ±1	G ±1
6U, 1/2 x 19”	214.0	259.3	240.4	190.5	34.4	13.2	6.4 diam
6U, 3/4 x 19”	326.4	259.3	352.8	190.5	34.4	13.2	6.4 diam
6U, 1/1 x 19”	438.7	259.3	465.1	190.5	34.4	13.2	6.4 diam

17.3.5 Wall mounting dimensions

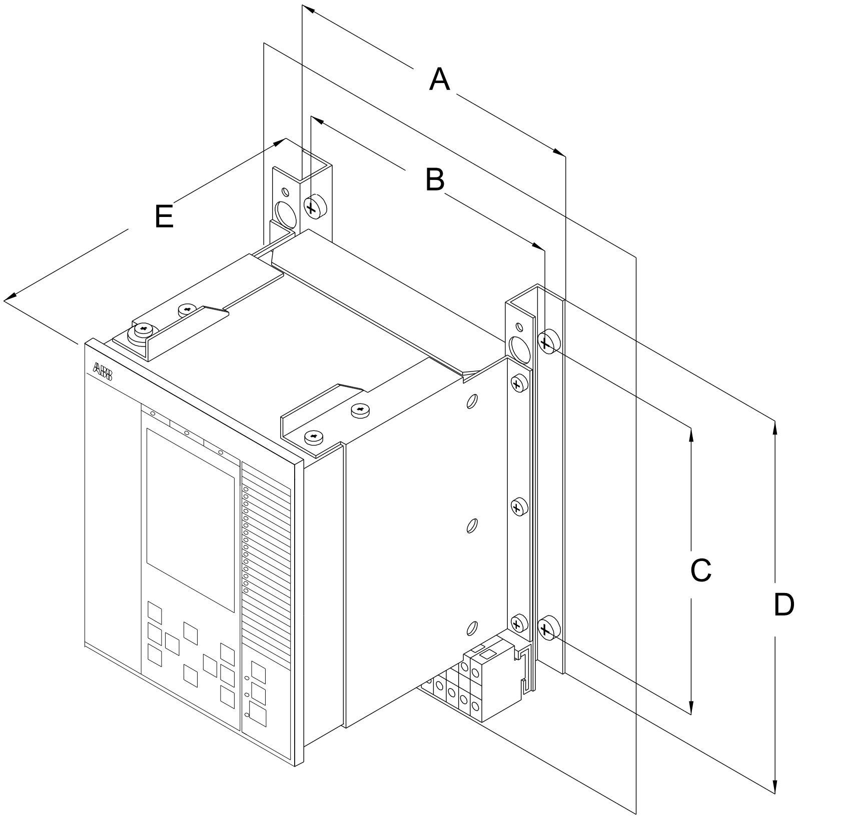


Figure 333: Wall mounting

Case size (mm)	A	B	C	D	E
6U, 1/2 x 19”	292.0	267.1	272.8	390.0	243.0
6U, 3/4 x 19”	404.3	379.4	272.8	390.0	243.0
6U, 1/1 x 19”	516.0	491.1	272.8	390.0	243.0

17.3.6 External current transformer unit

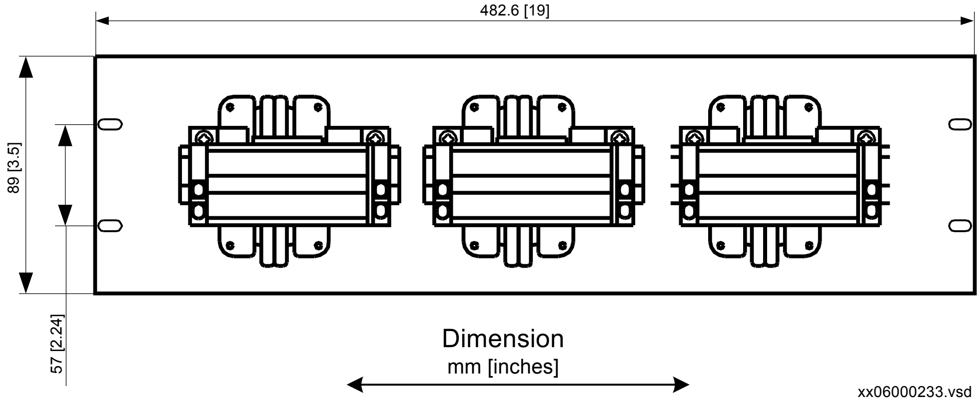


Figure 334: Dimension drawing of summation current transformers

17.4 Mounting alternatives

17.4.1 Flush mounting

17.4.1.1 Overview

The flush mounting kit are utilized for case sizes:

- 1/2 x 19”
- 3/4 x 19”
- 1/1 x 19”
- 1/4 x 19” (RHGS6 6U)

Only a single case can be mounted in each cut-out on the cubicle panel, for class IP54 protection.

Flush mounting cannot be used for side-by-side mounted IEDs when IP54 class must be fulfilled. Only IP20 class can be obtained when mounting two cases side-by-side in one (1) cut-out.

To obtain IP54 class protection, an additional factory mounted sealing must be ordered when ordering the IED.

17.4.1.2 Mounting procedure for flush mounting

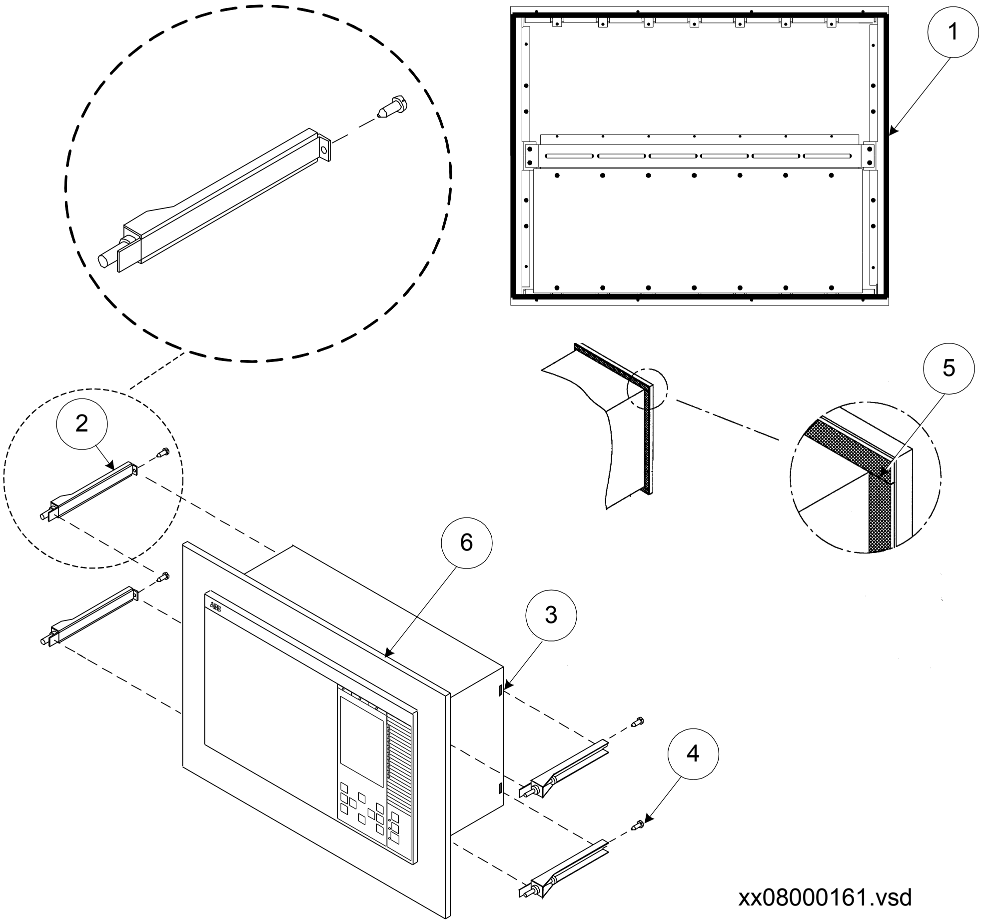


Figure 335: Flush mounting details.

PosNo	Description	Quantity	Type
1	Sealing strip, used to obtain IP54 class. The sealing strip is factory mounted between the case and front plate.	-	-
2	Fastener	4	-
3	Groove	-	-
4	Screw, self tapping	4	2.9x9.5 mm
5	Joining point of sealing strip	-	-
6	Panel	-	-

17.4.2 19” panel rack mounting

17.4.2.1 Overview

All IED sizes can be mounted in a standard 19” cubicle rack by using the for each size suited mounting kit which consists of two mounting angles and fastening screws for the angles.

Please note that the separately ordered rack mounting kit for side-by-side mounted IEDs, or IEDs together with RHGS cases, is to be selected so that the total size equals 19”.

When mounting the mounting angles, be sure to use screws that follows the recommended dimensions. Using screws with other dimensions than the original may damage the PCBs inside the IED.

17.4.2.2 Mounting procedure for 19” panel rack mounting

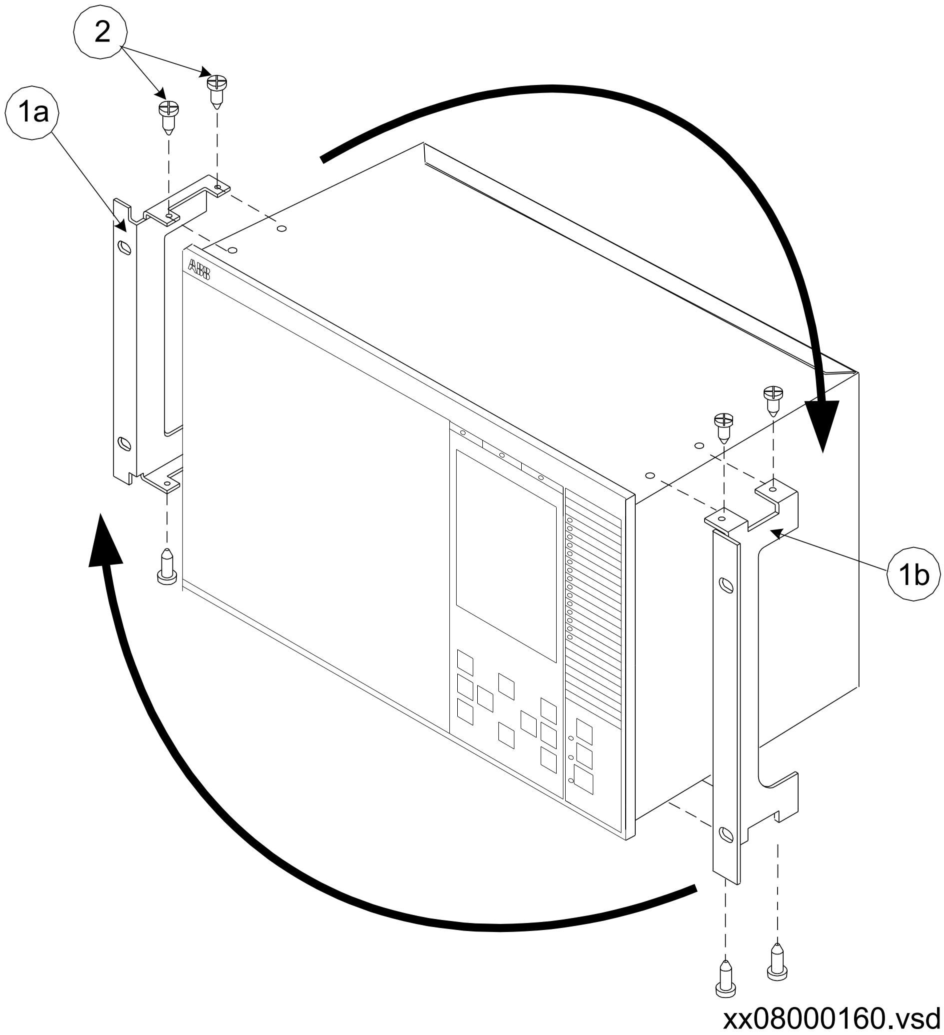


Figure 336: 19” panel rack mounting details

Pos	Description	Quantity	Type
1a, 1b	Mounting angels, which can be mounted, either to the left or right side of the case.	2	-
2	Screw	8	M4x6

17.4.3 Wall mounting

17.4.3.1 Overview

All case sizes, 1/2 x 19”, 3/4 x 19” and 1/1 x 19”, can be wall mounted. It is also possible to mount the IED on a panel or in a cubicle.

When mounting the side plates, be sure to use screws that follows the recommended dimensions. Using screws with other dimensions than the original may damage the PCBs inside the IED.

If fiber cables are bent too much, the signal can be weakened. Wall mounting is therefore not recommended for communication modules with fiber connection; Serial SPA/IEC 60870-5-103, DNP3 and LON communication module (SLM), Optical Ethernet module (OEM) and Line data communication module (LDCM).

17.4.3.2 Mounting procedure for wall mounting

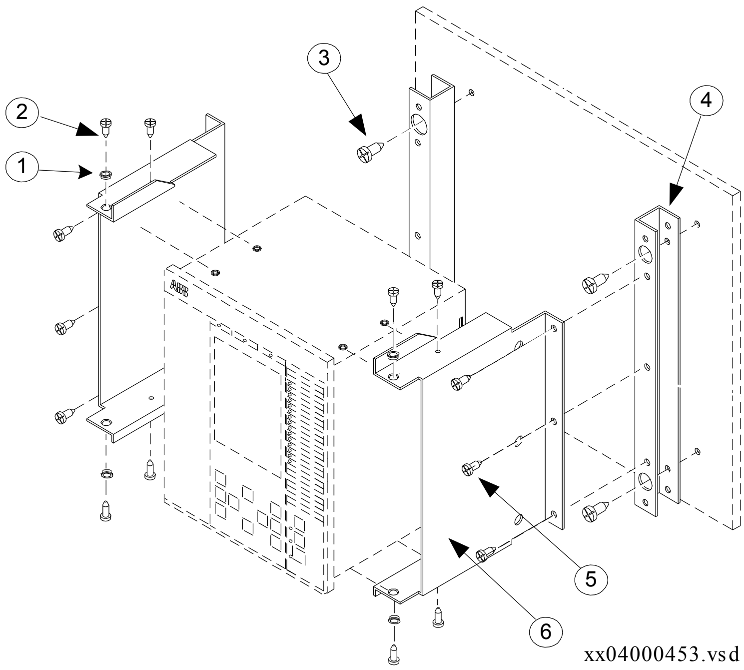


Figure 337: Wall mounting details.

PosNo	Description	Quantity	Type
1	Bushing	4	-
2	Screw	8	M4x10
3	Screw	4	M6x12 or corresponding

Table continues on next page

4	Mounting bar	2	-
5	Screw	6	M5x8
6	Side plate	2	-

17.4.3.3 How to reach the rear side of the IED

The IED can be equipped with a rear protection cover, which is recommended to use with this type of mounting. See figure 338.

To reach the rear side of the IED, a free space of 80 mmis required on the unhinged side.

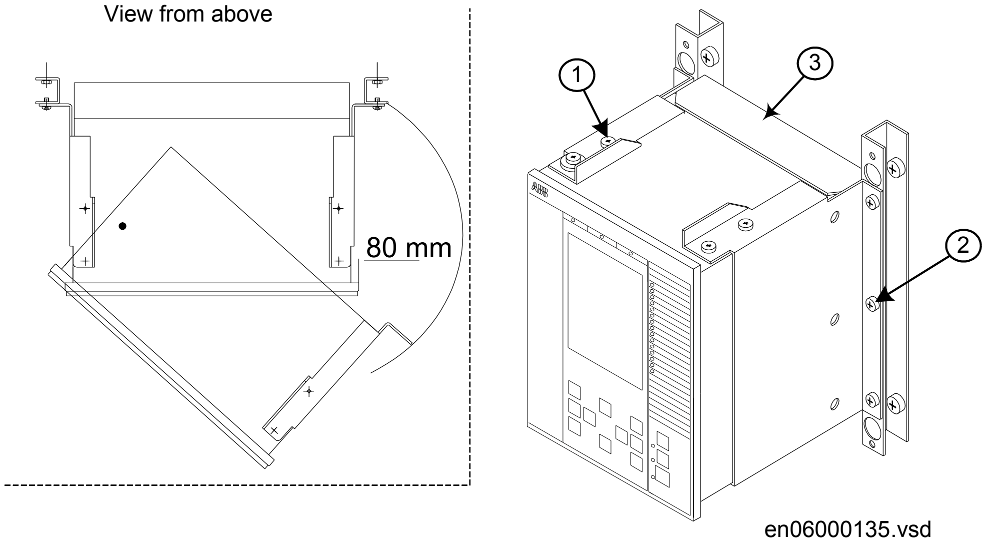


Figure 338: How to reach the connectors on the rear side of the IED.

PosNo	Description	Type
1	Screw	M4x10
2	Screw	M5x8
3	Rear protection cover	-

17.4.4 Side-by-side 19” rack mounting

17.4.4.1 Overview

IED case sizes, 1/2 x 19” or 3/4 x 19” and RHGS cases, can be mounted side-by-side up to a maximum size of 19”. For side-by-side rack mounting, the side-by-side mounting kit together with the 19” rack panel mounting kit must be used. The mounting kit has to be ordered separately.

When mounting the plates and the angles on the IED, be sure to use screws that follows the recommended dimensions. Using screws with other dimensions than the original may damage the PCBs inside the IED.

17.4.4.2 Mounting procedure for side-by-side rack mounting

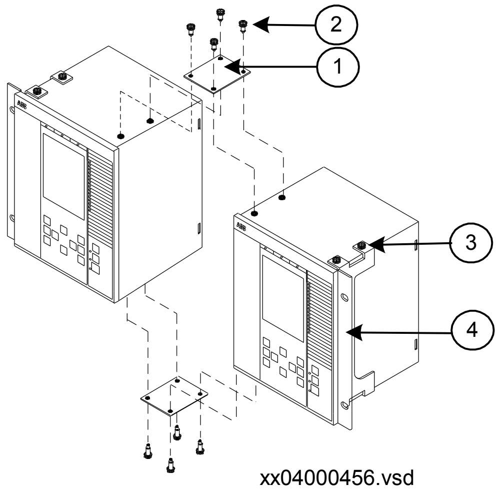


Figure 339: Side-by-side rack mounting details.

PosNo	Description	Quantity	Type
1	Mounting plate	2	-
2, 3	Screw	16	M4x6
4	Mounting angle	2	-

17.4.4.3 IED in the 670 series mounted with a RHGS6 case

An 1/2 x 19” or 3/4 x 19” size IED can be mounted with a RHGS (6 or 12 depending on IED size) case. The RHGS case can be used for mounting a test switch of type RTXP 24. It also has enough space for a terminal base of RX 2 type for mounting of, for example, a DC-switch or two trip IEDs.

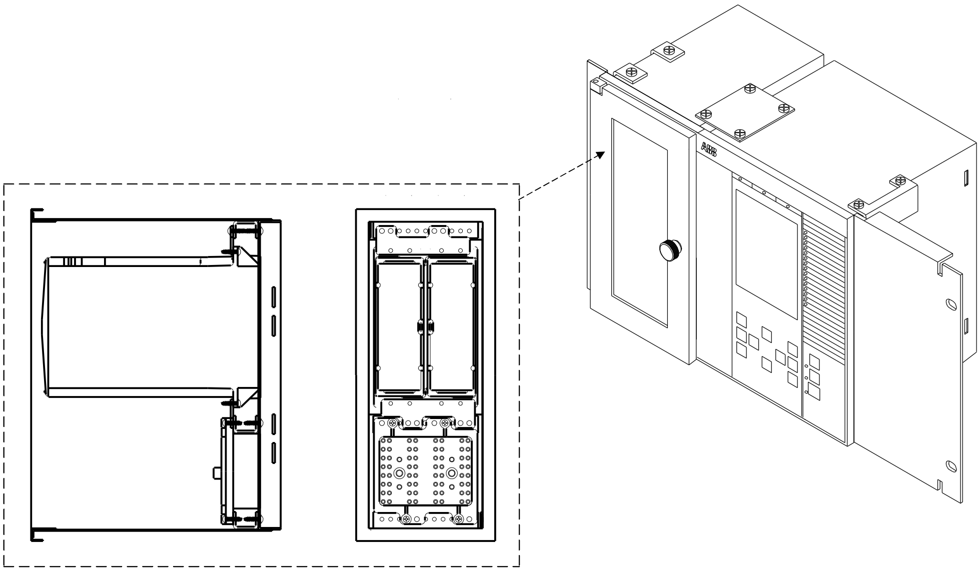


Figure 340: IED in the 670 series (1/2 x 19”) mounted with a RHGS6 case containing a test switch module equipped with only a test switch and a RX2 terminal base

17.4.5 Side-by-side flush mounting

17.4.5.1 Overview

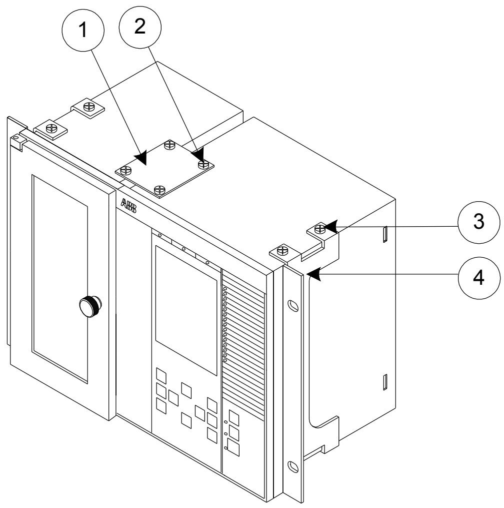
It is not recommended to flush mount side by side mounted cases if IP54 is required. If your application demands side-by-side flush mounting, the side-by-side mounting details kit and the 19” panel rack mounting kit must be used. The mounting kit has to be ordered separately. The maximum size of the panel cut out is 19”.

With side-by-side flush mounting installation, only IP class 20 is obtained. To reach IP class 54, it is recommended to mount the IEDs separately. For cut out dimensions of separately mounted IEDs, see section "Flush mounting".

When mounting the plates and the angles on the IED, be sure to use screws that follows the recommended dimensions. Using screws with other dimensions than the original may damage the PCBs inside the IED.

Please contact factory for special add on plates for mounting FT switches on the side (for 1/2 19" case) or bottom of the relay.

17.4.5.2 Mounting procedure for side-by-side flush mounting



xx06000181.vsd

Figure 341: Side-by-side flush mounting details (RHGS6 side-by-side with 1/2 x 19” IED).

PosNo	Description	Quantity	Type
1	Mounting plate	2	-
2, 3	Screw	16	M4x6
4	Mounting angle	2	-

17.5 Technical data

17.5.1 Enclosure

Table 470: Case

Material	Steel sheet
Front plate	Steel sheet profile with cut-out for HMI
Surface treatment	Aluzink preplated steel
Finish	Light grey (RAL 7035)

Table 471: Water and dust protection level according to IEC 60529

Front	IP40 (IP54 with sealing strip)
Rear, sides, top and bottom	IP20

Table 472: Weight

Case size	Weight
6U, 1/2 x 19”	≤ 10 kg
6U, 3/4 x 19”	≤ 15 kg
6U, 1/1 x 19”	≤ 18 kg

17.5.2 Connection system

Table 473: CT and VT circuit connectors

Connector type	Rated voltage and current	Maximum conductor area
Screw compression type	250 V AC, 20 A	4 mm^2 (AWG12) 2 x 2.5 mm^2 (2 x AWG14)
Terminal blocks suitable for ring lug terminals	250 V AC, 20 A	4 mm^2 (AWG12)

Table 474: Binary I/O connection system

Connector type	Rated voltage	Maximum conductor area
Screw compression type	250 V AC	2.5 mm^2 (AWG14) 2 × 1 mm^2 (2 x AWG18)
Terminal blocks suitable for ring lug terminals	300 V AC	3 mm^2 (AWG14)

Because of limitations of space, when ring lug terminal is ordered for Binary I/O connections, one blank slot is necessary between two adjacent IO cards. Please refer to the ordering particulars for details.

17.5.3 Influencing factors

Table 475: Temperature and humidity influence

Parameter	Reference value	Nominal range	Influence
Ambient temperature, operate value	+20 °C	-10 °C to +55 °C	0.02% /°C
Relative humidity Operative range	10%-90% 0%-95%	10%-90%	-
Storage temperature	-40 °C to +70 °C	-	-

Table 476: Auxiliary DC supply voltage influence on functionality during operation

Dependence on	Reference value	Within nominal range	Influence
Ripple, in DC auxiliary voltage Operative range	max. 2% Full wave rectified	15% of EL	0.01% /%
Auxiliary voltage dependence, operate value		± 20% of EL	0.01% /%
Interrupted auxiliary DC voltage		24-60 V DC ± 20% 90-250 V DC ± 20%	
Interruption interval 0–50 ms			No restart
0–∞ s			Correct behaviour at power down
Restart time			<180 s

Table 477: Frequency influence (reference standard: IEC 60255–1)

Dependence on	Within nominal range	Influence
Frequency dependence, operate value	f_r ± 2.5 Hz for 50 Hz f_r ± 3.0 Hz for 60 Hz	± 1.0% / Hz
Frequency dependence for differential protection	f_r ± 2.5 Hz for 50 Hz f_r ± 3.0 Hz for 50 Hz	± 2.0% / Hz
Harmonic frequency dependence (20% content)	2nd, 3rd and 5th harmonic of f_r	± 1.0%
Harmonic frequency dependence for differential protection (10% content)	2nd, 3rd and 5th harmonic of f_r	± 6.0%

17.5.4 Type tests according to standard

Table 478: Electromagnetic compatibility

Test	Type test values	Reference standards
1 MHz burst disturbance	2.5 kV	IEC 60255-22-1
100 kHz slow damped oscillatory wave immunity test	2.5 kV	IEC 61000-4-18, Class III
Ring wave immunity test, 100 kHz	2-4 kV	IEC 61000-4-12, Class IV
Surge withstand capability test	2.5 kV, oscillatory 4.0 kV, fast transient	IEEE/ANSI C37.90.1
Electrostatic discharge Direct application Indirect application	15 kV air discharge 8 kV contact discharge 8 kV contact discharge	IEC 60255-22-2, Class IV IEC 61000-4-2, Class IV
Electrostatic discharge Direct application Indirect application	15 kV air discharge 8 kV contact discharge 8 kV contact discharge	IEEE/ANSI C37.90.1
Table continues on next page		

Test	Type test values	Reference standards
Fast transient disturbance	4 kV	IEC 60255-22-4, Class A
Surge immunity test	1-2 kV, 1.2/50 μs high energy	IEC 60255-22-5
Power frequency immunity test	150-300 V, 50 Hz	IEC 60255-22-7, Class A
Conducted common mode immunity test	15 Hz-150 kHz	IEC 61000-4-16, Class IV
Power frequency magnetic field test	1000 A/m, 3 s 100 A/m, cont.	IEC 61000-4-8, Class V
Damped oscillatory magnetic field test	100 A/m	IEC 61000-4-10, Class V
Radiated electromagnetic field disturbance	20 V/m, 80-1000 MHz 1.4-2.7 GHz	IEC 60255-22-3
Radiated electromagnetic field disturbance	35 V/m 26-1000 MHz	IEEE/ANSI C37.90.2
Conducted electromagnetic field disturbance	10 V, 0.15-80 MHz	IEC 60255-22-6
Radiated emission	30-1000 MHz	IEC 60255-25
Conducted emission	0.15-30 MHz	IEC 60255-25

Table 479: Insulation

Test	Type test values	Reference standard
Dielectric test	2.0 kV AC, 1 min.	IEC 60255-5
Impulse voltage test	5 kV, 1.2/50 μs, 0.5 J	
Insulation resistance	>100 MΩ at 500 VDC	

Table 480: Environmental tests

Test	Type test value	Reference standard
Cold test	Test Ad for 16 h at -25°C	IEC 60068-2-1
Storage test	Test Ad for 16 h at -40°C	IEC 60068-2-1
Dry heat test	Test Bd for 16 h at +70°C	IEC 60068-2-2
Damp heat test, steady state	Test Ca for 4 days at +40 °C and humidity 93%	IEC 60068-2-78
Damp heat test, cyclic	Test Db for 6 cycles at +25 to +55 °C and humidity 93 to 95% (1 cycle = 24 hours)	IEC 60068-2-30

Table 481: CE compliance

Test	According to
Immunity	EN 50263
Emissivity	EN 50263
Low voltage directive	EN 50178

Table 482: Mechanical tests

Test	Type test values	Reference standards
Vibration response test	Class II	IEC 60255-21-1
Vibration endurance test	Class I	IEC 60255-21-1
Shock response test	Class II	IEC 60255-21-2
Shock withstand test	Class I	IEC 60255-21-2
Bump test	Class I	IEC 60255-21-2
Seismic test	Class II	IEC 60255-21-3

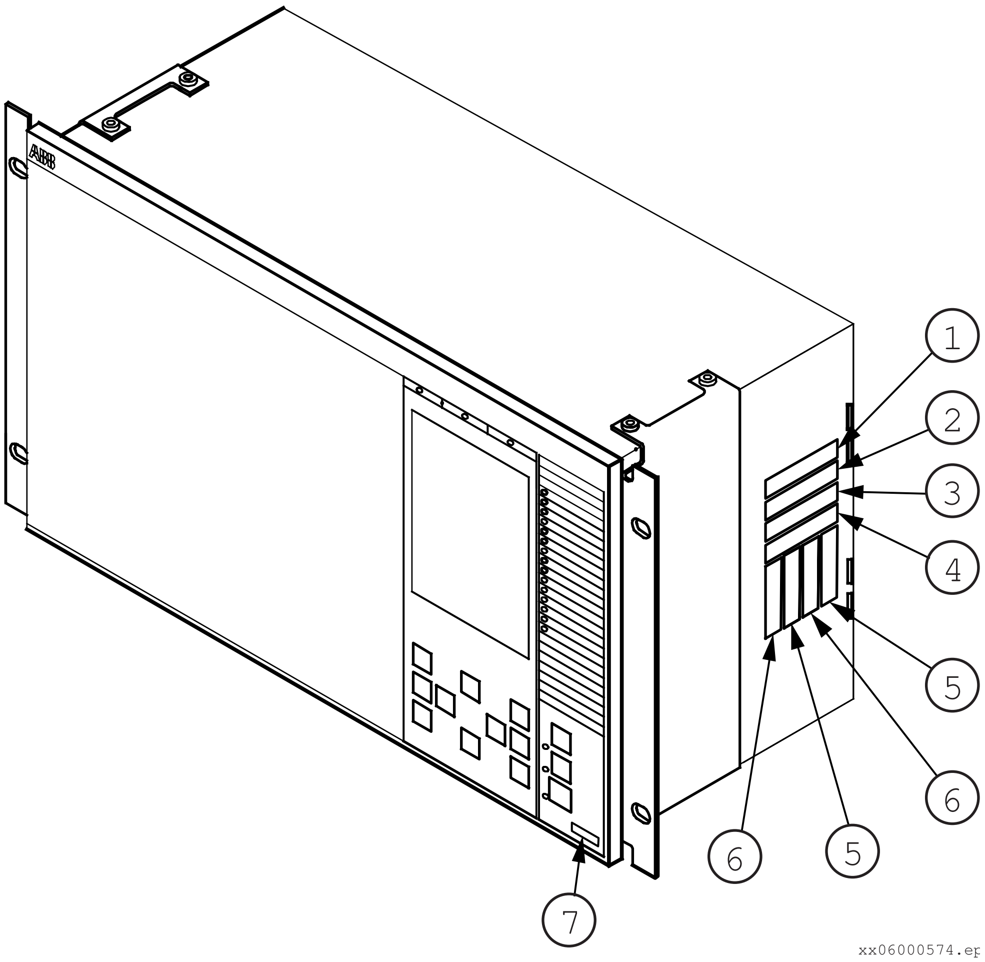
Section 18 Labels

About this chapter

This chapter includes descriptions of the different labels and where to find them.

18.1 Labels on IED

Front view of IED



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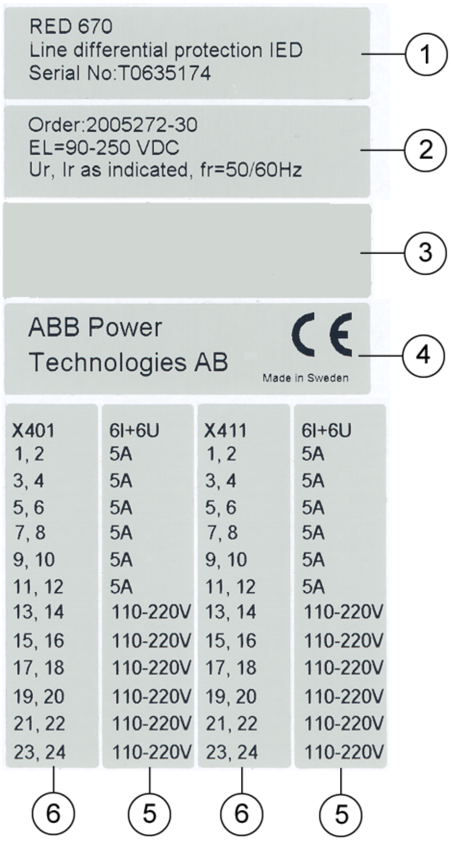


1 Product type, description and serial number

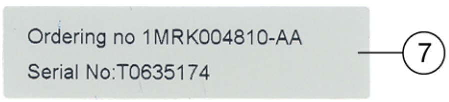
2 Order number, dc supply voltage and rated frequency

3 Optional, customer specific information

4 Manufacturer

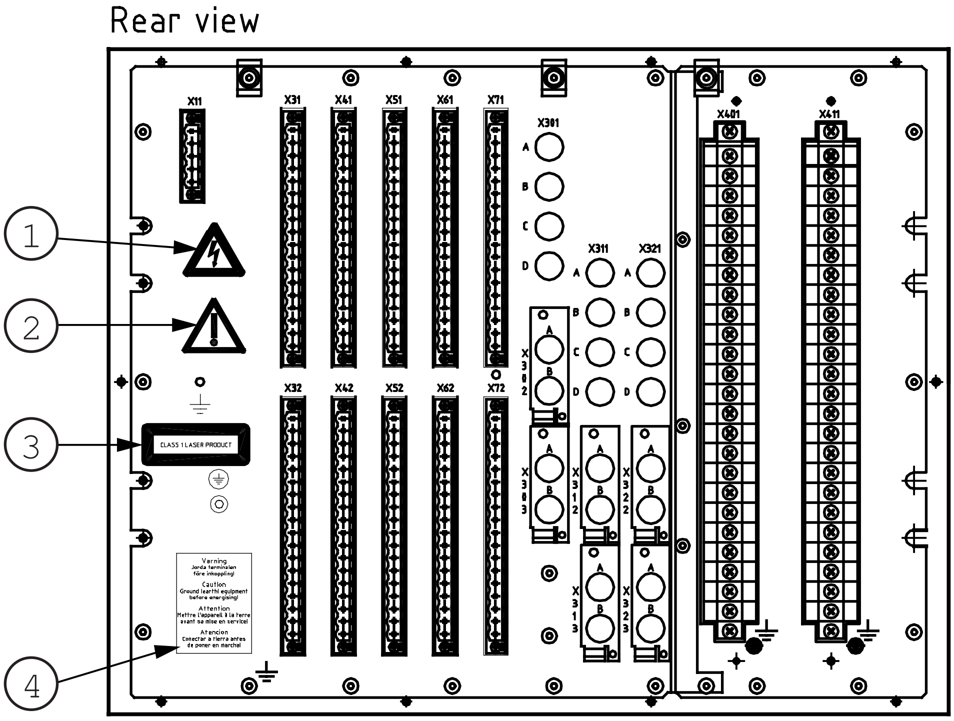
5 Transformer input module, rated currents and voltages

6 Transformer designations



7 Ordering and serial number

Rear view of IED

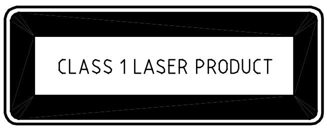


en06000573.ep

1 Warning label

2 Caution label

3 Class 1 laser product label



4 Warning label

Section 19 Connection diagrams

This chapter includes diagrams of the IED with all slot, terminal block and optical connector designations. It is a necessary guide when making electrical and optical connections to the IED.

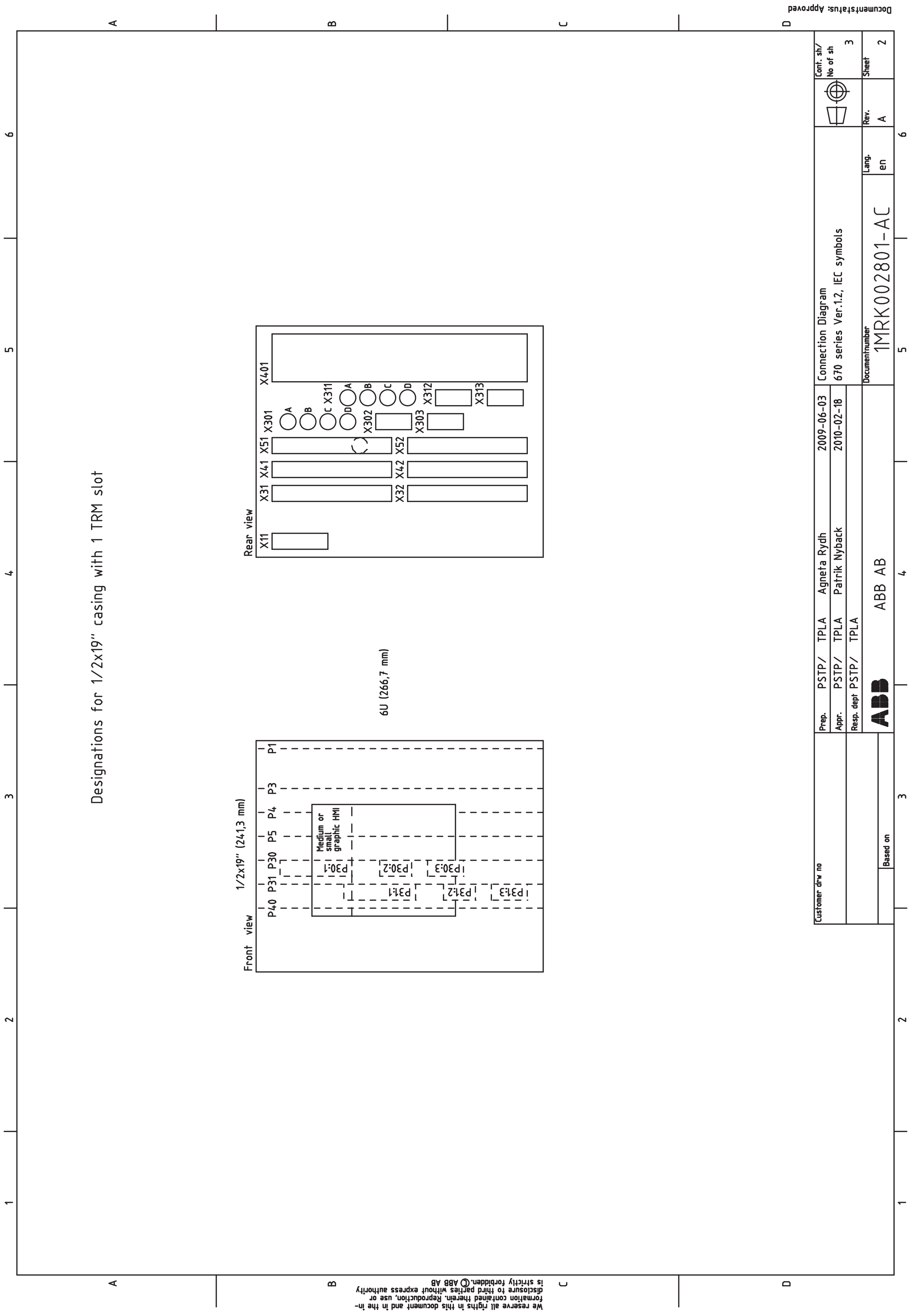
Table of contents

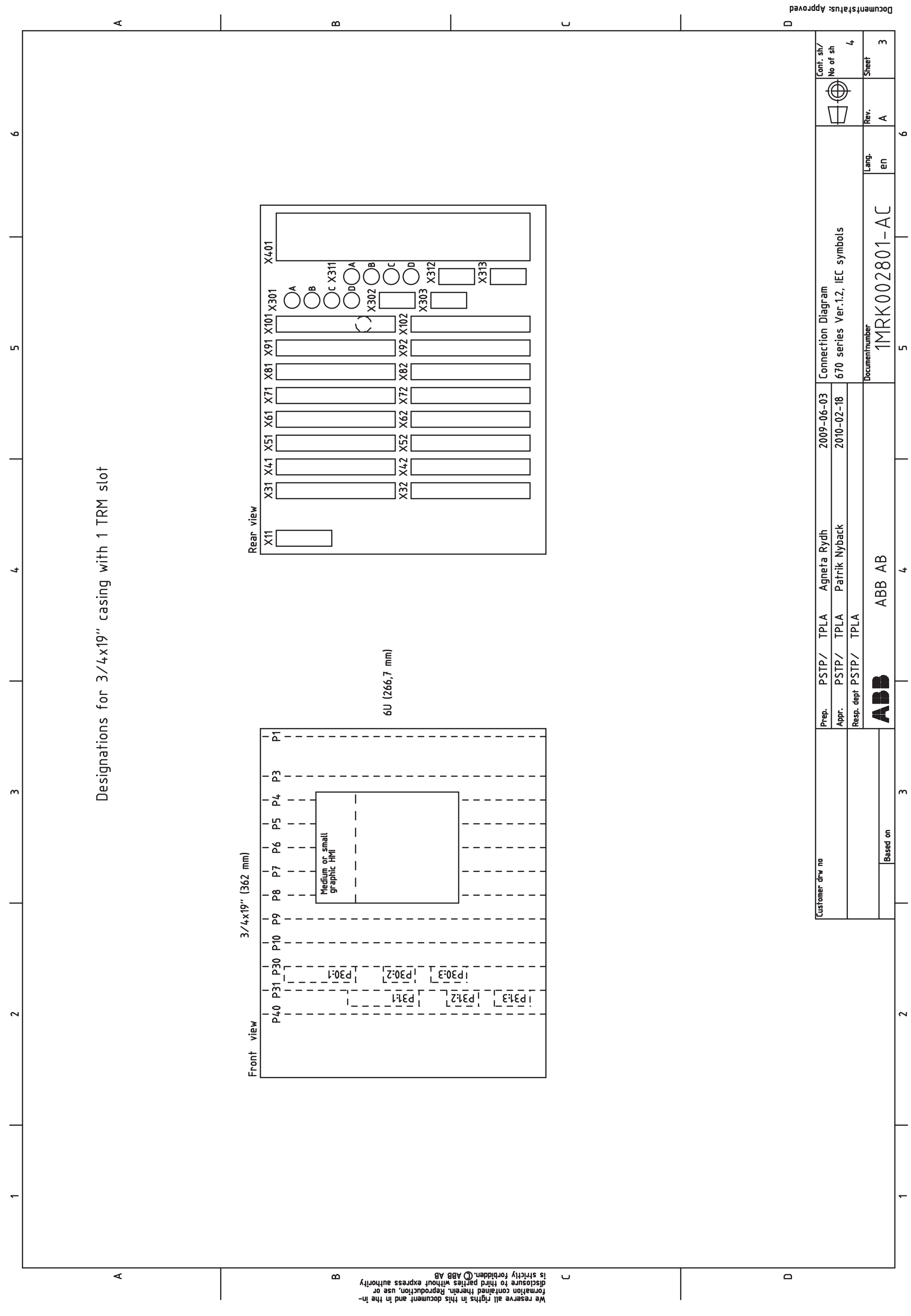
Used abbreviations

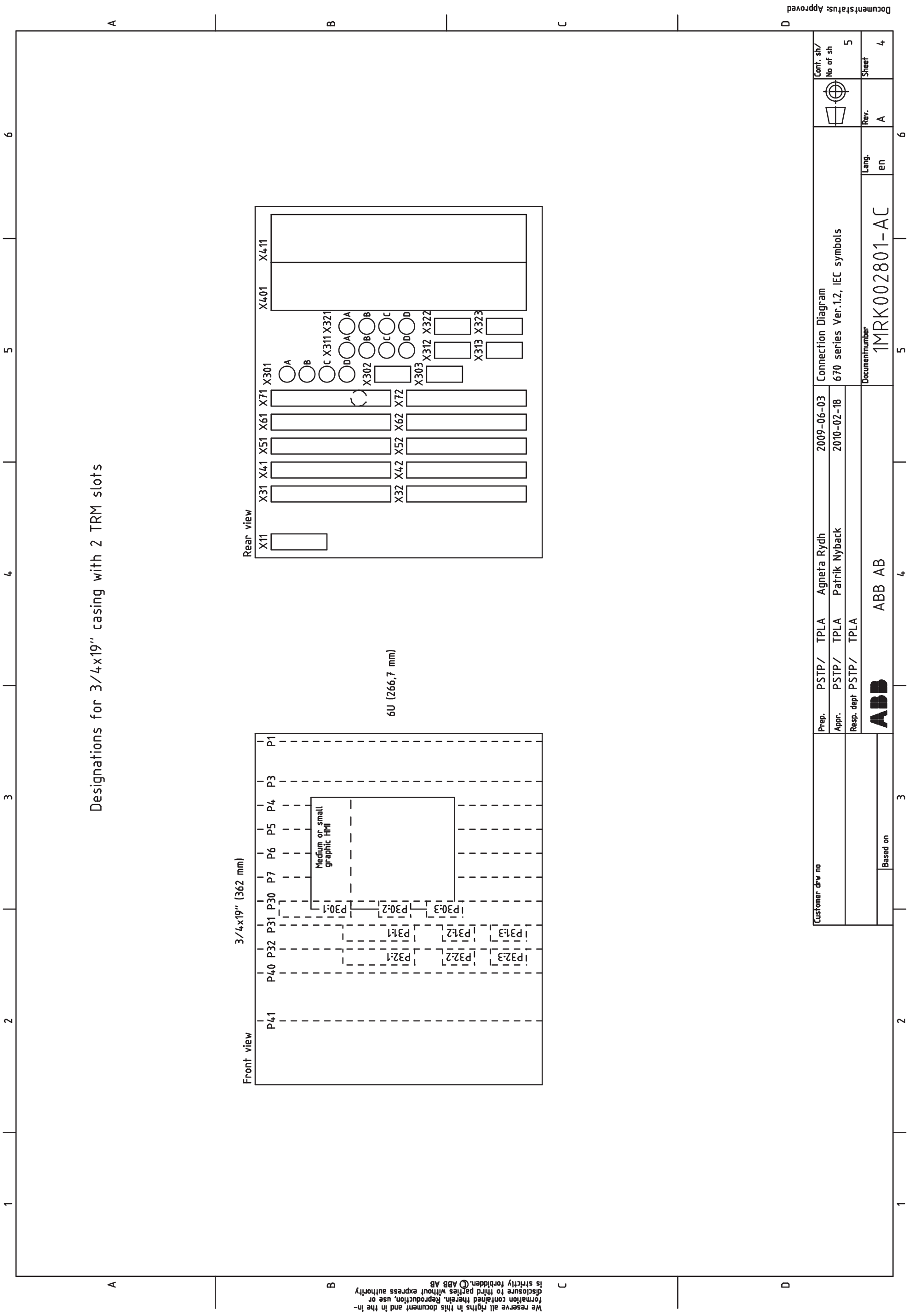
Abbreviation	Description
NUM	Numeric processing module
PSM	Power supply module
ADM	Analog digital conversion module
TRM	Transformer input module
OEM	Optical ethernet module
SLM	Serial communication module
RS485	Galvanic RS485 communication module
LDCM	Line data communication module
IRIG-B	IRIG-B time synchronization module
GTM	GPS time module
GSM	GPS time synchronization module
BIM	Binary input module
BOM	Binary output module
SOM	Static output module
IOM	Binary in/out module
MIM	mA input module
CBM	Combined backplane module
HMI	Human machine interface

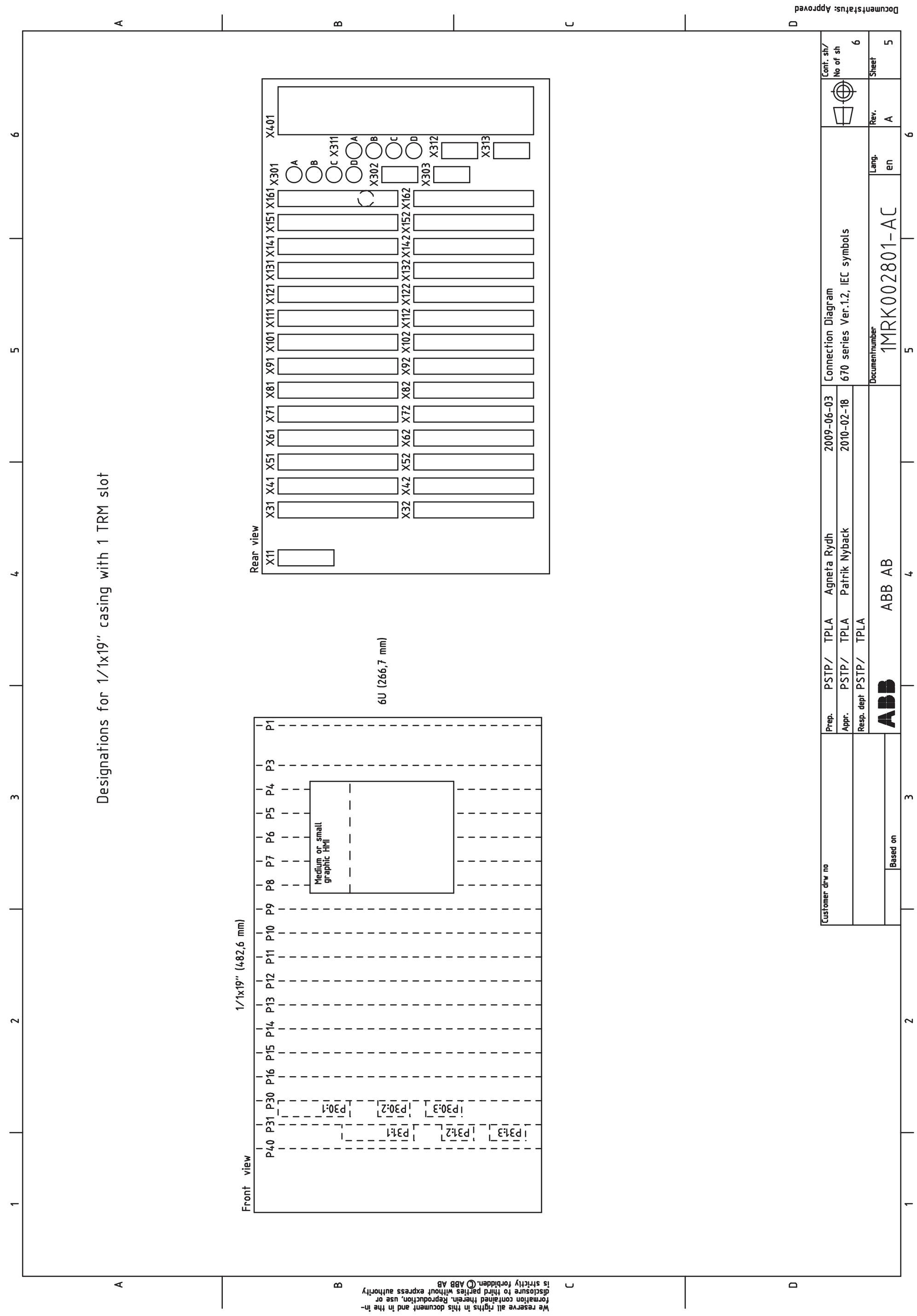
Customer drw no	Prep. PSTP/ TPLA	Agneta Rydh	2009-06-03	Connection Diagram 670 series Ver.1.2, IEC symbols	Cont. sh/ No of sh 2
	Appr. PSTP/ TPLA	Patrik Nyback	2010-02-18		
	Resp. dept PSTP/ TPLA				
Based on	ABB	ABB AB		Documentnumber 1MRK002801-AC	Lang. en / Rev. A / Sheet 1

Documentstatus: Approved


Designations for 1/2x19" casing with 1 TRM slot
Rear view
Front view
6U (266,7 mm)
1/2x19" (241,3 mm)
Medium or small graphic HMI
Connection Diagram
670 series Ver.1.2, IEC symbols
1MRK002801-AC
Agneta Rydth
Patrik Nyback
2009-06-03
2010-02-18
ABB AB
Documentstatus: Approved


Designations for 3/4x19" casing with 1 TRM slot
Rear view
Front view
6U (266,7 mm)
3/4x19" (362 mm)
Medium or small graphic HMI
Connection Diagram
670 series Ver.1.2, IEC symbols
1MRK002801-AC
ABB AB
Documentstatus: Approved


Designations for 3/4x19" casing with 2 TRM slots
Rear view
Front view
6U (266,7 mm)
3/4x19" (362 mm)
Medium or small graphic HMI
Connection Diagram
670 series Ver.1.2, IEC symbols
Agneta Rydh
Patrik Nyback
2009-06-03
2010-02-18
ABB AB
1MRK002801-AC
Documentstatus: Approved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Designations for 1/1x19" casing with 1 TRM slot
Rear view
X11
X31 X41 X51 X61 X71 X81 X91 X101 X111 X121 X131 X141 X151 X161
X32 X42 X52 X62 X72 X82 X92 X102 X112 X122 X132 X142 X152 X162
X301 X311 X302 X303 X312 X313 X401
6U (266,7 mm)
1/1x19" (482,6 mm)
Front view
P1 P3 P4 P5 P6 P7 P8 P9 P10 P11 P12 P13 P14 P15 P16 P30 P31 P40
P30:1 P30:2 P30:3
P31:1 P31:2 P31:3
Medium or small graphic HMI
Prep. PSTP/ TPLA Agneta Rydh 2009-06-03
Appr. PSTP/ TPLA Patrik Nyback 2010-02-18
Resp. dept PSTP/ TPLA
Connection Diagram
670 series Ver.1.2, IEC symbols
Documentnumber
1MRK002801-AC
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Customer drw no
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Rev. A
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Sheet 5
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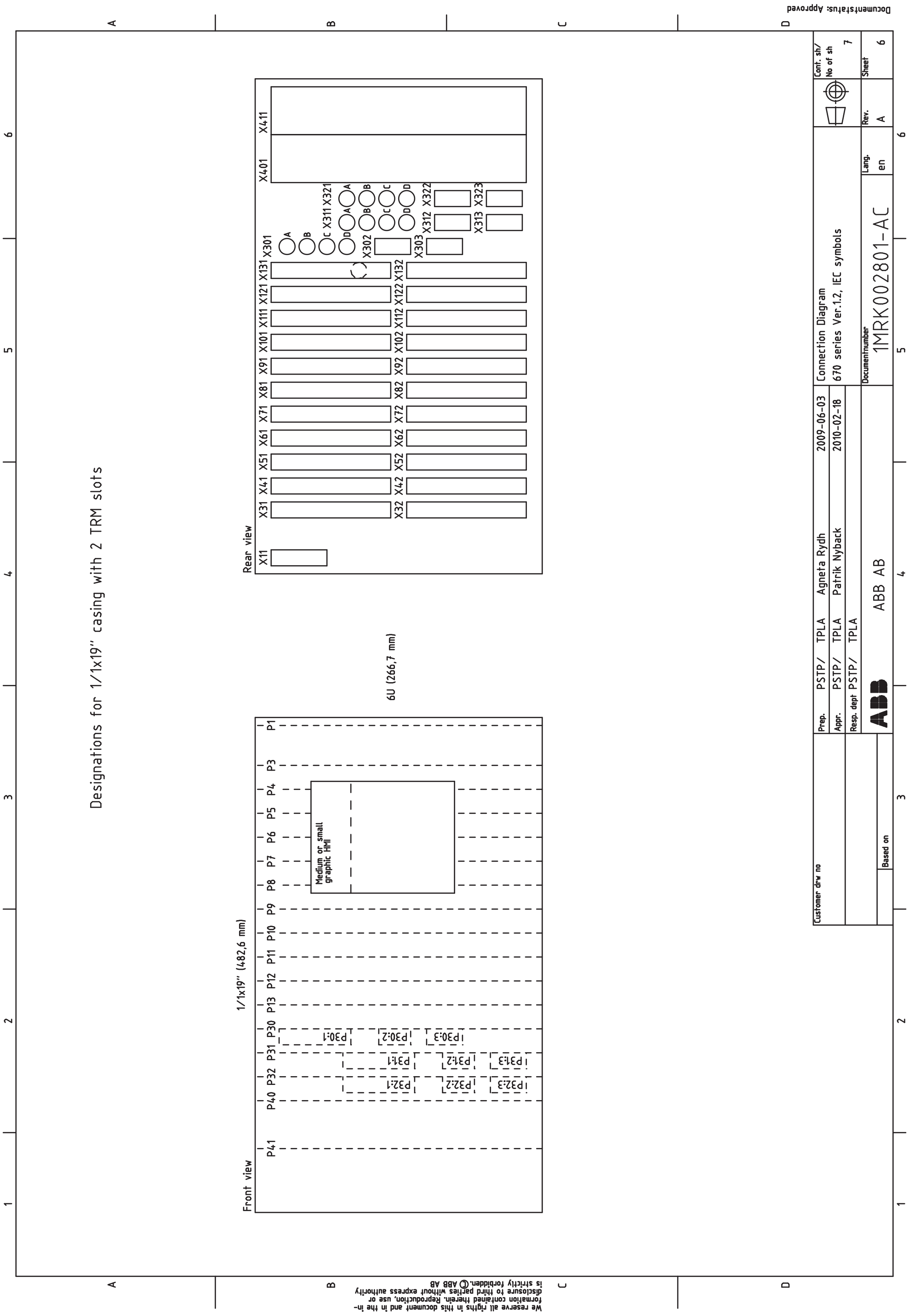
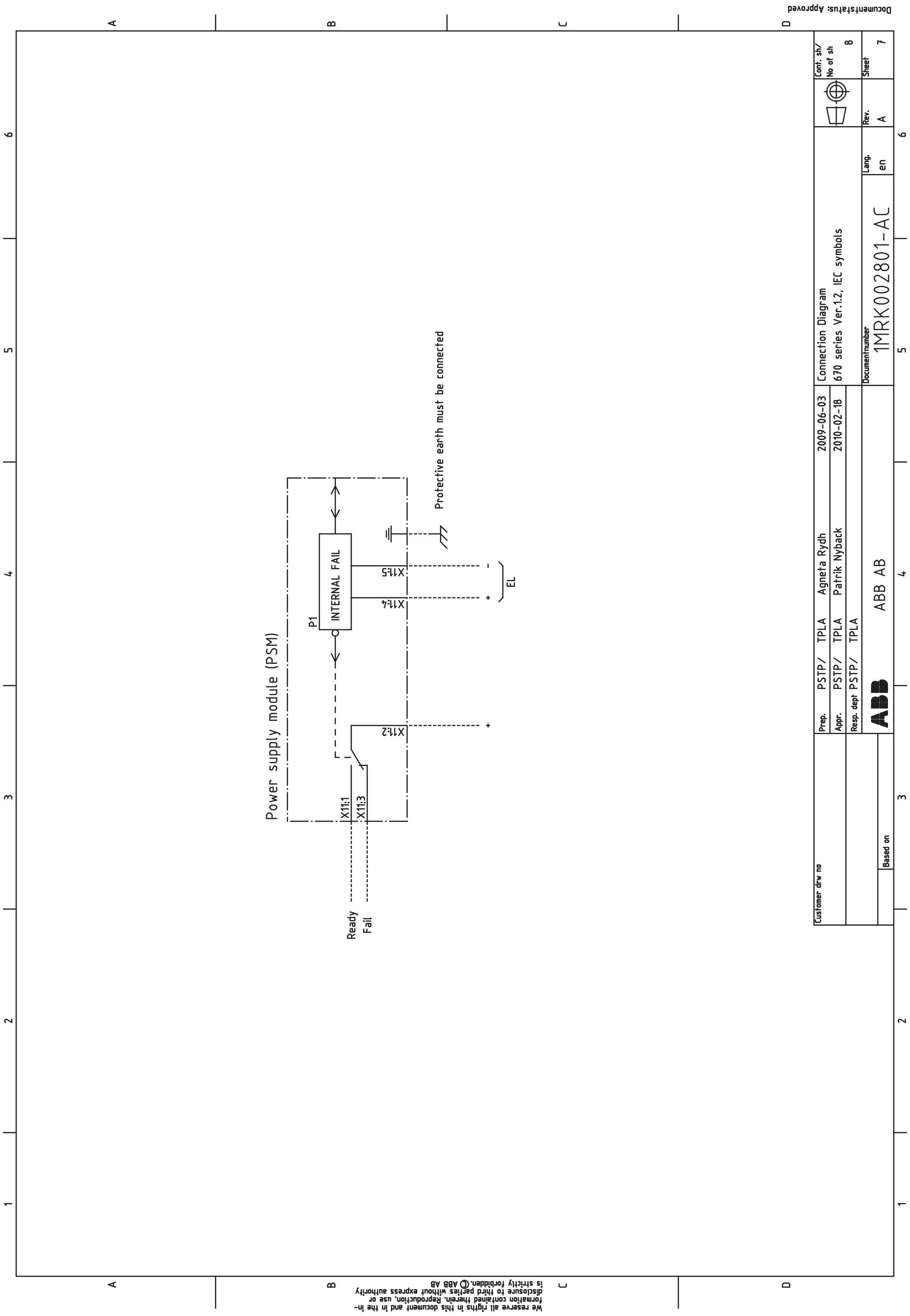

Designations for 1/1x19" casing with 2 TRM slots
Rear view
Front view
6U (266,7 mm)
1/1x19" (482,6 mm)
Medium or small graphic HMI
Connection Diagram
670 series Ver.1.2, IEC symbols
1MRK002801-AC
ABB AB
Agneta Rydh
Patrik Nyback
2009-06-03
2010-02-18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Power supply module (PSM)
P1
INTERNAL FAIL
X11:5
X11:4
X11:2
X11:1
X11:3
EL
Protective earth must be connected
Ready
Fail
Prep. PSTP/ TPLA Agneta Rydh 2009-06-03
Appr. PSTP/ TPLA Patrik Nyback 2010-02-18
Resp. dept PSTP/ TPLA
Connection Diagram
670 series Ver.1.2, IEC symbols
Documentnumber
1MRK002801-AC
ABB AB
Lang. en
Rev. A
Sheet 7
Cont. sh/ No of sh 8
Customer drw no
Based on
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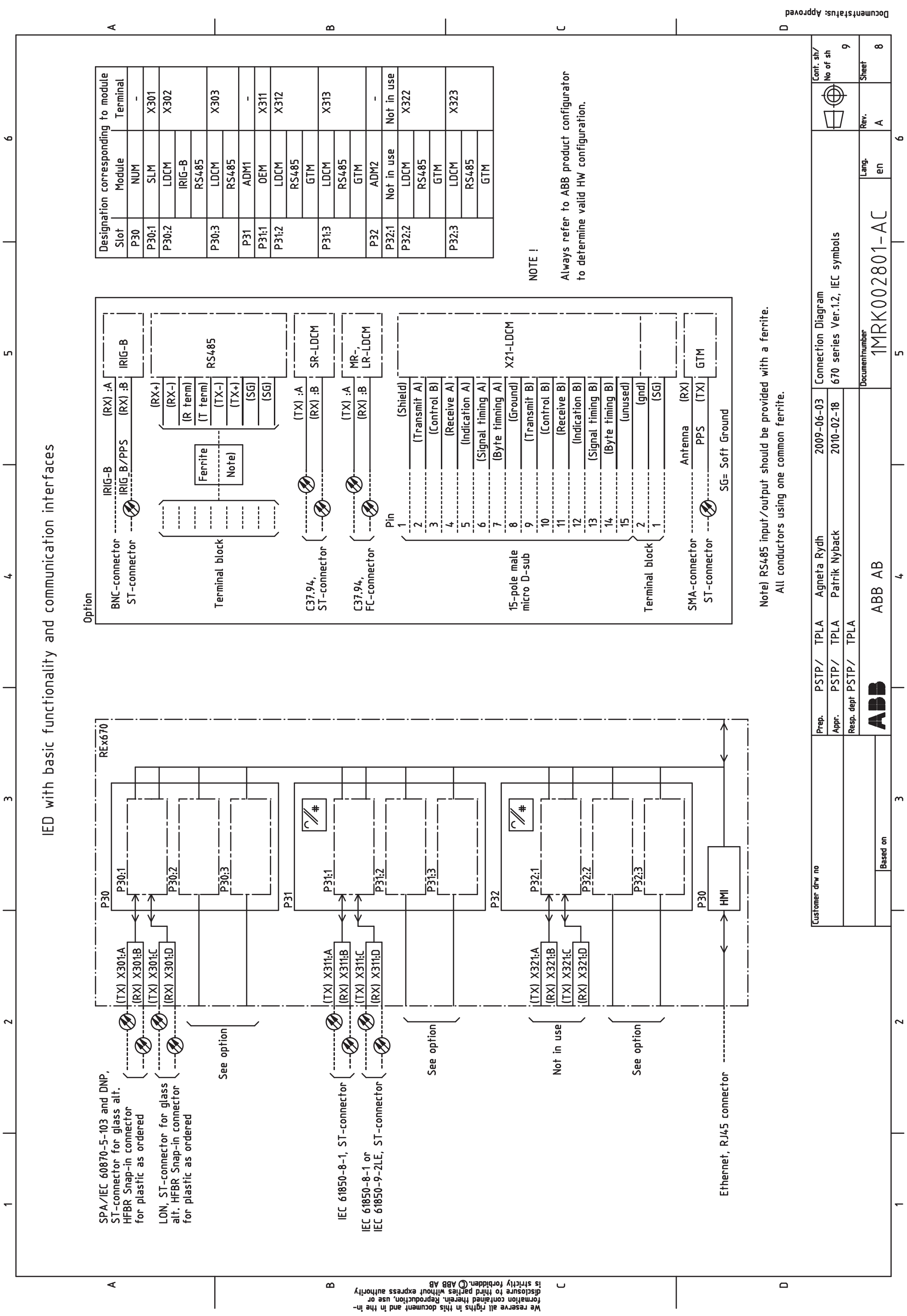
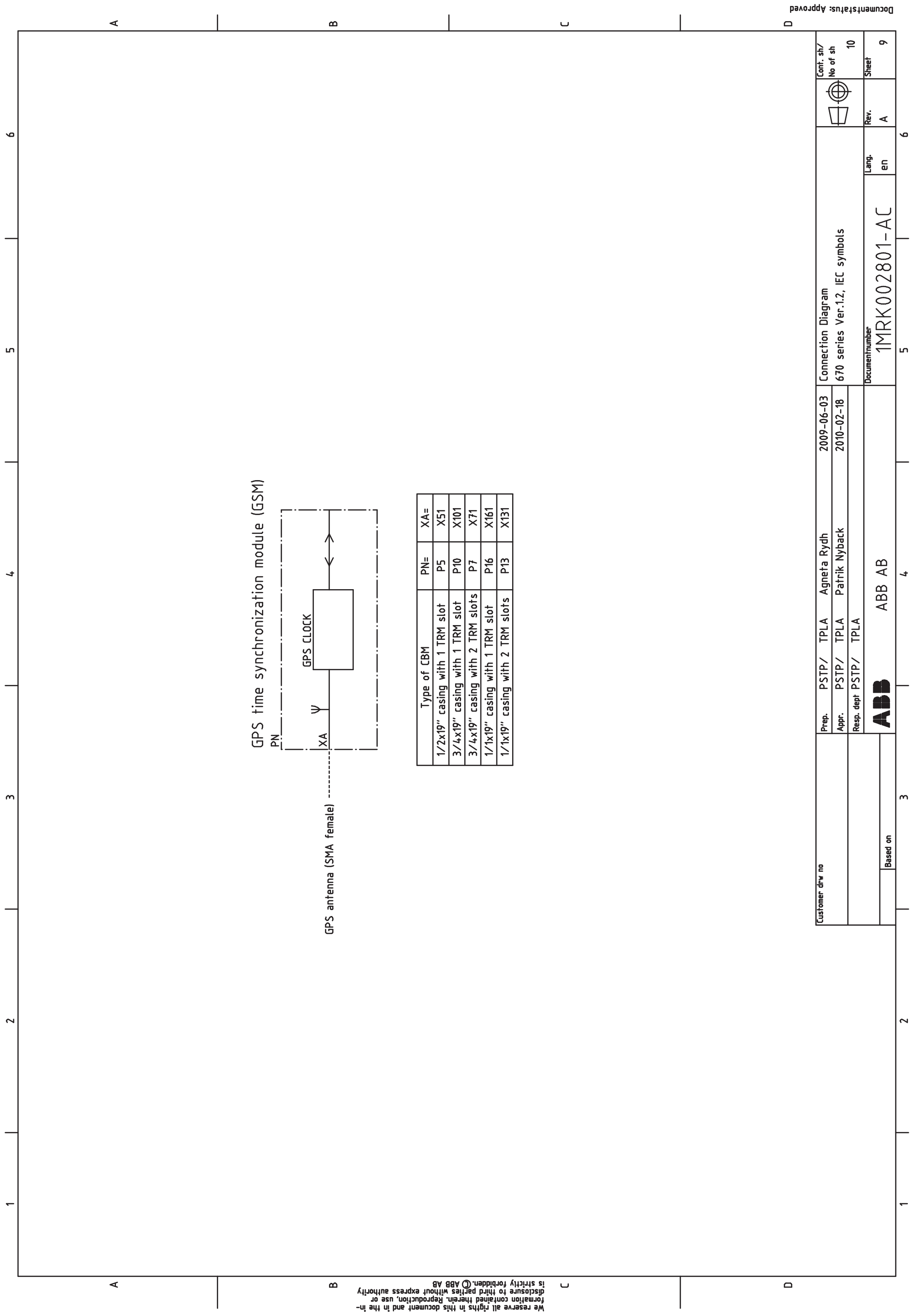

IED with basic functionality and communication interfaces
REx670
Option
BNC-connector
ST-connector
Terminal block
C37.94, ST-connector
C37.94, FC-connector
15-pole male micro D-sub
SMA-connector
ST-connector
SG= Soft Ground
Note) RS485 input/output should be provided with a ferrite.
All conductors using one common ferrite.
NOTE !
Always refer to ABB product configurator
to determine valid HW configuration.
SPA/IEC 60870-5-103 and DNP,
ST-connector for glass alt.
HFBR Snap-in connector
for plastic as ordered
LON, ST-connector for glass
alt. HFBR Snap-in connector
for plastic as ordered
IEC 61850-8-1, ST-connector
IEC 61850-8-1 or
IEC 61850-9-2LE, ST-connector
Not in use
See option
Ethernet, RJ45 connector
HMI
Connection Diagram
670 series Ver.1.2, IEC symbols
1MRK002801-AC
ABB AB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GPS time synchronization module (GSM)
PN
XA
GPS CLOCK
GPS antenna (SMA female)
Type of CBM
PN=
XA=
1/2x19" casing with 1 TRM slot
P5
X51
3/4x19" casing with 1 TRM slot
P10
X101
3/4x19" casing with 2 TRM slots
P7
X71
1/1x19" casing with 1 TRM slot
P16
X161
1/1x19" casing with 2 TRM slots
P13
X131
Customer drw no
Based on
Prep. PSTP/ TPLA Agneta Rydh 2009-06-03
Appr. PSTP/ TPLA Patrik Nyback 2010-02-18
Resp. dept PSTP/ TPLA
ABB AB
Connection Diagram
670 series Ver.1.2, IEC symbols
Documentnumber
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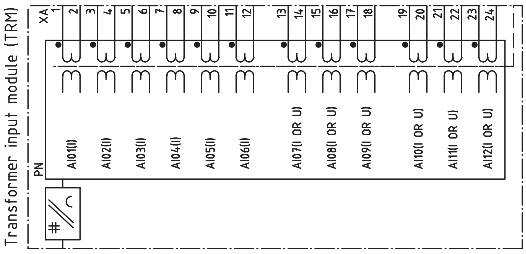

PN= P40	PN= P41	Designation corresponding to Transformer input module																
XA=	XA=	CT/VT input	Current/voltage configuration															
X401:	X411:	designation	6I	6I	6I+6U	6I+6U	3I+3I+6U	7I+5U	7I+5U	6I+1I+5U	3IM+4I+5U	3IM+4I+5U	3I+4I+5U	9I+3U	9I+3U	5I+4I+3U	12I	12I
1, 2	1, 2	AI01	1A	5A	1A	5A	5A	1A	5A	5A	1AM *)	5AM *)	5A	1A	5A	1A	1A	5A
3, 4	3, 4	AI02	1A	5A	1A	5A	5A	1A	5A	5A	1AM *)	5AM *)	5A	1A	5A	1A	1A	5A
5, 6	5, 6	AI03	1A	5A	1A	5A	5A	1A	5A	5A	1AM *)	5AM *)	5A	1A	5A	1A	1A	5A
7, 8	7, 8	AI04	1A	5A	1A	5A	1A	1A	5A	5A	1A	5A	1A	1A	5A	1A	1A	5A
9, 10	9, 10	AI05	1A	5A	1A	5A	1A	1A	5A	5A	1A	5A	1A	1A	5A	1A	1A	5A
11, 12	11, 12	AI06	1A	5A	1A	5A	1A	1A	5A	5A	1A	5A	1A	1A	5A	5A	1A	5A
13, 14	13, 14	AI07	-	-	110-220V	110-220V	110-220V	1A	5A	1A	1A	5A	1A	1A	5A	5A	1A	5A
15, 16	15, 16	AI08	-	-	110-220V	110-220V	110-220V	110-220V	110-220V	110-220V	110-220V	110-220V	110-220V	1A	5A	5A	1A	5A
17, 18	17, 18	AI09	-	-	110-220V	110-220V	110-220V	110-220V	110-220V	110-220V	110-220V	110-220V	110-220V	1A	5A	5A	1A	5A
19, 20	19, 20	AI10	-	-	110-220V	110-220V	110-220V	110-220V	110-220V	110-220V	110-220V	110-220V	110-220V	110-220V	110-220V	110-220V	1A	5A
21, 22	21, 22	AI11	-	-	110-220V	110-220V	110-220V	110-220V	110-220V	110-220V	110-220V	110-220V	110-220V	110-220V	110-220V	110-220V	1A	5A
23, 24	23, 24	AI12	-	-	110-220V	110-220V	110-220V	110-220V	110-220V	110-220V	110-220V	110-220V	110-220V	110-220V	110-220V	110-220V	1A	5A

● Indicates high polarity. Note that intarnal polarity can be adjusted by setting of analogue input CT neutral direction and or on SMAI pre-processing function blocks

*) Metering

Customer drw no	Prep. PSTP/ TPLA	Agneta Rydh	2009-06-03	Connection Diagram
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	Resp. dept PSTP/ TPLA			
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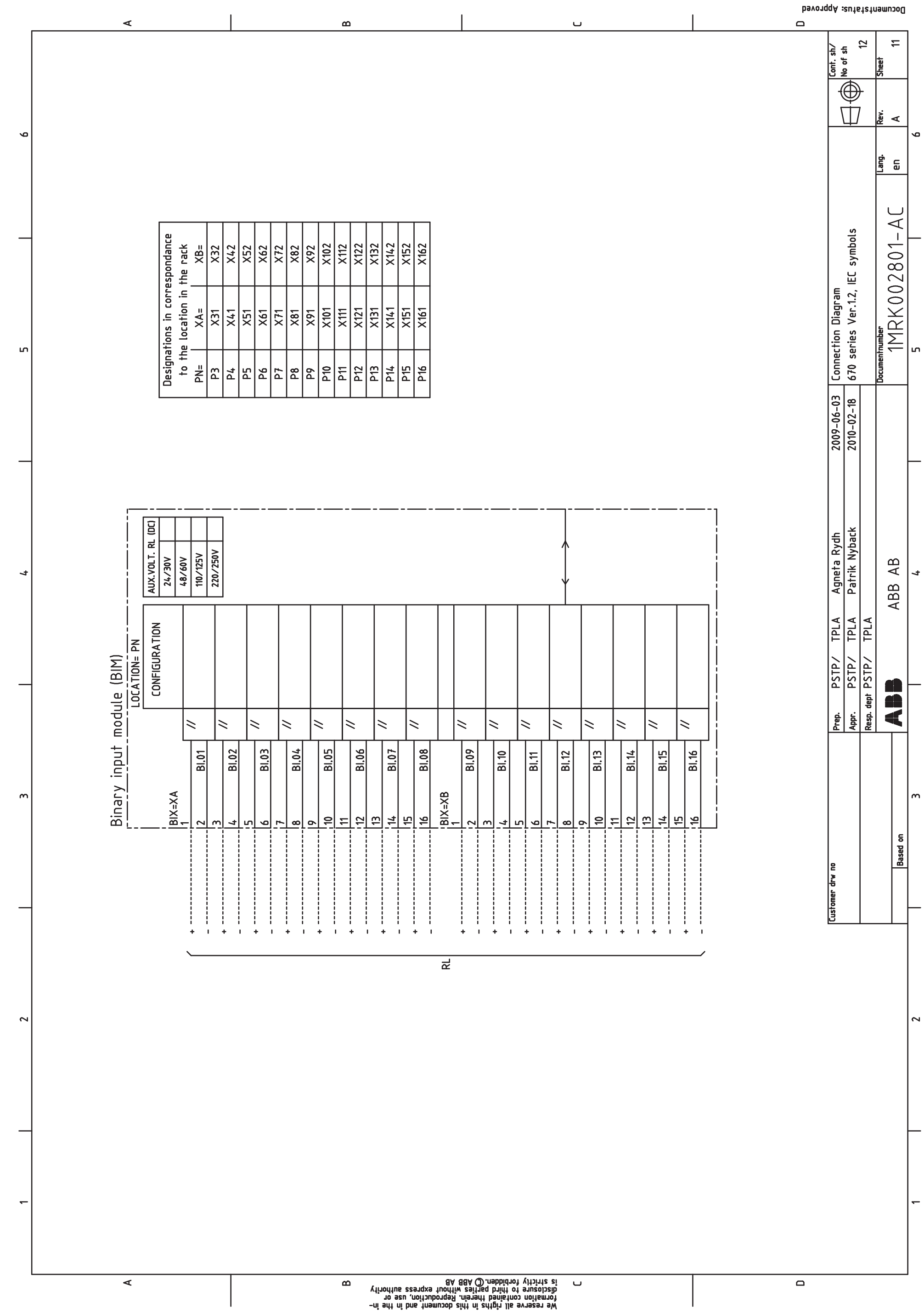
Documentstatus: Approved
Binary input module (BIM)
LOCATION= PN
CONFIGURATION
AUX.VOLT. RL (DC)
24/30V
48/60V
110/125V
220/250V
BIX=XA
BIX=XB
RL
Designations in correspondance to the location in the rack
Connection Diagram
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1MRK002801-AC
ABB AB
Agneta Rydh
Patrik Nyback
2009-06-03
2010-02-18
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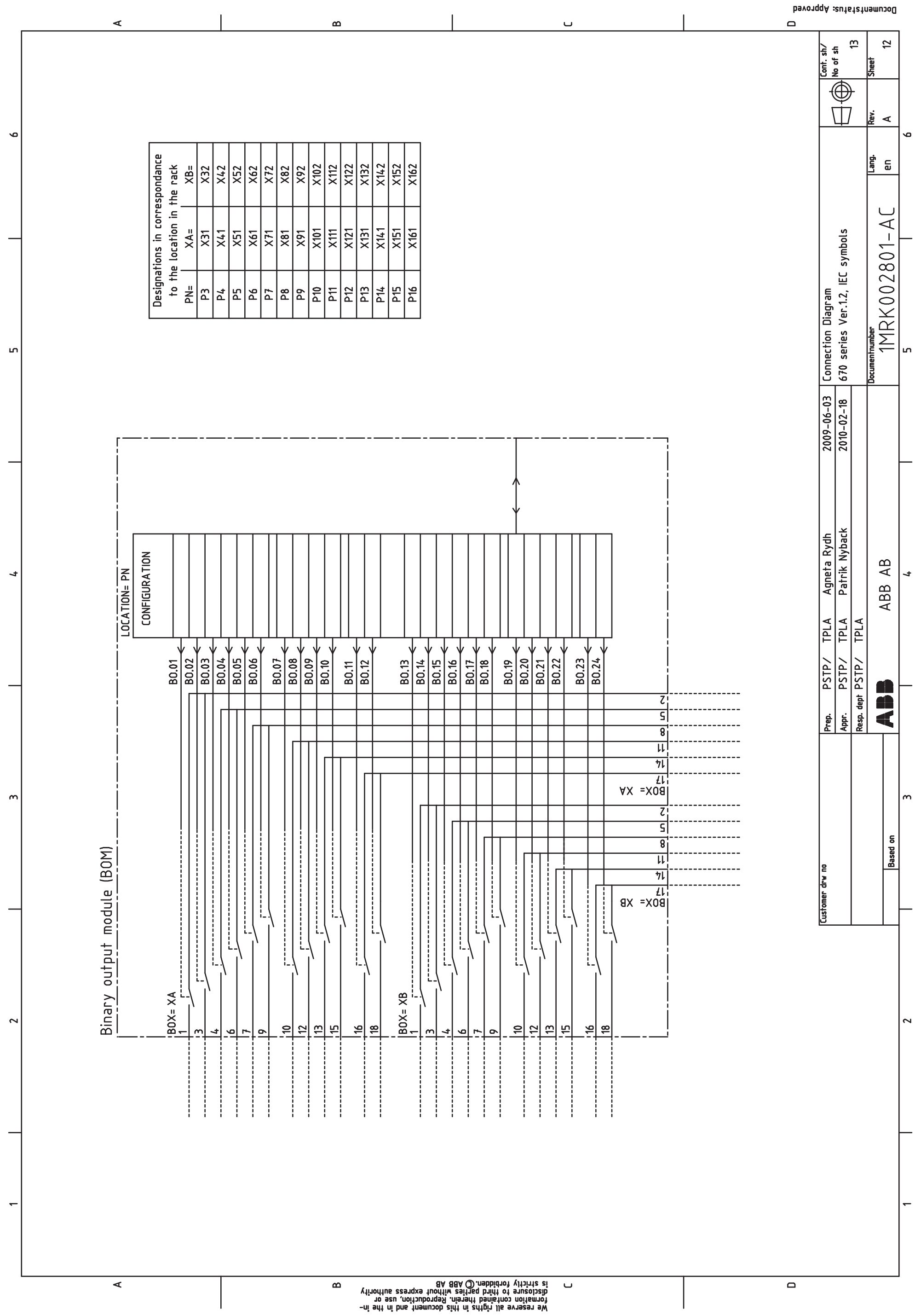
Binary output module (BOM)
LOCATION= PN
CONFIGURATION
Designations in correspondance to the location in the rack
Connection Diagram
670 series Ver.1.2, IEC symbols
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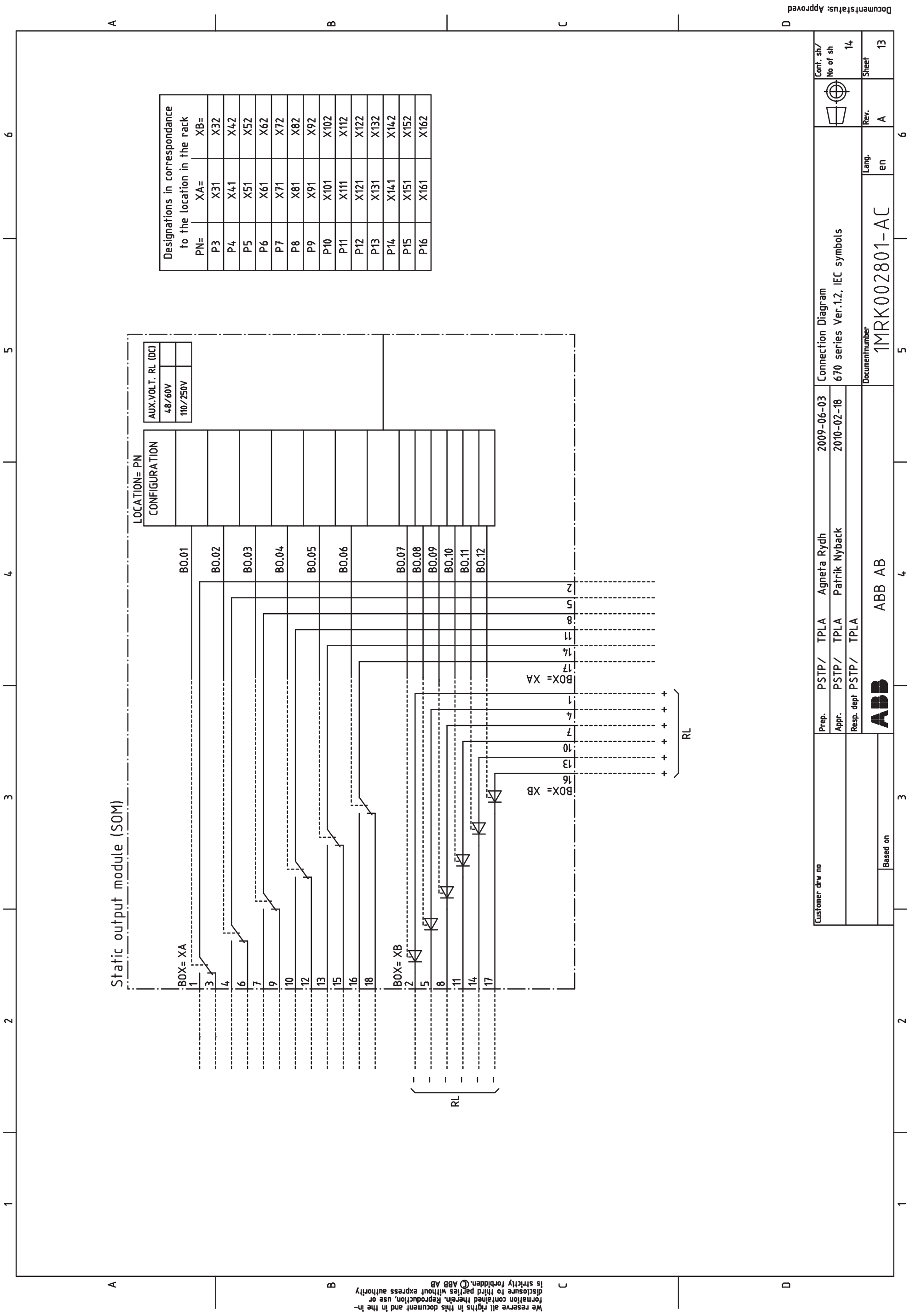
Documentstatus: Approved
Designations in correspondance to the location in the rack
PN= XA= XB=
P3 X31 X32
P4 X41 X42
P5 X51 X52
P6 X61 X62
P7 X71 X72
P8 X81 X82
P9 X91 X92
P10 X101 X102
P11 X111 X112
P12 X121 X122
P13 X131 X132
P14 X141 X142
P15 X151 X152
P16 X161 X162
Static output module (SOM)
LOCATION= PN
CONFIGURATION
AUX.VOLT. RL (DC)
48/60V
110/250V
BO.01
BO.02
BO.03
BO.04
BO.05
BO.06
BO.07
BO.08
BO.09
BO.10
BO.11
BO.12
BOX= XA
BOX= XB
RL
Customer drw no
Prep. PSTP/ TPLA Agneta Rydh 2009-06-03
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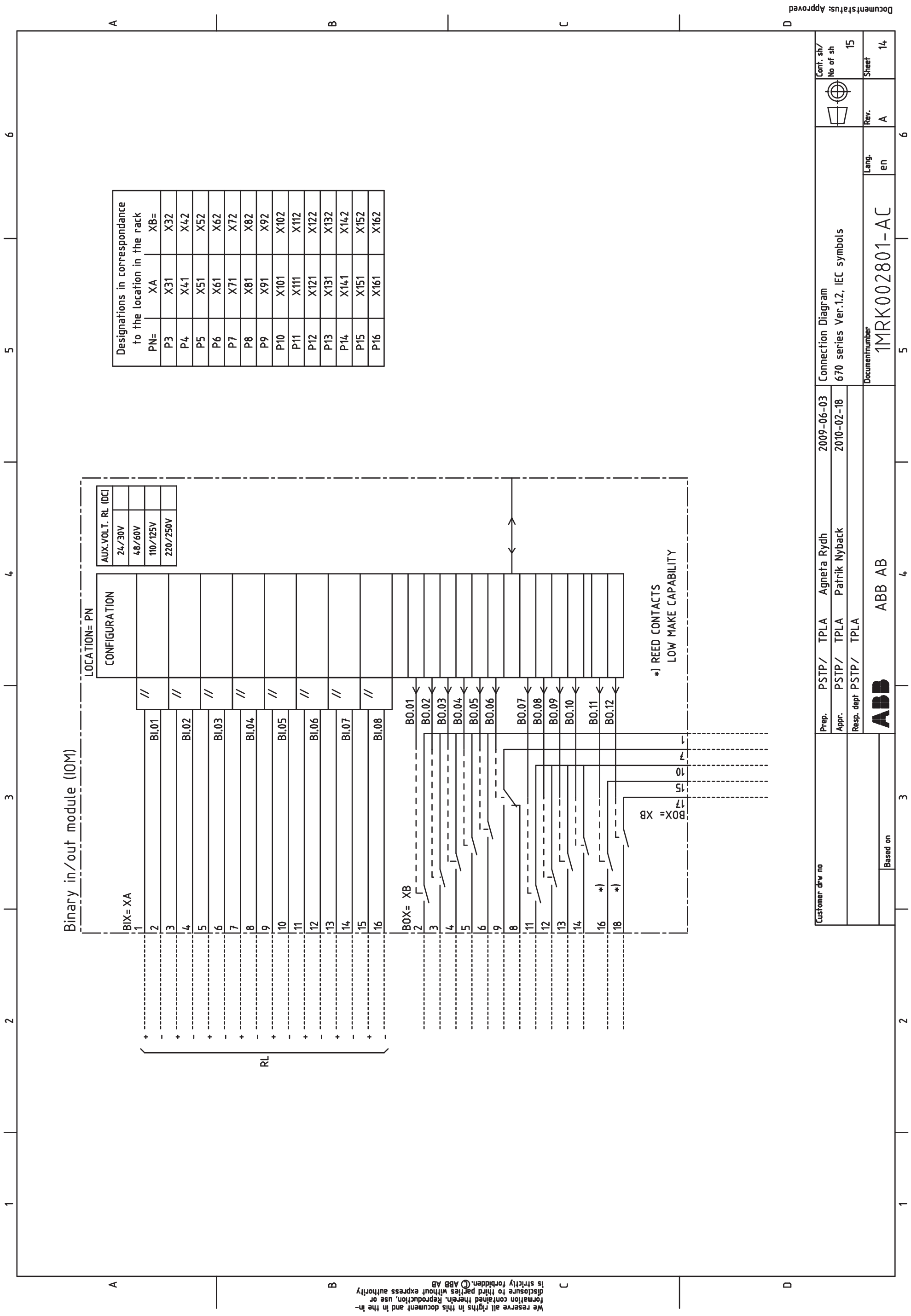
Binary in/out module (IOM)
LOCATION= PN
CONFIGURATION
AUX.VOLT. RL (DC)
24/30V
48/60V
110/125V
220/250V
BIX= XA
BOX= XB
BI.01
BI.02
BI.03
BI.04
BI.05
BI.06
BI.07
BI.08
BO.01
BO.02
BO.03
BO.04
BO.05
BO.06
BO.07
BO.08
BO.09
BO.10
BO.11
BO.12
*) REED CONTACTS
LOW MAKE CAPABILITY
RL
Designations in correspondance
to the location in the rack
PN=	XA	XB=
P3	X31	X32
P4	X41	X42
P5	X51	X52
P6	X61	X62
P7	X71	X72
P8	X81	X82
P9	X91	X92
P10	X101	X102
P11	X111	X112
P12	X121	X122
P13	X131	X132
P14	X141	X142
P15	X151	X152
P16	X161	X162
Prep. PSTP/ TPLA Agneta Rydh 2009-06-03
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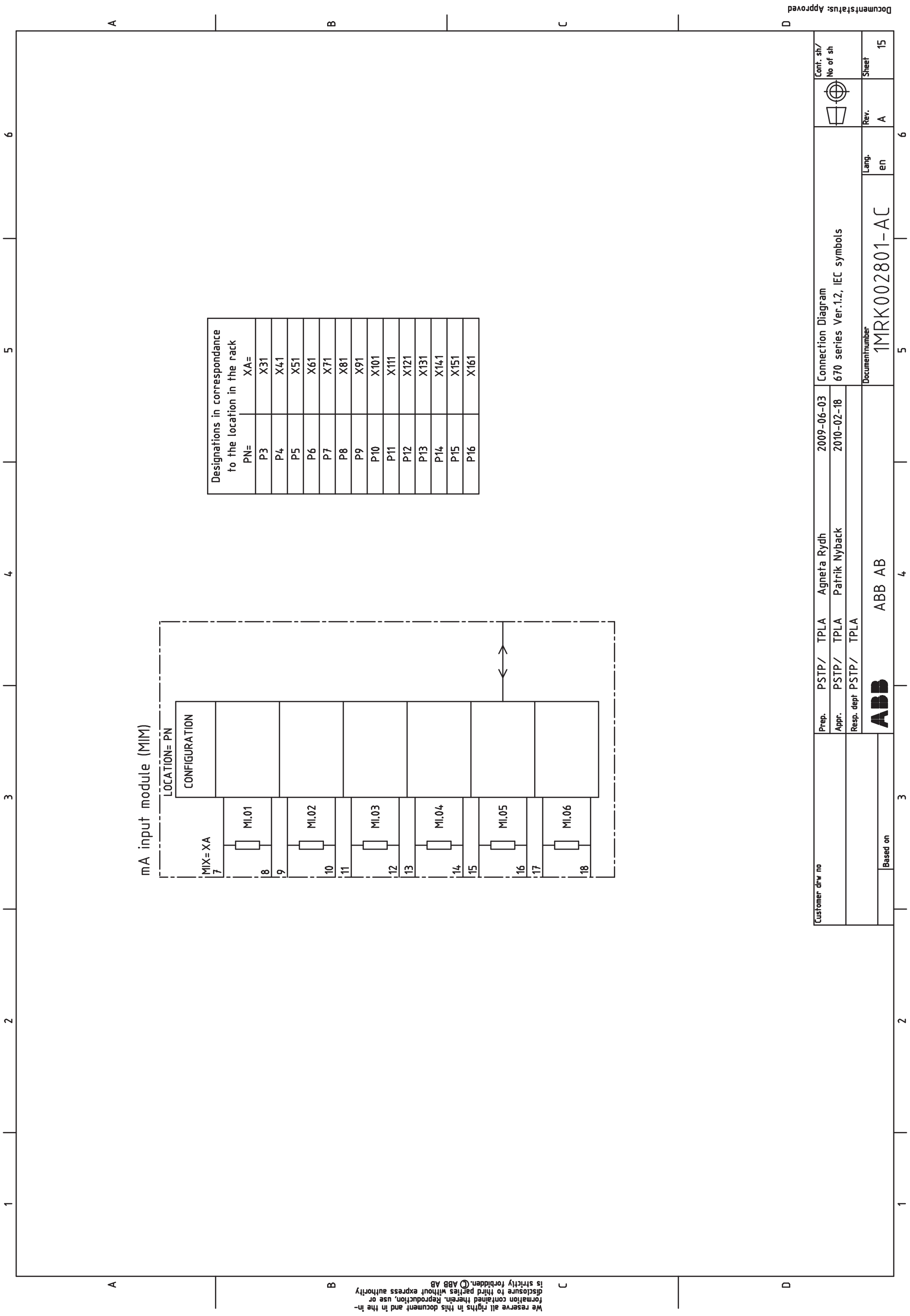
Documentstatus: Approved
mA input module (MIM)
LOCATION= PN
CONFIGURATION
MIX= XA
MI.01
MI.02
MI.03
MI.04
MI.05
MI.06
7
8
9
10
11
12
13
14
15
16
17
18
Designations in correspondance to the location in the rack
PN= XA=
P3 X31
P4 X41
P5 X51
P6 X61
P7 X71
P8 X81
P9 X91
P10 X101
P11 X111
P12 X121
P13 X131
P14 X141
P15 X151
P16 X161
Customer drw no
Prep. PSTP/ TPLA Agneta Rydh 2009-06-03
Appr. PSTP/ TPLA Patrik Nyback 2010-02-18
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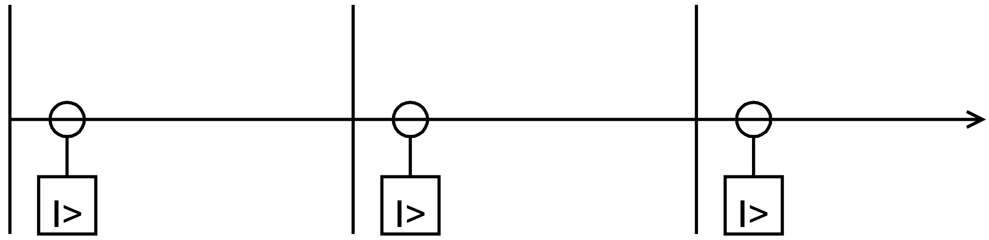
Section 20 Inverse time characteristics

About this chapter

This chapter describes current and voltage dependant time functionality. Both ANSI and IEC Inverse time curves and tables are included.

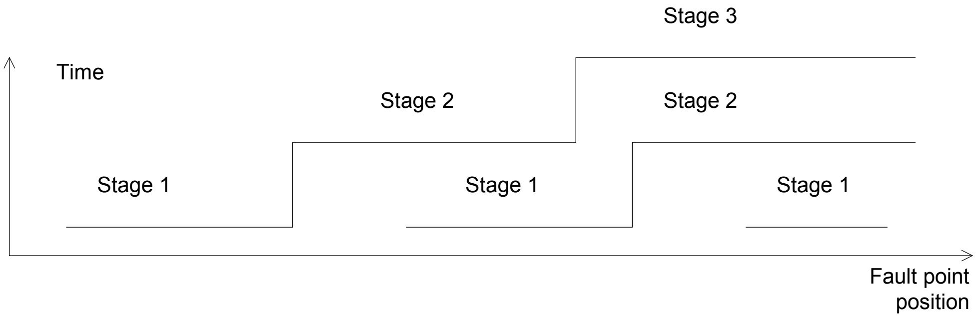
20.1 Application

In order to assure time selectivity between different overcurrent protections at different points in the network different time delays for the different protections are normally used. The simplest way to do this is to use definite time-lag. In more sophisticated applications current dependent time characteristics are used. Both alternatives are shown in a simple application with three overcurrent protections operating in series.



xx05000129.vsd

Figure 342: Three overcurrent protections operating in series



en05000130.vsd

Figure 343: Definite time overcurrent characteristics

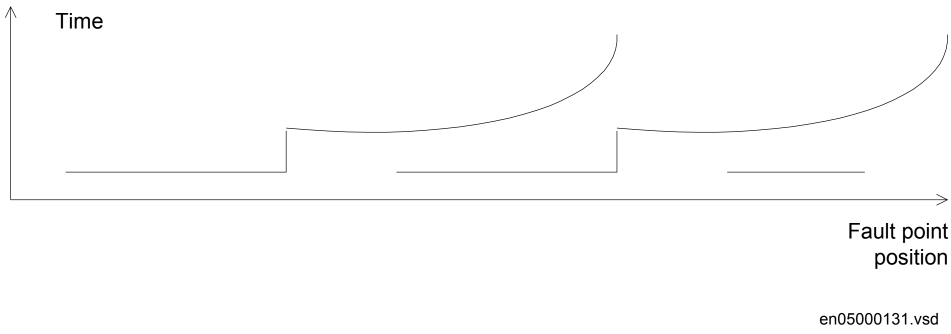


Figure 344: Inverse time overcurrent characteristics with inst. function

The inverse time characteristic makes it possible to minimize the fault clearance time and still assure the selectivity between protections.

To assure selectivity between protections there must be a time margin between the operation time of the protections. This required time margin is dependent of following factors, in a simple case with two protections in series:

- Difference between pickup time of the protections to be co-ordinated
- Opening time of the breaker closest to the studied fault
- Reset times of the protections
- Margin dependent of the time delay inaccuracy of the protections

Assume we have the following network case.

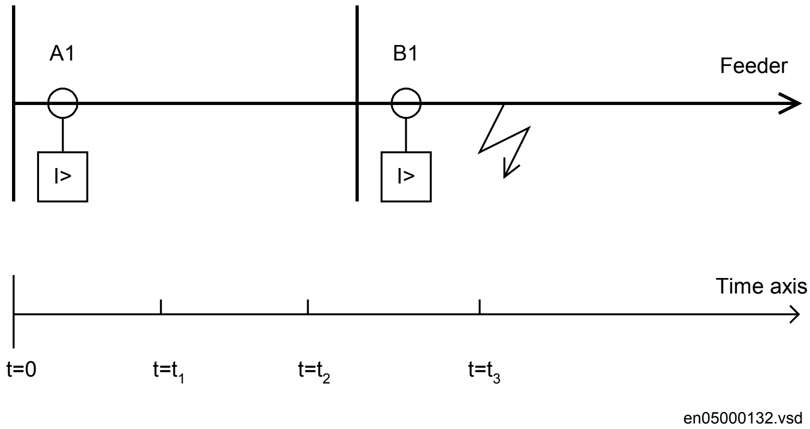


Figure 345: Selectivity steps for a fault on feeder B1

where:

t=0	is The fault occurs
$t=t_1$	is Protection B1 trips
$t=t_2$	is Breaker at B1 opens
$t=t_3$	is Protection A1 resets

In the case protection B1 shall operate without any intentional delay (instantaneous). When the fault occurs the protections start to detect the fault current. After the time t_1 the protection B1 send a trip signal to the circuit breaker. The protection A1 starts its delay timer at the same time, with some deviation in time due to differences between the two protections. There is a possibility that A1 will start before the trip is sent to the B1 circuit breaker. At the time t_2 the circuit breaker B1 has opened its primary contacts and thus the fault current is interrupted. The breaker time (t2 - t1) can differ between different faults. The maximum opening time can be given from manuals and test protocols. Still at t_2 the timer of protection A1 is active. At time t_3 the protection A1 is reset, that is the timer is stopped.

In most applications it is required that the times shall reset as fast as possible when the current fed to the protection drops below the set current level, the reset time shall be minimized. In some applications it is however beneficial to have some type of delayed reset time of the overcurrent function. This can be the case in the following applications:

- If there is a risk of intermittent faults. If the current IED, close to the faults, starts and resets there is a risk of unselective trip from other protections in the system.
- Delayed resetting could give accelerated fault clearance in case of automatic reclosing to a permanent fault.
- Overcurrent protection functions are sometimes used as release criterion for other protection functions. It can often be valuable to have a reset delay to assure the release function.

20.2 Principle of operation

20.2.1 Mode of operation

The function can operate in a definite time-lag mode or in a current definite inverse time mode. For the inverse time characteristic both ANSI and IEC based standard curves are available. Also programmable curve types are supported via the component inputs: p, A, B, C pr, tr, and cr.

Different characteristics for reset delay can also be chosen.

If current in any phase exceeds the set start current value (here internal signal startValue), a timer, according to the selected operating mode, is started. The component always uses the maximum of the three phase current values as the current level used in timing calculations.

In case of definite time-lag mode the timer will run constantly until the time is reached or until the current drops below the reset value (start value minus the hysteresis) and the reset time has elapsed.

For definite time delay curve ANSI/IEEE Definite time or IEC Definite time are chosen.

The general expression for inverse time curves is according to equation 84.

$$t[s] = \left(\frac{A}{\left(\frac{i}{in>} \right)^{p} - C} + B \right) \cdot k$$

(Equation 84)

where:

p, A, B, C	are constants defined for each curve type,
in>	is the set start current for step n,
k	is set time multiplier for step n and
i	is the measured current.

For inverse time characteristics a time will be initiated when the current reaches the set start level. From the general expression of the characteristic the following can be seen:

$$(t_{op} - B \cdot k) \cdot \left(\left(\frac{i}{in >} \right)^p - C \right) = A \cdot k$$

(Equation 85)

where:

t_{op}	is the operating time of the protection

The time elapsed to the moment of trip is reached when the integral fulfils according to equation 86, in addition to the constant time delay:

$$\int_0^t \left(\left(\frac{i}{in >} \right)^p - C \right) \cdot dt \geq A \cdot k$$

(Equation 86)

For the numerical protection the sum below must fulfil the equation for trip.

$$\Delta t \cdot \sum_{j=1}^{n} \left(\left(\frac{i(j)}{in >} \right)^p - C \right) \geq A \cdot k$$

(Equation 87)

where:

j = 1	is the first protection execution cycle when a fault has been detected, that is, when $\frac{i}{in >} > 1$
Δt	is the time interval between two consecutive executions of the protection algorithm,
n	is the number of the execution of the algorithm when the trip time equation is fulfilled, that is, when a trip is given and
i (j)	is the fault current at time j

For inverse time operation, the inverse time characteristic is selectable. Both the IEC and ANSI/IEEE standardized inverse time characteristics are supported.

For the IEC curves there is also a setting of the minimum time-lag of operation, see figure 346.

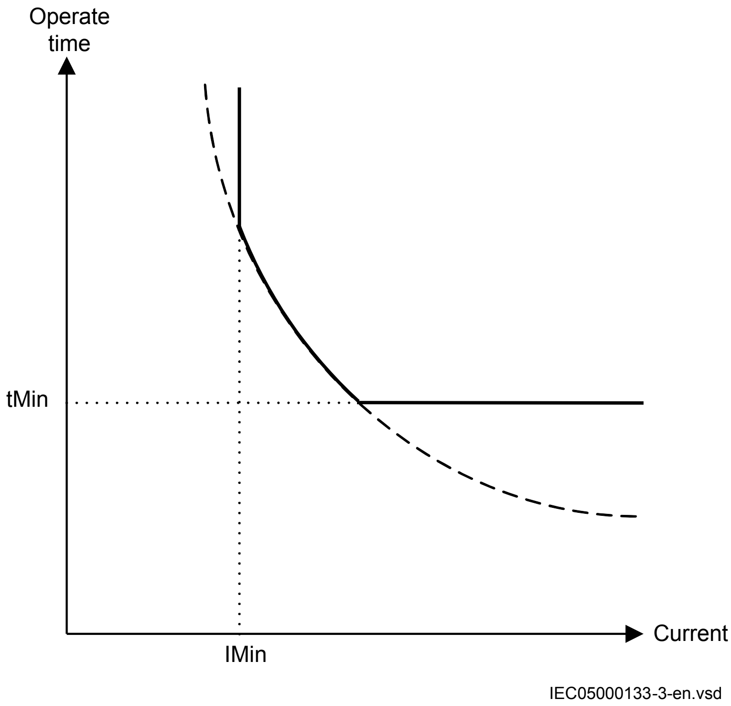


Figure 346: Minimum time-lag operation for the IEC curves

In order to fully comply with IEC curves definition setting parameter tMin shall be set to the value which is equal to the operating time of the selected IEC inverse time curve for measured current of twenty times the set current pickup value. Note that the operating time value is dependent on the selected setting value for time multiplier k.

In addition to the ANSI and IEC standardized characteristics, there are also two additional inverse curves available; the RI curve and the RD curve.

The RI inverse time curve emulates the characteristic of the electromechanical ASEA relay RI. The curve is described by equation 89:

$$t[s] = \left(\frac{k}{0.339 - 0.235 \cdot \frac{in>}{i}} \right)$$

(Equation 89)

where:

in>	is the set start current for step n
k	is set time multiplier for step n
i	is the measured current

The RD inverse curve gives a logarithmic delay, as used in the Combiflex protection RXIDG. The curve enables a high degree of selectivity required for sensitive residual earth-fault current protection, with ability to detect high-resistive earth faults. The curve is described by equation 90:

$$t[s] = 5.8 - 1.35 \cdot \ln\left(\frac{i}{k \cdot in >}\right)$$

(Equation 90)

where:

in>	is the set start current for step n,
k	is set time multiplier for step n and
i	is the measured current

If the curve type programmable is chosen, the user can make a tailor made inverse time curve according to the general equation 91.

$$t[s] = \left(\frac{A}{\left(\frac{i}{in >}\right)^{p} - C} + B\right) \cdot k$$

(Equation 91)

Also the reset time of the delayed function can be controlled. There is the possibility to choose between three different reset time-lags.

- Instantaneous Reset
- IEC Reset
- ANSI Reset.

If instantaneous reset is chosen the timer will be reset directly when the current drops below the set start current level minus the hysteresis.

If IEC reset is chosen the timer will be reset after a set constant time when the current drops below the set start current level minus the hysteresis.

If ANSI reset time is chosen the reset time will be dependent of the current after fault clearance (when the current drops below the start current level minus the hysteresis). The timer will reset according to equation 92.

$$t[s] = \left(\frac{t_r}{\left(\frac{i}{in >} \right)^2 - 1} \right) \cdot k$$

(Equation 92)

where:

The set value t_r is the reset time in case of zero current after fault clearance.

The possibility of choice of reset characteristics is to some extent dependent of the choice of time delay characteristic.

For the definite time delay characteristics the possible reset time settings are instantaneous and IEC constant time reset.

For ANSI inverse time delay characteristics all three types of reset time characteristics are available; instantaneous, IEC constant time reset and ANSI current dependent reset time.

For IEC inverse time delay characteristics the possible delay time settings are instantaneous and IEC set constant time reset).

For the programmable inverse time delay characteristics all three types of reset time characteristics are available; instantaneous, IEC constant time reset and ANSI current dependent reset time. If the current dependent type is used settings pr, tr and cr must be given, see equation 93:

$$t[s] = \left(\frac{t_r}{\left(\frac{i}{in >} \right)^{pr} - cr} \right) \cdot k$$

(Equation 93)

For RI and RD inverse time delay characteristics the possible delay time settings are instantaneous and IEC constant time reset.

When inverse time overcurrent characteristic is selected, the operate time of the stage will be the sum of the inverse time delay and the set definite time delay. Thus, if only the inverse time delay is required, it is of utmost importance to set the definite time delay for that stage to zero.

20.3 Inverse characteristics

Table 483: ANSI Inverse time characteristics

Function	Range or value	Accuracy
Operating characteristic: $t = \left(\frac{A}{\left(I^P - 1\right)} + B \right) \cdot k$ Reset characteristic: $t = \frac{t_r}{\left(I^2 - 1\right)} \cdot k$ $I = I_{measured}/I_{set}$	k = (0.05-999) in steps of 0.01 unless otherwise stated	-
ANSI Extremely Inverse	A=28.2, B=0.1217, P=2.0 , tr=29.1	ANSI/IEEE C37.112, class 5 + 40 ms
ANSI Very inverse	A=19.61, B=0.491, P=2.0 , tr=21.6	
ANSI Normal Inverse	A=0.0086, B=0.0185, P=0.02, tr=0.46	
ANSI Moderately Inverse	A=0.0515, B=0.1140, P=0.02, tr=4.85	
ANSI Long Time Extremely Inverse	A=64.07, B=0.250, P=2.0, tr=30	
ANSI Long Time Very Inverse	A=28.55, B=0.712, P=2.0, tr=13.46	
ANSI Long Time Inverse	k=(0.05-999) in steps of 0.01 A=0.086, B=0.185, P=0.02, tr=4.6	

Table 484: IEC Inverse time characteristics

Function	Range or value	Accuracy
Operating characteristic: $$t = \left(\frac{A}{\left(I^P - 1\right)} \right) \cdot k$$ $I = I_{measured}/I_{set}$	k = (0.05-999) in steps of 0.01	-
Time delay to reset, IEC inverse time	(0.000-60.000) s	± 0.5% of set time ± 10 ms
IEC Normal Inverse	A=0.14, P=0.02	IEC 60255-3, class 5 + 40 ms
IEC Very inverse	A=13.5, P=1.0	
IEC Inverse	A=0.14, P=0.02	
IEC Extremely inverse	A=80.0, P=2.0	
IEC Short time inverse	A=0.05, P=0.04	
IEC Long time inverse	A=120, P=1.0	
Programmable characteristic Operate characteristic: $$t = \left(\frac{A}{\left(I^P - C\right)} + B \right) \cdot k$$ Reset characteristic: $$t = \frac{TR}{\left(I^{PR} - CR\right)} \cdot k$$ $I = I_{measured}/I_{set}$	k = (0.05-999) in steps of 0.01 A=(0.005-200.000) in steps of 0.001 B=(0.00-20.00) in steps of 0.01 C=(0.1-10.0) in steps of 0.1 P=(0.005-3.000) in steps of 0.001 TR=(0.005-100.000) in steps of 0.001 CR=(0.1-10.0) in steps of 0.1 PR=(0.005-3.000) in steps of 0.001	IEC 60255, class 5 + 40 ms

Table 485: RI and RD type inverse time characteristics

Function	Range or value	Accuracy
RI type inverse characteristic $$t = \frac{1}{0.339 - \frac{0.236}{I}} \cdot k$$ $I = I_{measured}/I_{set}$	k = (0.05-999) in steps of 0.01	IEC 60255-3, class 5 + 40 ms
RD type logarithmic inverse characteristic $$t = 5.8 - \left(1.35 \cdot ln \frac{I}{k}\right)$$ $I = I_{measured}/I_{set}$	k = (0.05-999) in steps of 0.01	IEC 60255-3, class 5 + 40 ms

Table 486: Inverse time characteristics for overvoltage protection

Function	Range or value	Accuracy
Type A curve: $$t = \frac{k}{\left(\frac{U - U>}{U>}\right)}$$ U> = U_{set} U = $U_{measured}$	k = (0.05-1.10) in steps of 0.01 unless otherwise stated	Class 5 +40 ms
Type B curve: $$t = \frac{k \cdot 480}{\left(32 \cdot \frac{U - U>}{U>} - 0.5\right)^{2.0} - 0.035}$$	k = (0.05-1.10) in steps of 0.01 unless otherwise stated	
Type C curve: $$t = \frac{k \cdot 480}{\left(32 \cdot \frac{U - U>}{U>} - 0.5\right)^{3.0} - 0.035}$$	k = (0.05-1.10) in steps of 0.01 unless otherwise stated	
Programmable curve: $$t = \frac{k \cdot A}{\left(B \cdot \frac{U - U>}{U>} - C\right)^{P}} + D$$	k = (0.05-1.10) in steps of 0.01 unless otherwise stated A = (0.005-200.000) in steps of 0.001 B = (0.50-100.00) in steps of 0.01 C = (0.0-1.0) in steps of 0.1 D = (0.000-60.000) in steps of 0.001 P = (0.000-3.000) in steps of 0.001	

Table 487: Inverse time characteristics for undervoltage protection

Function	Range or value	Accuracy
Type A curve: $$t = \frac{k}{\left(\frac{U< - U}{U<}\right)}$$ $U< = U_{set}$ $U = UV_{measured}$	k = (0.05-1.10) in steps of 0.01 unless otherwise stated	Class 5 +40 ms
Type B curve: $$t = \frac{k \cdot 480}{\left(32 \cdot \frac{U< - U}{U<} - 0.5\right)^{2.0}} + 0.055$$ $U< = U_{set}$ $U = U_{measured}$	k = (0.05-1.10) in steps of 0.01 unless otherwise stated	
Programmable curve: $$t = \left[\frac{k \cdot A}{\left(B \cdot \frac{U< - U}{U<} - C\right)^{P}}\right] + D$$ $U< = U_{set}$ $U = U_{measured}$	k = (0.05-1.10) in steps of 0.01 unless otherwise stated A = (0.005-200.000) in steps of 0.001 B = (0.50-100.00) in steps of 0.01 C = (0.0-1.0) in steps of 0.1 D = (0.000-60.000) in steps of 0.001 P = (0.000-3.000) in steps of 0.001	

Table 488: Inverse time characteristics for residual overvoltage protection

Function	Range or value	Accuracy
Type A curve: $$t = \frac{k}{\left(\frac{U - U>}{U>}\right)}$$ U> = U_{set} U = $U_{measured}$	k = (0.05-1.10) in steps of 0.01	Class 5 +40 ms
Type B curve: $$t = \frac{k \cdot 480}{\left(32 \cdot \frac{U - U>}{U>} - 0.5\right)^{2.0} - 0.035}$$	k = (0.05-1.10) in steps of 0.01	
Type C curve: $$t = \frac{k \cdot 480}{\left(32 \cdot \frac{U - U>}{U>} - 0.5\right)^{3.0} - 0.035}$$	k = (0.05-1.10) in steps of 0.01	
Programmable curve: $$t = \frac{k \cdot A}{\left(B \cdot \frac{U - U>}{U>} - C\right)^{P}} + D$$	k = (0.05-1.10) in steps of 0.01 A = (0.005-200.000) in steps of 0.001 B = (0.50-100.00) in steps of 0.01 C = (0.0-1.0) in steps of 0.1 D = (0.000-60.000) in steps of 0.001 P = (0.000-3.000) in steps of 0.001	

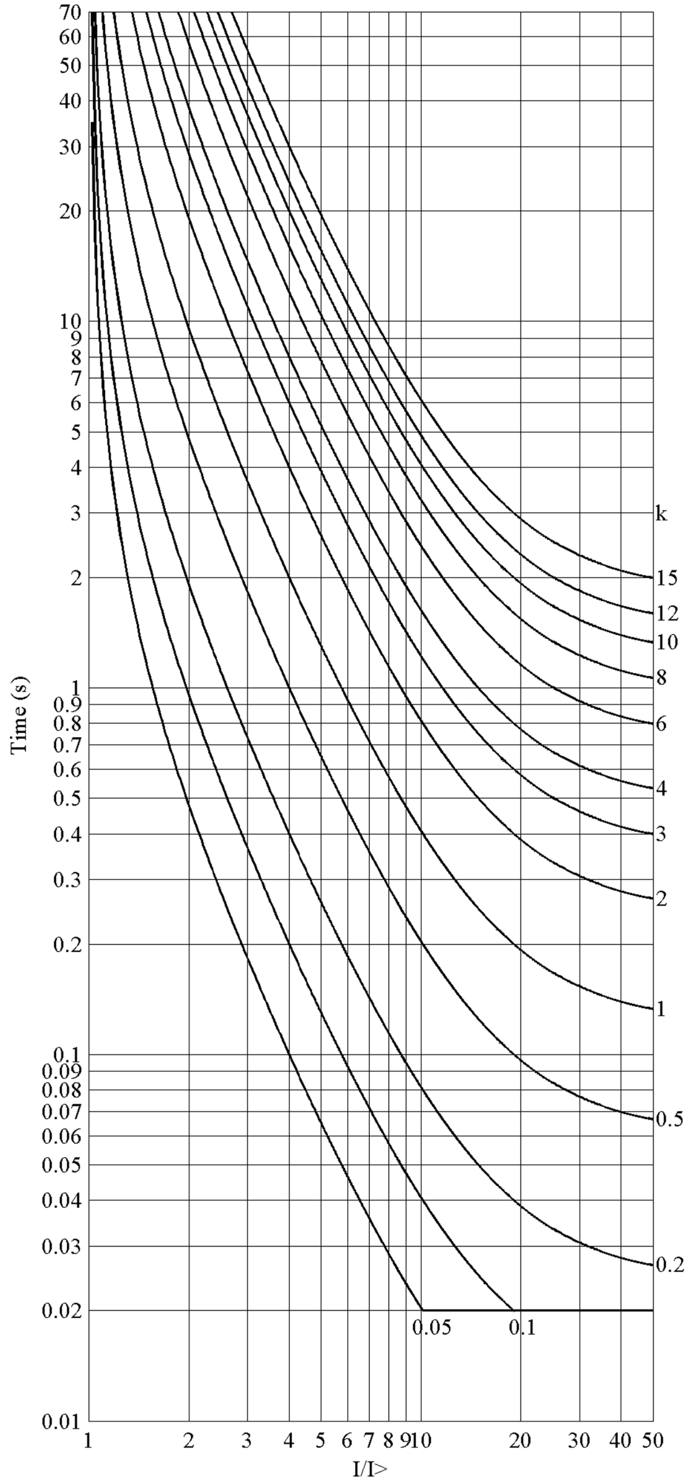


Figure 347: ANSI Extremely inverse time characteristics

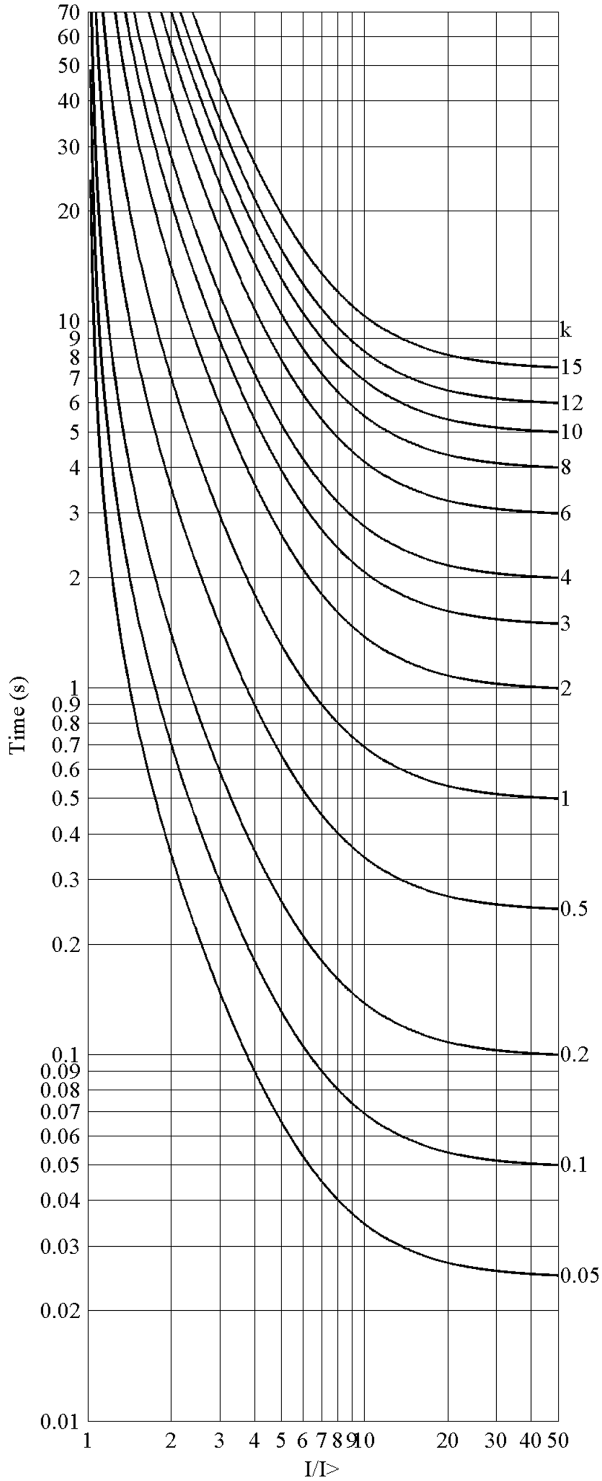


Figure 348: ANSI Very inverse time characteristics

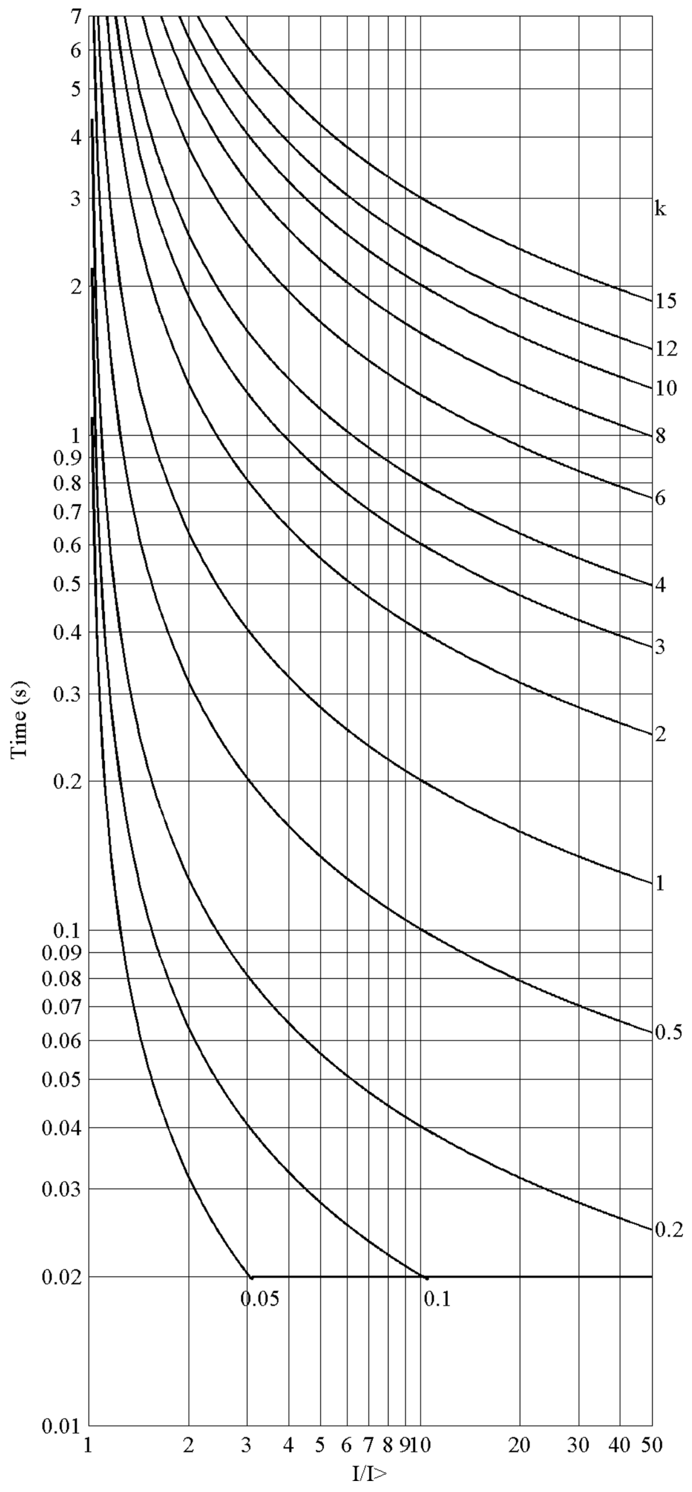


Figure 349: ANSI Normal inverse time characteristics

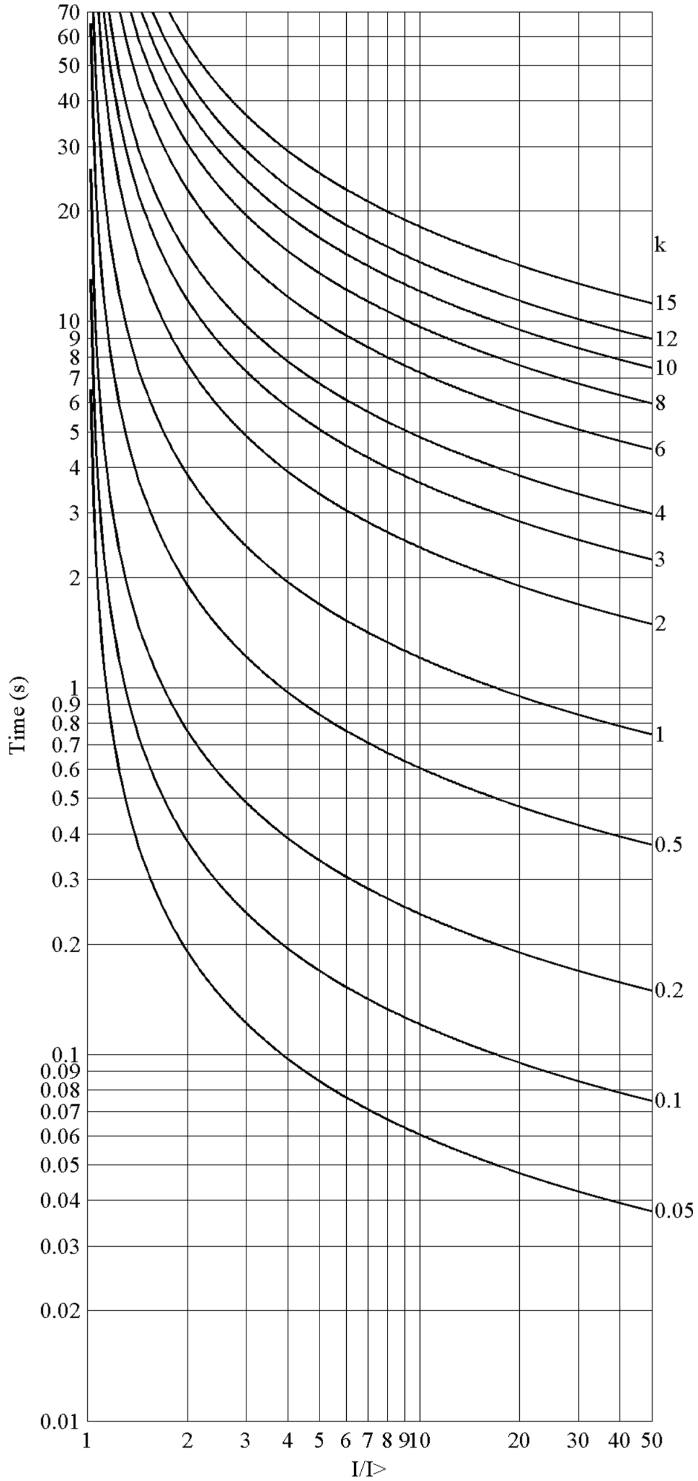


Figure 350: ANSI Moderately inverse time characteristics

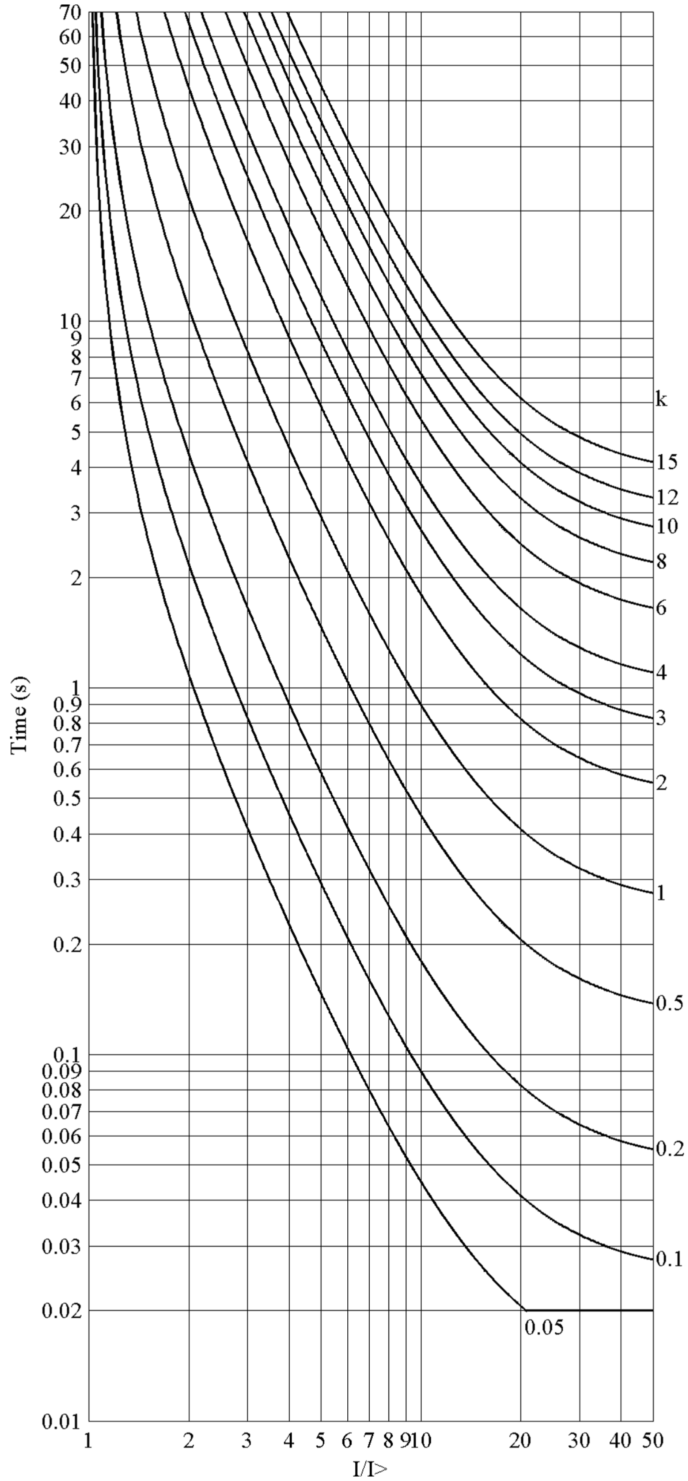


Figure 351: ANSI Long time extremely inverse time characteristics

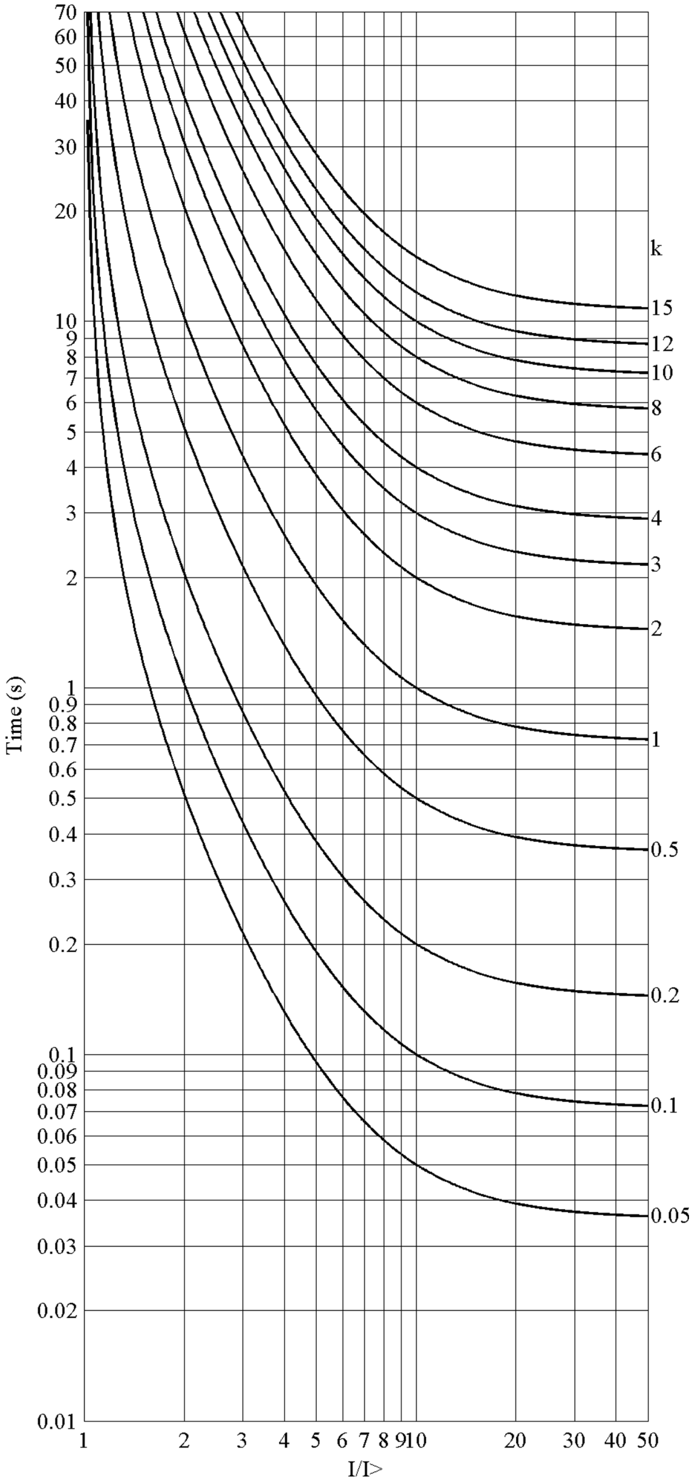


Figure 352: ANSI Long time very inverse time characteristics

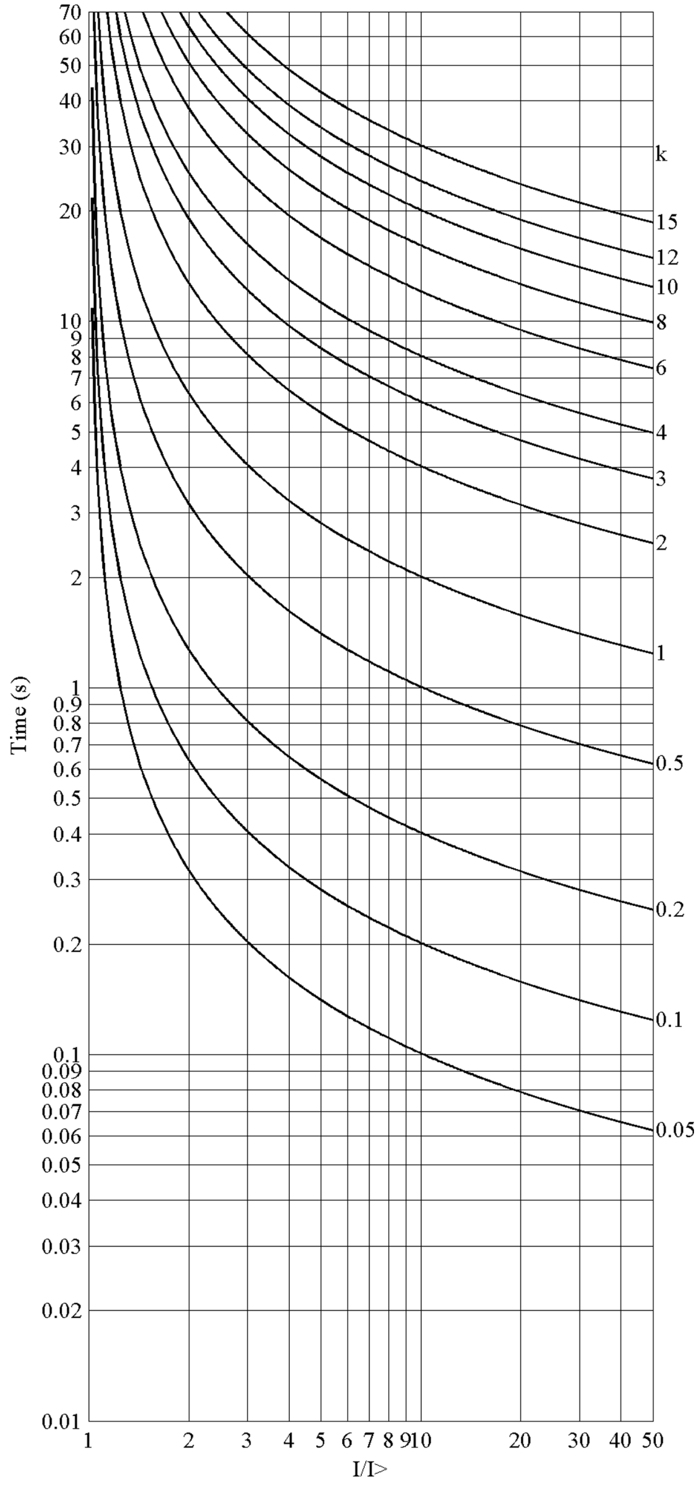


Figure 353: ANSI Long time inverse time characteristics

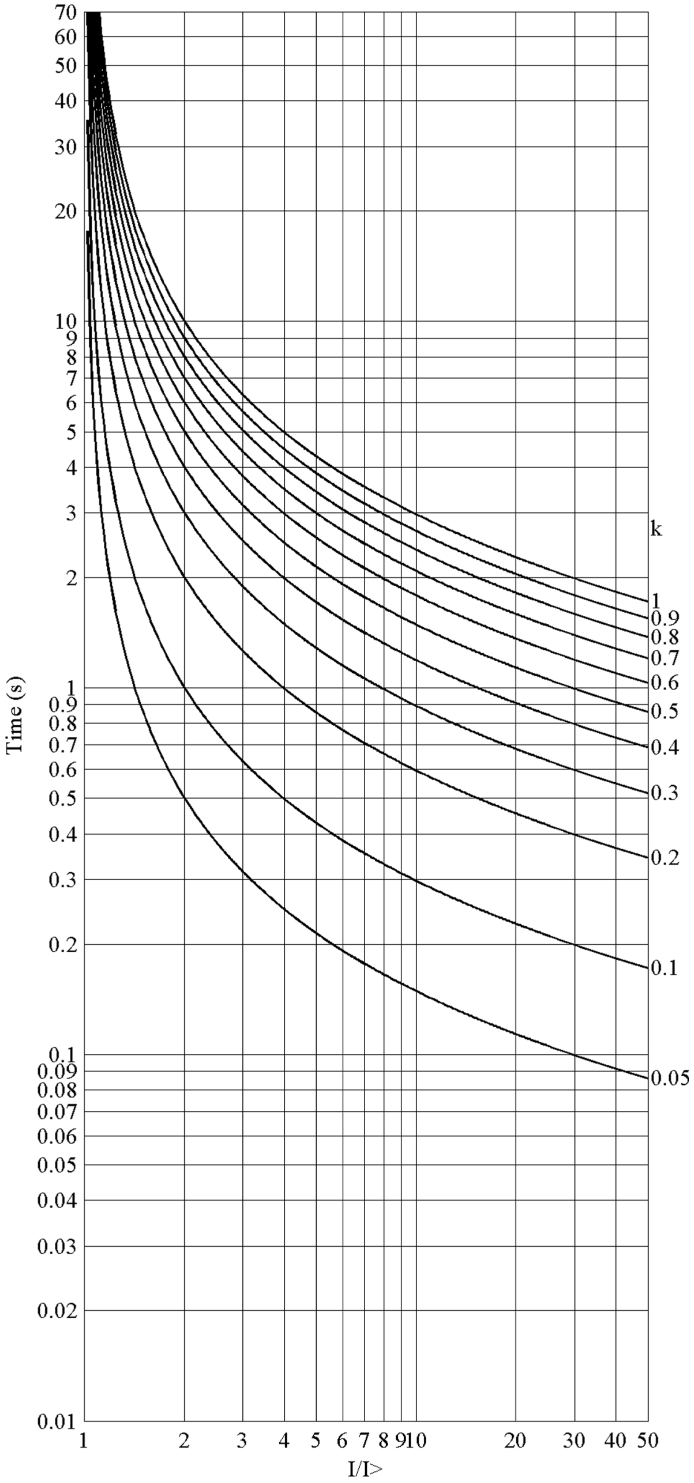


Figure 354: IEC Normal inverse time characteristics

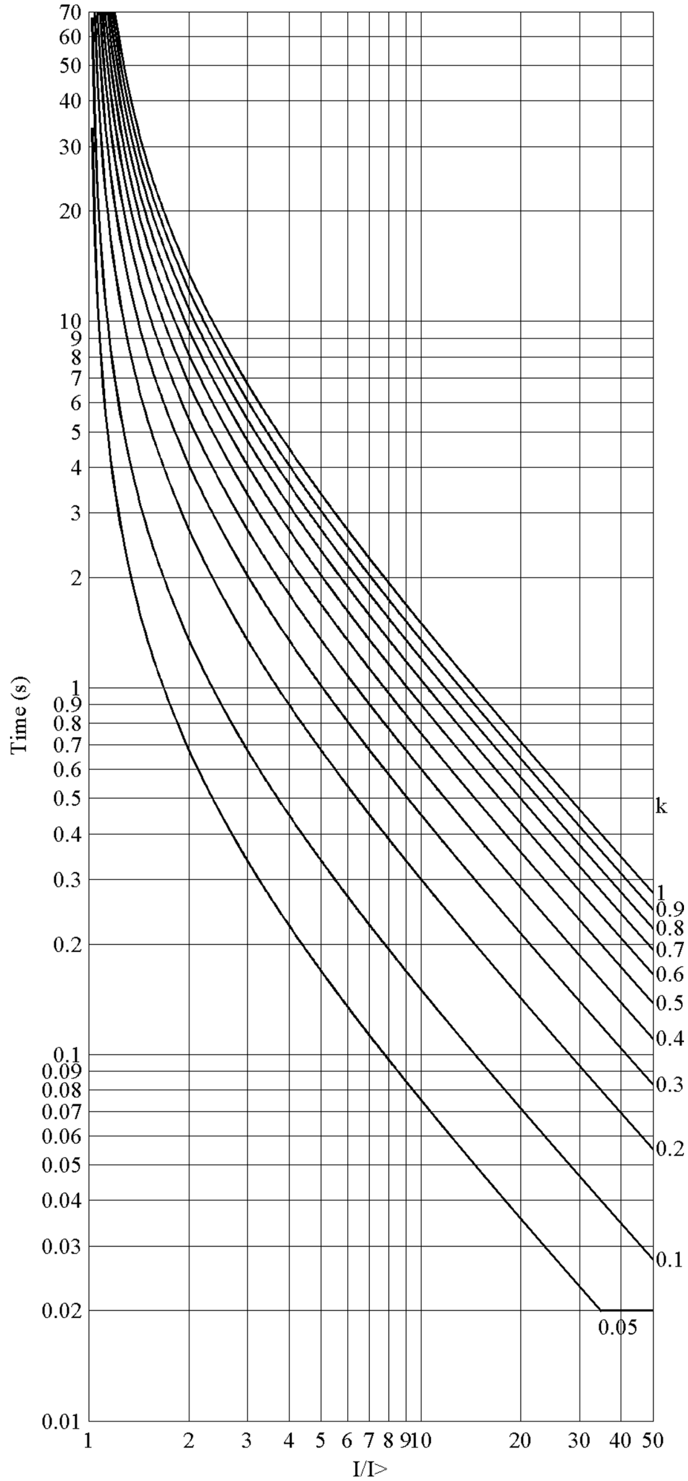


Figure 355: IEC Very inverse time characteristics

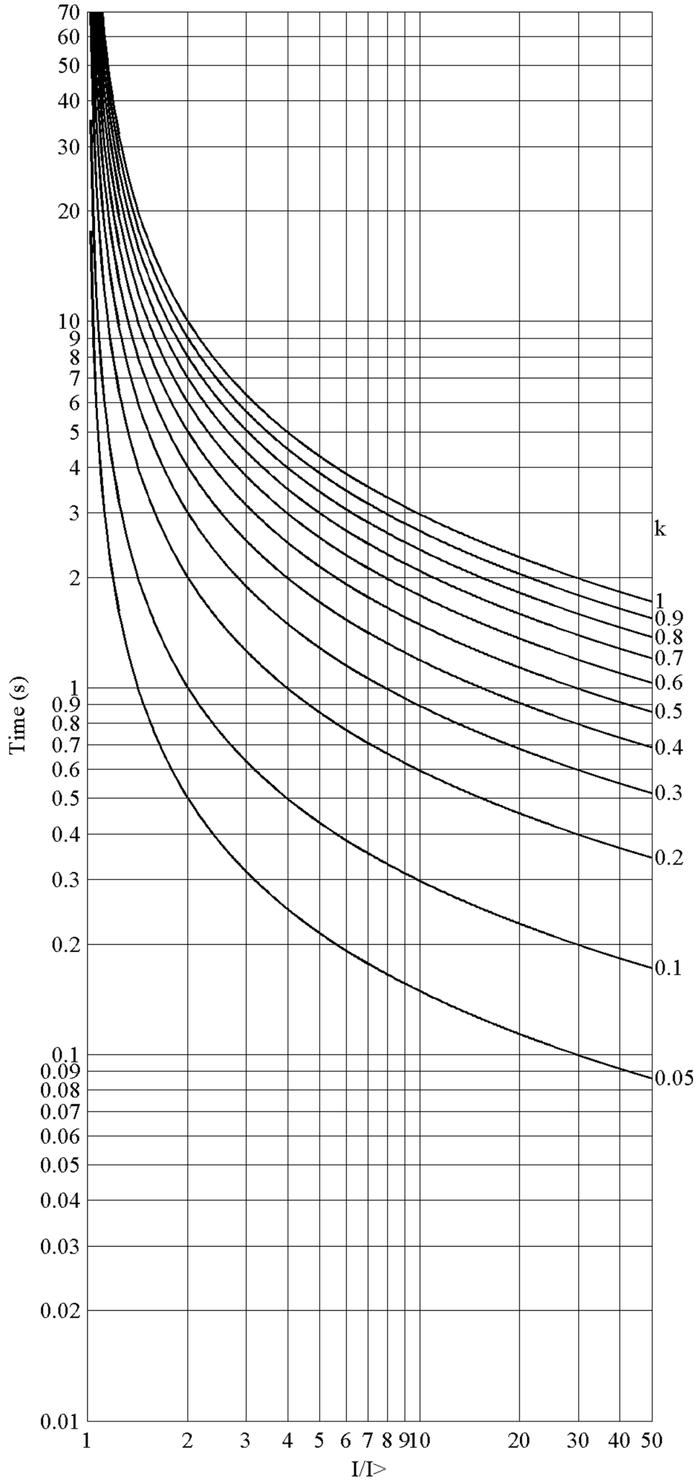


Figure 356: IEC Inverse time characteristics

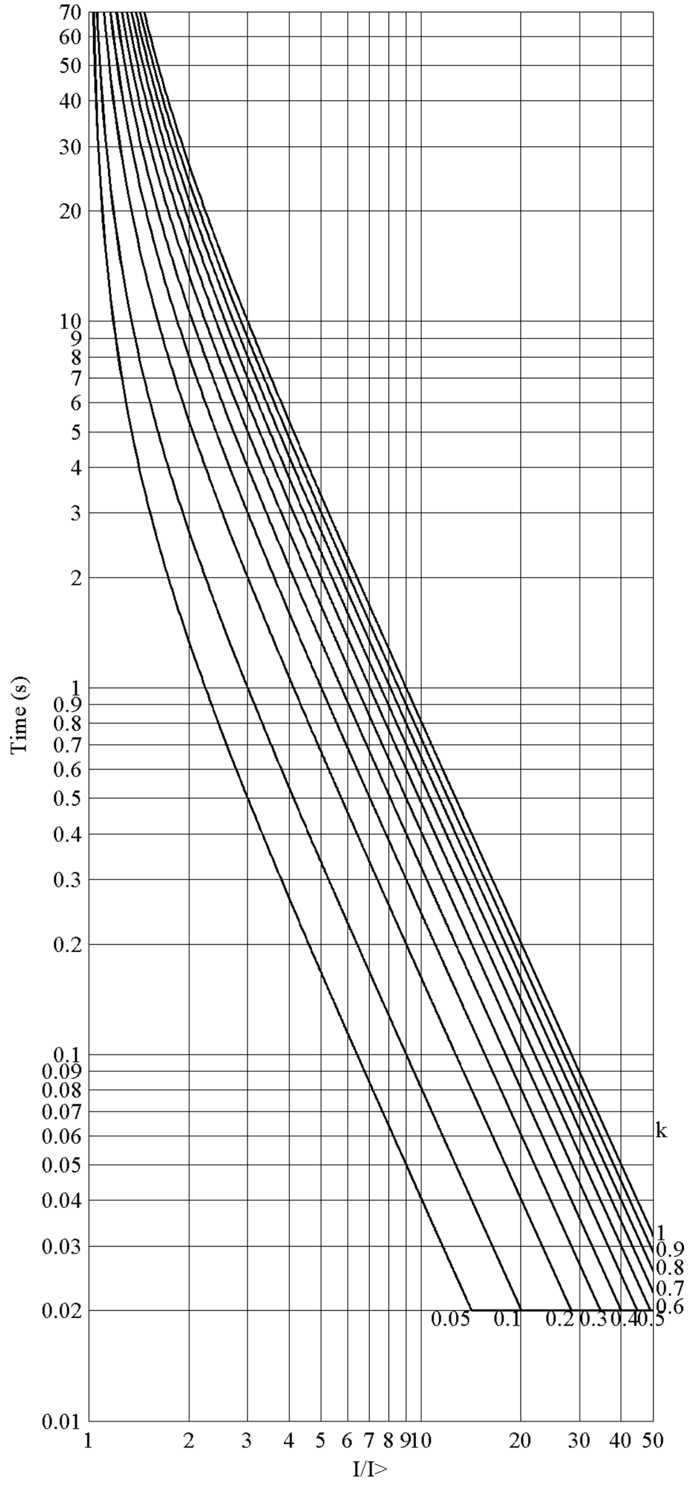


Figure 357: IEC Extremely inverse time characteristics

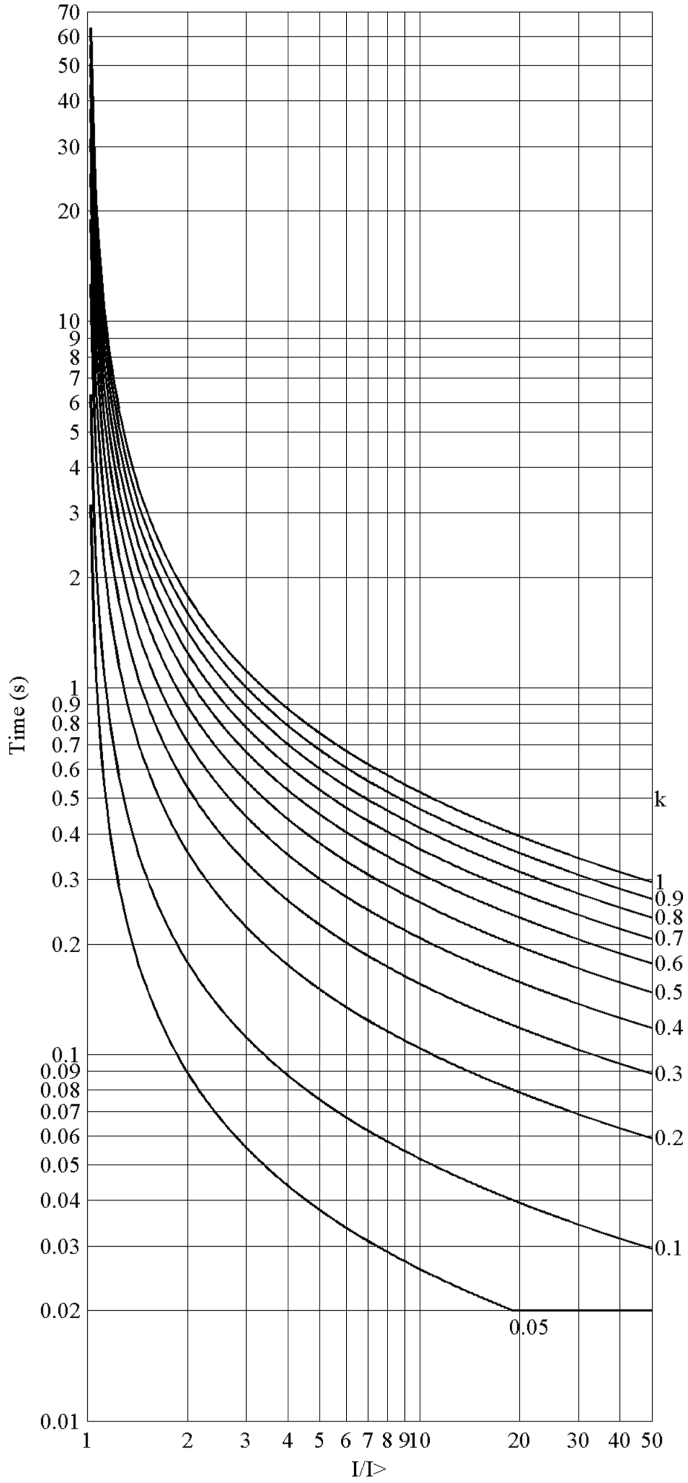


Figure 358: IEC Short time inverse time characteristics

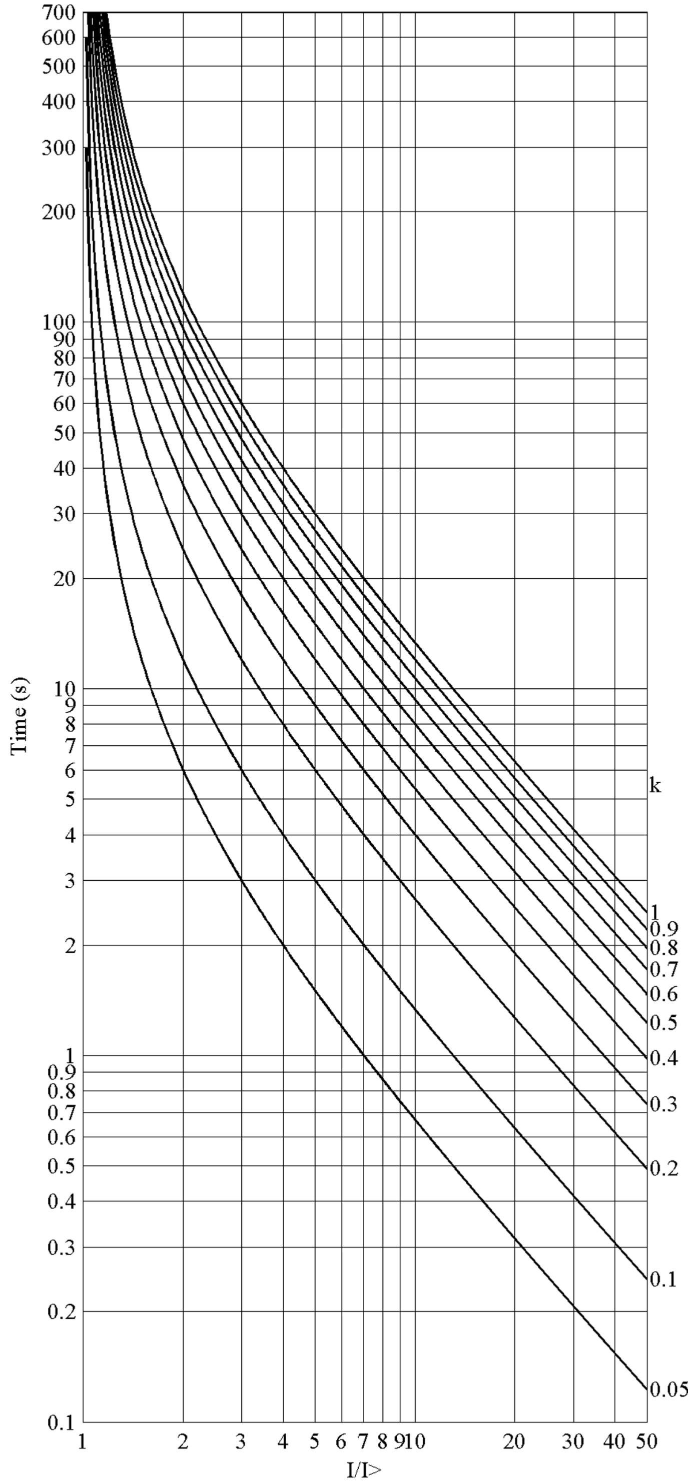


Figure 359: IEC Long time inverse time characteristics

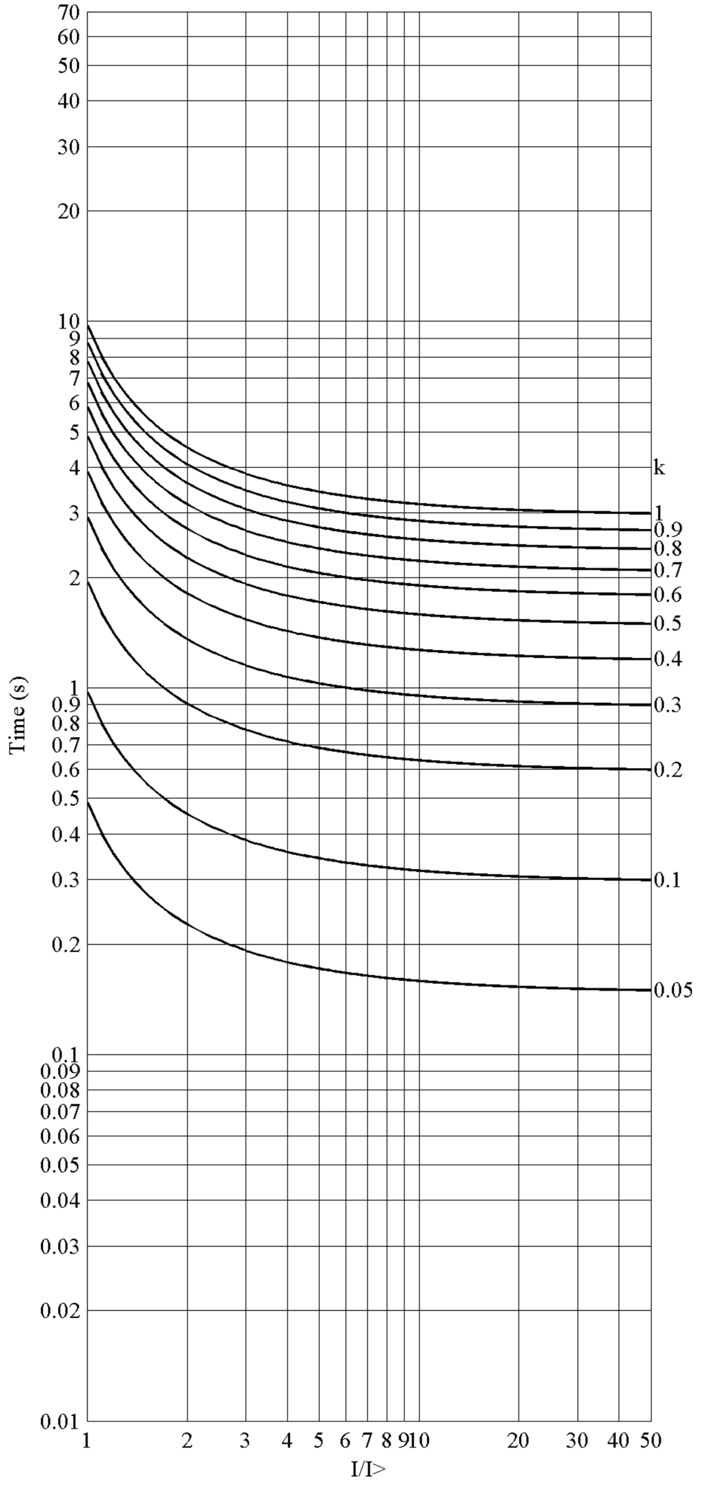


Figure 360: RI-type inverse time characteristics

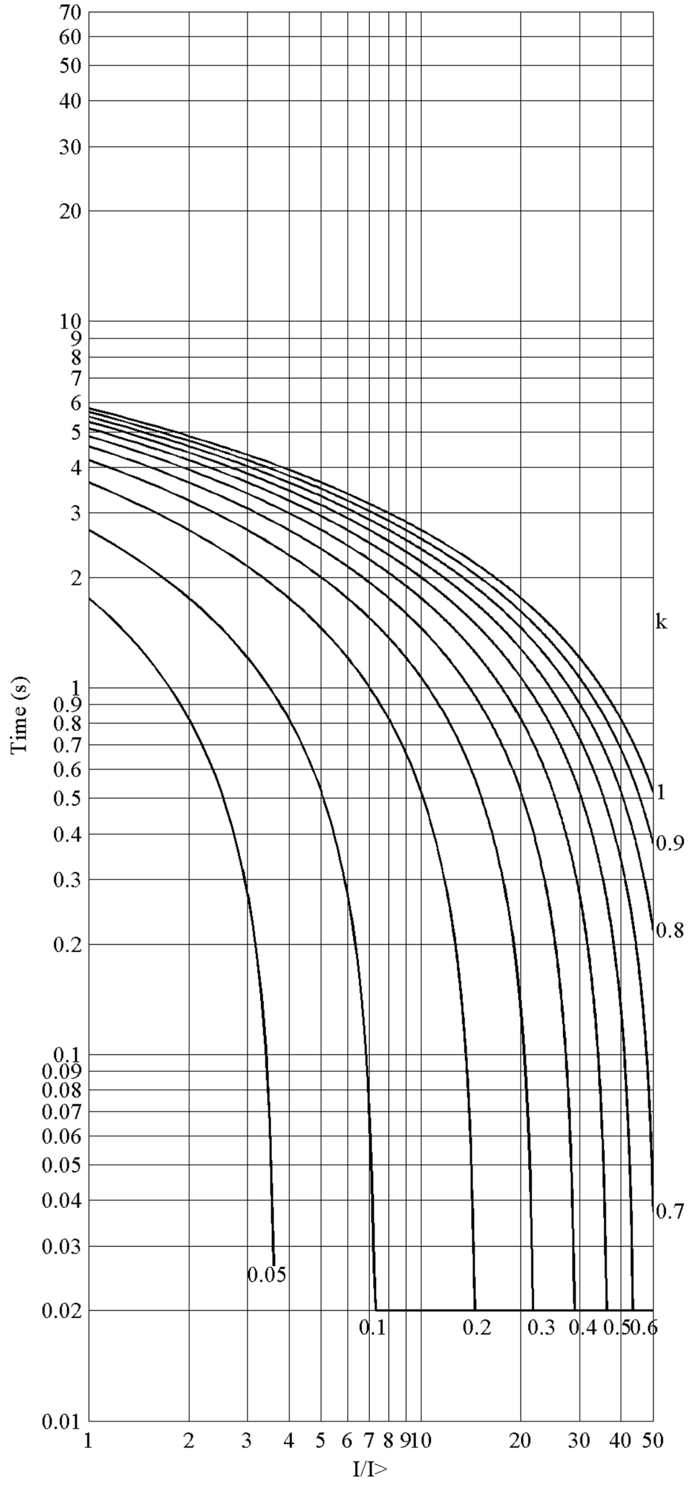


Figure 361: RD-type inverse time characteristics

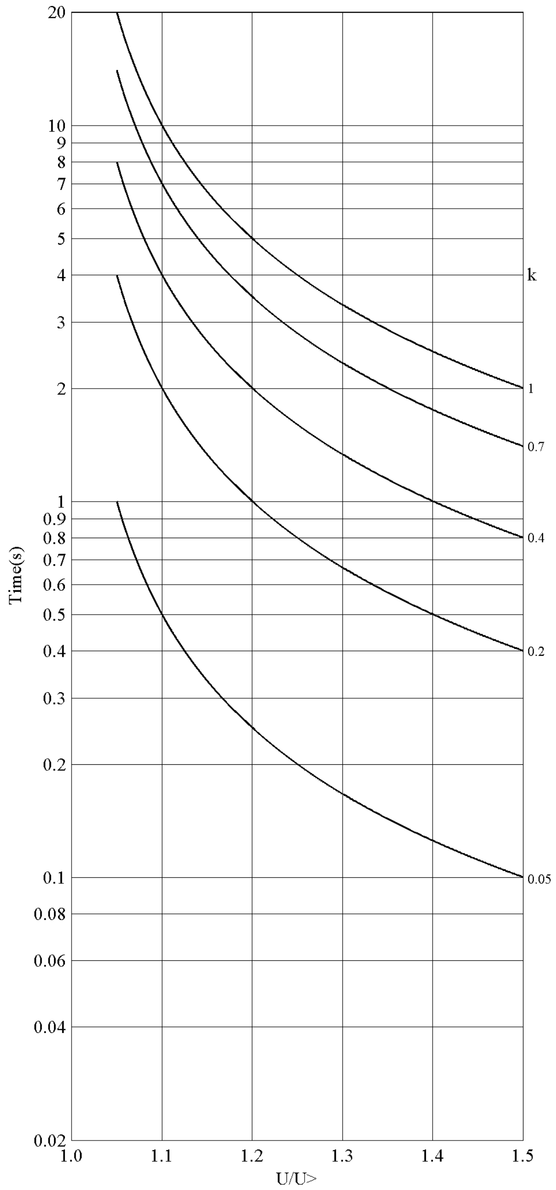


Figure 362: Inverse curve A characteristic of overvoltage protection

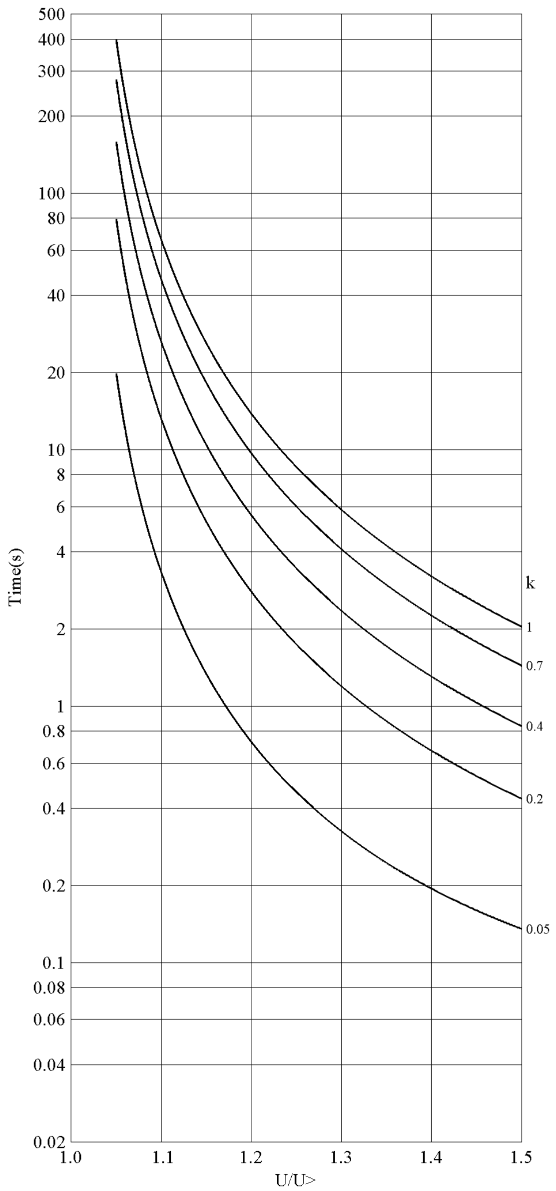


Figure 363: Inverse curve B characteristic of overvoltage protection

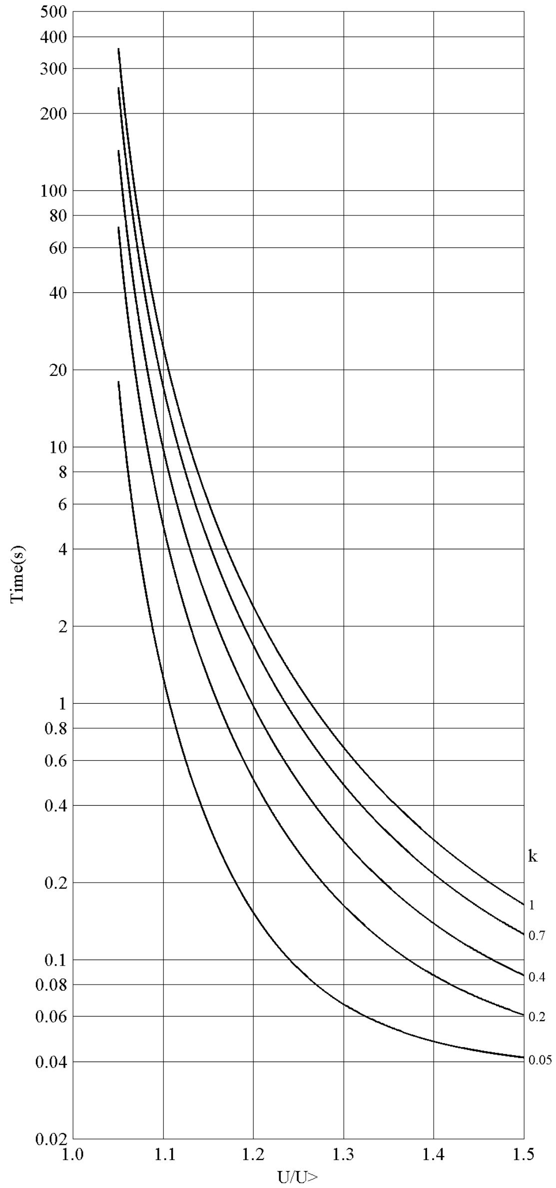


Figure 364: Inverse curve C characteristic of overvoltage protection

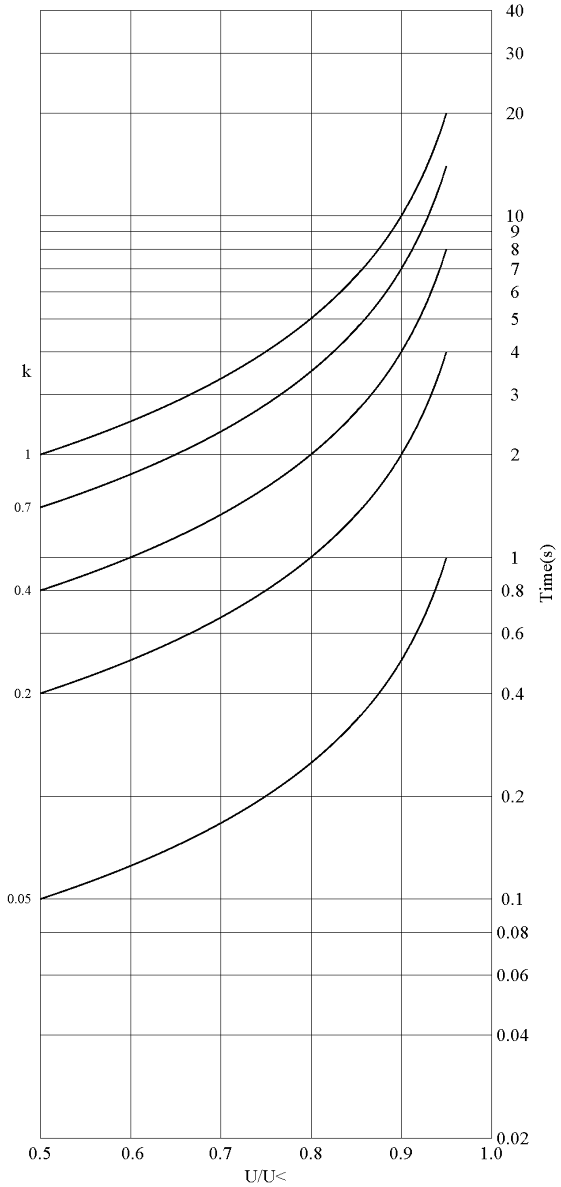


Figure 365: Inverse curve A characteristic of undervoltage protection

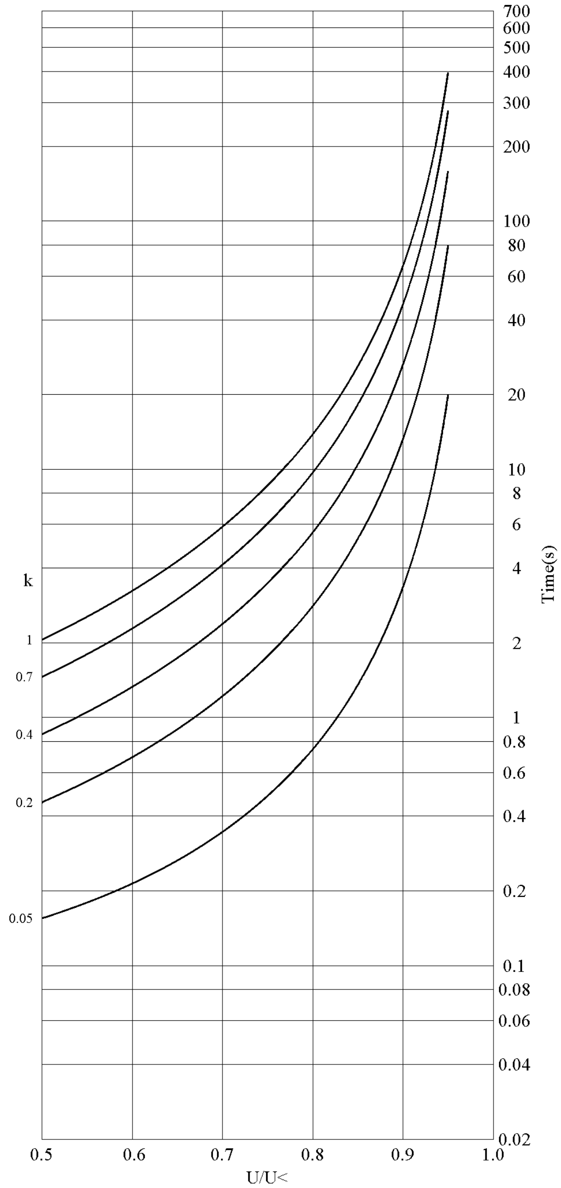


Figure 366: Inverse curve B characteristic of undervoltage protection

Section 21 Glossary

About this chapter

This chapter contains a glossary with terms, acronyms and abbreviations used in ABB technical documentation.

AC	Alternating current
ACT	Application configuration tool within PCM600
A/D converter	Analog-to-digital converter
ADBS	Amplitude deadband supervision
ADM	Analog digital conversion module, with time synchronization
AI	Analog input
ANSI	American National Standards Institute
AR	Autoreclosing
ArgNegRes	Setting parameter/ZD/
ArgDir	Setting parameter/ZD/
ASCT	Auxiliary summation current transformer
ASD	Adaptive signal detection
AWG	American Wire Gauge standard
BBP	Busbar protection
BFP	Breaker failure protection
BI	Binary input
BIM	Binary input module
BOM	Binary output module
BOS	Binary outputs status
BR	External bistable relay
BS	British Standards
BSR	Binary signal transfer function, receiver blocks
BST	Binary signal transfer function, transmit blocks
C37.94	IEEE/ANSI protocol used when sending binary signals between IEDs
CAN	Controller Area Network. ISO standard (ISO 11898) for serial communication
CB	Circuit breaker

CBM	Combined backplane module
CCITT	Consultative Committee for International Telegraph and Telephony. A United Nations-sponsored standards body within the International Telecommunications Union.
CCM	CAN carrier module
CCVT	Capacitive Coupled Voltage Transformer
Class C	Protection Current Transformer class as per IEEE/ ANSI
CMPPS	Combined megapulses per second
CMT	Communication Management tool in PCM600
CO cycle	Close-open cycle
Codirectional	Way of transmitting G.703 over a balanced line. Involves two twisted pairs making it possible to transmit information in both directions
COMTRADE	Standard format according to IEC 60255-24
Contra-directional	Way of transmitting G.703 over a balanced line. Involves four twisted pairs, two of which are used for transmitting data in both directions and two for transmitting clock signals
CPU	Central processor unit
CR	Carrier receive
CRC	Cyclic redundancy check
CROB	Control relay output block
CS	Carrier send
CT	Current transformer
CVT	Capacitive voltage transformer
DAR	Delayed autoreclosing
DARPA	Defense Advanced Research Projects Agency (The US developer of the TCP/IP protocol etc.)
DBDL	Dead bus dead line
DBLL	Dead bus live line
DC	Direct current
DFC	Data flow control
DFT	Discrete Fourier transform
DHCP	Dynamic Host Configuration Protocol
DIP-switch	Small switch mounted on a printed circuit board
DI	Digital input
DLLB	Dead line live bus

DNP	Distributed Network Protocol as per IEEE/ANSI Std. 1379-2000
DR	Disturbance recorder
DRAM	Dynamic random access memory
DRH	Disturbance report handler
DSP	Digital signal processor
DTT	Direct transfer trip scheme
EHV network	Extra high voltage network
EIA	Electronic Industries Association
EMC	Electromagnetic compatibility
EMF	(Electric Motive Force)
EMI	Electromagnetic interference
EnFP	End fault protection
EPA	Enhanced performance architecture
ESD	Electrostatic discharge
FCB	Flow control bit; Frame count bit
FOX 20	Modular 20 channel telecommunication system for speech, data and protection signals
FOX 512/515	Access multiplexer
FOX 6Plus	Compact time-division multiplexer for the transmission of up to seven duplex channels of digital data over optical fibers
G.703	Electrical and functional description for digital lines used by local telephone companies. Can be transported over balanced and unbalanced lines
GCM	Communication interface module with carrier of GPS receiver module
GDE	Graphical display editor within PCM600
GI	General interrogation command
GIS	Gas-insulated switchgear
GOOSE	Generic object-oriented substation event
GPS	Global positioning system
GTM	GPS Time Module
HDLC protocol	High-level data link control, protocol based on the HDLC standard
HFBR connector type	Plastic fiber connector
HMI	Human-machine interface

HSAR	High speed autoreclosing
HV	High-voltage
HVDC	High-voltage direct current
IDBS	Integrating deadband supervision
IEC	International Electrical Committee
IEC 60044-6	IEC Standard, Instrument transformers – Part 6: Requirements for protective current transformers for transient performance
IEC 60870-5-103	Communication standard for protective equipment. A serial master/slave protocol for point-to-point communication
IEC 61850	Substation automation communication standard
IEEE	Institute of Electrical and Electronics Engineers
IEEE 802.12	A network technology standard that provides 100 Mbits/s on twisted-pair or optical fiber cable
IEEE P1386.1	PCI Mezzanine Card (PMC) standard for local bus modules. References the CMC (IEEE P1386, also known as Common Mezzanine Card) standard for the mechanics and the PCI specifications from the PCI SIG (Special Interest Group) for the electrical EMF (Electromotive force).
IED	Intelligent electronic device
I-GIS	Intelligent gas-insulated switchgear
IOM	Binary input/output module
Instance	When several occurrences of the same function are available in the IED, they are referred to as instances of that function. One instance of a function is identical to another of the same kind but has a different number in the IED user interfaces. The word "instance" is sometimes defined as an item of information that is representative of a type. In the same way an instance of a function in the IED is representative of a type of function.
IP	1. Internet protocol. The network layer for the TCP/IP protocol suite widely used on Ethernet networks. IP is a connectionless, best-effort packet-switching protocol. It provides packet routing, fragmentation and reassembly through the data link layer. 2. Ingression protection, according to IEC standard
IP 20	Ingression protection, according to IEC standard, level 20
IP 40	Ingression protection, according to IEC standard, level 40
IP 54	Ingression protection, according to IEC standard, level 54
IRF	Internal failure signal

IRIG-B:	InterRange Instrumentation Group Time code format B, standard 200
ITU	International Telecommunications Union
LAN	Local area network
LIB 520	High-voltage software module
LCD	Liquid crystal display
LDCM	Line differential communication module
LDD	Local detection device
LED	Light-emitting diode
LNT	LON network tool
LON	Local operating network
MCB	Miniature circuit breaker
MCM	Mezzanine carrier module
MIM	Milli-ampere module
MPM	Main processing module
MVB	Multifunction vehicle bus. Standardized serial bus originally developed for use in trains.
NCC	National Control Centre
NUM	Numerical module
OCO cycle	Open-close-open cycle
OCP	Overcurrent protection
OEM	Optical ethernet module
OLTC	On-load tap changer
OV	Over-voltage
Overreach	A term used to describe how the relay behaves during a fault condition. For example, a distance relay is overreaching when the impedance presented to it is smaller than the apparent impedance to the fault applied to the balance point, that is, the set reach. The relay "sees" the fault but perhaps it should not have seen it.
PCI	Peripheral component interconnect, a local data bus
PCM	Pulse code modulation
PCM600	Protection and control IED manager
PC-MIP	Mezzanine card standard
PISA	Process interface for sensors & actuators
PMC	PCI Mezzanine card

POR	Permissive overreach
POTT	Permissive overreach transfer trip
Process bus	Bus or LAN used at the process level, that is, in near proximity to the measured and/or controlled components
PSM	Power supply module
PST	Parameter setting tool within PCM600
PT ratio	Potential transformer or voltage transformer ratio
PUTT	Permissive underreach transfer trip
RASC	Synchrocheck relay, COMBIFLEX
RCA	Relay characteristic angle
RFPP	Resistance for phase-to-phase faults
RFPE	Resistance for phase-to-earth faults
RISC	Reduced instruction set computer
RMS value	Root mean square value
RS422	A balanced serial interface for the transmission of digital data in point-to-point connections
RS485	Serial link according to EIA standard RS485
RTC	Real-time clock
RTU	Remote terminal unit
SA	Substation Automation
SBO	Select-before-operate
SC	Switch or push button to close
SCS	Station control system
SCADA	Supervision, control and data acquisition
SCT	System configuration tool according to standard IEC 61850
SDU	Service data unit
SLM	Serial communication module. Used for SPA/LON/IEC/DNP3 communication.
SMA connector	Subminiature version A, A threaded connector with constant impedance.
SMT	Signal matrix tool within PCM600
SMS	Station monitoring system
SNTP	Simple network time protocol – is used to synchronize computer clocks on local area networks. This reduces the requirement to have accurate hardware clocks in every embedded system in a network. Each embedded node can

	instead synchronize with a remote clock, providing the required accuracy.
SPA	Strömberg protection acquisition, a serial master/slave protocol for point-to-point communication
SRY	Switch for CB ready condition
ST	Switch or push button to trip
Starpoint	Neutral point of transformer or generator
SVC	Static VAr compensation
TC	Trip coil
TCS	Trip circuit supervision
TCP	Transmission control protocol. The most common transport layer protocol used on Ethernet and the Internet.
TCP/IP	Transmission control protocol over Internet Protocol. The de facto standard Ethernet protocols incorporated into 4.2BSD Unix. TCP/IP was developed by DARPA for Internet working and encompasses both network layer and transport layer protocols. While TCP and IP specify two protocols at specific protocol layers, TCP/IP is often used to refer to the entire US Department of Defense protocol suite based upon these, including Telnet, FTP, UDP and RDP.
TEF	Time delayed earth-fault protection function
TNC connector	Threaded Neill-Concelman, a threaded constant impedance version of a BNC connector
TPZ, TPY, TPX, TPS	Current transformer class according to IEC
UMT	User management tool
Underreach	A term used to describe how the relay behaves during a fault condition. For example, a distance relay is underreaching when the impedance presented to it is greater than the apparent impedance to the fault applied to the balance point, that is, the set reach. The relay does not “see” the fault but perhaps it should have seen it. See also Overreach.
U/I-PISA	Process interface components that deliver measured voltage and current values
UTC	Coordinated Universal Time. A coordinated time scale, maintained by the Bureau International des Poids et Mesures (BIPM), which forms the basis of a coordinated dissemination of standard frequencies and time signals. UTC is derived from International Atomic Time (TAI) by the addition of a whole number of "leap seconds" to synchronize it with Universal Time 1 (UT1), thus allowing for the eccentricity of the Earth's orbit, the rotational axis tilt (23.5

	degrees), but still showing the Earth's irregular rotation, on which UT1 is based. The Coordinated Universal Time is expressed using a 24-hour clock, and uses the Gregorian calendar. It is used for aeroplane and ship navigation, where it is also sometimes known by the military name, "Zulu time." "Zulu" in the phonetic alphabet stands for "Z", which stands for longitude zero.
UV	Undervoltage
WEI	Weak end infeed logic
VT	Voltage transformer
X.21	A digital signalling interface primarily used for telecom equipment
$3I_O$	Three times zero-sequence current. Often referred to as the residual or the earth-fault current
$3U_O$	Three times the zero sequence voltage. Often referred to as the residual voltage or the neutral point voltage

Contact us

ABB AB
Substation Automation Products
SE-721 59 Västerås, Sweden
Phone +46 (0) 21 32 50 00
Fax +46 (0) 21 14 69 18

www.abb.com/substationautomation

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