Relion® 650 series

Bay control
REC650
Technical Manual

Power and productivity
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ABB

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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 proved by tests conducted by ABB AB in accordance with the generic standard EN 50263 for the EMC directive, and with the standards EN 60255-5 and/or EN 50178 for the low voltage directive.

This product is designed and produced for industrial use.

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Section 1   Introduction

1.1   This manual

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

1.2   Intended audience

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

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

1.3   Product documentation

1.3.1   Product documentation set

en07000220.vsd
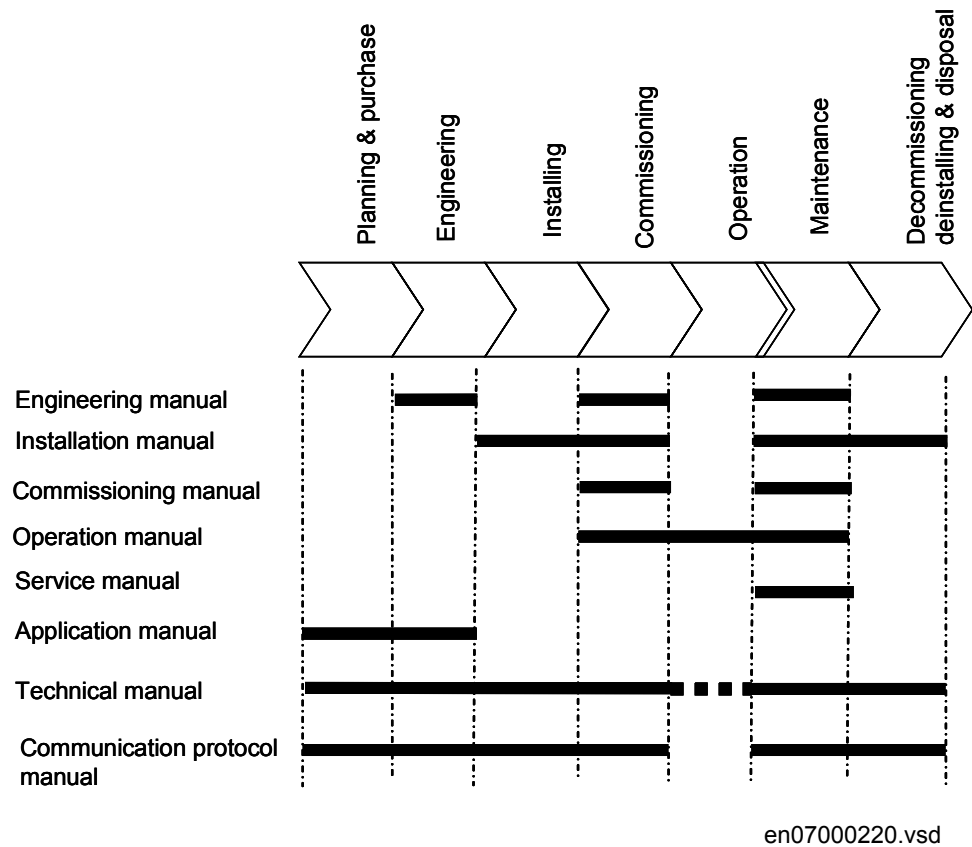
Figure 1:   *The intended use of manuals in different lifecycles*

The engineering manual 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.

The installation manual contains instructions on how to install the IED. The manual provides procedures for mechanical and electrical installation. The chapters are organized in chronological order in which the IED should be installed.

The commissioning manual contains instructions on how to commission the IED. The manual can also be used by system engineers and maintenance personnel for assistance during the testing phase. The manual provides procedures for checking of external circuitry and energizing the IED, parameter setting and configuration as well as verifying settings by secondary injection. The manual describes the process

of testing an IED in a substation which is not in service. The chapters are organized in chronological order in which the IED should be commissioned.

The operation manual contains instructions on how to operate the IED once it has been commissioned. The manual provides instructions for monitoring, controlling and setting the IED. The manual also describes how to identify disturbances and how to view calculated and measured power grid data to determine the cause of a fault.

The service manual contains instructions on how to service and maintain the IED. The manual also provides procedures for de-energizing, de-commissioning and disposal of the IED.

The application manual contains application descriptions and setting guidelines sorted per function. The manual can be used to find out when and for what purpose a typical protection function can be used. The manual can also be used when calculating settings.

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

The communication protocol manual describes a communication protocol supported by the IED. The manual concentrates on vendor-specific implementations.

The point list manual describes the outlook and properties of the data points specific to the IED. The manual should be used in conjunction with the corresponding communication protocol manual.

> The service manual is not available yet.

1.3.2 Document revision history

Document revision/date	Product series version	History
-/September 2009	1.0	First release

1.3.3 Related documents

Documents related to REC650	Identity number
Commissioning manual	1MRK 511 209-UEN
Technical manual	1MRK 511 204-UEN
Application manual	1MRK 511 203-UEN

Table continues on next page

Documents related to REC650	Identity number
Product Guide, configured	1MRK 511 211-BEN
Type test certificate	1MRK 511 211-TEN

650 series manuals	Identity number
Operation manual	1MRK 500 088-UEN
Communication protocol manual, DNP3	1MRK 511 224-UEN
Communication protocol manual, IEC 61850	1MRK 511 205-UEN
Engineering manual	1MRK 511 206-UEN
Installation manual	1MRK 514 013-UEN
Point list manual, DNP3	1MRK 511 225-UEN

1.4 Symbols and conventions

1.4.1 Safety indication symbols

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

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

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

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

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

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

1.4.2 Manual conventions

Conventions used in IED manuals. A particular convention may not be used in this manual.

- Abbreviations and acronyms in this manual are spelled out in Glossary. Glossary also contains definitions of important terms.
- Push button navigation in the LHMI menu structure is presented by using the push button icons, for example:
  To navigate between the options, use and .
- HMI menu paths are presented in bold, for example:
  Select **Main menu/Settings**.
- LHMI messages are shown in Courier font, for example:
  To save the changes in non-volatile memory, select Yes and press .
- Parameter names are shown in italics, for example:
  The function can be enabled and disabled with the *Operation* setting.
- 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 an own signal name 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.

Section 2 Available functions

2.1 Control and monitoring functions

IEC 61850	ANSI	Function description	Bay		
			REC650 (A01) 1CBA	REC650 (A02) 1CBAB	REC650 (A07) BCAB
Control					
SESRSYN	25	Synchrocheck, energizing check, and synchronizing	1	1	1
SMBRREC	79	Autorecloser	1	1	1
SCILO	3	Logical node for interlocking	8	8	8
BB_ES	3	Interlocking for busbar earthing switch	3	3	3
A1A2_BS	3	Interlocking for bus-section breaker	2	2	2
A1A2_DC	3	Interlocking for bus-section disconnector	3	3	3
ABC_BC	3	Interlocking for bus-coupler bay	1	1	1
BH_CONN	3	Interlocking for 1 1/2 breaker diameter	1	1	1
BH_LINE_A	3	Interlocking for 1 1/2 breaker diameter	1	1	1
BH_LINE_B	3	Interlocking for 1 1/2 breaker diameter	1	1	1
DB_BUS_A	3	Interlocking for double CB bay	1	1	1
DB_BUS_B	3	Interlocking for double CB bay	1	1	1
DB_LINE	3	Interlocking for double CB bay	1	1	1
ABC_LINE	3	Interlocking for line bay	1	1	1
AB_TRAFO	3	Interlocking for transformer bay	1	1	1
SCSWI		Switch controller	8	8	8
SXCBR		Circuit breaker	3	3	3
SXSWI		Circuit switch	7	7	7
POS_EVAL		Evaluation of position indication	8	8	8
SELGGIO		Select release	1	1	1
QCBAY		Bay control	1	1	1
LOCREM		Handling of LR-switch positions	1	1	1
LOCREMCTRL		LHMI control of PSTO	1	1	1
SLGGIO		Logic Rotating Switch for function selection and LHMI presentation	15	15	15
VSGGIO		Selector mini switch extension	20	20	20
DPGGIO		IEC 61850 generic communication I/O functions double point	16	16	16
SPC8GGIO		Single point generic control 8 signals	5	5	5

Table continues on next page

IEC 61850	ANSI	Function description	Bay		
			REC650 (A01) 1CBA	REC650 (A02) 1CBAB	REC650 (A07) BCAB
AUTOBITS		AutomationBits, command function for DNP3.0	3	3	3
Secondary system supervision					
CCSRDIF	87	Current circuit supervision	1	1	1
SDDRFUF		Fuse failure supervision	1	1	1
TCSSCBR		Breaker close/trip circuit monitoring	3	3	3
Logic					
SMPPTRC	94	Tripping logic	1	1	1
TMAGGIO		Trip matrix logic	12	12	12
OR		Configurable logic blocks, OR	283	283	283
INVERTER		Configurable logic blocks, Inverter	140	140	140
PULSETIMER		Configurable logic blocks, PULSETIMER	40	40	40
GATE		Configurable logic blocks, Controllable gate	40	40	40
XOR		Configurable logic blocks, exclusive OR	40	40	40
LOOPDELAY		Configurable logic blocks, loop delay	40	40	40
TimeSet		Configurable logic blocks, timer	40	40	40
AND		Configurable logic blocks, AND	280	280	280
SRMEMORY		Configurable logic blocks, set-reset memory	40	40	40
RSMEMORY		Configurable logic blocks, reset-set memory	40	40	40
ANDQT		Configurable logic Q/T, ANDQT	120	120	120
ORQT		Configurable logic Q/T, ORQT	120	120	120
INVERTERQT		Configurable logic Q/T, INVERTERQT	120	120	120
XORQT		Configurable logic Q/T, XORQT	40	40	40
SRMEMORYQT		Configurable logic Q/T, set-reset with memory	40	40	40
RSMEMORYQT		Configurable logic Q/T, reset-set with memory	40	40	40
TIMERSETQT		Configurable logic Q/T, settable timer	40	40	40
PULSETIMERQT		Configurable logic Q/T, pulse timer	40	40	40
INVALIDQT		Configurable logic Q/T, INVALIDQT	12	12	12
INDCOMBSPQT		Configurable logic Q/T, single indication signal combining	20	20	20
INDEXTSPQT		Configurable logic Q/T, single indication signal extractor	20	20	20
FXDSIGN		Fixed signal function block	1	1	1
B16I		Boolean 16 to Integer conversion	16	16	16
B16IFCVI		Boolean 16 to integer conversion with logic node representation	16	16	16
IB16A		Integer to Boolean 16 conversion	16	16	16
IB16FCVB		Integer to boolean 16 conversion with logic node representation	16	16	16
Monitoring					
CVMMXN		Measurements	6	6	6

Table continues on next page

IEC 61850	ANSI	Function description	Bay		
			REC650 (A01) 1CBA	REC650 (A02) 1CBAB	REC650 (A07) BCAB
CMMXU		Phase current measurement	10	10	10
VMMXU		Phase-phase voltage measurement	6	6	6
CMSQI		Current sequence component measurement	6	6	6
VMSQI		Voltage sequence measurement	6	6	6
VNMMXU		Phase-neutral voltage measurement	6	6	6
CNTGGIO		Event counter	5	5	5
DRPRDRE		Disturbance report	1	1	1
AxRADR		Analog input signals	1	1	1
BxRBDR		Binary input signals	1	1	1
SPGGIO		IEC 61850 generic communication I/O functions	64	64	64
SP16GGIO		IEC 61850 generic communication I/O functions 16 inputs	16	16	16
MVGGIO		IEC 61850 generic communication I/O functions	16	16	16
MVEXP		Measured value expander block	66	66	66
SPVNZBAT		Station battery supervision	1	1	1
SSIMG	63	Insulation gas monitoring function	1	1	1
SSIML	71	Insulation liquid monitoring function	1	1	1
SSCBR		Circuit breaker condition monitoring	1	1	1
Metering					
PCGGIO		Pulse counter logic	16	16	16
ETPMMTR		Function for energy calculation and demand handling	3	3	3

2.2 Back-up protection functions

IEC 61850	ANSI	Function description	Bay		
			REC650 (A01) 1CBA	REC650 (A02) 1CBAB	REC650 (A07) BCAB
Current protection					
PHPIOC	50	Instantaneous phase overcurrent protection	1	1	1
OC4PTOC	51/67	Four step directional phase overcurrent protection	1	1	1
EFPIOC	50N	Instantaneous residual overcurrent protection	1	1	1
EF4PTOC	51N/67N	Four step directional residual overcurrent protection	1	1	
SDEPSDE	67N	Sensitive directional residual overcurrent and power protection	1	1	1
LPTTR	26	Thermal overload protection, one time constant	1	1	1
Table continues on next page					

IEC 61850	ANSI	Function description	Bay		
			REC650 (A01) 1CBA	REC650 (A02) 1CBAB	REC650 (A07) BCAB
CCRBRF	50BF	Breaker failure protection	1	1	1
STBPTOC	50STB	Stub protection	1	1	1
CCRPLD	52PD	Pole discordance protection	1	1	1
BRCPTOC	46	Broken conductor check	1	1	1
GUPPDUP	37	Directional underpower protection	1	1	1
GOPPDOP	32	Directional overpower protection	1	1	1
DNSPTOC	46	Negative sequence based overcurrent function	1	1	1
Voltage protection					
UV2PTUV	27	Two step undervoltage protection	1	1	1
OV2PTOV	59	Two step overvoltage protection	1	1	1
ROV2PTOV	59N	Two step residual overvoltage protection	1	1	1
LOVPTUV	27	Loss of voltage check	1	1	1
Frequency protection					
SAPTUF	81	Underfrequency function	2	2	2
SAPTOF	81	Overfrequency function	2	2	2
SAPFRC	81	Rate-of-change frequency protection	2	2	2

2.3 Designed to communicate

IEC 61850	ANSI	Function description	Bay		
			REC650 (A01) 1CBA	REC650 (A02) 1CBAB	REC650 (A07) BCAB
Station communication					
		IEC 61850 communication protocol	1	1	1
		DNP3.0 for TCP/IP communication protocol	1	1	1
GOOSEINTLK RCV		Horizontal communication via GOOSE for interlocking	59	59	59
GOOSEBINR CV		GOOSE binary receive	4	4	4

2.4   Basic IED functions

IEC 61850	Function description	
Basic functions included in all products		
INTERRSIG	Self supervision with internal event list	1
	Time synchronization	1
SETGRPS	Setting group handling	1
ACTVGRP	Parameter setting groups	1
TESTMODE	Test mode functionality	1
CHNGLCK	Change lock function	1
ATHSTAT	Authority status	1
ATHCHCK	Authority check	1

Section 3 Local Human-Machine-Interface LHMI

3.1 Local HMI screen behaviour

3.1.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Local HMI screen behaviour	SCREEN	-	-

3.1.2 Settings

Table 1: *SCREEN Non group settings (basic)*

Name	Values (Range)	Unit	Step	Default	Description
DisplayTimeout	10 - 120	Min	10	60	Local HMI display timeout
ContrastLevel	-100 - 100	%	10	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
AutoIndicationDRP	Off On	-	-	Off	Automatic indication of disturbance report
SubstIndSLD	No Yes	-	-	No	Substitute indication on single line diagram
InterlockIndSLD	No Yes	-	-	No	Interlock indication on single line diagram
BypassCommands	No Yes	-	-	No	Enable bypass of commands

3.2 Local HMI signals

3.2.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Local HMI signals	LHMICTRL	-	-

3.2.2 Function block

```
        LHMICTRL
  CLRLEDS        HMI-ON
                  RED-S
               YELLOW-S
               YELLOW-F
               CLRPULSE
               LEDSCLRD
```

IEC09000320-1-en.vsd
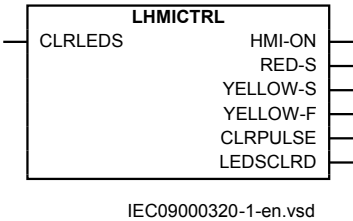
Figure 2:   *LHMICTRL function block*

3.2.3 Signals

Table 2:   *LHMICTRL Input signals*

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

Table 3:   *LHMICTRL 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

3.3 Basic part for LED indication module

3.3.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Basic part for LED indication module	LEDGEN	-	-
Basic part for LED indication module	GRP1_LED1 - GRP1_LED15 GRP2_LED1 - GRP2_LED15 GRP3_LED1 - GRP3_LED15	-	-

3.3.2   Function block

```
                LEDGEN
    ─── BLOCK           NEWIND ───
    ─── RESET              ACK ───
```

IEC09000321-1-en.vsd
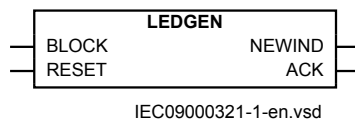
Figure 3:   *LEDGEN function block*

```
                GRP1_LED1
    ─── ^HM1L01R
    ─── ^HM1L01Y
    ─── ^HM1L01G
```
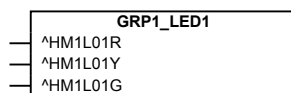
Figure 4:   *GRP1_LED1 function block*

The GRP1_LED1 function block is an example, all 15 LED in each of group 1 - 3 has a similar function block.

3.3.3   Signals

Table 4:   *LEDGEN Input signals*

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Input to block the operation of the LEDs
RESET	BOOLEAN	0	Input to acknowledge/reset the indication LEDs

Table 5:   *GRP1_LED1 Input signals*

Name	Type	Default	Description
HM1L01R	BOOLEAN	0	Red indication of LED1, local HMI alarm group 1
HM1L01Y	BOOLEAN	0	Yellow indication of LED1, local HMI alarm group 1
HM1L01G	BOOLEAN	0	Green indication of LED1, local HMI alarm group 1

Table 6:   *LEDGEN Output signals*

Name	Type	Description
NEWIND	BOOLEAN	New indication signal if any LED indication input is set
ACK	BOOLEAN	A pulse is provided when the LEDs are acknowledged

3.3.4 Settings

Table 7: *LEDGEN Non group settings (basic)*

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off/On
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

Table 8: *GRP1_LED1 Non group settings (basic)*

Name	Values (Range)	Unit	Step	Default	Description
SequenceType	Follow-S Follow-F LatchedAck-F-S LatchedAck-S-F LatchedColl-S LatchedReset-S	-	-	Follow-S	Sequence type for LED 1, local HMI alarm group 1
LabelOff	0 - 18	-	1	G1L01_OFF	Label string shown when LED 1, alarm group 1 is off
LabelRed	0 - 18	-	1	G1L01_RED	Label string shown when LED 1, alarm group 1 is red
LabelYellow	0 - 18	-	1	G1L01_YELLOW	Label string shown when LED 1, alarm group 1 is yellow
LabelGreen	0 - 18	-	1	G1L01_GREEN	Label string shown when LED 1, alarm group 1 is green

3.4 LCD part for HMI function keys control module

3.4.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
LCD part for HMI Function Keys Control module	FNKEYMD1 - FNKEYMD5	-	-

3.4.2 Function block

Figure 5: *FNKEYMD1 function block*

Only the function block for the first button is shown above. There is a similar block for every function button.

3.4.3 Signals

Table 9:   *FNKEYMD1 Input signals*

Name	Type	Default	Description
LEDCTL1	BOOLEAN	0	LED control input for function key

Table 10:   *FNKEYMD1 Output signals*

Name	Type	Description
FKEYOUT1	BOOLEAN	Output controlled by function key

3.4.4 Settings

Table 11:   *FNKEYMD1 Non group settings (basic)*

Name	Values (Range)	Unit	Step	Default	Description
Mode	Off Toggle Pulsed	-	-	Off	Output operation mode
PulseTime	0.001 - 60.000	s	0.001	0.200	Pulse time for output controlled by LCDFn1
LabelOn	0 - 18	-	1	LCD_FN1_ON	Label for LED on state
LabelOff	0 - 18	-	1	LCD_FN1_OFF	Label for LED off state

Table 12:   *FNKEYTY1 Non group settings (basic)*

Name	Values (Range)	Unit	Step	Default	Description
Type	Off Menu shortcut Control	-	-	Off	Function key type
MenuShortcut	Menu shortcut for function key				

3.5 Operation principle

3.5.1 Local HMI

Figure 6:   Local human-machine interface

The LHMI of the IED contains the following elements:

- Display (LCD)
- Buttons
- LED indicators
- Communication port

The LHMI is used for setting, monitoring and controlling.

3.5.1.1 LCD

The LHMI includes a graphical monochrome LCD with a resolution of 320 x 240 pixels. The character size can vary. The amount of characters and rows fitting the view depends on the character size and the view that is shown.

The display view is divided into four basic areas.
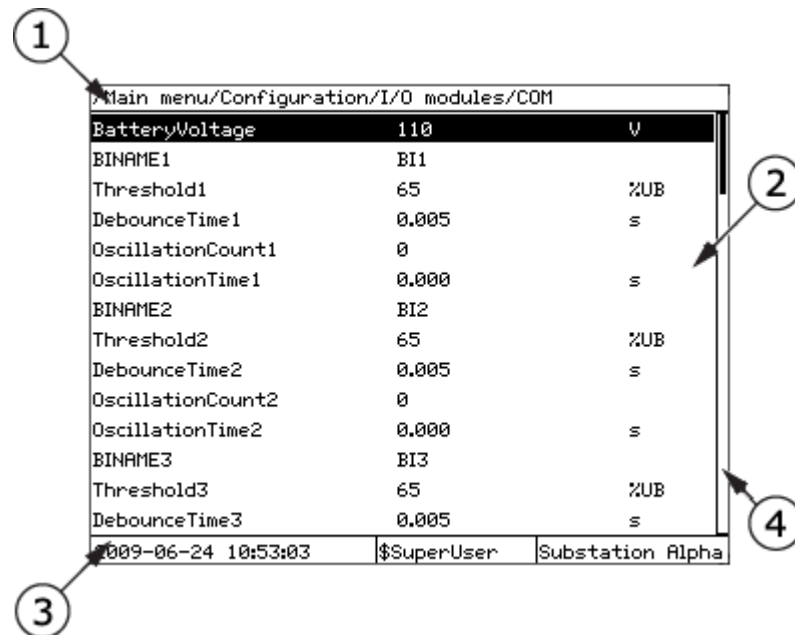
Figure 7:   Display layout

1   Path

2   Content

3   Status

4   Scroll bar (appears when needed)

- The path shows the current location in the menu structure. If the path is too long to be shown, it is truncated from the beginning, and the truncation is indicated with three dots.
- The content area shows the menu content.
- The status area shows the current IED time, the user that is currently logged in and the object identification string which is settable via the LHMI or with PCM600.
- If text, pictures or other items do not fit in the display, a vertical scroll bar appears on the right. The text in content area is truncated from the beginning if it does not fit in the display horizontally. Truncation is indicated with three dots.
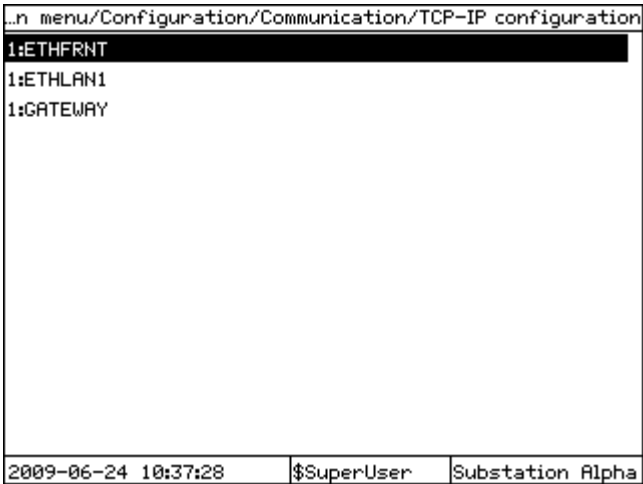
Figure 8:   Truncated path

The number before the function instance, for example 1:ETHFRNT, indicates the instance number.

The function button panel shows on request what actions are possible with the function buttons. Each function button has a LED indication that can be used as a feedback signal for the function button control action. The LED is connected to the required signal with PCM600.
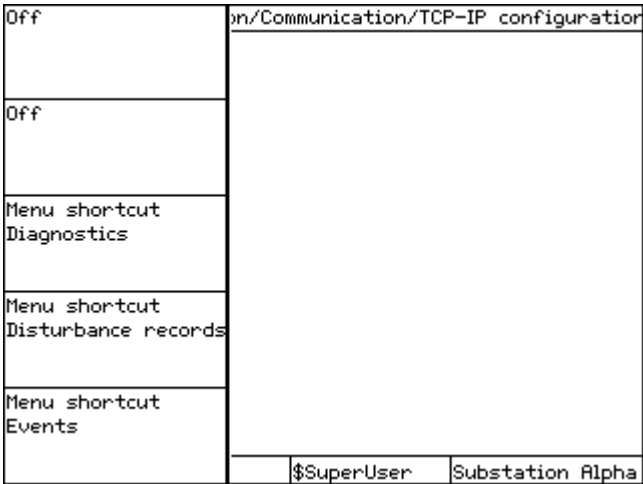
Figure 9:   Function button panel

The alarm LED panel shows on request the alarm text labels for the alarm LEDs.

```
/Main menu              1 G2L01_YELLOW
Control                 2
Events                  3
Measurements
Disturbance records
Settings                  G2L05_YELLOW
Configuration
Diagnostics               TRIP CKT ALARM
Tests
Clear
Languages




2009-06-24 10:41:24     $SuperUser
```
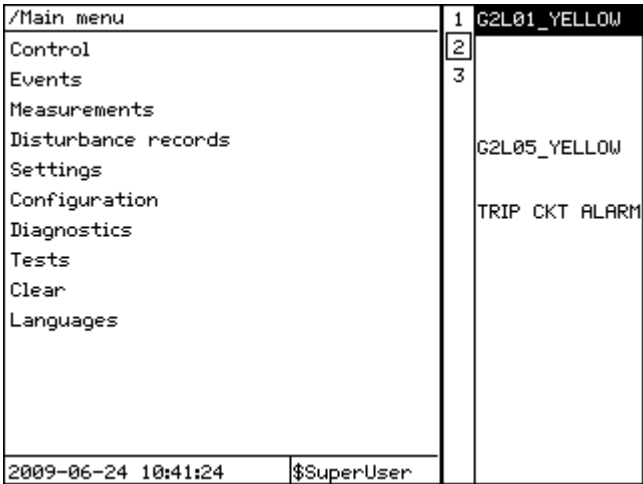
Figure 10:   Alarm LED panel

The function button and alarm LED panels are not visible at the same time. Each panel is shown by pressing one of the LCD function buttons or the Multipage button. Pressing the ESC button clears the panel from the display. Both the panels have dynamic width that depends on the label string length that the panel contains.

3.5.1.2   LEDs

The LHMI includes three protection indicators above the display: Ready, Start and Trip.

There are also 15 matrix programmable alarm LEDs on front of the LHMI. Each LED can indicate three states with the colors: green, yellow and red. The alarm texts related to each three-color LED are divided into three pages. The 15 physical three-color LEDs in one LED group can indicate 45 different signals. Altogether, 135 signals can be indicated since there are three LED groups. The LEDs can be configured with PCM600 and the operation mode can be selected with the LHMI or PCM600.

3.5.1.3   Keypad

The LHMI keypad contains push-buttons which are used to navigate in different views or menus. With push-buttons you can give open or close commands to one primary object, for example, a circuit breaker, disconnector or an earthing switch. The push-buttons are also used to acknowledge alarms, reset indications, provide help and switch between local and remote control mode.

The keypad also contains programmable push-buttons that can be configured either as menu shortcut or control buttons.
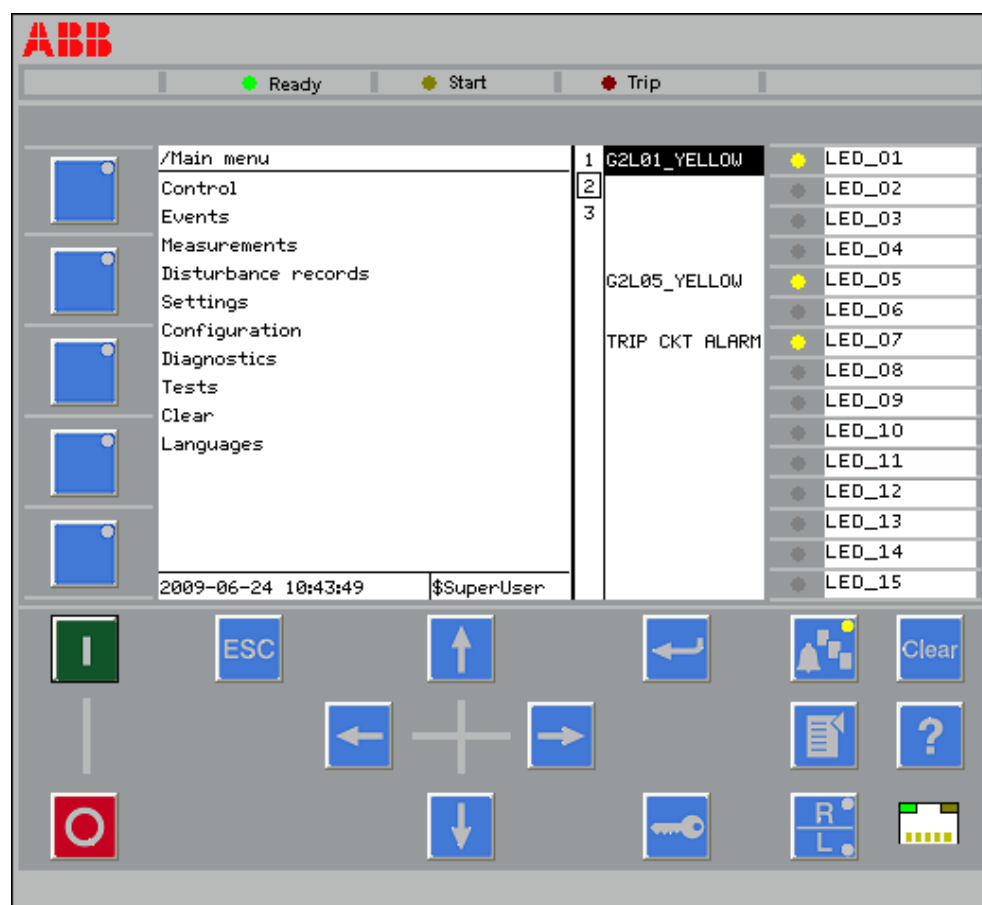
Figure 11:   LHMI keypad

3.5.2   LED

3.5.2.1   Functionality

The function blocks LEDGEN and GRP1_LEDx, GRP2_LEDx and GRP3_LEDx
(x=1-15) controls and supplies information about the status of the indication LEDs.
The input and output signals of the function blocks are configured with PCM600.
The input signal for each LED is selected individually using SMT or ACT. Each
LED is controlled by a GRP1_LEDx function block, that controls the color and the
operating mode.

Each indication LED on local HMI can be set individually to operate in six
different sequences; two as follow type and four 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. The other two are intended
to be used as signalling system in collecting mode with acknowledgment
functionality.

3.5.2.2 Status LEDs

There are three status LEDs above the LCD in the front of the IED, green, yellow and red.

The green LED has a fixed function, while the yellow and red LEDs are user configured. The yellow LED can be used to indicate that a disturbance report is created (steady) or that the IED is in test mode (flashing). The red LED can be used to indicate a trip command.

3.5.2.3 Indication LEDs

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
  - The active indications can be acknowledged/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 acknowledgment/reset is performed via the Clear button and menus on the LHMI.

- From function input
  - The active indications can also be acknowledged/reset from an input, ACK_RST, 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/reset only affects indications active at the moment when the button is first pressed.

- Automatic reset

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

Operating sequence

The sequences can be of type Follow or Latched. For the Follow type the LED follow the input signal completely. For the Latched type each LED latches to the correspond¬ing input signal until it is reset.

The figures below show the function of available sequences selectable for each LED separately. For sequence 1 and 2 (Follow type), the acknowledgment/reset function is not applicable. Sequence 3 and 4 (Latched type with acknowledgement) are only work¬ing in collecting mode. Sequence 5 is working according to Latched type and collecting mode while 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 = Flash.

At the activation of the input signal, the indication obtains corresponding color corresponding to the activated input and operates according to the selected sequence diagrams below.

In the sequence diagrams the LEDs have the following characteristics:
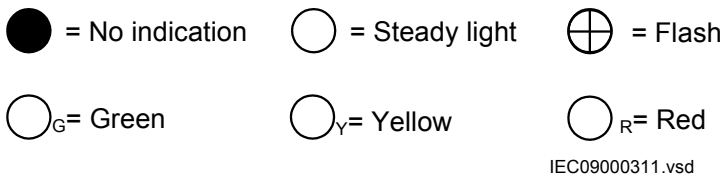
Figure 12: *Symbols used in the sequence diagrams*

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.
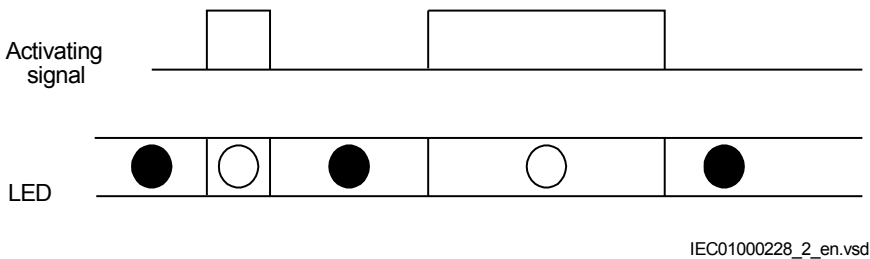
Figure 13: *Operating sequence 1 (Follow-S)*

If inputs for two or more colors are active at the same time to one LED the priority is as described above. An example of the operation when two colors are activated in parallel is shown in the figure 14.

IEC09000312_1_en.vsd
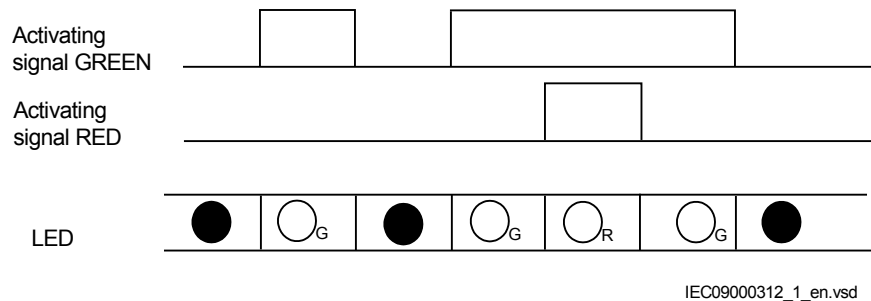
Figure 14:   Operating sequence 1, two colors

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.

en01000231.vsd
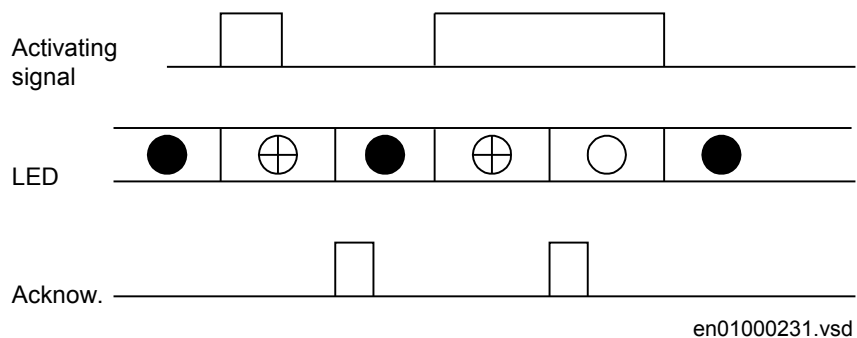
Figure 15:   Operating sequence 3 (LatchedAck-F-S)

When an acknowledgment is performed, all indications that appear before the indication with higher priority has been reset, will be acknowledged, independent of if the low priority indication appeared before or after acknowledgment. In Figure 16 it is shown the sequence when a signal of lower priority becomes activated after acknowledgment has been performed on a higher priority signal. The low priority signal will be shown as acknowledged when the high priority signal resets.

IEC09000313_1_en.vsd
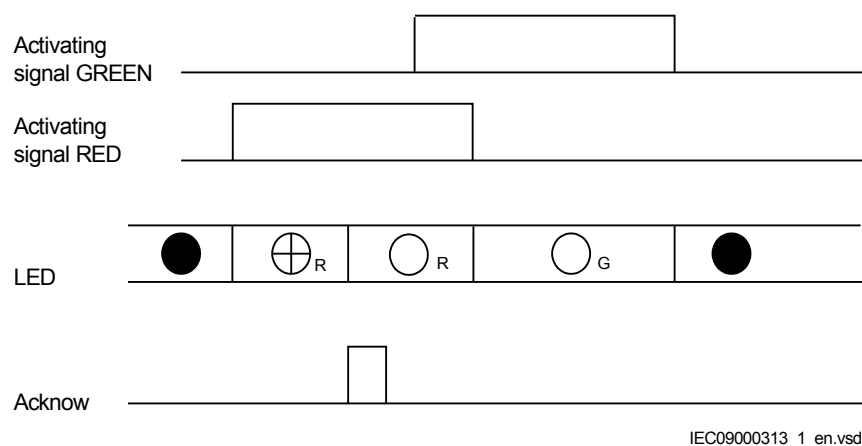
Figure 16:   Operating sequence 3, 2 colors involved

If all three signals are activated the order of priority is still maintained. Acknowledgment of indications with higher priority will acknowledge also low priority indications, which are not visible according to figure 17.

IEC09000314-1-en.vsd
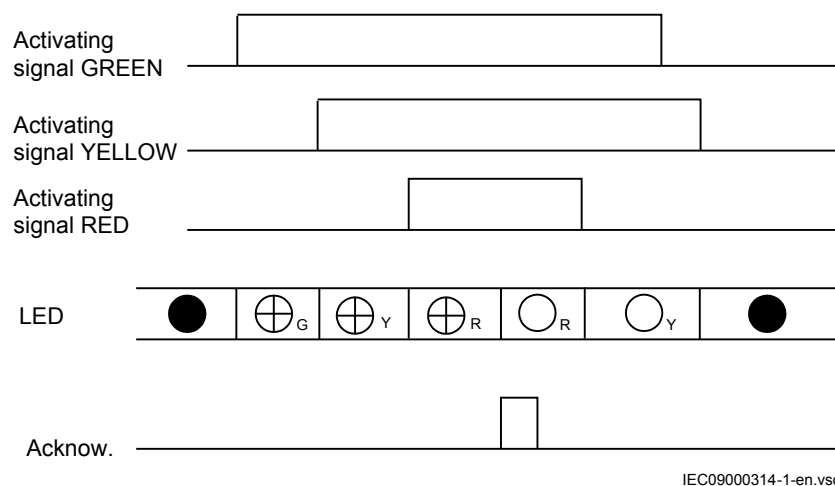
Figure 17:   Operating sequence 3, three colors involved, alternative 1

If an indication with higher priority appears after acknowledgment of a lower priority indication the high priority indication will be shown as not acknowledged according to figure 18.
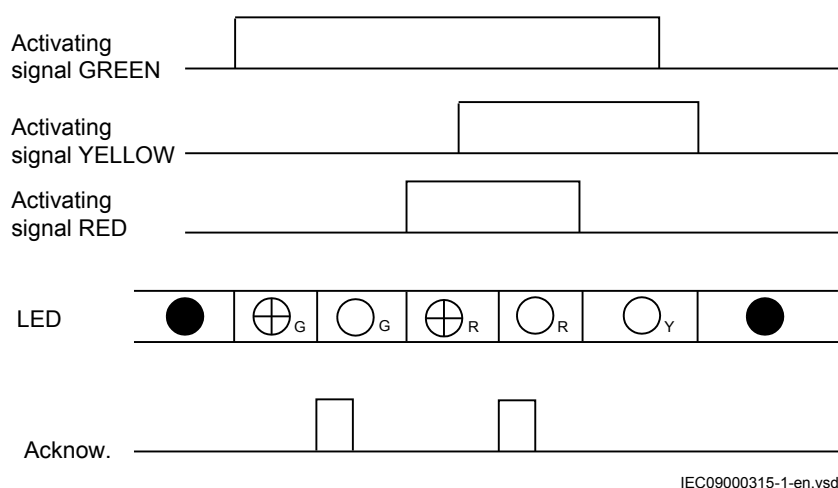
Figure 18:   *Operating sequence 3, three colors involved, alternative 2*

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.
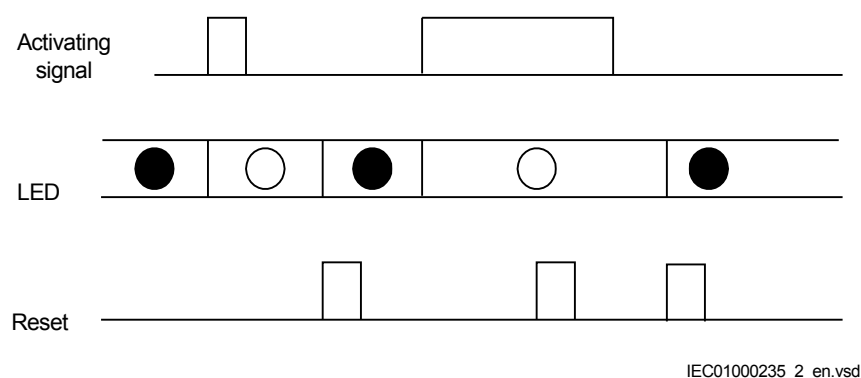
Figure 19:   *Operating sequence 5 (LatchedColl-S)*

That means if an indication with higher priority has reset while an indication with lower priority still is active at the time of reset, the LED will change color according to figure 20.
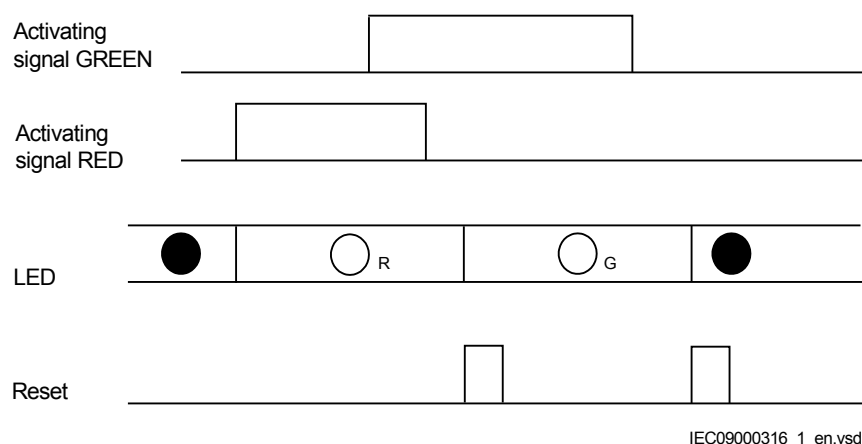
Figure 20:   *Operating sequence 5, two colors*

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.

Timing diagram for sequence 6
Figure 21 shows the timing diagram for two indications within one disturbance.

IEC01000239_2-en.vsd
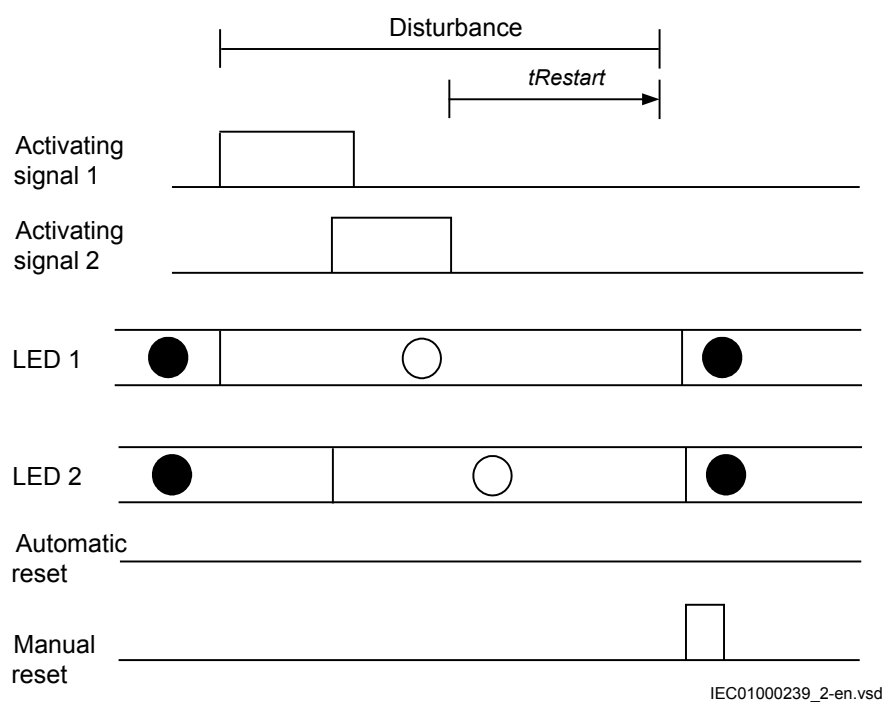
Figure 21:   *Operating sequence 6 (LatchedReset-S), two indications within same disturbance*

Figure 22 shows the timing diagram for a new indication after *tRestart* time has elapsed.

IEC01000240_2_en.vsd
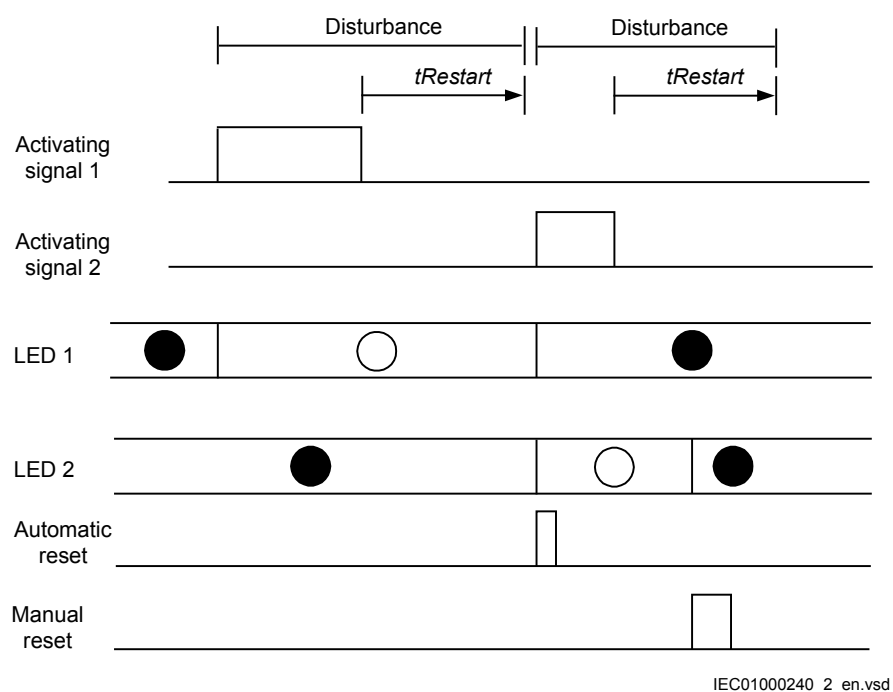
Figure 22:   *Operating sequence 6 (LatchedReset-S), two different disturbances*

Figure 23 shows the timing diagram when a new indication appears after the first one has reset but before *tRestart* has elapsed.
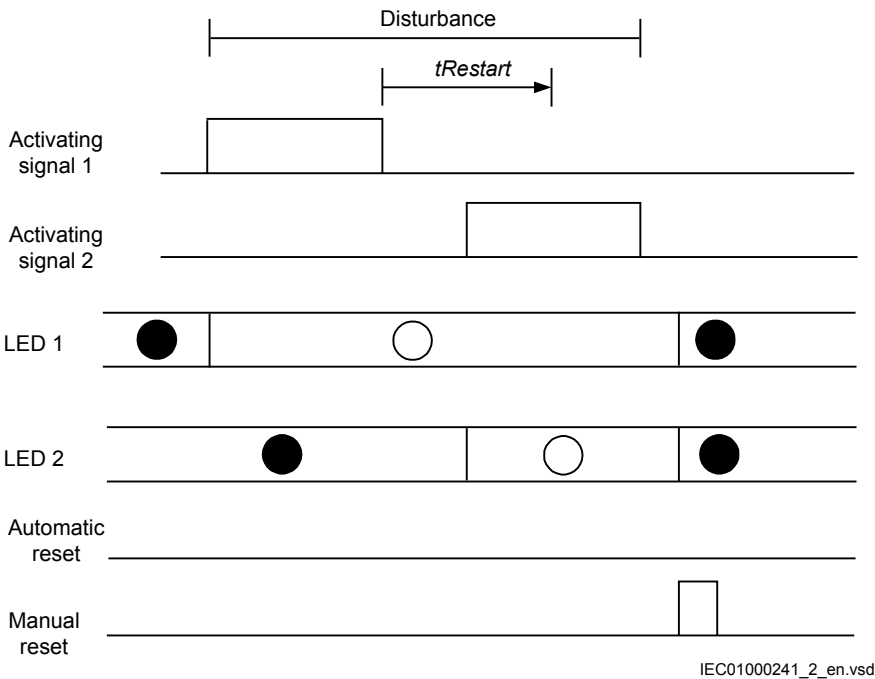
Figure 23: *Operating sequence 6 (LatchedReset-S), two indications within same disturbance but with reset of activating signal between*

Figure 24 shows the timing diagram for manual reset.
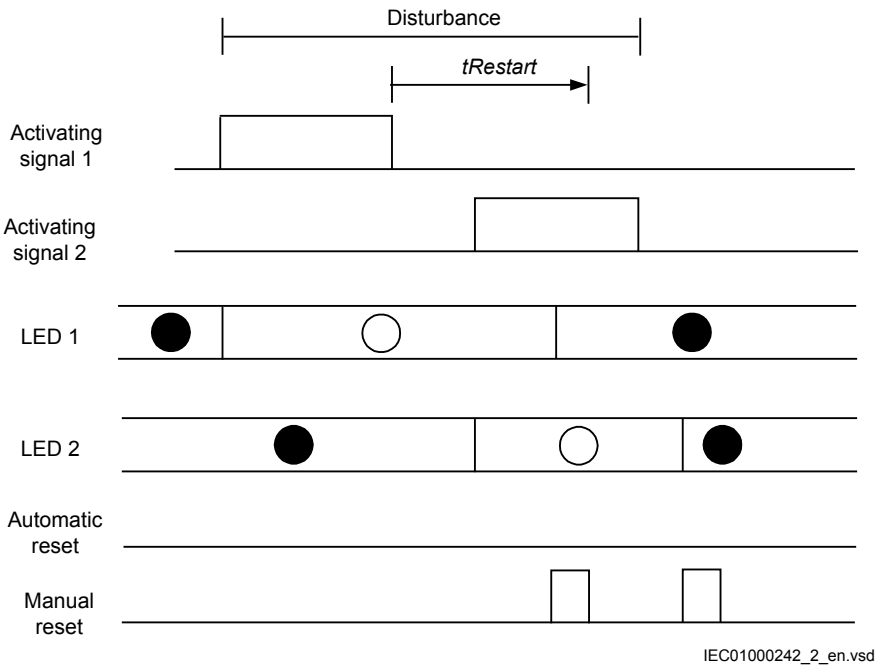
Figure 24: *Operating sequence 6 (LatchedReset-S), manual reset*

3.5.3 Function keys

3.5.3.1 Functionality

Local Human-Machine-Interface (LHMI) has five function buttons, directly to the left of the LCD, that can be configured either as menu shortcut or control buttons. Each button has an indication LED that can be configured in the application configuration.

When used as a menu shortcut, a function button provides a fast way to navigate between default nodes in the menu tree. When used as a control, the button can control a binary signal.

3.5.3.2 Operation principle

Each output on FNKEYMD1 - FNKEYMD5 function blocks can be controlled from the LHMI function keys. By pressing a function button on the LHMI, the output status of the actual function block will change. These binary outputs can in turn be used to control other function blocks, for example, switch control blocks, binary I/O outputs etc.

FNKEYMD1 - FNKEYMD5 function block also has a number of settings and parameters that controls the behavior of the function block. These settings and parameters are normally set using the PST.

Operating sequence
The operation mode is set individually for each output, either OFF, TOGGLE or PULSED.

Mode 0 (OFF)

This mode always gives the output the value 0 (FALSE). Changes on the IO attribute are ignored.

IEC09000330-1-en.vsd
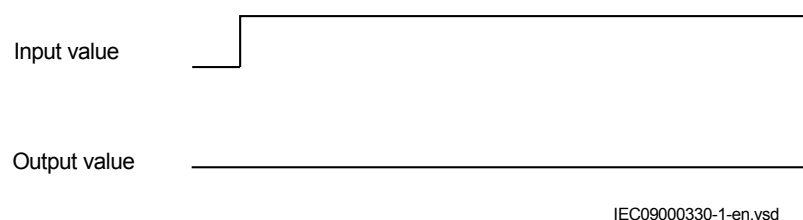
Figure 25:   Sequence diagram for Mode 0

Mode 1 (TOGGLE)

In this mode the output toggles each time the function block detects that the input has been written. Note that the input attribute is reset each time the function block executes. The function block execution is marked with a dotted line below.

IEC09000331_1_en.vsd
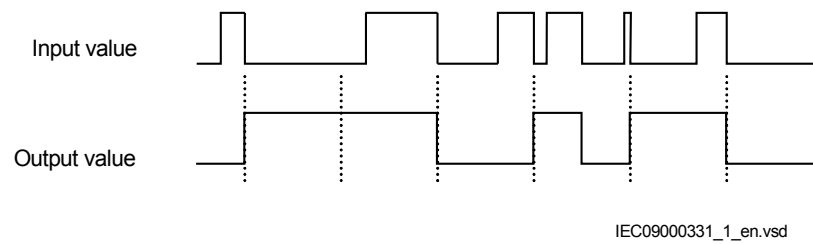
Figure 26:   *Sequence diagram for Mode 1*

Mode 2 (PULSED)

In this mode the output will be high for as long as the setting *pulse time*. After this time the output will go back to 0. The input attribute is reset when the function block detects it being high and there is no output pulse.

Note that the third positive edge on the input attribute does not cause a pulse, since the edge was applied during pulse output. A new pulse can only begin when the output is zero; else the trigger edge is lost.

IEC09000332_1_en.vsd
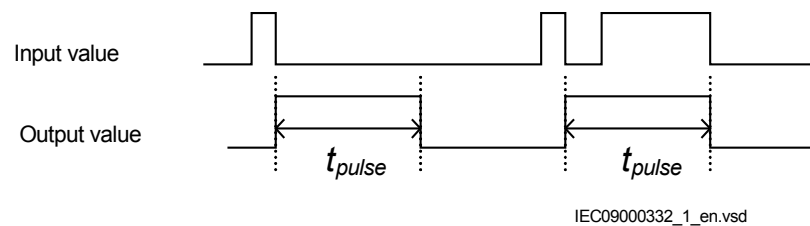
Figure 27:   *Sequence diagram for Mode 2*

Input function

All inputs work the same way: When the LHMI is configured so that a certain function button is of type CONTROL, then the corresponding input on this function block becomes active, and will light the yellow function button LED when high. This functionality is active even if the function block operation setting is set to off.

Section 4   Current protection

4.1   Instantaneous phase overcurrent protection PHPIOC

4.1.1   Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Instantaneous phase overcurrent protection	PHPIOC	*3I>>*	50

4.1.2   Functionality

The instantaneous three phase overcurrent function has a low transient overreach and short tripping time to allow use as a high set short-circuit protection function.

4.1.3   Function block

```
      ┌─────────────────┐
      │     PHPIOC      │
   ───┤ I3P*       TRIP ├───
   ───┤ BLOCK           │
      └─────────────────┘
```
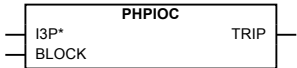
Figure 28:   PHPIOC function block

4.1.4   Signals

Table 13:   PHPIOC Input signals

Name	Type	Default	Description
I3P	GROUP SIGNAL	-	Three phase group signal for current inputs
BLOCK	BOOLEAN	0	Block of function

Table 14:   PHPIOC Output signals

Name	Type	Description
TRIP	BOOLEAN	General trip signal

4.1.5 Settings

Table 15: *PHPIOC Group settings (basic)*

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
IP>>	5 - 2500	%IB	1	200	Operate phase current level in % of IBase

Table 16: *PHPIOC Non group settings (basic)*

Name	Values (Range)	Unit	Step	Default	Description
GlobalBaseSel	1 - 6	-	1	1	Global Base Selector

4.1.6 Monitored data

Table 17: *PHPIOC Monitored data*

Name	Type	Values (Range)	Unit	Description
IL1	REAL	-	A	Current in phase L1
IL2	REAL	-	A	Current in phase L2
IL3	REAL	-	A	Current in phase L3

4.1.7 Operation principle

The sampled analogue phase currents are pre-processed in a discrete Fourier filter (DFT) block. From the fundamental frequency components, as well as sampled values, of each phase current the RMS value of each phase current is derived. These phase current values are fed to the Instantaneous phase overcurrent protection (PHPIOC) function. In a comparator the RMS values are compared to the set operation current value of the function *(IP>>)*. If a phase current is larger than the set operation current a signal from the comparator for this phase is set to true. This signal will, without delay, activate the TRIP signal that is common for all three phases.

The function can be blocked from the binary input BLOCK.

4.1.8 Technical data
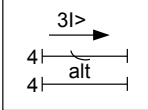
Table 18: *PHPIOC Technical data*

Function	Range or value	Accuracy
Operate current	(5-2500)% of IBase	$\pm$ 1.0% of I_r at $I \leq I_r$ $\pm$ 1.0% of I at I > I_r
Reset ratio	> 95%	-
Operate time	20 ms typically at 0 to 2 x I_{set}	-
Table continues on next page		

Function	Range or value	Accuracy
Reset time	25 ms typically at 2 to 0 x I_{set}	-
Critical impulse time	10 ms typically at 0 to 2 x I_{set}	-
Operate time	10 ms typically at 0 to 10 x I_{set}	-
Reset time	35 ms typically at 10 to 0 x I_{set}	-
Critical impulse time	2 ms typically at 0 to 10 x I_{set}	-
Dynamic overreach	< 5% at τ = 100 ms	-

4.2 Four step phase overcurrent protection OC4PTOC

4.2.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Four step phase overcurrent protection	OC4PTOC	3I> 4 alt 4	51/67

4.2.2 Functionality

The four step phase overcurrent function has an inverse or definite time delay independent for each step separately.

All IEC and ANSI time delayed characteristics are available.

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.

4.2.3 Function block
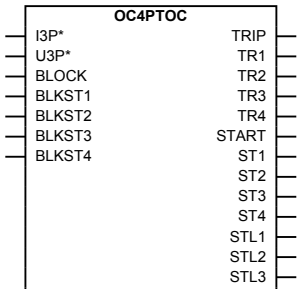
Figure 29: *OC4PTOC function block*

4.2.4 Signals

Table 19: *OC4PTOC Input signals*

Name	Type	Default	Description
I3P	GROUP SIGNAL	-	Three phase group signal for current inputs
U3P	GROUP SIGNAL	-	Three phase group signal for voltage inputs
BLOCK	BOOLEAN	0	Block of function
BLKST1	BOOLEAN	0	Block of step 1
BLKST2	BOOLEAN	0	Block of step 2
BLKST3	BOOLEAN	0	Block of step 3
BLKST4	BOOLEAN	0	Block of step 4

Table 20: *OC4PTOC Output signals*

Name	Type	Description
TRIP	BOOLEAN	General trip signal
TR1	BOOLEAN	Trip signal from step 1
TR2	BOOLEAN	Trip signal from step 2
TR3	BOOLEAN	Trip signal from step 3
TR4	BOOLEAN	Trip signal from step 4
START	BOOLEAN	General start signal
ST1	BOOLEAN	Start signal from step 1
ST2	BOOLEAN	Start signal from step 2
ST3	BOOLEAN	Start signal from step 3
ST4	BOOLEAN	Start signal from step 4
STL1	BOOLEAN	Start signal from phase L1
STL2	BOOLEAN	Start signal from phase L2
STL3	BOOLEAN	Start signal from phase L3

4.2.5 Settings

Table 21: *OC4PTOC Group settings (basic)*

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
DirMode1	Off Non-directional Forward Reverse	-	-	Non-directional	Directional mode of step 1 off / non-directional / forward / reverse
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 RI type RD type	-	-	ANSI Def. Time	Selection of time delay curve type for step 1
I1>	5 - 2500	%IB	1	1000	Phase current operate level for step1 in % of IBase
t1	0.000 - 60.000	s	0.001	0.000	Definite 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
DirMode2	Off Non-directional Forward Reverse	-	-	Non-directional	Directional mode of step 2 off / non-directional / forward / reverse
I2>	5 - 2500	%IB	1	500	Phase current operate level for step 2 in % of IBase
t2	0.000 - 60.000	s	0.001	0.400	Definite time delay of step 2
DirMode3	Off Non-directional Forward Reverse	-	-	Non-directional	Directional mode of step 3 off / non-directional / forward / reverse
I3>	5 - 2500	%IB	1	250	Phase current operate level for step3 in % of IBase
t3	0.000 - 60.000	s	0.001	0.800	Definite time delay of step 3
DirMode4	Off Non-directional Forward Reverse	-	-	Non-directional	Directional mode of step 4 off / non-directional / 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 RI type RD type	-	-	ANSI Def. Time	Selection of time delay curve type for step 4
I4>	5 - 2500	%IB	1	175	Phase current operate level for step 4 in % of IBase
t4	0.000 - 60.000	s	0.001	2.000	Definite 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

Table 22:   OC4PTOC Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
GlobalBaseSel	1 - 6	-	1	1	Global Base Selector
MeasType	DFT RMS	-	-	DFT	Selection between DFT and RMS measurement

4.2.6   Monitored data

Table 23:   OC4PTOC Monitored data

Name	Type	Values (Range)	Unit	Description
DIRL1	INTEGER	0=No direction 1=Forward 2=Reverse	-	Direction for phase L1
DIRL2	INTEGER	0=No direction 1=Forward 2=Reverse	-	Direction for phase L2
DIRL3	INTEGER	0=No direction 1=Forward 2=Reverse	-	Direction for phase L3
IL1	REAL	-	A	Current in phase L1
IL2	REAL	-	A	Current in phase L2
IL3	REAL	-	A	Current in phase L3

4.2.7 Operation principle

The function is divided into three 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 three parts:

- The direction element
- The four step over current function
- The mode selection

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

The sampled analog 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 (OC4PTOC) function; 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 the OC4PTOC function.

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 function.

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.

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 or phase voltage (85%) and a memory phase voltage (15%). The following combinations are used.

Phase-phase short circuit:

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

<div align="right">(Equation 1)</div>

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

<div align="right">(Equation 2)</div>

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

<div align="right">(Equation 3)</div>

Phase-earth short circuit:

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

<div align="right">(Equation 4)</div>

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

<div align="right">(Equation 5)</div>

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

<div align="right">(Equation 6)</div>
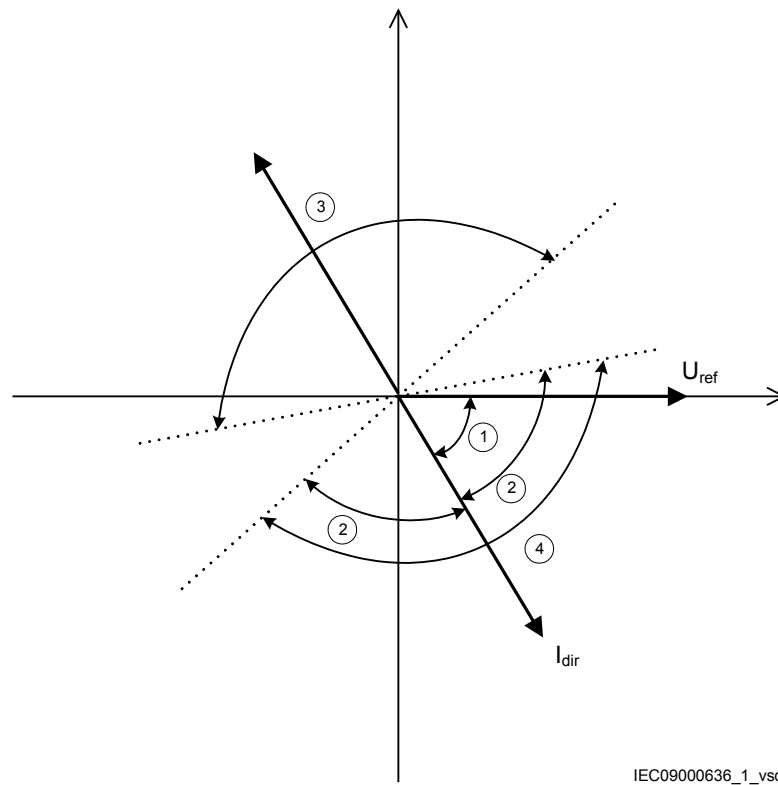
Figure 30:   *Directional characteristic of the phase overcurrent protection*

1   RCA = Relay characteristic angle

2   ROA = Relay operating angle

3   Reverse

4   Forward

If no blockings are given the start signals will start the timers of the step. The time characteristic for step 1 and 4 can be chosen as definite time delay or inverse time characteristic. Step 2 and 3 are always definite time delayed. A wide range of standardized inverse time characteristics is available. The possibilities for inverse time characteristics are described in section 17.3 "Inverse time 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.
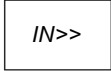
4.2.8 Technical data

Table 24: *OC4PTOCTechnical data*

Function	Setting range	Accuracy
Operate current	(5-2500)% of IBase	$\pm$ 1.0% of I_r at $I \le I_r$ $\pm$ 1.0% of I at $I > I_r$
Reset ratio	> 95%	-
Min. operating current	(1-100)% of IBase	$\pm$ 1.0% of I_r
Independent time delay	(0.000-60.000) s	$\pm$ 0.5% $\pm$ 10 ms
Minimum operate time for inverse characteristics	(0.000-60.000) s	$\pm$ 0.5% $\pm$ 10 ms
Inverse characteristics, see table 484, table 485 and table 486	17 curve types	See table 484, table 485 and table 486
Operate time, nondirectionalstart function	20 ms typically at 0 to 2 x I_{set}	-
Reset time, nondirectional start function	25 ms typically at 2 to 0 x I_{set}	-
Operate time, directional start function	30 ms typically at 0 to 2 x I_{set}	-
Reset time, directional start funciton	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	-

4.3 Instantaneous residual overcurrent protection EFPIOC

4.3.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Instantaneous residual overcurrent protection	EFPIOC	*IN>>*	50N

4.3.2 Functionality

The instantaneous residual overcurrent protection (EFPIOC) has a low transient overreach and short tripping times to allow the use for instantaneous earth fault protection, with the reach limited to less than typical eighty percent of the line at minimum source impedance. The function can be configured to measure the

residual current from the three phase current inputs or the current from a separate current input. The function can be blocked by activating the input BLOCK.

4.3.3   Function block


```
        EFPIOC
── I3P*            TRIP ──
── BLOCK
```
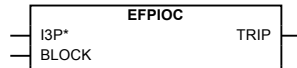
Figure 31:   *EFPIOC function block*

4.3.4   Signals

Table 25:   *EFPIOC Input signals*

Name	Type	Default	Description
I3P	GROUP SIGNAL	-	Three phase group signal for current inputs
BLOCK	BOOLEAN	0	Block of function

Table 26:   *EFPIOC Output signals*

Name	Type	Description
TRIP	BOOLEAN	Trip signal

4.3.5   Settings

Table 27:   *EFPIOC Group settings (basic)*

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
IN>>	1 - 2500	%IB	1	200	Operate residual current level in % of IBase

Table 28:   *EFPIOC Non group settings (basic)*

Name	Values (Range)	Unit	Step	Default	Description
GlobalBaseSel	1 - 6	-	1	1	Global Base Selector

4.3.6   Monitored data

Table 29:   *EFPIOC Monitored data*

Name	Type	Values (Range)	Unit	Description
IN	REAL	-	A	Residual current

4.3.7 Operation principle

The sampled analogue residual currents are pre-processed in a discrete Fourier filter (DFT) block. From the fundamental frequency components of the residual current as well as, from the sample values the equivalent RMS value is derived. This current value is fed to the Instantaneous residual overcurrent protection (EFPIOC) function. In a comparator the RMS value is compared to the set operation current value of the function ($IN>>$). If the residual 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 TRIP.
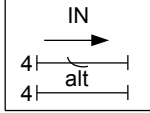
4.3.8 Technical data

Table 30:   EFPIOC Technical data

Function	Range or value	Accuracy
Operate current	(1-2500)% of IBase	± 1.0% of I_r at $I \le I_r$ ± 1.0% of I at $I > I_r$
Reset ratio	> 95%	-
Operate time	20 ms typically at 0 to 2 x I_{set}	-
Reset time	30 ms typically at 2 to 0 x I_{set}	-
Critical impulse time	10 ms typically at 0 to 2 x I_{set}	-
Operate time	10 ms typically at 0 to 10 x I_{set}	-
Reset time	40 ms typically at 10 to 0 x I_{set}	-
Critical impulse time	2 ms typically at 0 to 10 x I_{set}	-
Dynamic overreach	< 5% at τ = 100 ms	-

4.4 Four step residual overcurrent protection EF4PTOC

4.4.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Four step residual overcurrent protection	EF4PTOC	IN 4 — alt 4 —	51N/67N

4.4.2 Functionality

The four step residual overcurrent protection (EF4PTOC) has an setable 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 time delayed characteristics are available.

The directional function is voltage polarized, current polarized or dual polarized.

The protection can be set directional or non-directional independently for each of the steps.

A second harmonic blocking can be enabled individually for each step.

The protection can be used as main protection for phase-to-earth faults.

The protection can also be used to provide a system back-up for example, in the case of the primary protection being out of service due to communication or voltage transformer circuit failure.

Directional operation can be combined together with corresponding communication logic in permissive or blocking teleprotection scheme. Current reversal and weak-end infeed functionality are available as well.

4.4.3   Function block


```
            EF4PTOC
 ─── I3P*              TRIP   ───
 ─── U3P*             TRIN1   ───
 ─── I3PPOL*          TRIN2   ───
 ─── BLOCK            TRIN3   ───
 ─── BLKST1           TRIN4   ───
 ─── BLKST2           START   ───
 ─── BLKST3           STIN1   ───
 ─── BLKST4           STIN2   ───
                      STIN3   ───
                      STIN4   ───
                       STFW   ───
                       STRV   ───
                   2NDHARMD   ───
```
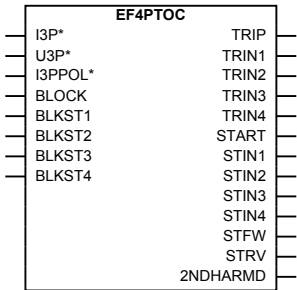
Figure 32:   EF4PTOC function block

4.4.4   Signals

Table 31:   EF4PTOC Input signals

Name	Type	Default	Description
I3P	GROUP SIGNAL	-	Three phase group signal for current inputs
U3P	GROUP SIGNAL	-	Three phase group signal for polarizing voltage inputs
I3PPOL	GROUP SIGNAL	-	Three phase group signal for polarizing current inputs
BLOCK	BOOLEAN	0	Block of function
BLKST1	BOOLEAN	0	Block of step 1 (start and trip)
BLKST2	BOOLEAN	0	Block of step 2 (start and trip)
BLKST3	BOOLEAN	0	Block of step 3 (start and trip)
BLKST4	BOOLEAN	0	Block of step 4 (start and trip)

Table 32:   *EF4PTOC Output signals*

Name	Type	Description
TRIP	BOOLEAN	General trip signal
TRIN1	BOOLEAN	Trip signal from step 1
TRIN2	BOOLEAN	Trip signal from step 2
TRIN3	BOOLEAN	Trip signal from step 3
TRIN4	BOOLEAN	Trip signal from step 4
START	BOOLEAN	General start signal
STIN1	BOOLEAN	Start signal step 1
STIN2	BOOLEAN	Start signal step 2
STIN3	BOOLEAN	Start signal step 3
STIN4	BOOLEAN	Start signal step 4
STFW	BOOLEAN	Forward directional start signal
STRV	BOOLEAN	Reverse directional start signal
2NDHARMD	BOOLEAN	2nd harmonic block signal

4.4.5   Settings

Table 33:   *EF4PTOC Group settings (basic)*

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
AngleRCA	-180 - 180	Deg	1	65	Relay characteristic angle (RCA)
polMethod	Voltage Current Dual	-	-	Voltage	Type of polarization
UPolMin	1 - 100	%UB	1	1	Minimum voltage level for polarization in % of UBase
IPolMin	2 - 100	%IB	1	5	Minimum current level for polarization in % of IBase
RNPol	0.50 - 1000.00	ohm	0.01	5.00	Real part of source Z to be used for current polarisation
XNPol	0.50 - 3000.00	ohm	0.01	40.00	Imaginary part of source Z to be used for current polarisation
IN>Dir	1 - 100	%IB	1	10	Residual current level for direction release in % of IBase
2ndHarmStab	5 - 100	%	1	20	Second harmonic restrain operation in % of IN amplitude
DirMode1	Off Non-directional Forward Reverse	-	-	Non-directional	Directional mode of step 1 (off, non-directional, 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 RI type RD type	-	-	ANSI Def. Time	Time delay curve type for step 1
IN1>	1 - 2500	%IB	1	100	Operate residual current level for step 1 in % of IBase
t1	0.000 - 60.000	s	0.001	0.000	Independent (definite) time delay of step 1
k1	0.05 - 999.00	-	0.01	0.05	Time multiplier for the dependent 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
HarmRestrain1	Off On	-	-	On	Enable block of step 1 from harmonic restrain
DirMode2	Off Non-directional Forward Reverse	-	-	Non-directional	Directional mode of step 2 (off, non-directional, forward, reverse)
IN2>	1 - 2500	%IB	1	50	Operate residual current level for step 2 in % of IBase
t2	0.000 - 60.000	s	0.001	0.400	Independent (definite) time delay of step 2
IMin2	1 - 10000	%IB	1	50	Minimum operate current for step 2 in % of IBase
HarmRestrain2	Off On	-	-	On	Enable block of step 2 from harmonic restrain
DirMode3	Off Non-directional Forward Reverse	-	-	Non-directional	Directional mode of step 3 (off, non-directional, forward, reverse)
IN3>	1 - 2500	%IB	1	33	Operate residual current level for step 3 in % of IBase
t3	0.000 - 60.000	s	0.001	0.800	Independent (definite) time delay of step 3
IMin3	1 - 10000	%IB	1	33	Minimum operate current for step 3 in % of IBase
HarmRestrain3	Off On	-	-	On	Enable block of step 3 from harmonic restrain
Table continues on next page					

Name	Values (Range)	Unit	Step	Default	Description
DirMode4	Off Non-directional Forward Reverse	-	-	Non-directional	Directional mode of step 4 (off, non-directional, forward, reverse)
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 RI type RD type	-	-	ANSI Def. Time	Time delay curve type for step 4
IN4>	1 - 2500	%IB	1	17	Operate residual current level for step 4 in % of IBase
t4	0.000 - 60.000	s	0.001	1.200	Independent (definite) time delay of step 4
k4	0.05 - 999.00	-	0.01	0.05	Time multiplier for the dependent time delay for step 4
IMin4	1 - 10000	%IB	1	17	Minimum operate current for step 4 in % of IBase
t4Min	0.000 - 60.000	s	0.001	0.000	Minimum operate time in inverse curves step 4
HarmRestrain4	Off On	-	-	On	Enable block of step 4 from harmonic restrain

Table 34: EF4PTOC Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
GlobalBaseSel	1 - 6	-	1	1	Global Base Selector

4.4.6   Monitored data

Table 35:   *EF4PTOC Monitored data*

Name	Type	Values (Range)	Unit	Description
IOp	REAL	-	A	Operating current level
UPol	REAL	-	kV	Polarizing voltage level
IPol	REAL	-	A	Polarizing current level
UPOLIANG	REAL	-	deg	Angle between polarizing voltage and operating current
IPOLIANG	REAL	-	deg	Angle between polarizing current and operating current

4.4.7   Operation principle

This function has the following three "Analog Inputs" on its function block in the configuration tool:

1. I3P, input used for "Operating Quantity".
2. U3P, input used for "Voltage Polarizing Quantity".
3. I3PPOL, input used for "Current Polarizing Quantity".

These inputs are connected from the corresponding pre-processing function blocks in the Configuration Tool within PCM600.

4.4.7.1   Operating quantity within the function

The function always uses Residual Current ($3I_0$) for its operating quantity. The residual current can be:

1. directly measured (when a dedicated CT input of the IED is connected in PCM600 tool to the fourth analog input of the pre-processing block connected to EF4PTOC (function input I3P). This dedicated IED CT input can be for example, connected to:
   - parallel connection of current instrument transformers in all three phases (Holm-Green connection).
   - one single core balance, current instrument transformer (cable CT).
   - one single current instrument transformer located between power system star point and earth(that is, current transformer located in the star point of a star connected transformer winding).
   - one single current instrument transformer located between two parts of a protected object (that is, current transformer located between two star points of double star shunt capacitor bank).
2. calculated from three-phase current input within the IED (when the fourth analog input into the pre-processing block connected to EF4PTOC function Analog Input I3P is not connected to a dedicated CT input of the IED in

PCM600 tool). In such case the pre-processing block will calculate $3I_0$ from the first three inputs into the pre-processing block by using the following formula:

$$Iop = 3I_0 = IL1 + IL2 + IL3$$

(Equation 7)

where:

IL1, IL2 and IL3   are fundamental frequency phasors of three individual phase currents.

The residual current is pre-processed by a discrete Fourier filter. Thus the phasor of the fundamental frequency component of the residual current is derived. The phasor magnitude is used within the EF4PTOC protection to compare it with the set operation current value of the four steps (*IN1>*, *IN2>*, *IN3>* or *IN4>*). If the residual current is larger than the set operation current and the step is used in non-directional mode a signal from the comparator for this step is set to true. This signal will, without delay, activate the output signal STINx (x=step 1-4) for this step and a common START signal.

4.4.7.2   Internal polarizing

A polarizing quantity is used within the protection in order to determine the direction to the earth-fault (Forward/Reverse).

The function can be set to use voltage polarizing, current polarizing or dual polarizing.

Voltage polarizing

When voltage polarizing is selected the protection will use the residual voltage $-3U_0$ as polarizing quantity U3P. This voltage can be:

1.   directly measured (when a dedicated VT input of the IED is connected in PCM600 tool to the fourth analog input of the pre-processing block connected to EF4PTOC function input U3P). This dedicated IED VT input shall be then connected to open delta winding of a three phase main VT.
2.   calculated from three phase voltage input within the IED (when the fourth analog input into the pre-processing block connected to EF4PTOC function analogue input U3P is NOT connected to a dedicated VT input of the IED in PCM600 tool). In such case the pre-processing block will calculate $-3U_0$ from the first three inputs into the pre-processing block by using the following formula:

$$UPol = -3U_0 = -(UL1 + UL2 + UL3)$$

(Equation 8)

where:

UL1, UL2 and UL3   are fundamental frequency phasors of three individual phase voltages.

Note! In order to use this all three phase-to-earth voltages must be connected to three IED VT inputs.

The residual voltage is pre-processed by a discrete fourier filter. Thus, the phasor of the fundamental frequency component of the residual voltage is derived. This phasor is used together with the phasor of the operating current, in order to determine the direction to the earth-fault (Forward/Reverse). In order to enable voltage polarizing the magnitude of polarizing voltage shall be bigger than a minimum level defined by setting parameter *UpolMin*.

It shall be noted that $-3U_0$ is used to determine the location of the earth-fault. This insures the required inversion of the polarizing voltage within the earth-fault function.

Current polarizing

When current polarizing is selected the function will use the residual current ($3I_0$) as polarizing quantity IPol. This current can be:

1. directly measured (when a dedicated CT input of the IED is connected in PCM600 tool to the fourth analog input of the pre-processing block connected to EF4PTOC function input I3PPOL). This dedicated IED CT input is then typically connected to one single current transformer located between power system star point and earth (current transformer located in the star point of a star connected transformer winding).

   - For some special line protection applications this dedicated IED CT input can be connected to parallel connection of current transformers in all three phases (Holm-Green connection)

2. calculated from three phase current input within the IED (when the fourth analog input into the pre-processing block connected to EF4PTOC function analog input I3PPOL is NOT connected to a dedicated CT input of the IED in PCM600 tool). In such case the pre-processing block will calculate $3I_0$ from the first three inputs into the pre-processing block by using the following formula:

$$IPol = 3I_0 = IL1 + IL2 + IL3$$

<div align="right">(Equation 9)</div>

where:

IL1, IL2 and IL3   are fundamental frequency phasors of three individual phase currents.

The residual polarizing current is pre-processed by a discrete fourier filter. Thus the phasor of the fundamental frequency component of the residual current is derived. This phasor is then multiplied with pre-set equivalent zero sequence source Impedance in order to calculate equivalent polarizing voltage UIPol in accordance with the following formula:

$$UIPol = Z_{0s} \cdot IPol = (RNPol + j \cdot XNPol) \cdot IPol$$

<div align="right">(Equation 10)</div>

which will be then used, together with the phasor of the operating current, in order to determine the direction to the earth-fault (Forward/Reverse). In order to enable current polarizing the magnitude of polarizing current shall be bigger than a minimum level defined by setting parameter *IPolMin*.

Dual polarizing

When dual polarizing is selected the function will use the vectorial sum of the voltage based and current based polarizing in accordance with the following formula:

$$UTotPol = UUPol + UIPol = -3U_0 + Z_{0s} \cdot IPol = -3U_0 + (RNPol + jXNPol) \cdot IPol$$

(Equation 11)

Then the phasor of the total polarizing voltage UTotPol will be used, together with the phasor of the operating current, to determine the direction to the earth-fault (Forward/Reverse).

4.4.7.3 External polarizing for earth-fault function

The individual steps within the protection can be set as non-directional. When this setting is selected it is then possible via function binary input BLKSTx (where x indicates the relevant step within the protection) to provide external directional control (that is, torque control) by for example using one of the following functions if available in the IED:

1. Distance protection directional function.
2. Negative sequence based overcurrent function.

4.4.7.4 Base quantities within the protection

The base quantities are entered as global settings for all functions in the IED. Base current (*IBase*) shall be entered as rated phase current of the protected object in primary amperes. Base voltage (*UBase*) shall be entered as rated phase-to-phase voltage of the protected object in primary kV.

4.4.7.5 Internal earth-fault protection structure

The protection is internally divided into the following parts:

1. Four residual overcurrent steps.
2. Directional supervision element for residual overcurrent steps with integrated directional comparison step for communication based earth-fault protection schemes (permissive or blocking).
3. Second harmonic blocking element with additional feature for sealed-in blocking during switching of parallel transformers.

Each part is described separately in the following sections.

4.4.7.6 Four residual overcurrent steps

Each overcurrent step uses operating quantity Iop (residual current) as measuring quantity. Each of the four residual overcurrent step has the following built-in facilities:

- Operating mode can be set *Off*/*Non-directional*/*Forward*/*Reverse*. By this parameter setting the operating mode of the step is selected. It shall be noted that the directional decision (Forward/Reverse) is not made within residual overcurrent step itself. The direction of the fault is determined in common "directional supervision element".
- Residual current pickup value.
- Type of operating characteristic. By this parameter setting it is possible to select inverse or definitive time delay for step 1 and 4 separately. Step 2 and 3 are always definite time delayed. Most of the standard IEC and ANSI inverse characteristics are available. For the complete list of available inverse curves please refer to section 17.3 "Inverse time characteristics".
- Time delay related settings. By these parameter settings the properties like definite time delay and minimum operating time for inverse curves delay are defined.
- Supervision by second harmonic blocking feature (On/Off). By this parameter setting it is possible to prevent operation of the step if the second harmonic content in the residual current exceeds the preset level.

Simplified logic diagram for one residual overcurrent step is shown in following figure 33:

IEC09000638_1_en.vsd
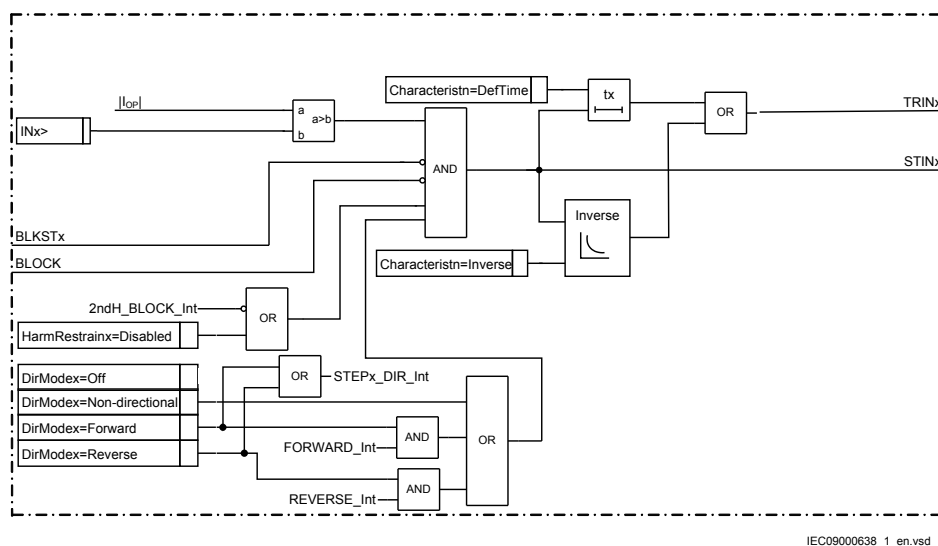
Figure 33:   Simplified logic diagram for residual overcurrent, where x= step 1, 2, 3 or 4 n= step 1 and 4

The protection can be completely blocked from the binary input BLOCK. Output signals for respective step, STINx and TRINx, can be blocked from the binary input BLKSTx.

4.4.7.7 Directional supervision element with integrated directional comparison function

It shall be noted that at least one of the four residual overcurrent steps shall be set as directional in order to enable execution of the directional supervision element and the integrated directional comparison function.

The protection has integrated directional feature. As the operating quantity current Iop is always used. The polarizing method is determined by the parameter setting *polMethod*. The polarizing quantity will be selected by the function in one of the following three ways:

1. When *polMethod=Voltage*, UVPol will be used as polarizing quantity.
2. When *polMethod=Current*, UIpol will be used as polarizing quantity.
3. When *polMethod=Dual*, UTotPol will be used as polarizing quantity.

The operating and polarizing quantity are then used inside the directional element, as shown in figure 34, in order to determine the direction of the earth-fault.
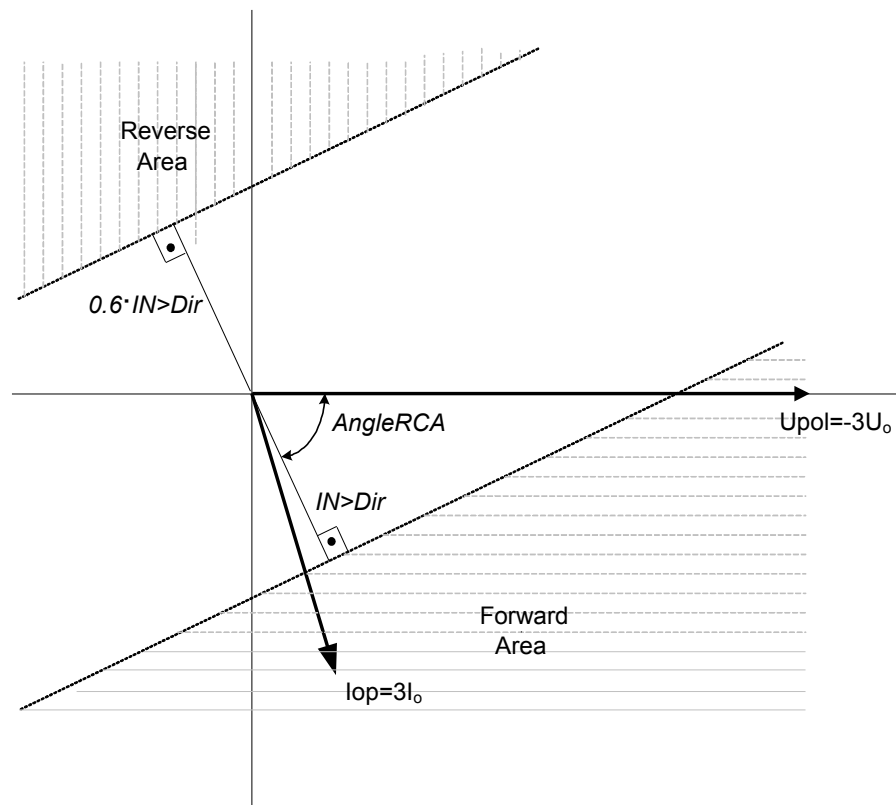
en07000066_2_en.vsd

Figure 34:   *Operating characteristic for earth-fault directional element*

Two relevant setting parameters for directional supervision element are:

- Operating current pickup *IN>Dir*. However it shall be noted that the directional element will be internally enabled to operate as soon as Iop cos(φ - *AngleRCA*) is bigger than 40% of *IN>Dir*.
- Relay characteristic angle *AngleRCA* which defines the position of forward and reverse areas in the operating characteristic.

Directional comparison step, built-in within directional supervision element, will set EF4PTOC function output binary signals:

1. STFW=1 when operating quantity magnitude is bigger than setting parameter *IN>Dir* and directional supervision element detects fault in forward direction.
2. STRV=1 when operating quantity magnitude is bigger than 60% of setting parameter *IN>Dir* and directional supervision element detects fault in reverse direction.

These signals shall be used for communication based earth-fault teleprotection communication schemes (permissive or blocking).

Simplified logic diagram for directional supervision element with integrated directional comparison step is shown in figure 35:
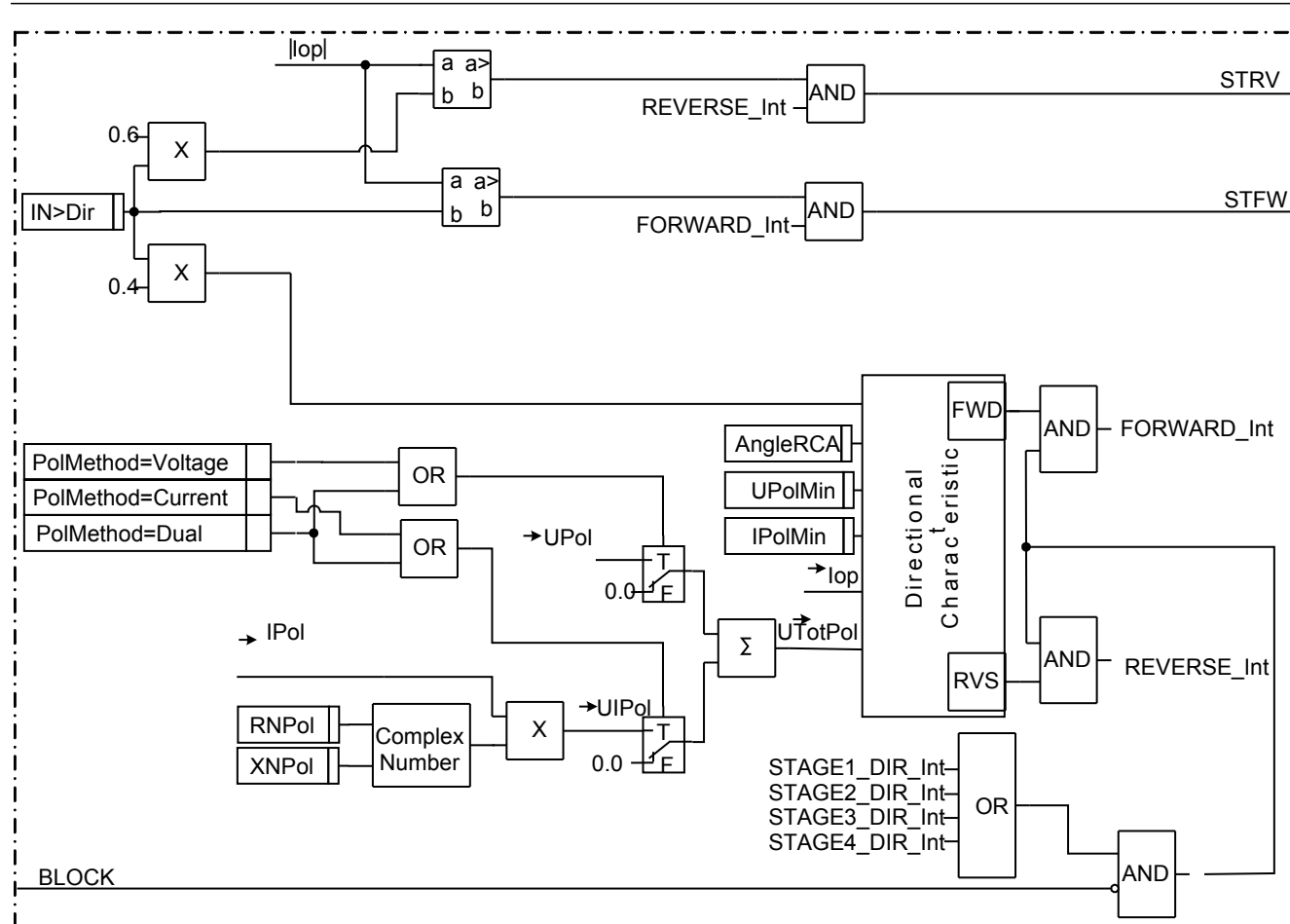
Figure 35: *Simplified logic diagram for directional supervision element with integrated directional comparison step*

4.4.8 Technical data

Table 36: *EF4PTOC Technical data*

Function	Range or value	Accuracy
Operate current	(1-2500)% of IBase	$\pm 1.0\%$ of I_r at $I \le I_r$ $\pm 1.0\%$ of I at $I > I_r$
Reset ratio	> 95%	-
Operate current for directional comparison	(1–100)% of IBase	$\pm 1.0\%$ of I_r
Timers	(0.000-60.000) s	$\pm 0.5\% \pm 10$ ms
Inverse characteristics, see table 484, table 485 and table 486	17 curve types	See table 484, table 485 and table 486
Table continues on next page		

Function	Range or value	Accuracy
Second harmonic restrain operation	(5–100)% of fundamental	$\pm$ 2.0% of I_r
Relay characteristic angle	(-180 to 180) degrees	$\pm$ 2.0 degrees
Minimum polarizing voltage	(1–100)% of UBase	$\pm$ 0.5% of U_r
Minimum polarizing current	(2-100)% of IBase	$\pm$1.0% of I_r
Real part of source Z used for current polarization	(0.50-1000.00) Ω/phase	-
Imaginary part of source Z used for current polarization	(0.50–3000.00) Ω/phase	-
Operate time, start function	30 ms typically at 0.5 to 2 x Iset	-
Reset time, start function	30 ms typically at 2 to x I_{set}	-
Critical impulse time	10 ms typically at 0 to 2 x I_{set}	-
Impulse margin time	15 ms typically	-

4.5 Sensitive directional residual overcurrent and power protection SDEPSDE

4.5.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Sensitive directional residual over current and power protection	SDEPSDE	-	67N

4.5.2 Functionality

In isolated networks or in networks with high impedance earthing, the earth fault current is significantly smaller than the short circuit currents. In addition to this, the magnitude of the fault current is almost independent on the fault location in the network. The protection can be selected to use either the residual current or residual power component $3U_0 \cdot 3I_0 \cdot \cos \varphi$, for operating quantity. There is also available one non-directional $3I_0$ step and one non-directional $3U_0$ overvoltage tripping step.

4.5.3 Function block

```
           SDEPSDE
── I3P*              TRIP ──
── U3P*           TRDIRIN ──
── BLOCK           TRNDIN ──
── BLKUN             TRUN ──
                    START ──
                   STDIRIN ──
                   STNDIN ──
                     STUN ──
                     STFW ──
                     STRV ──
                    STDIR ──
                    UNREL ──
```
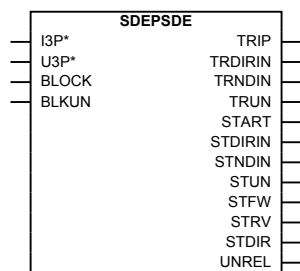
Figure 36: *SDEPSDE function block*

4.5.4 Signals

Table 37: *SDEPSDE Input signals*

Name	Type	Default	Description
I3P	GROUP SIGNAL	-	Three phase group signal for current inputs
U3P	GROUP SIGNAL	-	'Three phase group signal for voltage inputs
BLOCK	BOOLEAN	0	Block of function
BLKUN	BOOLEAN	0	Blocks the non-directional voltage residual outputs

Table 38: *SDEPSDE Output signals*

Name	Type	Description
TRIP	BOOLEAN	General trip signal
TRDIRIN	BOOLEAN	Trip of the directional residual overcurrent
TRNDIN	BOOLEAN	Trip of non-directional residual overcurrent
TRUN	BOOLEAN	Trip of non-directional residual overvoltage
START	BOOLEAN	General start signal
STDIRIN	BOOLEAN	Start of the directional residual overcurrent function
STNDIN	BOOLEAN	Start of non directional residual overcurrent
STUN	BOOLEAN	Start of non directional residual overvoltage
STFW	BOOLEAN	Start of directional function for fault in forward direction
STRV	BOOLEAN	Start of directional function for fault in reverse direction
STDIR	INTEGER	Direction of fault
UNREL	BOOLEAN	Residual voltage release of operation of directional modes

4.5.5 Settings

Table 39: *SDEPSDE Group settings (basic)*

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
OpMode	3I0Cosfi 3I03U0Cosfi 3I0 and fi	-	-	3I0Cosfi	Selection of operation mode for protection
DirMode	Forward Reverse	-	-	Forward	Direction of operation forward or reverse
RCADir	-179 - 180	Deg	1	-90	Relay characteristic angle RCA
RCAComp	-10.0 - 10.0	Deg	0.1	0.0	Relay characteristic angle compensation
ROADir	0 - 90	Deg	1	90	Relay open angle ROA used as release in phase mode
INCosPhi>	0.25 - 200.00	%IB	0.01	1.00	Set level for 3I0cosPhi, directional residual overcurrent, in % of IBase
SN>	0.25 - 200.00	%SB	0.01	10.00	Set level for 3I0U0cosPhi, starting inverse time count, in % of SBase
INDir>	0.25 - 200.00	%IB	0.01	5.00	Set level for directional residual overcurrent protection, in % of IBase
tDef	0.000 - 60.000	s	0.001	0.100	Definite time delay directional residual overcurrent
SRef	0.03 - 200.00	%SB	0.01	10.00	Reference value of residual power for inverse time count, in % of SBase
kSN	0.00 - 2.00	-	0.01	0.10	Time multiplier setting for directional residual power mode
OpINNonDir>	Off On	-	-	Off	Operation of non-directional residual overcurrent protection
INNonDir>	1.00 - 400.00	%IB	0.01	10.00	Set level for non-directional residual overcurrent, in % of IBase
tINNonDir	0.000 - 60.000	s	0.001	1.000	Time delay for non-directional residual overcurrent
TimeChar	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 RI type RD type	-	-	IEC Norm. inv.	Operation curve selection for IDMT operation
tMin	0.000 - 60.000	s	0.001	0.040	Minimum operate time for IEC IDMT curves
Table continues on next page					

Name	Values (Range)	Unit	Step	Default	Description
kIN	0.00 - 2.00	-	0.01	1.00	IDMT time multiplier for non-directional residual overcurrent
OpUN>	Off On	-	-	Off	Operation of non-directional residual overvoltage
UN>	1.00 - 300.00	%UB	0.01	20.00	Set level for non-dir residual voltage, % of UBase
tUN	0.000 - 60.000	s	0.001	0.100	Time delay for non-directional residual overvoltage
INRel>	0.25 - 200.00	%IB	0.01	1.00	Residual release current for all directional modes, in % of IBase
UNRel>	1.00 - 300.00	%UB	0.01	3.00	Residual release volt for all dir modes, % of UBase

Table 40:   *SDEPSDE Non group settings (basic)*

Name	Values (Range)	Unit	Step	Default	Description
GlobalBaseSel	1 - 6	-	1	1	Selection of one of the Global Base Value groups

4.5.6   Monitored data

Table 41:   *SDEPSDE Monitored data*

Name	Type	Values (Range)	Unit	Description
INCOSPHI	REAL	-	A	Mag of residual current along polarizing qty 3I0cos(Fi-RCA)
IN	REAL	-	A	Measured magnitude of the residual current 3I0
UN	REAL	-	kV	Measured magnitude of the residual voltage 3U0
SN	REAL	-	MVA	Measured magnitude of residual power 3I03U0cos(Fi-RCA)
ANG FI-RCA	REAL	-	deg	Angle between 3U0 and 3I0 minus RCA (Fi-RCA)

4.5.7   Operation principle

4.5.7.1   Function inputs

The function is using phasors of the residual current and voltage. Group signals I3P and U3P containing phasors of residual current and voltage is taken from pre-processor blocks.

The sensitive directional earth fault protection has the following sub-functions included:

4.5.7.2 Directional residual current protection measuring $3I_0 \cdot \cos \varphi$

φ is defined as the angle between the residual current $3I_0$ and the reference voltage compensated with the set characteristic angle *RCADir* ($\varphi = \text{ang}(3I_0) - \text{ang}(U_{ref})$). $U\text{ref} = -3U_0 \, e^{j\text{RCADIr}}$. *RCADir* is normally set equal to 0 in a high impedance earthed network with a neutral point resistor as the active current component is appearing out on the faulted feeder only. *RCADir* is set equal to -90° in an isolated network as all currents are mainly capacitive. The function operates when $3I_0 \cdot \cos \varphi$ gets larger than the set value.
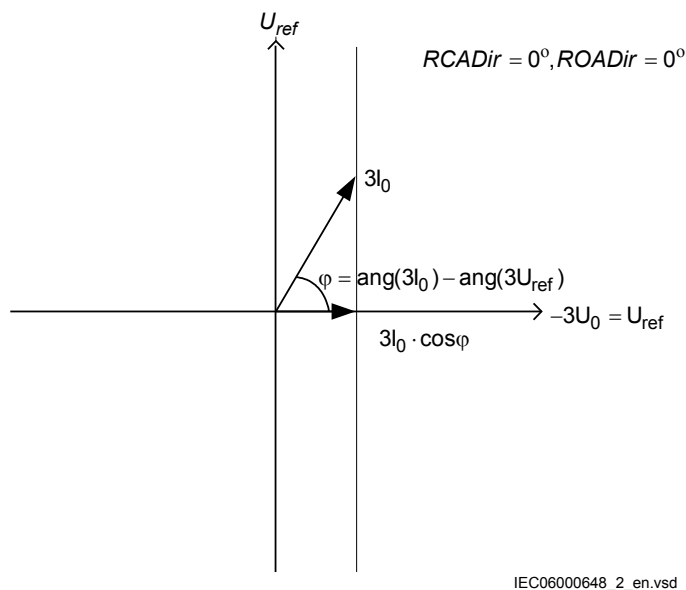
Figure 37: *RCADIr set to 0°*
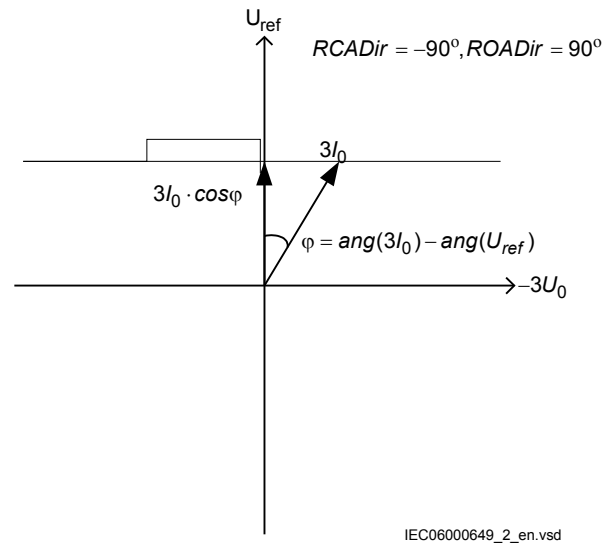
Figure 38: *RCADIr set to -90°*

For trip, both the residual current $3I_0 \cdot \cos \varphi$ and the release voltage $3U_0$, shall be larger than the set levels: *INCosPhi>* and *UNRel>*.

When the function is activated binary output signals START and STDIRIN are activated. If the activation is active after the set delay *tDef* the binary output signals TRIP and TRDIRIN are activated. The trip from this sub-function has definite time delay.

There is a possibility to increase the operate level for currents where the angle φ is larger than a set value as shown in the figure below. This is equivalent to blocking of the function if $\varphi > ROADir$. This option is used to handle angle error for the instrument transformers.

IEC06000650_2_en.vsd
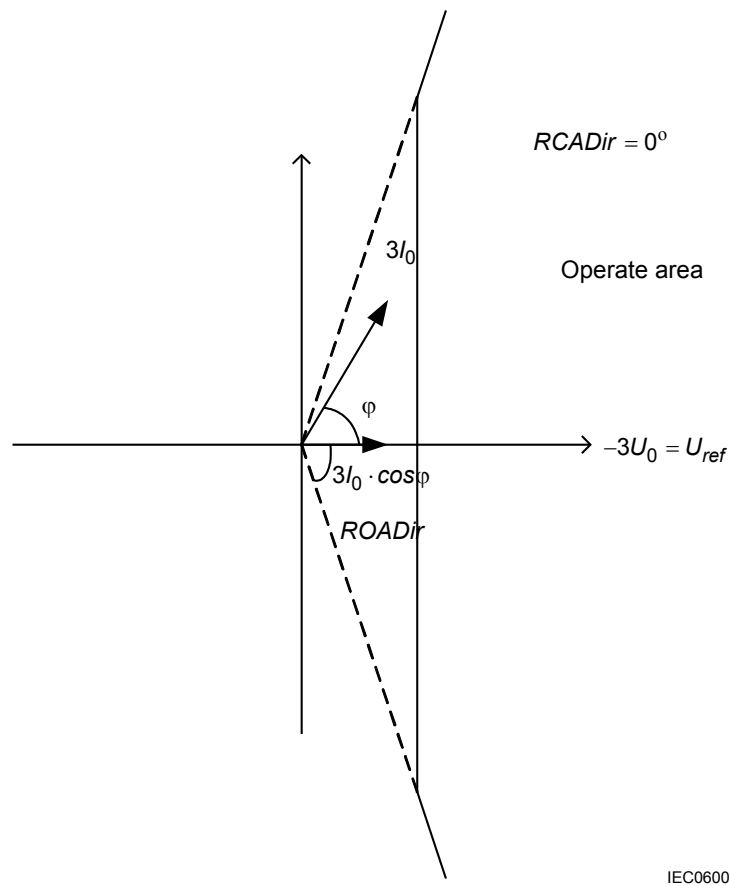
Figure 39:   Characteristic with ROADir restriction

The function will indicate forward/reverse direction to the fault. Reverse direction is defined as $3I_0 \cdot \cos(\varphi + 180°) \geq$ the set value.

It shall also be possible to tilt the characteristic to compensate for current transformer angle error with a setting *RCAComp* as shown in the figure below:
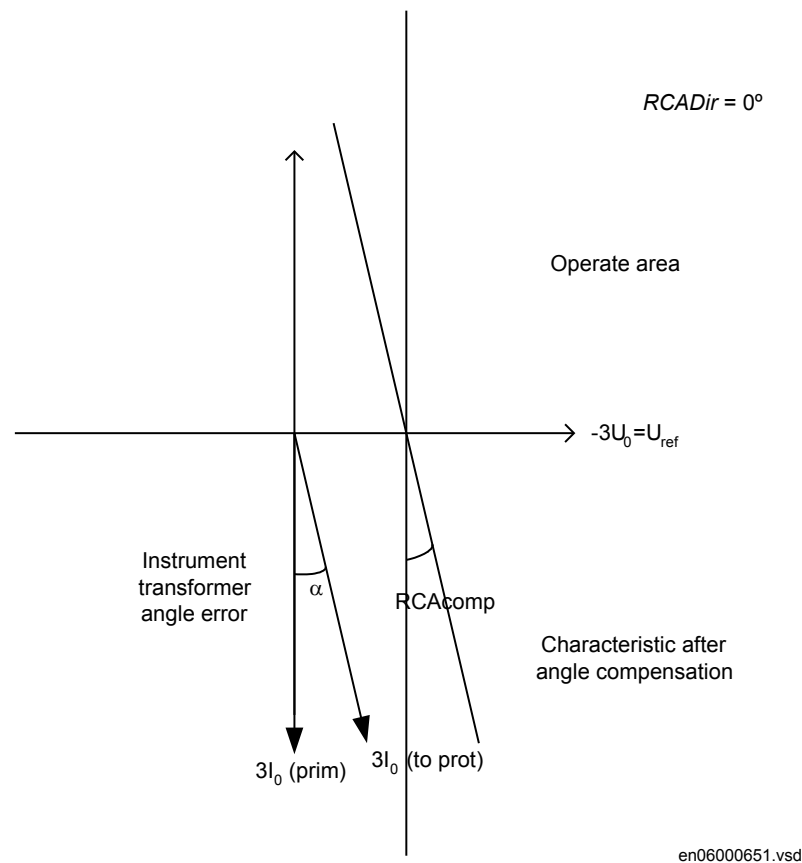
Figure 40:   *Explanation of RCAcomp.*

4.5.7.3   Directional residual power protection measuring $3I_0 \cdot 3U_0 \cdot \cos \varphi$

φ is defined as the angle between the residual current $3I_0$ and the reference voltage compensated with the set characteristic angle *RCADir* (φ=ang($3I_0$)—ang(U_{ref})). $U_{ref} = -3U_0 \, e^{jRCA}$. The function operates when $3I_0 \cdot 3U_0 \cdot \cos \varphi$ gets larger than the set value.

For trip, both the residual power $3I_0 \cdot 3U_0 \cdot \cos \varphi$, the residual current $3I_0$ and the release voltage $3U_0$, shall be larger than the set levels (*SN>*, *INRel>* and *UNRel>*).

When the function is activated binary output signals START and STDIRIN are activated. If the activation is active after the set delay *tDef* or after the inverse time delay (setting *kSN*) the binary output signals TRIP and TRDIRIN are activated.

The function shall indicate forward/reverse direction to the fault. Reverse direction is defined as $3I_0 \cdot 3U_0 \cdot \cos (\varphi + 180°) \geq$ the set value.

This variant has the possibility of choice between definite time delay and inverse time delay.

The inverse time delay is defined as:

$$t_{inv} = \frac{kSN \cdot (3I_0 \cdot 3U_0 \cdot \cos\varphi(\text{reference}))}{3I_0 \cdot 3U_0 \cdot \cos\varphi(\text{measured})}$$

(Equation 12)

4.5.7.4 Directional residual current protection measuring $3I_0$ and φ

The function will operate if the residual current is larger that the set value and the angle $\varphi = \text{ang}(3I_0)\text{-ang}(U_{ref})$ is within the sector *RCADir ± ROADir*
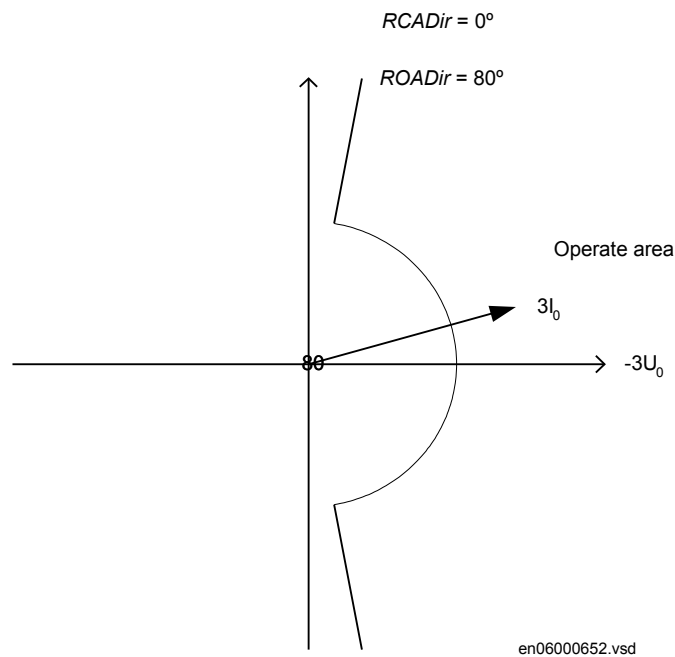
Figure 41:   *Example of characteristic*

For trip, both the residual current $3I_0$ and the release voltage $3U_0$, shall be larger than the set levels *INDir>* and *UNREL>* and the angle φ shall be in the set sector *ROADir* and *RCADir*.

When the function is activated binary output signals START and STDIRIN are activated. If the activation is active after the set delay *tDef* the binary output signals TRIP and TRDIRIN are activated.

The function indicate forward/reverse direction to the fault. Reverse direction is defined as φ is within the angle sector: *RCADir* + 180° ± *ROADir*

This variant shall have definite time delay.

4.5.7.5 Directional functions

For all the directional functions there are directional start signals STFW: fault in the forward direction, and STRV: start in the reverse direction. Even if the directional function is set to operate for faults in the forward direction a fault in the reverse direction will give the start signal STRV. Also if the directional function is set to operate for faults in the reverse direction a fault in the forward direction will give the start signal STFW.

4.5.7.6 Non-directional earth fault current protection

This function will measure the residual current without checking the phase angle. The function will be used to detect cross-country faults. This function can serve as alternative or back-up to distance protection with phase preference logic.

If available the non-directional function is using the calculated residual current, derived as sum of the phase currents. This will give a better ability to detect cross-country faults with high residual current, also when dedicated core balance CT for the sensitive earth fault protection will saturate.

This variant shall have the possibility of choice between definite time delay and inverse time delay. The inverse time delay shall be according to IEC 60255-3.

For trip, the residual current $3I_0$ shall be larger than the set levels (*INNonDir>*).

When the function is activated binary output signal STNDIN is activated. If the activation is active after the set delay *tINNonDir* or after the inverse time delay the binary output signals TRIP and TRNDIN are activated.

4.5.7.7 Residual overvoltage release and protection

The directional function shall be released when the residual voltage gets higher than a set level.

There shall also be a separate trip, with its own definite time delay, from this set voltage level.

For trip, the residual voltage $3U_0$ shall be larger than the set levels (*UN>*).

Trip from this function can be blocked from the binary input BLKUN.

When the function is activated binary output signal STUN is activated. If the activation is active after the set delay *tUNNonDir* TRIP and TRUN are activated. A simplified logical diagram of the total function is shown in figure .
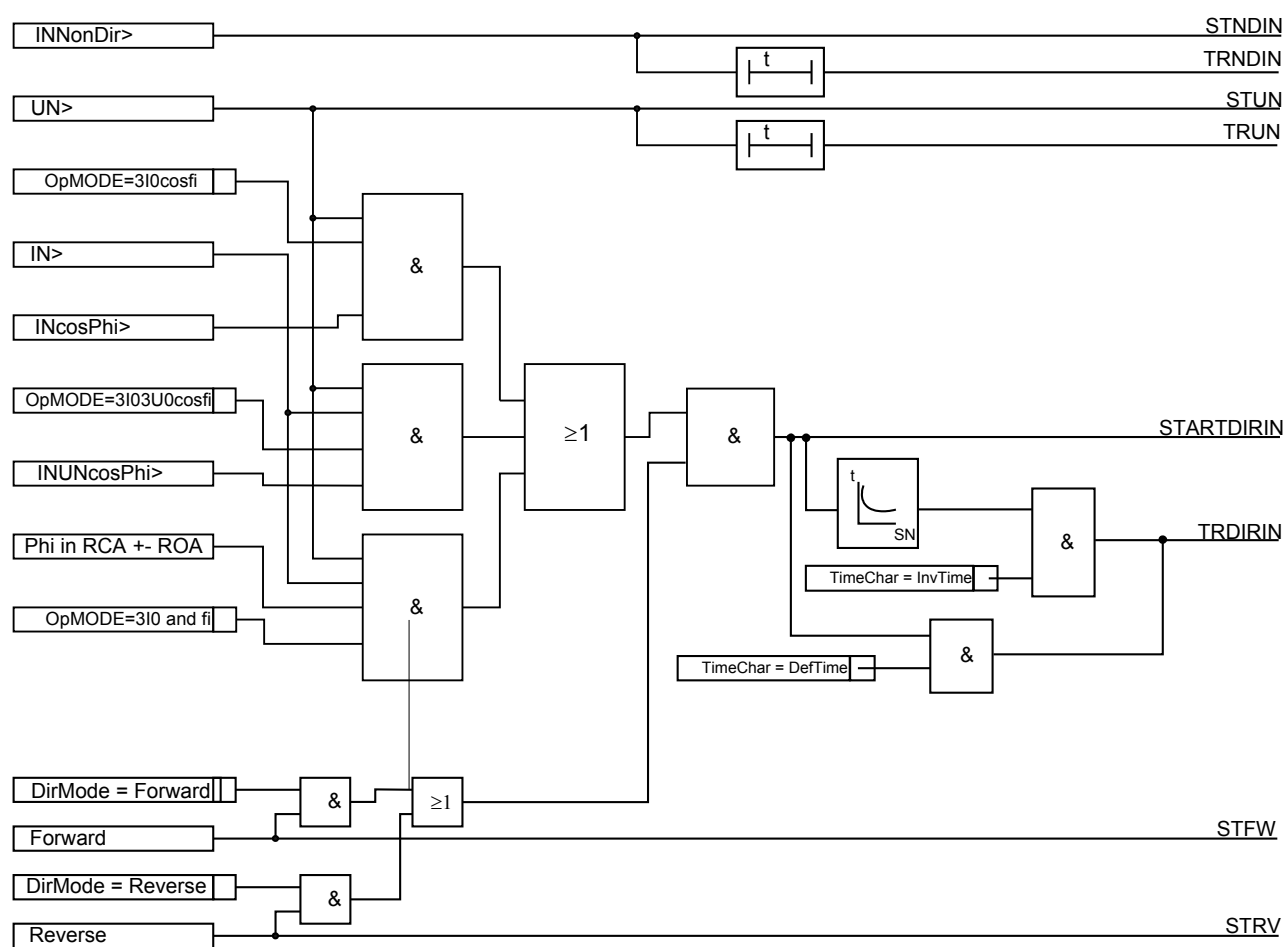
Figure 42: *Simplified logical diagram of the sensitive earth-fault current protection*

4.5.8 Technical data

Table 42:   SDEPSDE Technical data

Function	Range or value	Accuracy
Operate level for $3I_0 \cdot \cos\varphi$ directional residual overcurrent	(0.25-200.00)% of IBase At low setting: (2.5-10) mA (10-50) mA	$\pm$ 1.0% of I_r at $I \le I_r$ $\pm$ 1.0% of I at I > I_r $\pm$0.5 mA $\pm$1.0 mA
Operate level for $3I_0 \cdot 3U_0 \cdot \cos\varphi$ directional residual power	(0.25-200.00)% of SBase At low setting: (0.25-5.00)% of SBase	$\pm$ 1.0% of S_r at $S \le S_r$ $\pm$ 1.0% of S at S > S_r $\pm$ 10% of set value
Operate level for $3I_0$ and φ residual overcurrent	(0.25-200.00)% of IBase At low setting: (2.5-10) mA (10-50) mA	$\pm$ 1.0% of I_r at $\le I_r$ $\pm$ 1.0% of I at I > I_r $\pm$0.5 mA $\pm$1.0 mA
Operate level for non directional overcurrent	(1.00-400.00)% of IBase At low setting: (10-50) mA	$\pm$ 1.0% of I_r at $I \le I_r$ $\pm$ 1.0% of I at I > I_r $\pm$ 1.0 mA
Operate level for non directional residual overvoltage	(1.00-200.00)% of UBase	$\pm$ 0.5% of U_r at $U \le U_r$ $\pm$ 0.5% of U at U > U_r
Residual release current for all directional modes	(0.25-200.00)% of IBase At low setting: (2.5-10) mA (10-50) mA	$\pm$ 1.0% of I_r at $I \le I_r$ $\pm$ 1.0% of I at I > I_r $\pm$0.5 mA $\pm$ 1.0 mA
Residual release voltage for all directional modes	(1.00 - 300.00)% of UBase	$\pm$ 0.5% of U_r at $U \le U_r$ $\pm$ 0.5% of U at > U_r
Reset ratio	> 95%	-
Timers	(0.000-60.000) s	$\pm$ 0.5% $\pm$ 10 ms
Inverse characteristics, see table 484, table 485 and table 486	17 curve types	See table 484, table 485 and table 486
Relay characteristic angle RCA	(-179 to 180) degrees	$\pm$ 2.0 degrees
Relay open angle ROA	(0-90) degrees	$\pm$ 2.0 degrees
Operate time, non directional residual over current	35 ms typically at 0.5 to 2 $\cdot I_{set}$	-
Reset time, non directinal residual over current	40 ms typically at 1.2 to 0 $\cdot I_{set}$	-
Operate time, nondirectional residual overvoltage	150 ms typically at 0.8 to 1.5 $\cdot U_{set}$	-
Reset time, nondirectional residual overvoltage	60 ms typically at 1.2 to 0.8 $\cdot U_{set}$	-

4.6 Thermal overload protection, one time constant LPTTR

4.6.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Thermal overload protection, one time constant	LPTTR		26

4.6.2 Functionality

The increasing utilizing of the power system closer to the thermal limits have generated a need of a thermal overload protection also for power lines.

A thermal overload will often not be detected by other protection functions and the introduction of the thermal overload protection can allow the protected circuit to operate closer to the thermal limits.

The three-phase current measuring protection has an I^2t characteristic with settable time constant and a thermal memory.

An alarm level gives early warning to allow operators to take action well before the line is tripped.

4.6.3 Function block
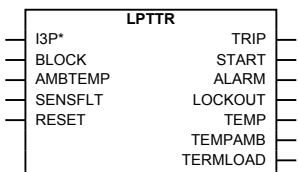
Figure 43:   LPTTR function block

4.6.4 Signals

LPTTR has no input for external temperature sensor in first release of 650 series.

Table 43:   *LPTTR Input signals*

Name	Type	Default	Description
I3P	GROUP SIGNAL	-	Three phase group signal for current inputs
BLOCK	BOOLEAN	0	Block of function
AMBTEMP	REAL	0	Ambient temperature from external temperature sensor
SENSFLT	BOOLEAN	0	Validity status of ambient temperature sensor
RESET	BOOLEAN	0	Reset of internal thermal load counter

Table 44:   *LPTTR Output signals*

Name	Type	Description
TRIP	BOOLEAN	General trip signal
START	BOOLEAN	General start signal
ALARM	BOOLEAN	Alarm signal
LOCKOUT	BOOLEAN	Lockout signal
TEMP	REAL	Calculated temperature of the device
TEMPAMB	REAL	Ambient temperature used in the calculations
TERMLOAD	REAL	Temperature relative to operate temperature

4.6.5   Settings

Table 45:   *LPTTR Group settings (basic)*

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
TRef	0 - 600	Deg	1	90	End temperature rise above ambient of the line when loaded with IRef
IRef	0 - 400	%IB	1	100	Load current in % of IBase leading to TRef temperature
Tau	0 - 1000	Min	1	45	Time constant of the line
AlarmTemp	0 - 200	Deg	1	80	Temperature level for start (alarm)
TripTemp	0 - 600	Deg	1	90	Temperature level for trip
ReclTemp	0 - 600	Deg	1	75	Temperature for reset of lockout after trip
AmbiSens	Off On	-	-	Off	External temperature sensor available
DefaultAmbTemp	-50 - 250	Deg	1	20	Ambient temperature used when AmbiSens is set to Off
DefaultTemp	-50 - 600	Deg	1	50	Temperature raise above ambient temperature at startup

Table 46:   *LPTTR Non group settings (basic)*

Name	Values (Range)	Unit	Step	Default	Description
GlobalBaseSel	1 - 6	-	1	1	Global Base Selector

4.6.6   Monitored data

Table 47:   *LPTTR Monitored data*

Name	Type	Values (Range)	Unit	Description
TTRIP	REAL	-	-	Estimated time to trip (in min)
TENRECL	REAL	-	-	Estimated time to reset of lockout (in min)
TEMP	REAL	-	-	Calculated temperature of the device
TEMPAMB	REAL	-	-	Ambient temperature used in the calculations

4.6.7   Operation principle

The sampled analog phase currents are pre-processed and for each phase current the RMS value is derived. These phase current values are fed to the Thermal overload protection, one time constant function (LPTTR).

From the largest of the three-phase currents a final temperature is calculated according to the expression:

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

(Equation 13)

where:

I is the largest phase current,

I_{ref} is a given reference current and

T_{ref} is steady state temperature corresponding to I_{ref}

If this temperature is larger than the set operate temperature level, *TripTemp*, a START output signal is activated.

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

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

(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 temperature with the actual current,
Δt	is the time step between calculation of the actual temperature and
τ	is the set thermal time constant for the protected device (line or cable)

The calculated component temperature is available as a real figure signal, TEMP.

When the component temperature reaches the set alarm level *AlarmTemp* the output signal ALARM is set. When the component temperature reaches the set trip level *TripTemp* the output signal TRIP is set.

There is also a calculation of the present time to operate 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 is available as a real figure signal, 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 device temperature is above the set lockout release temperature setting *ReclTemp*.

The time to lockout release is calculated that is, a calculation of the cooling time to a set value. The thermal content of the function can be reset with input RESET.

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

(Equation 16)

The calculated time to reset of lockout is available as a real figure signal, TENRECL.

The protection has a reset input: RESET. By activating this input the calculated temperature is reset to its default initial value. This is useful during testing when secondary injected current has given a calculated "false" temperature level.

IEC09000637_1_en.vsd
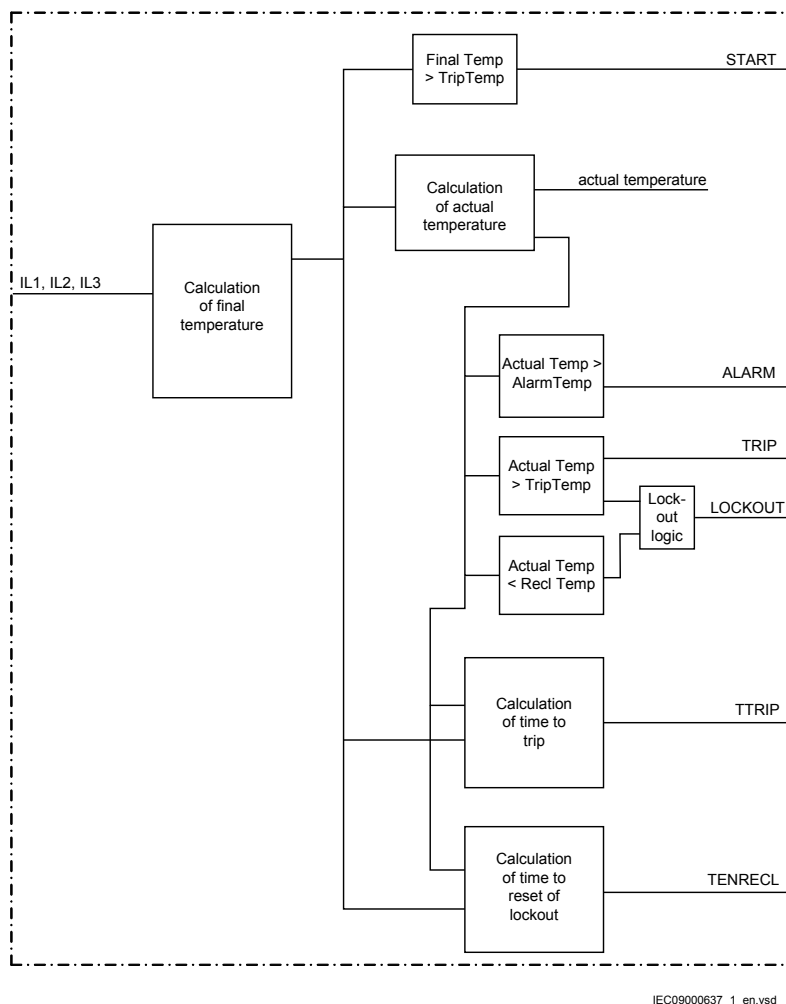
Figure 44:   Functional overview of LPTTR
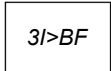
4.6.8 Technical data

Table 48: LPTTR Technical data

Function	Range or value	Accuracy
Reference current	(0-400)% of IBase	± 1.0% of I_r
Start temperature reference	(0-400)°C	± 1.0°C
Operate time: $$t = \tau \cdot \ln\left(\frac{I^2 - I_p^{\ 2}}{I^2 - I_b^{\ 2}} \right)$$ (Equation 17) I = actual measured current I_p = load current before overload occurs I_b = base current, IBase	Time constant τ = (0–1000) minutes	IEC 60255-8, class 5 + 200 ms
Alarm temperature	(0-200)°C	± 2.0% of heat content trip
Trip temperature	(0-600)°C	± 2.0% of heat content trip
Reset level temperature	(0-600)°C	± 2.0% of heat content trip

4.7 Breaker failure protection CCRBRF

4.7.1 Identification

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

4.7.2 Functionality

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

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

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

Breaker failure protection (CCRBRF) function current criteria can be fulfilled by one or two phase currents, or one phase current plus residual current. When those

currents exceed the user defined settings, the function is activated. These conditions increase the security of the back-up trip command.

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

4.7.3 Function block

IEC09000272_1_en.vsd
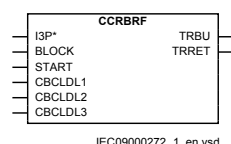
Figure 45: *CCRBRF function block*

4.7.4 Signals

Table 49: *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
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

Table 50: *CCRBRF Output signals*

Name	Type	Description
TRBU	BOOLEAN	Back-up trip by breaker failure protection function
TRRET	BOOLEAN	Retrip by breaker failure protection function

4.7.5 Settings

Table 51:   CCRBRF Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
FunctionMode	Current Contact Current&Contact	-	-	Current	Detection principle for back-up trip
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

Table 52:   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

Table 53:   CCRBRF Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
GlobalBaseSel	1 - 6	-	1	1	Selection of one of the Global Base Value groups

4.7.6 Monitored data

Table 54:   CCRBRF Monitored data

Name	Type	Values (Range)	Unit	Description
IL1	REAL	-	A	Measured current in phase L1
IL2	REAL	-	A	Measured current in phase L2
IL3	REAL	-	A	Measured current in phase L3
IN	REAL	-	A	Measured residual current

4.7.7   Operation principle

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 is general for all three phases. A re-trip attempt can be made after a set time delay. The re-trip function can be done with or without current or contact 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. With contact check the re-trip is only performed if breaker is indicated as closed.

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, 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 back-up timer has run its time a back-up trip is initiated.

Further the following possibilities are available:

*   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.
*   Back-up trip is always made with current or contact check.It is possible to have this option activated for small load currents only.

en08000007.vsd
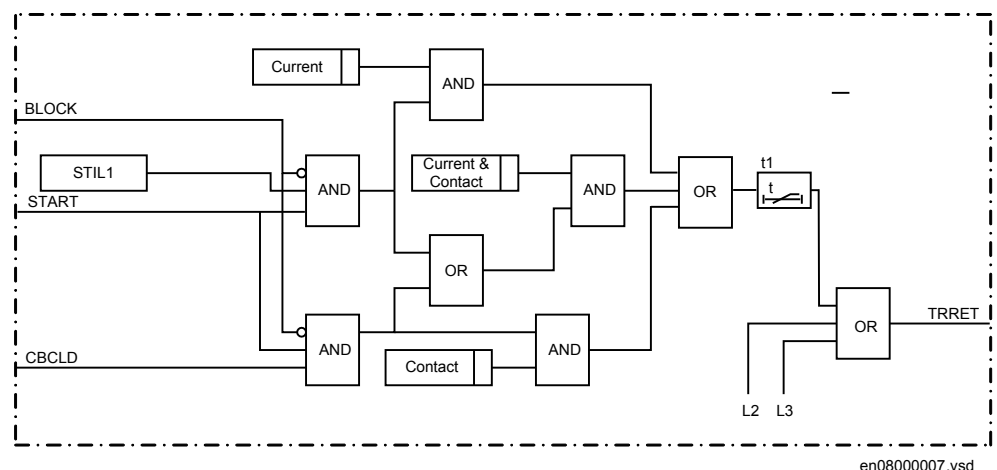
Figure 46:   Simplified logic scheme of the retrip function

Internal logical signals STIL1, STIL2, STIL3 have logical value 1 when current in respective phase has magnitude larger than setting parameter *IP>*.

Internal logical signal STN has logical value 1 when neutral current has magnitude larger than setting parameter *IN>*.

4.7.8 Technical data

Table 55:   CCRBRF Technical data
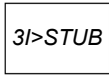
Function	Range or value	Accuracy
Operate phase current	(5-200)% of IBase	$\pm$ 1.0% of I_r at $I \leq I_r$ $\pm$ 1.0% of I at I > I_r
Reset ratio, phase current	> 95%	-
Operate residual current	(2-200)% of IBase	$\pm$ 1.0% of I_r at $I \leq I_r$ $\pm$ 1.0% of I at I > I_r
Reset ratio, residual current	> 95%	-
Phase current level for blocking of contact function	(5-200)% of IBase	$\pm$ 1.0% of I_r at $I \leq I_r$ $\pm$ 1.0% of I at I > I_r
Reset ratio	> 95%	-
Timers	(0.000-60.000) s	$\pm$ 0.5% $\pm$ 10 ms
Operate time for current detection	10 ms typically	-
Reset time for current detection	15 ms maximum	-

4.8 Stub protection STBPTOC

4.8.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Stub protection	STBPTOC	*3I>STUB*	50STB

4.8.2 Functionality

When a power line is taken out of service for maintenance and the line disconnector is opened the voltage transformers will mostly be outside on the disconnected part. The primary line distance protection will thus not be able to operate and must be blocked.

The stub protection covers the zone between the current transformers and the open disconnector. The three-phase instantaneous overcurrent function is released from a normally open, NO (b) auxiliary contact on the line disconnector.

4.8.3 Function block

```
        STBPTOC
── I3P*            TRIP ──
── BLOCK          START ──
── RELEASE
```
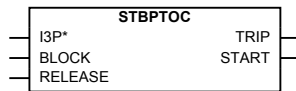
Figure 47:   STBPTOC function block

4.8.4 Signals

Table 56:   STBPTOC Input signals

Name	Type	Default	Description
I3P	GROUP SIGNAL	-	Three phase group signal for current inputs
BLOCK	BOOLEAN	0	Block of function
RELEASE	BOOLEAN	0	Release of stub protection

Table 57:   STBPTOC Output signals

Name	Type	Description
TRIP	BOOLEAN	General trip signal
START	BOOLEAN	General start signal

4.8.5 Settings

Table 58:   STBPTOC Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
I>	1 - 2500	%IB	1	200	Operate current level in % of IBase

Table 59:   STBPTOC Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
GlobalBaseSel	1 - 6	-	1	1	Global Base Selector

4.8.6 Monitored data

Table 60:   *STBPTOC Monitored data*

Name	Type	Values (Range)	Unit	Description
IL1	REAL	-	A	Current in phase L1
IL2	REAL	-	A	Current in phase L2
IL3	REAL	-	A	Current in phase L3

4.8.7 Operation principle

The sampled analog phase currents are pre-processed in a discrete Fourier filter (DFT) block. From the fundamental frequency components of each phase current the RMS value of each phase current is derived. These phase current values are fed to a comparator in Stub protection (STBPTOC) function. In a comparator the RMS values are compared to the set operating current value of the function $I>$. If a phase current is larger than the set operating current the signal from the comparator for this phase is set to true and a TRIP signal is activated. The function can be blocked by activation of the BLOCK input.

STUB PROTECTION FUNCTION
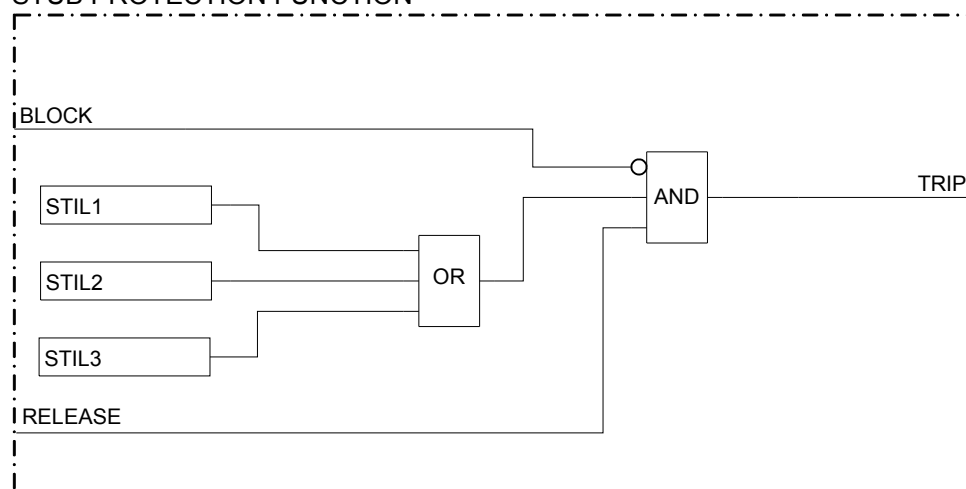
en05000731.vsd

Figure 48:   *Simplified logic diagram for the stub protection*

4.8.8 Technical data

Table 61: *STBPTOC Technical data*

Function	Range or value	Accuracy
Operating current	(1-2500)% of IBase	$\pm$ 1.0% of I_r at $I \leq I_r$ $\pm$ 1.0% of I at $I > I_r$
Reset ratio	> 95%	-
Operating time	20 ms typically at 0 to 2 x I_{set}	-
Resetting time	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	-

4.9 Pole discordance protection CCRPLD

4.9.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Pole discordance protection	CCRPLD	PD	52PD

4.9.2 Functionality

Circuit breakers or disconnectors can due to electrical or mechanical failures end up with the different poles in different positions (close-open). This can cause negative and zero sequence currents which gives thermal stress on rotating machines and can cause unwanted operation of zero sequence or negative sequence current functions.

Normally the own breaker is tripped to correct such a situation. If the situation persists the surrounding breaker should be tripped to clear the unsymmetrical load situation.

The pole discordance function operates based on information from the circuit breaker logic with additional criteria from unsymmetrical phase current when required.

4.9.3   Function block

```
        CCRPLD
 ── I3P*           TRIP ──
 ── BLOCK         START ──
 ── CLOSECMD
 ── OPENCMD
 ── EXTPDIND
```
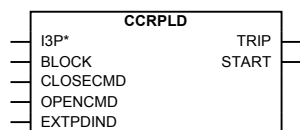
Figure 49:   *CCRPLD function block*

4.9.4   Signals

Table 62:   *CCRPLD Input signals*

Name	Type	Default	Description
I3P	GROUP SIGNAL	-	Three phase group signal for current inputs
BLOCK	BOOLEAN	0	Block of function
CLOSECMD	BOOLEAN	0	Close order to CB
OPENCMD	BOOLEAN	0	Open order to CB
EXTPDIND	BOOLEAN	0	Pole discordance signal from CB logic

Table 63:   *CCRPLD Output signals*

Name	Type	Description
TRIP	BOOLEAN	Trip signal to CB
START	BOOLEAN	Trip condition TRUE, waiting for time delay

4.9.5   Settings

Table 64:   *CCRPLD Group settings (basic)*

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
tTrip	0.000 - 60.000	s	0.001	0.300	Time delay between trip condition and trip signal
ContSel	Off PD signal from CB	-	-	Off	Contact function selection
CurrSel	Off CB oper monitor Continuous monitor	-	-	Off	Current function selection
CurrUnsymLevel	0 - 100	%	1	80	Unsym magn of lowest phase current compared to the highest.
CurrRelLevel	0 - 100	%IB	1	10	Current magnitude for release of the function in % of IBase

Name	Values (Range)	Unit	Step	Default	Description
GlobalBaseSel	1 - 6	-	1	1	Global Base Selector

4.9.6 Monitored data

Table 66: CCRPLD Monitored data

Name	Type	Values (Range)	Unit	Description
IMin	REAL	-	A	Lowest phase current
IMax	REAL	-	A	Highest phase current

4.9.7 Operation principle

The detection of pole discordance can be made in two different ways. If the contact based function is used an external logic can be made by connecting the auxiliary contacts of the circuit breaker so that a pole discordance is indicated. This is shown in figure 50
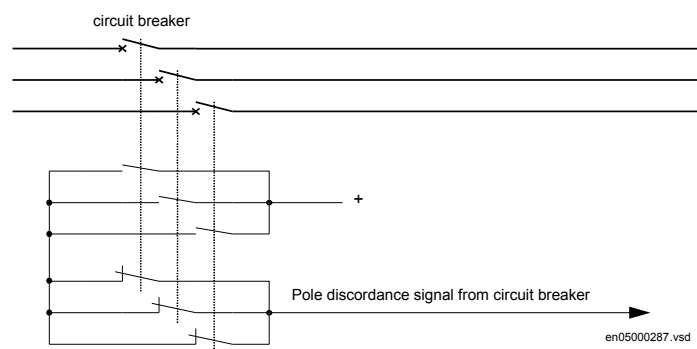
Figure 50: Pole discordance external detection logic

This binary signal is connected to a binary input of the IED. The appearance of this signal will start a timer that will give a trip signal after the set time delay.

Pole discordance can also be detected by means of phase selective current measurement. The sampled analogue phase currents are pre-processed in a discrete Fourier filter (DFT) block. From the fundamental frequency components of each phase current the RMS value of each phase current is derived. The difference between the smallest and the largest phase current is derived. If this difference is larger than the setting *CurrUnsymLevel* the setable trip timer (*tTrip*) is started. The *tTrip* timer gives a trip signal after the set delay. The TRIP signal is a pulse 150 ms long. The current based pole discordance function can be set to be active either continuously or only directly in connection to breaker open or close command.
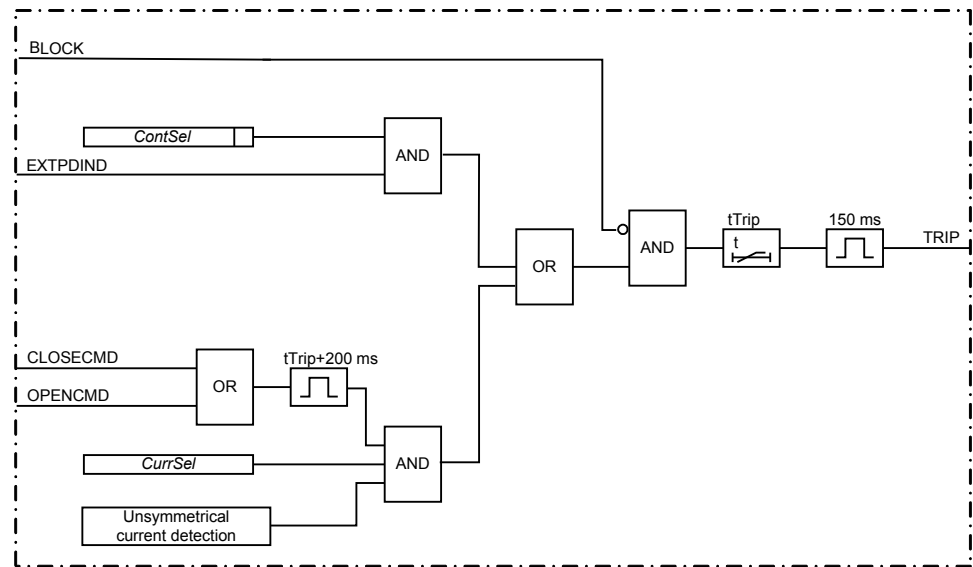
IED08000014_1_en.vsd

Figure 51:   Simplified block diagram of pole discordance function - contact and current based

The pole discordance protection is blocked if the input signal BLOCK is high.

The BLOCK signal is a general purpose blocking signal of the pole discordance protection. 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.

If the pole discordance protection is enabled, then two different criteria can generate a trip signal TRIP:

- Pole discordance signalling from the circuit breaker.
- Unsymmetrical current detection.

4.9.7.1   Pole discordance signalling from circuit breaker

If one or two poles of the circuit breaker have failed to open or to close (pole discordance status), then the function input EXTPDIND is activated from the pole discordance signal in figure 50.After a settable time *tTrip*, a 150 ms trip pulse command TRIP is generated by the pole discordance function.

4.9.7.2   Unsymmetrical current detection

Unsymmetrical current detection is based on:

- any phase current is lower than *CurrUnsymLevel* · the highest phase current.
- the highest phase current is greater than *CurrRelLevel* of the rated current.

If these conditions are true, an unsymmetrical condition is detected. This detection is enabled to generate a trip after a set time delay *tTrip* if the detection occurs in the next 200 ms after the circuit breaker has received a command to open trip or close and if the unbalance persists. The 200 ms limitation is for avoiding unwanted operation during unsymmetrical load conditions.

The pole discordance protection is informed that a trip or close command has been given to the circuit breaker through the inputs CLOSECMD (for closing command information) and OPENCMD (for opening command information). These inputs can be connected to terminal binary inputs if the information are generated from the field (that is from auxiliary contacts of the close and open push buttons) or may be software connected to the outputs of other integrated functions (that is close command from a control function or a general trip from integrated protections).

4.9.8 Technical data

Table 67: CCRPLD Technical data

Function	Range or value	Accuracy
Operate value, current unsymmetry level	(0-100) %	± 1.0% of I_r
Reset ratio	>95%	-
Operate current, current release level	(0–100)% of IBase	± 1.0% of I_r
Time delay	(0.000-60.000) s	± 0.5% ± 10 ms

4.10 Broken conductor check BRCPTOC

4.10.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Broken conductor check	BRCPTOC	-	46

4.10.2 Functionality

Conventional protection functions can not detect the broken conductor condition. Broken conductor check (BRCPTOC) function, consisting of continuous current unsymmetry check on the line where the IED is connected will give alarm or trip at detecting broken conductors.

4.10.3 Function block

```
          BRCPTOC
── I3P*              TRIP ──
── BLOCK            START ──
```

IEC09000277_1_en.vsd
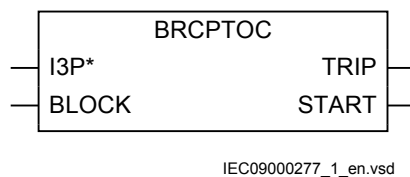
Figure 52: *BRCPTOC function block*

4.10.4 Signals

Table 68: *BRCPTOC Input signals*

Name	Type	Default	Description
I3P	GROUP SIGNAL	-	Three phase group signal for current inputs
BLOCK	BOOLEAN	0	Block of function

Table 69: *BRCPTOC Output signals*

Name	Type	Description
TRIP	BOOLEAN	Operate signal of the protection logic
START	BOOLEAN	Start signal of the protection logic

4.10.5 Settings

Table 70: *BRCPTOC Group settings (basic)*

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
Iub>	50 - 90	%IM	1	50	Unbalance current operation value in percent of max current
IP>	5 - 100	%IB	1	20	Minimum phase current for operation of Iub> in % of Ibase
tOper	0.000 - 60.000	s	0.001	5.000	Operate time delay

Table 71: *BRCPTOC Non group settings (basic)*

Name	Values (Range)	Unit	Step	Default	Description
GlobalBaseSel	1 - 6	-	1	1	Selection of one of the Global Base Value groups

4.10.6   Monitored data

Table 72:   *BRCPTOC Monitored data*

Name	Type	Values (Range)	Unit	Description
IUNBAL	REAL	-	-	Measured unbalance of phase currents

4.10.7   Operation principle

Broken conductor check (BRCPTOC) detects a broken conductor condition by detecting the unsymmetry between currents in the three phases. The current-measuring elements continuously measure the three-phase currents.

The current unsymmetry signal output START is set on if :

- The difference in currents between the phase with the lowest current and the phase with the highest current is greater than set percentage *Iub>* of the highest phase current
- The highest phase current is greater than the minimum setting value *IP>*.
- The lowest phase current is below 50% of the minimum setting value *IP>*

The third condition is included to avoid problems in systems involving parallel lines. If a conductor breaks in one phase on one line, the parallel line will experience an increase in current in the same phase. This might result in the first two conditions being satisfied. If the unsymmetrical detection lasts for a period longer than the set time *tOper* the TRIP output is activated.

The simplified logic diagram of the broken conductor check function is shown in figure 53

BRCPTOC is disabled (blocked) if:

- The IED is in test mode and BRCPTOC has been blocked from the HMI test menu (*Blocked=Yes*).
- The input signal BLOCK is high.

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 to receive a block command from internal functions.

The output trip signal TRIP is a three-phase trip. It can be used to command a trip to the circuit breaker or for alarm purpose only.
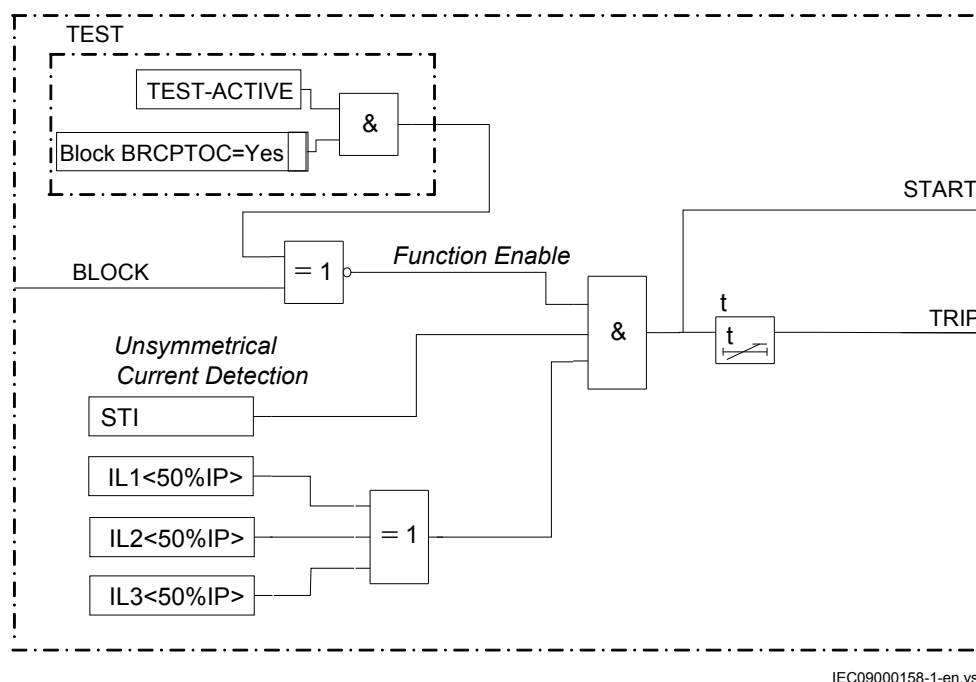
Figure 53:   Simplified logic diagram for Broken conductor check (BRCPTOC)

4.10.8   Technical data

Table 73:   BRCPTOC Technical data

Function	Range or value	Accuracy
Minimum phase current for operation	(5–100)% of IBase	± 1.0% of I_r
Unbalance current operation	(50-90)% of maximum current	± 1.0% of I_r
Timer	(0.00-6000.00) s	± 0.5% ± 10 ms
Operate time for start function	25 ms typically	-
Reset time for start function	15 ms typically	-
Critical impulse time	15 ms typically	-
Impulse margin time	10 ms typically	-

4.11   Directional over-/under-power protection GOPPDOP/GUPPDUP

4.11.1   Functionality

The directional over-/under-power protection (GOPPDOP/GUPPDUP) can be used wherever a high/low active, reactive or apparent power protection or alarming is required. The functions can alternatively be used to check the direction of active or

reactive power flow in the power system. There are number of applications where such functionality is needed. Some of them are:

*   detection of reversed active power flow
*   detection of high reactive power flow
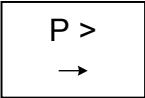
Each function has two steps with definite time delay. Reset times for every step can be set as well.

4.11.2   Directional over-power protection GOPPDOP

4.11.2.1   Identification

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

4.11.2.2   Function block

```
            GOPPDOP
 ——  I3P*                  TRIP   ——
 ——  U3P*                 TRIP1   ——
 ——  BLOCK               TRIP2   ——
                         START   ——
                        START1   ——
                        START2   ——
                            P    ——
                     PPERCENT    ——
                            Q    ——
                     QPERCENT    ——
```
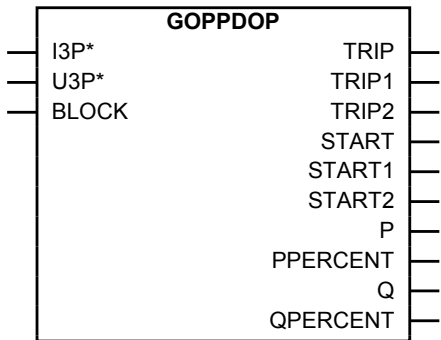
IEC08000506-1-en.vsd

Figure 54:   *GOPPDOP function block*

4.11.2.3   Signals

Table 74:   *GOPPDOP Input signals*

Name	Type	Default	Description
I3P	GROUP SIGNAL	-	Three phase group signal for current inputs
U3P	GROUP SIGNAL	-	Three phase group signal for voltage inputs
BLOCK	BOOLEAN	0	Block of function

Table 75:   *GOPPDOP Output signals*

Name	Type	Description
TRIP	BOOLEAN	General trip signal
TRIP1	BOOLEAN	Trip signal from stage 1
TRIP2	BOOLEAN	Trip signal from stage 2
START	BOOLEAN	General start signal
START1	BOOLEAN	Start signal from stage 1
START2	BOOLEAN	Start signal from 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

4.11.2.4   Settings

Table 76:   *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	%	0.1	1.0	Power setting for stage 1 in % of calculated power base value
Angle1	-180.0 - 180.0	Deg	0.1	0.0	Characteristic angle for stage 1
TripDelay1	0.010 - 6000.000	s	0.001	1.000	Trip delay for stage 1
OpMode2	Off OverPower	-	-	OverPower	Operation mode 2
Power2	0.0 - 500.0	%	0.1	1.0	Power setting for stage 2 in % of calculated power base value
Angle2	-180.0 - 180.0	Deg	0.1	0.0	Characteristic angle for stage 2
TripDelay2	0.010 - 6000.000	s	0.001	1.000	Trip delay for stage 2

Table 77:   *GOPPDOP Group settings (advanced)*

Name	Values (Range)	Unit	Step	Default	Description
k	0.00 - 0.99	-	0.01	0.00	Low pass filter coefficient for power measurement, U and I

Table 78:   *GOPPDOP Non group settings (basic)*

Name	Values (Range)	Unit	Step	Default	Description
GlobalBaseSel	1 - 6	-	1	1	Global Base Selector
Mode	L1, L2, L3 Arone Pos Seq L1L2 L2L3 L3L1 L1 L2 L3	-	-	Pos Seq	Mode of measurement for current and voltage

4.11.2.5   Monitored data

Table 79:   *GOPPDOP Monitored data*
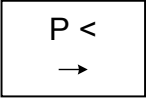
Name	Type	Values (Range)	Unit	Description
P	REAL	-	MW	Active Power
PPERCENT	REAL	-	%	Active power in % of calculated power base value
Q	REAL	-	MVAr	Reactive power
QPERCENT	REAL	-	%	Reactive power in % of calculated power base value

4.11.3   Directional under-power protection GUPPDUP

4.11.3.1   Identification

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

4.11.3.2   Function block

```
           GUPPDUP
—  I3P*                    TRIP  —
—  U3P*                   TRIP1  —
—  BLOCK                  TRIP2  —
                          START  —
                         START1  —
                         START2  —
                              P  —
                       PPERCENT  —
                              Q  —
                       QPERCENT  —
```
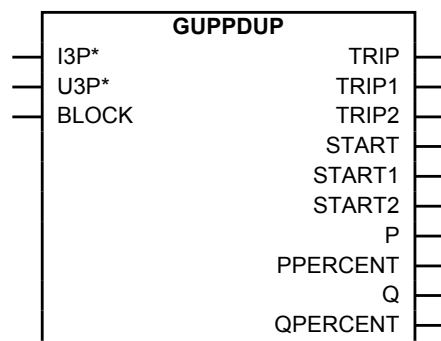
IEC08000507-1-en.vsd

Figure 55:   *GUPPDUP function block*

4.11.3.3   Signals

Table 80:   *GUPPDUP Input signals*

Name	Type	Default	Description
I3P	GROUP SIGNAL	-	Three phase group signal for current inputs
U3P	GROUP SIGNAL	-	Three phase group signal for voltage inputs
BLOCK	BOOLEAN	0	Block of function

Table 81:   *GUPPDUP Output signals*

Name	Type	Description
TRIP	BOOLEAN	General trip signal
TRIP1	BOOLEAN	Trip signal from stage 1
TRIP2	BOOLEAN	Trip signal from stage 2
START	BOOLEAN	General start signal
START1	BOOLEAN	Start signal from stage 1
START2	BOOLEAN	Start signal from 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

4.11.3.4 Settings

Table 82: *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	%	0.1	1.0	Power setting for stage 1 in % of calculated power base value
Angle1	-180.0 - 180.0	Deg	0.1	0.0	Characteristic angle for stage 1
TripDelay1	0.010 - 6000.000	s	0.001	1.000	Trip delay for stage 1
OpMode2	Off UnderPower	-	-	UnderPower	Operation mode 2
Power2	0.0 - 500.0	%	0.1	1.0	Power setting for stage 2 in % of calculated power base value
Angle2	-180.0 - 180.0	Deg	0.1	0.0	Characteristic angle for stage 2
TripDelay2	0.010 - 6000.000	s	0.001	1.000	Trip delay for stage 2

Table 83: *GUPPDUP Group settings (advanced)*

Name	Values (Range)	Unit	Step	Default	Description
k	0.00 - 0.99	-	0.01	0.00	Low pass filter coefficient for power measurement, U and I

Table 84: *GUPPDUP Non group settings (basic)*

Name	Values (Range)	Unit	Step	Default	Description
GlobalBaseSel	1 - 6	-	1	1	Global Base Selector
Mode	L1, L2, L3 Arone Pos Seq L1L2 L2L3 L3L1 L1 L2 L3	-	-	Pos Seq	Mode of measurement for current and voltage

4.11.3.5   Monitored data

Table 85:   *GUPPDUP Monitored data*

Name	Type	Values (Range)	Unit	Description
P	REAL	-	MW	Active Power
PPERCENT	REAL	-	%	Active power in % of calculated power base value
Q	REAL	-	MVAr	Reactive power
QPERCENT	REAL	-	%	Reactive power in % of calculated power base value

4.11.4   Operation principle

A simplified scheme showing the principle of the power protection function is shown in figure 56. The function has two stages with individual settings.

IEC09000018-1-en.vsd
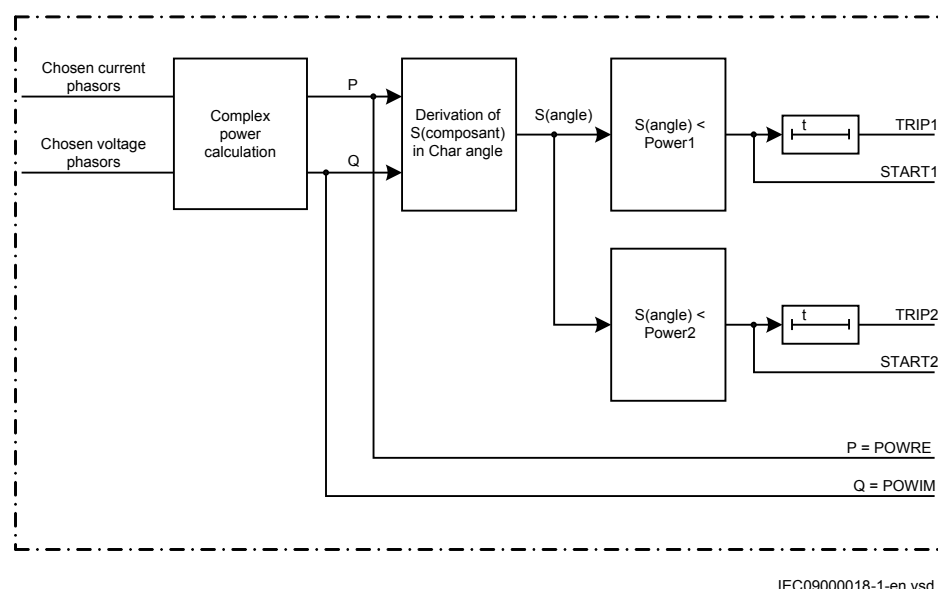
Figure 56:   *Simplified logic diagram of the power protection function*

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 86.

Table 86:   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 18)
Arone	$$\bar{S} = \bar{U}_{L1L2} \cdot \bar{I}_{L1}{}^* - \bar{U}_{L2L3} \cdot \bar{I}_{L3}{}^*$$ (Equation 19)
PosSeq	$$\bar{S} = 3 \cdot \bar{U}_{PosSeq} \cdot \bar{I}_{PosSeq}{}^*$$ (Equation 20)
L1L2	$$\bar{S} = \bar{U}_{L1L2} \cdot (\bar{I}_{L1}{}^* - \bar{I}_{L2}{}^*)$$ (Equation 21)
L2L3	$$\bar{S} = \bar{U}_{L2L3} \cdot (\bar{I}_{L2}{}^* - \bar{I}_{L3}{}^*)$$ (Equation 22)
L3L1	$$\bar{S} = \bar{U}_{L3L1} \cdot (\bar{I}_{L3}{}^* - \bar{I}_{L1}{}^*)$$ (Equation 23)
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 under-power protection, a start signal START1(2) is activated if the calculated power component is smaller than the pick up value. For directional over-power 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 hysteresis in the power function. The absolute hysteresis for stage 1(2) is 0.5 pu for Power1(2) ≥ 1.0 pu, else the hysteresis is 0.5 Power1(2).

If the measured power drops under the (Power1(2) - hysteresis) value, the over-power function will reset after 0.06 seconds. If the measured power comes over the (Power1(2) + hysteresis) value, the under-power function will reset after 0.06 seconds. The reset means that the start signal will drop out and that the timer of the stage will reset.

4.11.4.1 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.

4.11.5 Technical data

Table 87:   *GOPPDOP/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	(0.010 - 6000.000) s	± 0.5% ± 10 ms

4.12 Negative sequence based overcurrent function DNSPTOC

4.12.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Negative sequence based overcurrent function	DNSPTOC	*I2>*	46

4.12.2 Functionality

Negative sequence based overcurrent function (DNSPTOC) is typically used as sensitive earth-fault protection of power lines, where incorrect zero sequence polarization may result from mutual induction between two or more parallel lines.

Additionally, it is used in applications on underground cables, where zero sequence impedance depends on the fault current return paths, but the cable negative sequence impedance is practically constant.

DNSPTOC protects against all unbalance faults including phase-to-phase faults. Always remember to set the minimum pickup current of the function above natural system unbalance level.

4.12.3 Function block

```
        DNSPTOC
  I3P*              TRIP
  U3P*             TROC1
  BLOCK            TROC2
  BLKOC1           START
  ENMLTOC1         STOC1
  BLKOC2           STOC2
  ENMLTOC2        DIROC1
                  DIROC2
                 CURRENT
                 VOLTAGE
                 UIANGLE
```

IEC09000125-1-en.vsd
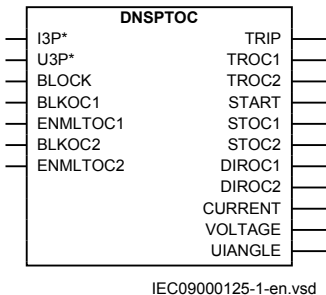
Figure 57:   DNSPTOC function block

4.12.4 Signals

Table 88: *DNSPTOC Input signals*

Name	Type	Default	Description
I3P	GROUP SIGNAL	-	Three phase group signal for current inputs
U3P	GROUP SIGNAL	-	Three phase group signal for voltage inputs
BLOCK	BOOLEAN	0	Block of function
BLKOC1	BOOLEAN	0	Block of over current function OC1
ENMLTOC1	BOOLEAN	0	Enable signal for current multiplier - step1 (OC1)
BLKOC2	BOOLEAN	0	Block of over current function OC2
ENMLTOC2	BOOLEAN	0	Enable signal for current multiplier - step 2 (OC2)

Table 89: *DNSPTOC Output signals*

Name	Type	Description
TRIP	BOOLEAN	General trip signal
TROC1	BOOLEAN	Trip signal from step 1 (OC1)
TROC2	BOOLEAN	Trip signal from step 2 (OC2)
START	BOOLEAN	General start signal
STOC1	BOOLEAN	Start signal from step 1 (OC1)
STOC2	BOOLEAN	Start signal from step 2 (OC2)
DIROC1	INTEGER	Directional mode of step 1 (non-directional, forward, reverse)
DIROC2	INTEGER	Directional mode of step 2 (non-directional, forward, reverse)
CURRENT	REAL	Measured current value
VOLTAGE	REAL	Measured voltage value
UIANGLE	REAL	Angle between voltage and current

4.12.5 Settings

Table 90: *DNSPTOC Group settings (basic)*

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
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	Voltage level in % of Ubase below which ActLowVolt control takes over
Operation_OC1	Off On	-	-	Off	Operation Off/On for step 1 (OC1)
Table continues on next page					

Name	Values (Range)	Unit	Step	Default	Description
StartCurr_OC1	2.0 - 5000.0	%IB	1.0	120.0	Operate current level in % of IBase for step 1 (OC1)
CurrMult_OC1	1.0 - 10.0	-	0.1	2.0	Multiplier for current operate level for step 1 (OC1)
tDef_OC1	0.00 - 6000.00	s	0.01	0.50	Independent (definite) time delay for step 1 (OC1)
DirMode_OC1	Non-directional Forward Reverse	-	-	Non-directional	Directional mode of step 1 (non-directional, forward, reverse)
DirPrinc_OC1	I&U IcosPhi&U	-	-	I&U	Measuring on I & U or IcosPhi & U for step 1 (OC1)
ActLowVolt1_VM	Non-directional Block Memory	-	-	Non-directional	Low votlage level action for step 1 (Non-directional, Block, Memory)
Operation_OC2	Off On	-	-	Off	Operation Off/On for step 2 (OC2)
StartCurr_OC2	2.0 - 5000.0	%IB	1.0	120.0	Operate current level in % of Ibase for step 2 (OC2)
CurrMult_OC2	1.0 - 10.0	-	0.1	2.0	Multiplier for current operate level for step 2 (OC2)
tDef_OC2	0.00 - 6000.00	s	0.01	0.50	Independent (definite) time delay for step 2 (OC2)
DirMode_OC2	Non-directional Forward Reverse	-	-	Non-directional	Directional mode of step 2 (non-directional, forward, reverse)
DirPrinc_OC2	I&U IcosPhi&U	-	-	I&U	Measuring on I & U or IcosPhi & U for step 2 (OC2)
ActLowVolt2_VM	Non-directional Block Memory	-	-	Non-directional	Low votlage level action for step 2 (Non-directional, Block, Memory)

Table 91:   *DNSPTOC Non group settings (basic)*

Name	Values (Range)	Unit	Step	Default	Description
GlobalBaseSel	1 - 6	-	1	1	Global Base Selector

4.12.6   Monitored data

Table 92:   *DNSPTOC Monitored data*

Name	Type	Values (Range)	Unit	Description
CURRENT	REAL	-	A	Measured current value
VOLTAGE	REAL	-	kV	Measured voltage value
UIANGLE	REAL	-	deg	Angle between voltage and current

4.12.7 Operation principle

Negative sequence based overcurrent function (DNSPTOC) has two settable current levels, setting parameters *StartCurr_OC1* and *StartCurr_OC2*. Both features have definite time characteristics with settings *tDef_OC1* and *tDef_OC2* respectively. It is possible to change the direction of these steps to *forward*, *reverse* or *non-directional* by setting parameters *DirMode_OC1* and *DirMode_OC2*. At too low polarizing voltage the overcurrent feature can be either blocked, non-directional or use the voltage memory. This is controlled by settings *ActLowVolt1_VM* and *ActLowVolt2_VM*.

4.12.8 Technical data

Table 93:   DNSPTOC Technical data

Function	Range or value	Accuracy
Operate current	(2.0 - 5000.0) % of IBase	± 1.0% of I_r at I <I_r ± 1.0% of I at I > I_r
Reset ratio	> 95 %	-
Low voltage level for memory	(0.0 - 5.0) % of UBase	< ± 0,5% of U_r
Relay characteristic angle	(-180 - 180) degrees	± 2,0 degrees
Relay operate angle	(1 - 90) degrees	± 2,0 degrees
Timers	(0.00 - 6000.00) s	± 0.5% ± 10 ms
Operate time, nondirectional	25 ms typically at 0 to 2 x I_{set} 15 ms typically at 0 to 10 x I_{set}	-
Reset time, nondirectional	30 ms typically at 2 to 0 x I_{set}	-
Operate time, directional	25 ms typically at 0.5 to 2 x I_{set} 15 ms typically at 0 to 10 x I_{set}	-
Reset time, directional	30 ms typically at 2 to 0 x I_{set}	-
Critical impulse time	10 ms typically at 0 to 2 x I_{set} 2 ms typically at 0 to 10 x I_{set}	-
Impulse margin time	15 ms typically	-
Dynamic overreach	< 10% at t = 300 ms	-

Section 5 Voltage protection

5.1 Two step undervoltage protection UV2PTUV

5.1.1 Identification

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

5.1.2 Functionality

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.

5.1.3 Function block

```
        UV2PTUV
── U3P*        TRIP ──
── BLOCK        TR1 ──
── BLKST1       TR2 ──
── BLKST2     START ──
                ST1 ──
              ST1L1 ──
              ST1L2 ──
              ST1L3 ──
                ST2 ──
```
IEC09000285_1_en.vsd
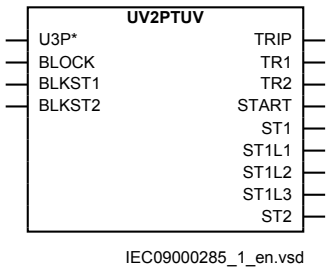
Figure 58: UV2PTUV function block

5.1.4 Signals

Table 94: UV2PTUV Input signals

Name	Type	Default	Description
U3P	GROUP SIGNAL	-	Three phase group signal for voltage inputs
BLOCK	BOOLEAN	0	Block of function
BLKST1	BOOLEAN	0	Block of step 1
BLKST2	BOOLEAN	0	Block of step 2

Table 95: UV2PTUV Output signals

Name	Type	Description
TRIP	BOOLEAN	General trip signal
TR1	BOOLEAN	Trip signal from step 1
TR2	BOOLEAN	Trip signal from step 2
START	BOOLEAN	General start signal
ST1	BOOLEAN	Start signal from step 1
ST1L1	BOOLEAN	Start signal from step 1 phase L1
ST1L2	BOOLEAN	Start signal from step 1 phase L2
ST1L3	BOOLEAN	Start signal from step 1 phase L3
ST2	BOOLEAN	Start signal from step 2

5.1.5 Settings

Table 96: UV2PTUV Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
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 to operate (1 of 3, 2 of 3, 3 of 3) from step 1
U1<	1 - 100	%UB	1	70	Voltage start value (DT & IDMT) in % of UBase for step 1
t1	0.00 - 6000.00	s	0.01	5.00	Definite 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
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 to operate (1 of 3, 2 of 3, 3 of 3) from step 2
U2<	1 - 100	%UB	1	50	Voltage start value (DT & IDMT) in % of UBase for step 2
t2	0.000 - 60.000	s	0.001	5.000	Definie time delay of step 2

Table 97:   *UV2PTUV Non group settings (basic)*

Name	Values (Range)	Unit	Step	Default	Description
GlobalBaseSel	1 - 6	-	1	1	Selection of one of the Global Base Value groups
ConnType	PhN DFT PhN RMS PhPh DFT PhPh RMS	-	-	PhN DFT	Group selector for connection type

5.1.6 Monitored data

Table 98:   *UV2PTUV Monitored data*

Name	Type	Values (Range)	Unit	Description
UL1	REAL	-	kV	Voltage in phase L1
UL2	REAL	-	kV	Voltage in phase L2
UL3	REAL	-	kV	Voltage in phase L3

5.1.7 Operation principle

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:

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

<div align="right">(Equation 28)</div>

and operation for phase-to-phase voltage under:

$$U < (\%) \cdot UBase(kV)$$

<div align="right">(Equation 29)</div>

5.1.7.1 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.

5.1.7.2 Time delay

The time delay for step 1 can be either definite time delay (DT) or inverse time delay (IDMT). Step 2 is always definite time delay (DT). For the inverse time delay two different modes are available; inverse curve A and inverse curve B.

The type A curve is described as:

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

<div align="right">(Equation 30)</div>

The type B curve is described as:

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

<div align="right">(Equation 31)</div>

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 is set to compensate for this phenomenon.

The lowest voltage is always used for the inverse time delay integration. The details of the different inverse time characteristics are shown in section 17.3 "Inverse time 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 defined reset 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 return back into 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 59 and figure 60.
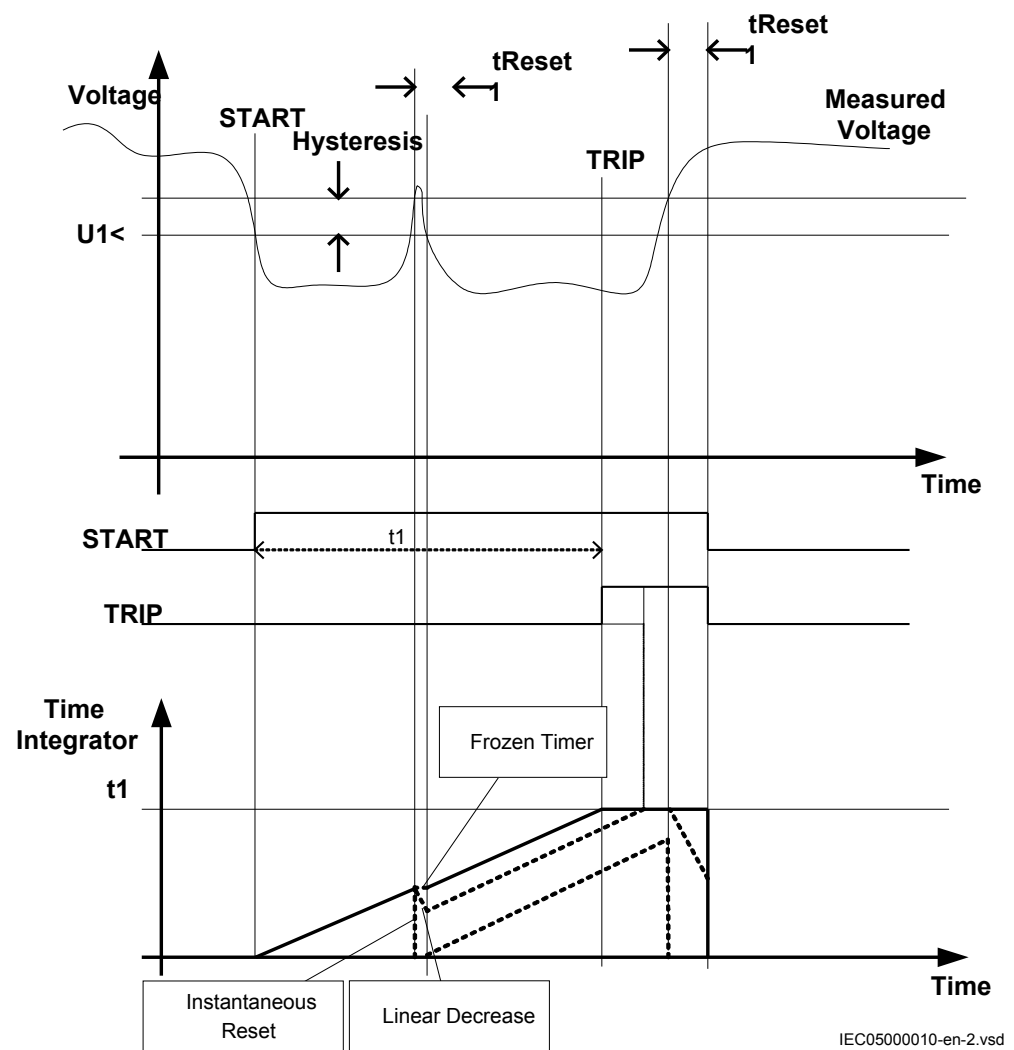
Figure 59:   *Voltage profile not causing a reset of the start signal for step 1, and definite time delay*
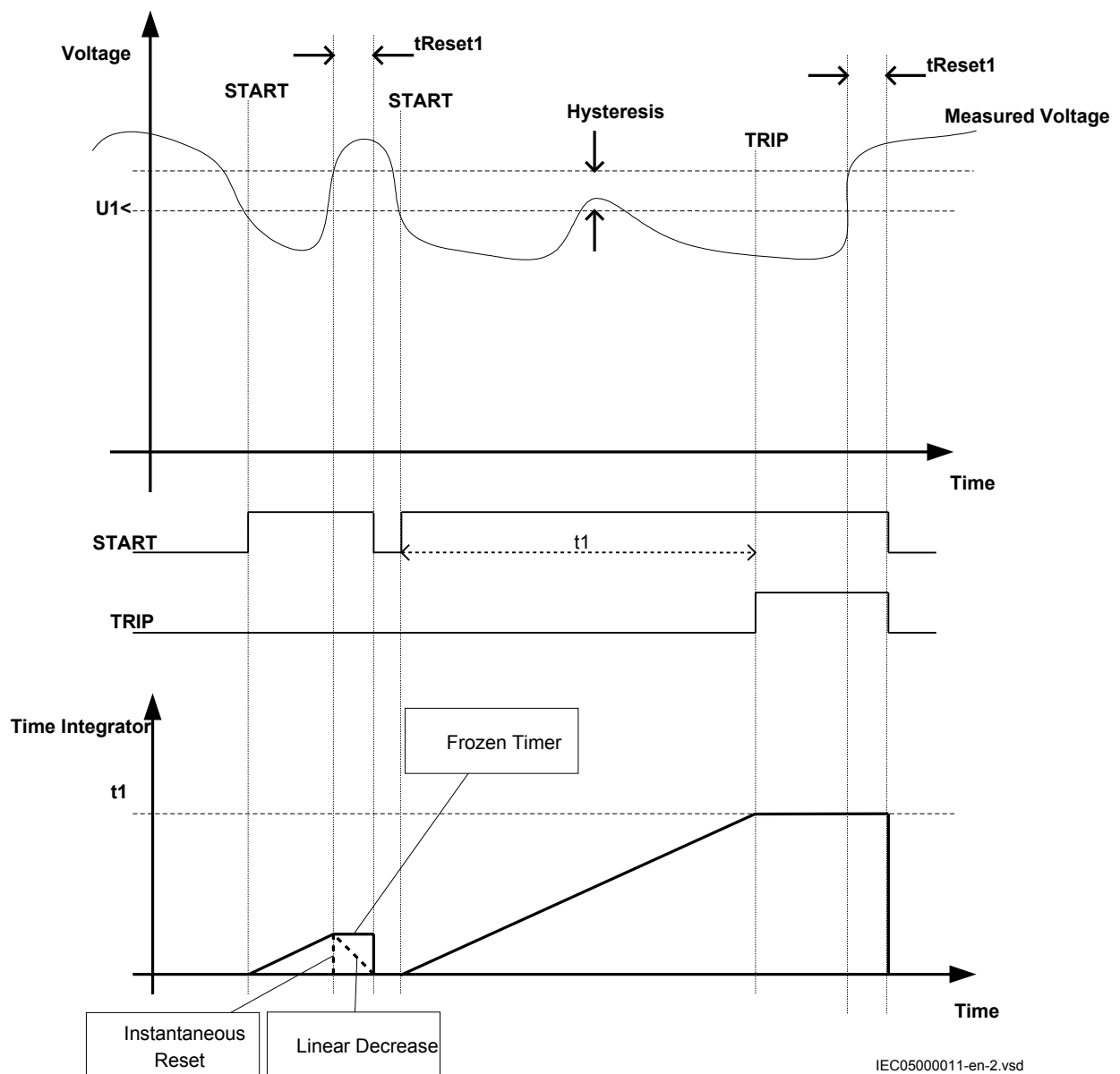
Figure 60: *Voltage profile causing a reset of the start signal for step 1, and definite time delay*

5.1.7.3 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
BLKST1:	blocks all start and trip outputs related to step 1
BLKST2:	blocks all start and trip outputs related to step 2

5.1.7.4   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 61.
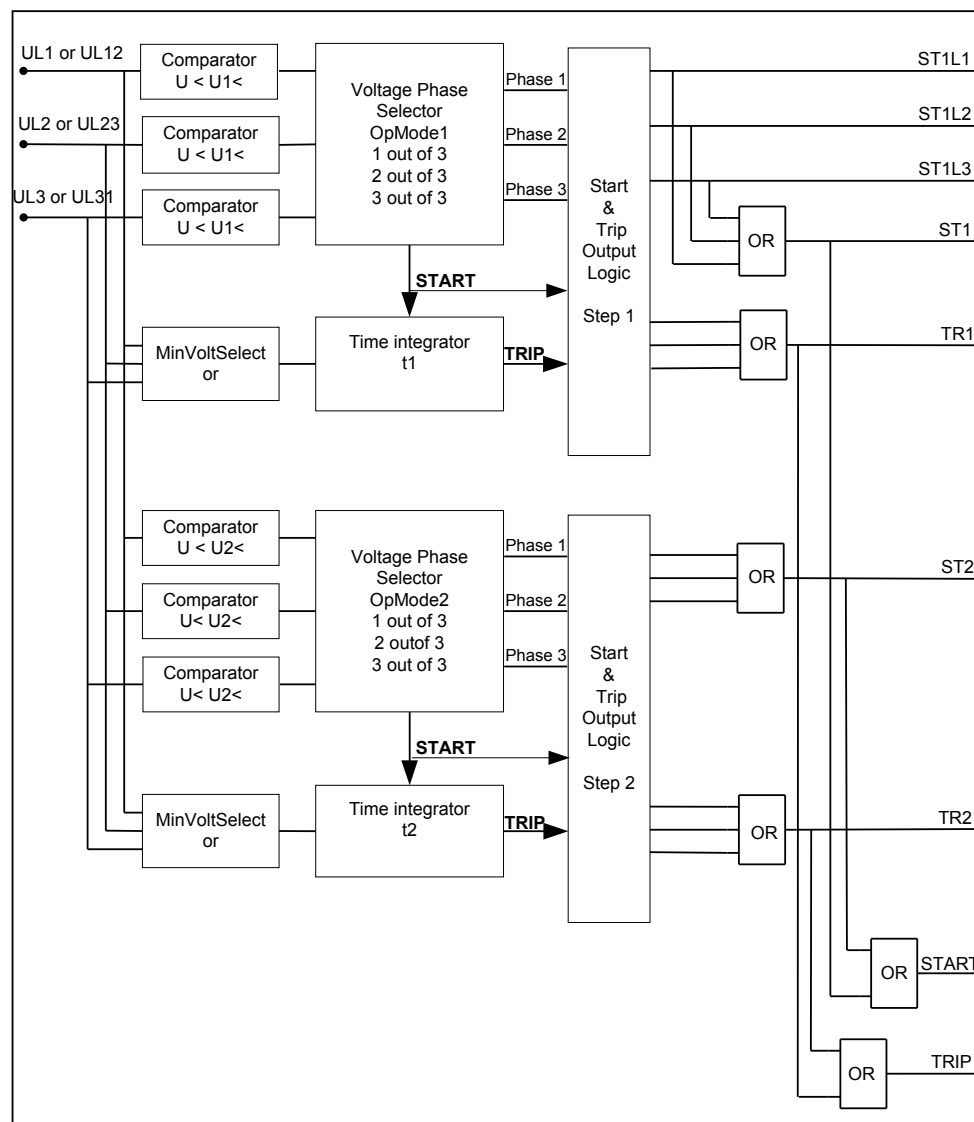
IEC08000016_1_en.vsd

Figure 61:   *Schematic design of Two step undervoltage protection (UV2PTUV)*

5.1.8　　　　Technical data

Table 99:　　　　*UV2PTUV Technical data*

Function	Range or value	Accuracy
Operate voltage, low and high step	(1–100)% of UBase	± 0.5% of U_r
Reset ratio	<105%	-
Inverse time characteristics for low and high step, see table [487]	-	See table [487]
Definite time delay, step 1	(0.00 - 6000.00) s	± 0.5% ± 10 ms
Definite time delays, step 2	(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	20 ms typically at 2 to 0.5 x U_{set}	-
Reset time, start function	25 ms typically at 0.5 to 2 x U_{set}	-
Critical impulse time	10 ms typically at 2 to 0 x U_{set}	-
Impulse margin time	15 ms typically	-

5.2　　　　Two step overvoltage protection OV2PTOV

5.2.1　　　　Identification

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

5.2.2　　　　Functionality

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.

Two step overvoltage protection (OV2PTOV) can be used as open line end detector, normally then combined with directional reactive over-power function or as system voltage supervision, normally then giving alarm only or switching in reactors or switch out capacitor banks to control the voltage.

OV2PTOV has two voltage steps, where step 1 is setable as inverse or definite time delayed. Step 2 is always definite time delayed.

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

5.2.3　　Function block

```
          OV2PTOV
──  U3P*            TRIP  ──
──  BLOCK           TR1   ──
──  BLKST1          TR2   ──
──  BLKST2         START  ──
                    ST1   ──
                   ST1L1  ──
                   ST1L2  ──
                   ST1L3  ──
                    ST2   ──
```

IEC09000278_1_en.vsd
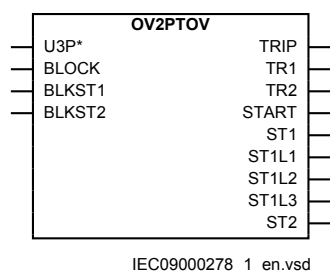
Figure 62:　　*OV2PTOV function block*

5.2.4　　Signals

Table 100:　　*OV2PTOV Input signals*

Name	Type	Default	Description
U3P	GROUP SIGNAL	-	Three phase group signal for voltage inputs
BLOCK	BOOLEAN	0	Block of function
BLKST1	BOOLEAN	0	Block of step 1
BLKST2	BOOLEAN	0	Block of step 2

Table 101:　　*OV2PTOV Output signals*

Name	Type	Description
TRIP	BOOLEAN	General trip signal
TR1	BOOLEAN	Trip signal from step 1
TR2	BOOLEAN	Trip signal from step 2
START	BOOLEAN	General start signal
ST1	BOOLEAN	Start signal from step 1
ST1L1	BOOLEAN	Start signal from step 1 phase L1
ST1L2	BOOLEAN	Start signal from step 1 phase L2
ST1L3	BOOLEAN	Start signal from step 1 phase L3
ST2	BOOLEAN	Start signal from step 2

5.2.5 Settings

Table 102: *OV2PTOV Group settings (basic)*

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
Characterist1	Definite time Inverse curve A Inverse curve B Inverse curve C	-	-	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 to operate (1 of 3, 2 of 3, 3 of 3) from step 1
U1>	1 - 200	%UB	1	120	Voltage start value (DT & IDMT) in % of UBase for step 1
t1	0.00 - 6000.00	s	0.01	5.00	Definite 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
OpMode2	1 out of 3 2 out of 3 3 out of 3	-	-	1 out of 3	Number of phases required to operate (1 of 3, 2 of 3, 3 of 3) from step 2
U2>	1 - 200	%UB	1	150	Voltage start value (DT & IDMT) in % of UBase for step 2
t2	0.000 - 60.000	s	0.001	5.000	Definite time delay of step 2

Table 103: *OV2PTOV Non group settings (basic)*

Name	Values (Range)	Unit	Step	Default	Description
GlobalBaseSel	1 - 6	-	1	1	Selection of one of the Global Base Value groups
ConnType	PhN DFT PhN RMS PhPh DFT PhPh RMS	-	-	PhN DFT	Group selector for connection type

5.2.6 Monitored data

Table 104: *OV2PTOV Monitored data*

Name	Type	Values (Range)	Unit	Description
UL1	REAL	-	kV	Voltage in phase L1
UL2	REAL	-	kV	Voltage in phase L2
UL3	REAL	-	kV	Voltage in phase L3

5.2.7 Operation principle

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 setable for step 1 and can be either definite or inverse time delayed. Step 2 is always definite time delayed.

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* in PST or local HMI.

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 global base voltage *UBase*. This means operation for phase to earth voltage over:

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

(Equation 32)

and operation for phase for phase voltage over:

$$U > (\%) \cdot UBase(kV)$$

(Equation 33)

5.2.7.1 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.

5.2.7.2 Time delay

The time delay for step 1 can be either definite time delay (DT) or inverse time delay (IDMT). Step 2 is always definite time delayed (DT). For the inverse time

delay three different modes are available; inverse curve A, inverse curve B and inverse curve C.

The type A curve is described as:

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

<div align="right">(Equation 34)</div>

The type B curve is described as:

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

<div align="right">(Equation 35)</div>

The type C curve is described as:

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

<div align="right">(Equation 36)</div>

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 is set to compensate for this phenomenon.

The highest phase (or phase-to-phase) voltage is always used for the inverse time delay integration, see figure 63. The details of the different inverse time characteristics are shown in section 17.3 "Inverse time characteristics"
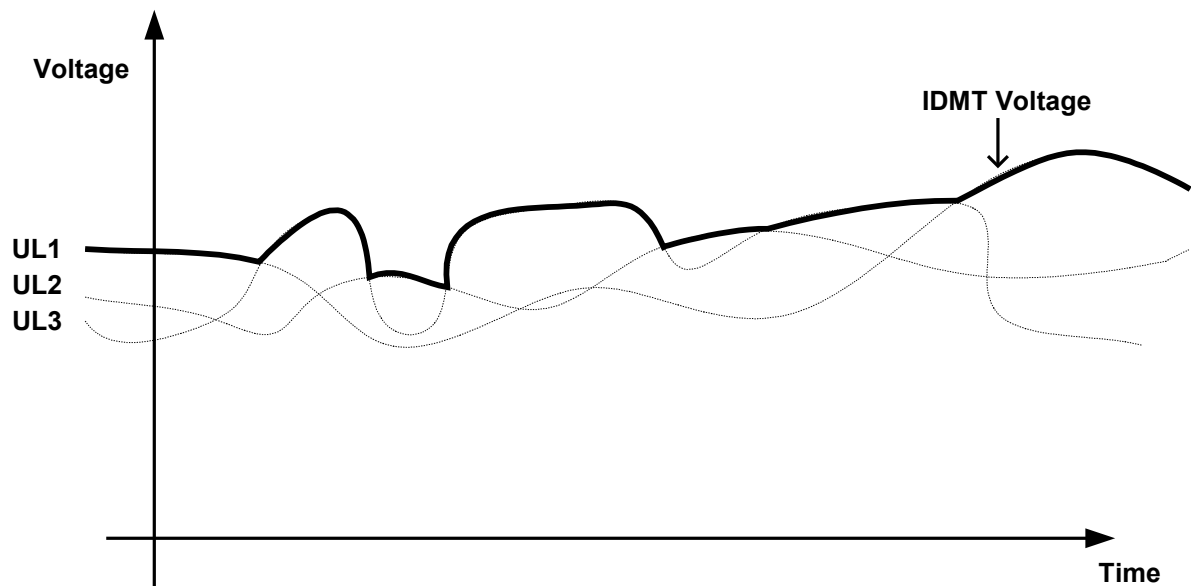
en05000016.vsd

Figure 63:   *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 defined reset 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. It is also remarkable 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.

5.2.7.3   Blocking

It is possible to block two step overvoltage protection (OV2PTOV) partially or completely, by binary input signals where:

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

5.2.7.4   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 64.

IEC08000012_1_en.vsd
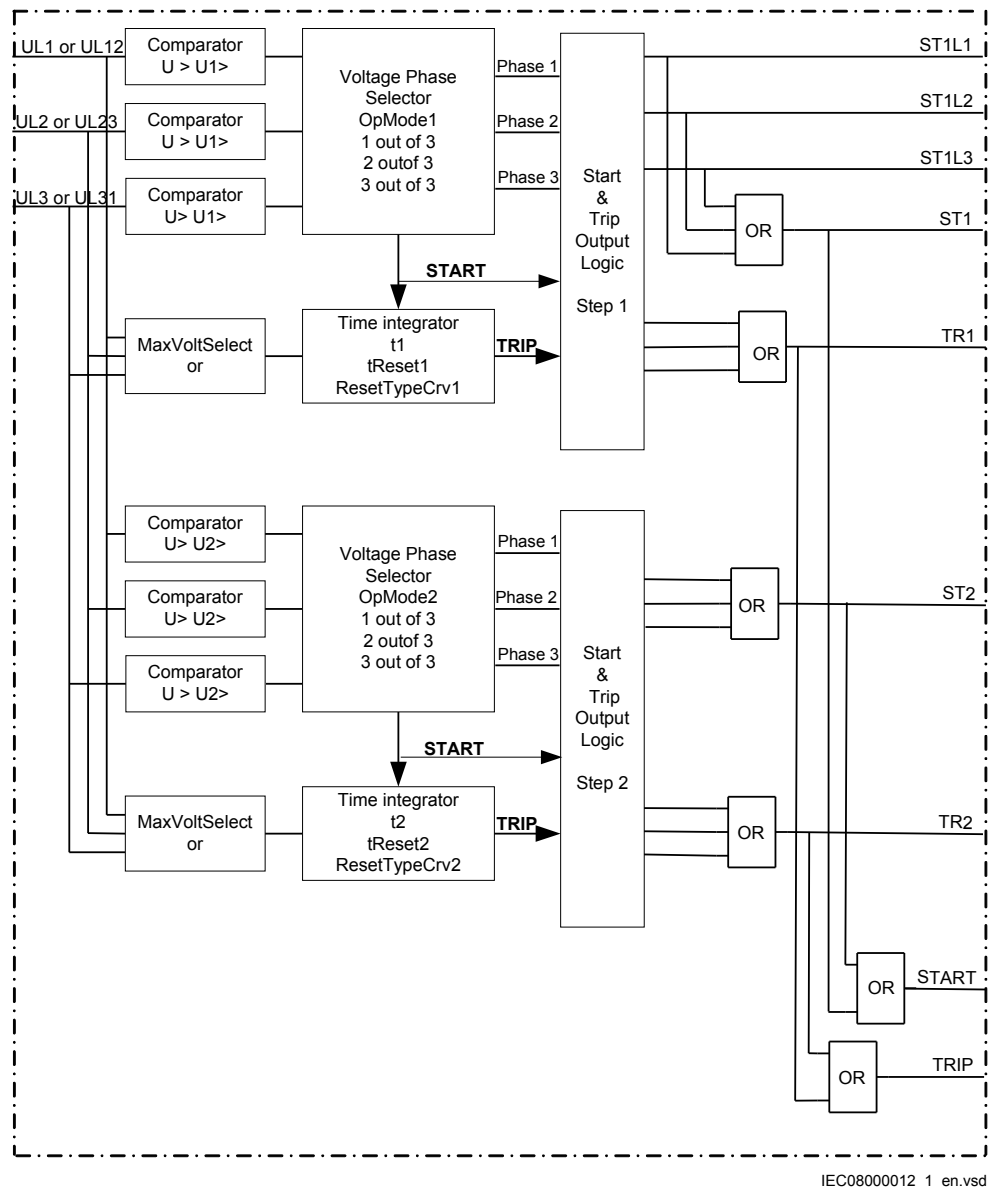
Figure 64:   Schematic design of Two step overvoltage protection (OV2PTOV)
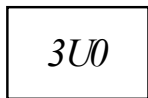
5.2.8 Technical data

Table 105:   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
Reset ratio	>95%	-
Inverse time characteristics for low and high step, see table 488	-	See table 488
Definite time delay, step 1	(0.00 - 6000.00) s	± 0.5% ± 10 ms
Definite time delays, step 2	(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	20 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	-

5.3 Two step residual overvoltage protection ROV2PTOV

5.3.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Two step residual overvoltage protection	ROV2PTOV	*3U0*	59N

5.3.2 Functionality

Residual voltages may occur in the power system during earth-faults.

Two step residual overvoltage protection (ROV2PTOV) calculates the residual voltage from the three-phase voltage input transformers or from a single-phase voltage input transformer fed from an open delta or neutral point voltage transformer.

ROV2PTOV has two voltage steps, where step 1 is setable as inverse or definite time delayed. Step 2 is always definite time delayed.

5.3.3 Function block


```
         ROV2PTOV
   U3P*              TRIP
   BLOCK             TR1
   BLKST1            TR2
   BLKST2          START
                     ST1
                     ST2
      IEC09000273_1_en.vsd
```
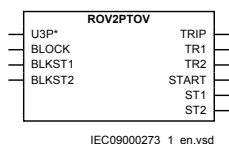
Figure 65:   ROV2PTOV function block

5.3.4 Signals

Table 106:   ROV2PTOV Input signals

Name	Type	Default	Description
U3P	GROUP SIGNAL	-	Three phase group signal for voltage inputs
BLOCK	BOOLEAN	0	Block of function
BLKST1	BOOLEAN	0	Block of step 1
BLKST2	BOOLEAN	0	Block of step 2

Table 107:   ROV2PTOV Output signals

Name	Type	Description
TRIP	BOOLEAN	General trip signal
TR1	BOOLEAN	Trip signal from step 1
TR2	BOOLEAN	Trip signal from step 2
START	BOOLEAN	General start signal
ST1	BOOLEAN	Start signal from step 1
ST2	BOOLEAN	Start signal from step 2

5.3.5 Settings

Table 108: *ROV2PTOV Group settings (basic)*

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
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 start value (DT & IDMT) in % of UBase for step 1
t1	0.00 - 6000.00	s	0.01	5.00	Definite 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
U2>	1 - 100	%UB	1	45	Voltage start value (DT & IDMT) in % of UBase for step 2
t2	0.000 - 60.000	s	0.001	5.000	Definite time delay of step 2

Table 109: *ROV2PTOV Non group settings (basic)*

Name	Values (Range)	Unit	Step	Default	Description
GlobalBaseSel	1 - 6	-	1	1	Selection of one of the Global Base Value groups

5.3.6 Monitored data

Table 110: *ROV2PTOV Monitored data*

Name	Type	Values (Range)	Unit	Description
ULevel	REAL	-	kV	Magnitude of measured voltage

5.3.7 Operation principle

Two-step residual overvoltage protection (ROV2PTOV) is used to detect high single-phase voltage, such as high residual voltage, also called 3U0. 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 function. 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 setable for step 1 and can be either definite or inverse time delayed. Step 2 is always definite time delayed.

The voltage related settings are made in percent of the global phase-to-phase base voltage divided by √3.

5.3.7.1 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.

5.3.7.2 Time delay

The time delay for step 1 can be either definite time delay (DT) or inverse time delay (IDMT). Step 2 is always definite time delay (DT). For the inverse time delay three different modes are available; inverse curve A, inverse curve B and inverse curve C.

The type A curve is described as:

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

The type B curve is described as:

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

<div align="right">(Equation 37)</div>

The type C curve is described as:

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

<div align="right">(Equation 38)</div>

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 is set to compensate for this phenomenon.

The details of the different inverse time characteristics are shown in section 17.3 "Inverse time 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 defined reset 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. 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 66 and figure 67.
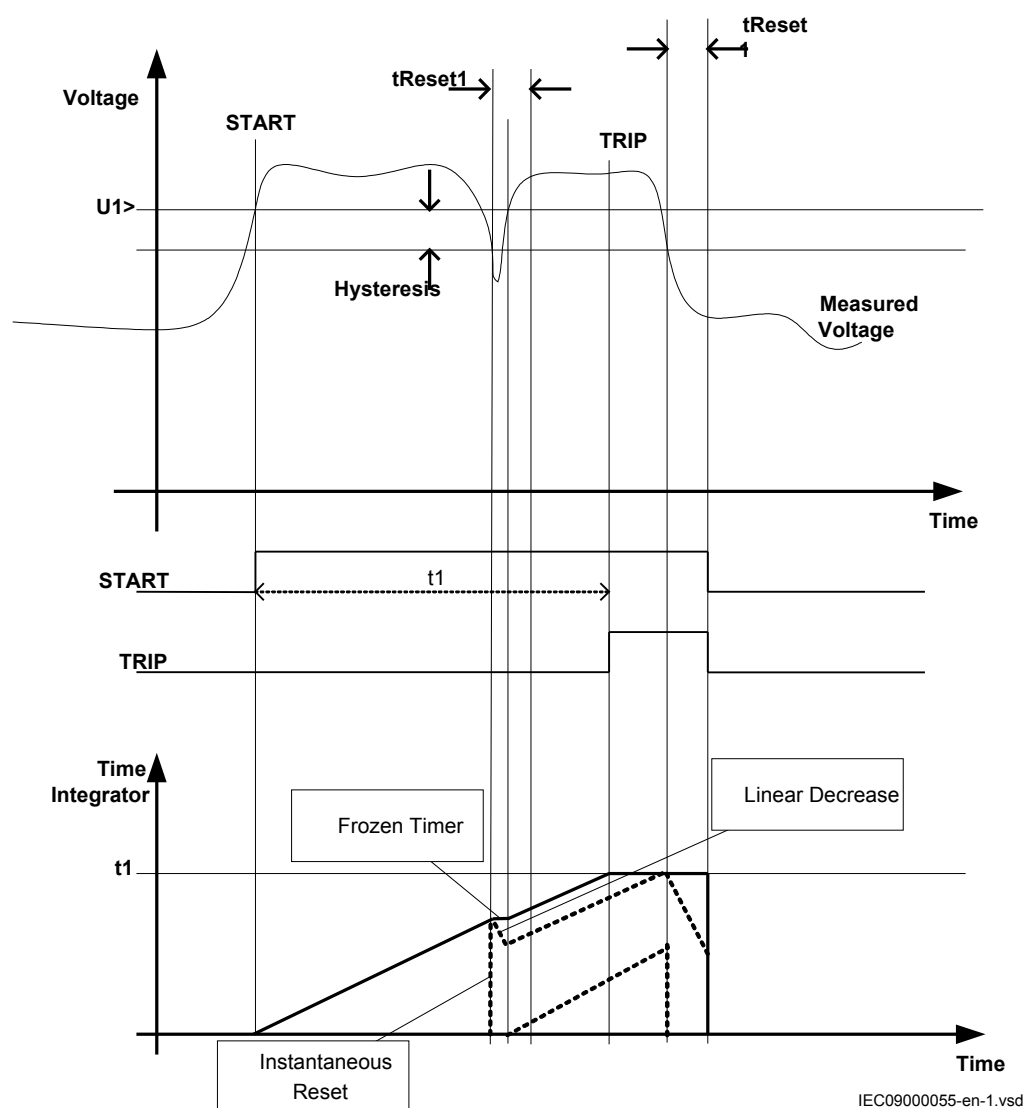
Figure 66: *Voltage profile not causing a reset of the START signal for step 1, and definite time delay*
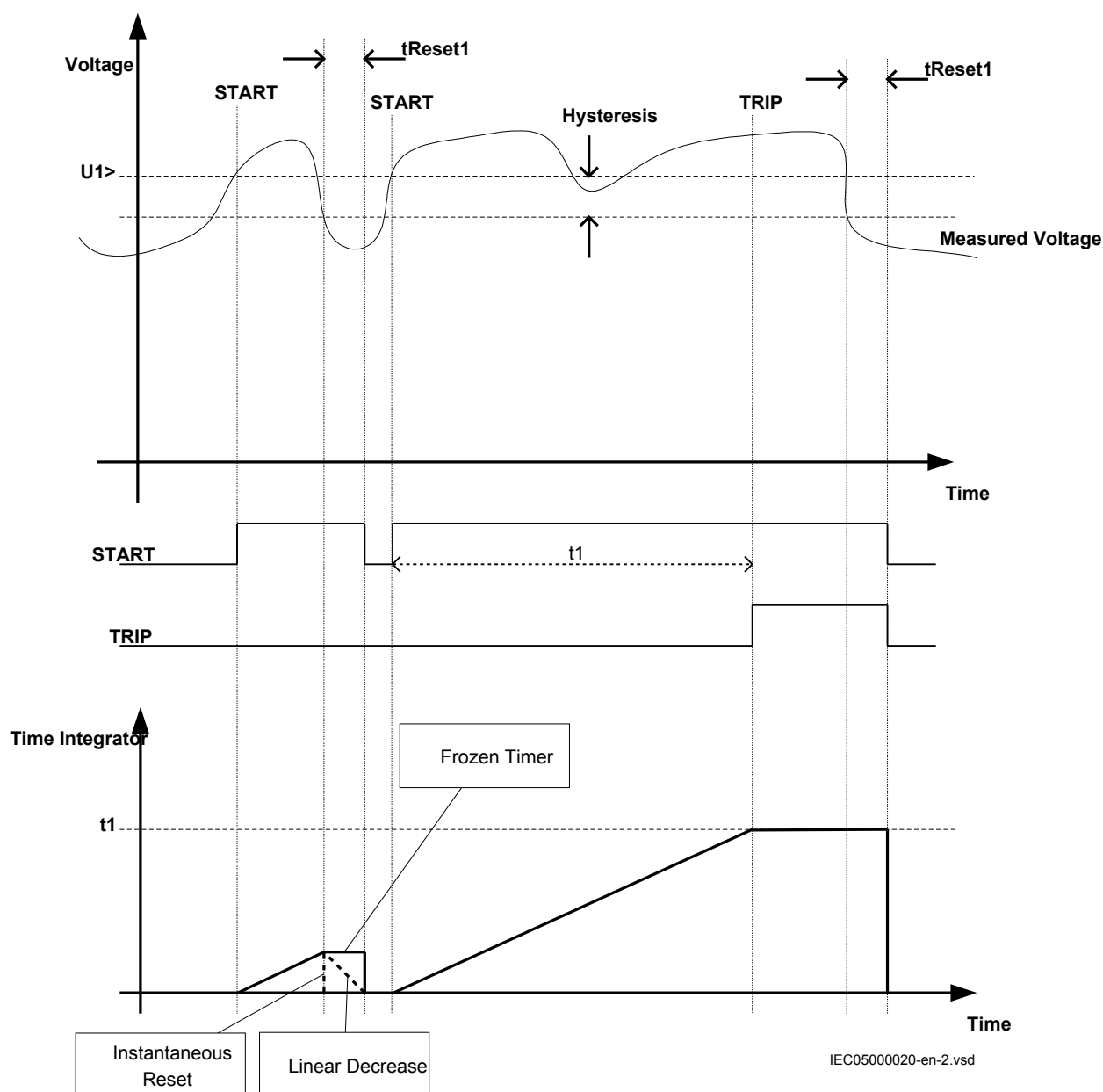
Figure 67: *Voltage profile causing a reset of the START signal for step 1, and definite time delay*

5.3.7.3 Blocking

It is possible to block Two step residual overvoltage protection (ROV2PTOV) partially or completely, by binary input signals where:

BLOCK:	blocks all outputs
BLKST1:	blocks all startand trip outputs related to step 1
BLKST2:	blocks all start and trip inputs related to step 2

5.3.7.4   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 68.

en08000013.vsd
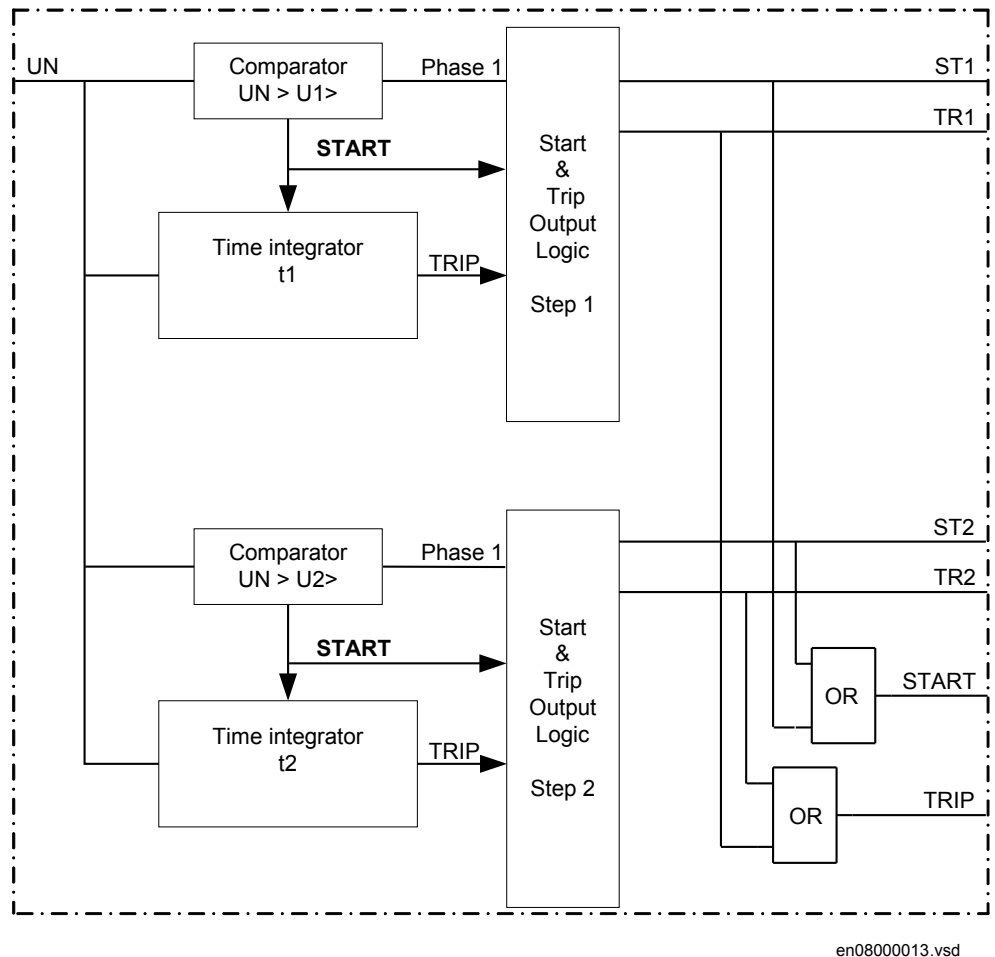
*Figure 68:   Schematic design of Two step residual overvoltage protection
(ROV2PTOV)*

5.3.8 Technical data

Table 111:   ROV2PTOV Technical data

Function	Range or value	Accuracy
Operate voltage, step 1	(1-200)% of Ubase	± 0.5% of U_r at U < U_r ± 0.5% of U at U > U_r
Operate voltage, step 2	(1–100)% of Ubase	± 0.5% of U_r at U < U_r ± % of U at U > U_r
Reset ratio	>95%	-
Inverse time characteristics for low and high step, see table 489	-	See table 489
Definite time setting, step 1	(0.00–6000.00) s	± 0.5% ± 10 ms
Definite time setting, step 2	(0.000–60.000) s	± 0.5% ± 10 ms
Minimum operate time for step 1 inverse characteristic	(0.000-60.000) s	± 0.5% ± 10 ms
Operate time, start function	20 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	-

5.4 Loss of voltage check LOVPTUV

5.4.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Loss of voltage check	LOVPTUV	-	27

5.4.2 Functionality

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.

5.4.3 Function block

IEC09000279_1_en.vsd
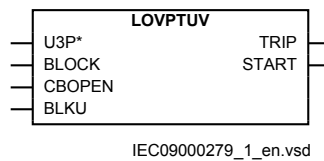
Figure 69:   LOVPTUV function block

5.4.4 Signals

Table 112:   LOVPTUV Input signals

Name	Type	Default	Description
U3P	GROUP SIGNAL	-	Three phase group signal for voltage inputs
BLOCK	BOOLEAN	0	Block of function
CBOPEN	BOOLEAN	0	Circuit breaker open
BLKU	BOOLEAN	0	Block from voltage circuit supervision

Table 113:   LOVPTUV Output signals

Name	Type	Description
TRIP	BOOLEAN	Trip signal
START	BOOLEAN	Start signal

5.4.5 Settings

Table 114:   LOVPTUV Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off/On
UPE	1 - 100	%UB	1	70	Operate voltage in% of base voltage Ubase
tTrip	0.000 - 60.000	s	0.001	7.000	Operate time delay

Table 115:   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

Table 116:   *LOVPTUV Non group settings (basic)*

Name	Values (Range)	Unit	Step	Default	Description
GlobalBaseSel	1 - 6	-	1	1	Selection of one of the Global Base Value groups

5.4.6   Operation principle

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. START is available on output 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 mode and LOVPTUV has been blocked from the HMI test menu (*Blocked=Yes*).

LOSS OF VOLTAGE CHECK FUNCTION
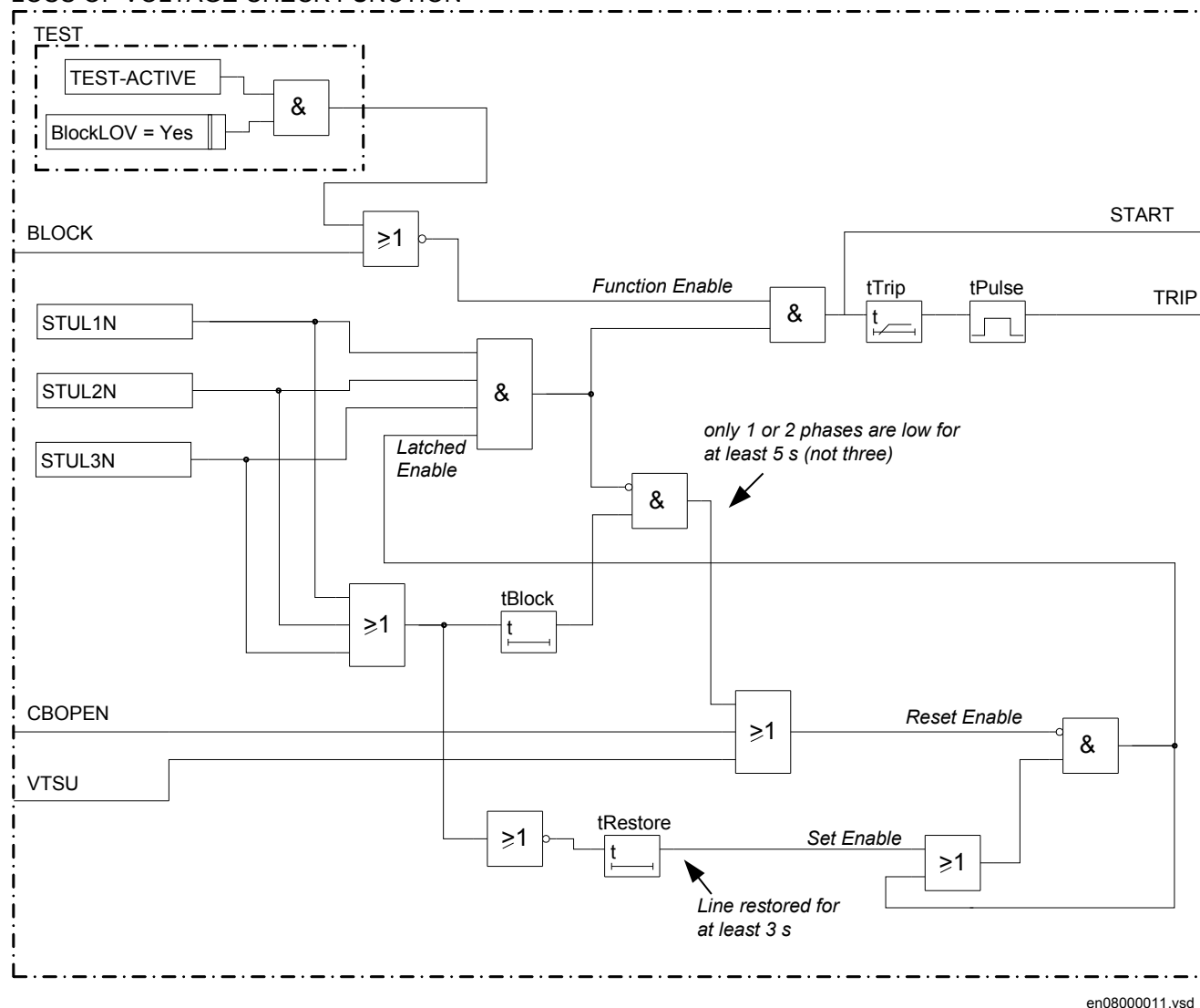
en08000011.vsd

Figure 70: *Simplified diagram of Loss of voltage check (LOVPTUV)*

5.4.7 Technical data

Table 117: *LOVPTUV Technical data*

Function	Range or value	Accuracy
Operate voltage	(0–100)% of Ubase	± 0.5% of U_r
Reset ratio	<105%	-
Pulse timer	(0.050–60.000) s	± 0.5% ± 10 ms
Timers	(0.000–60.000) s	± 0.5% ± 10 ms

Section 6 Frequency protection

6.1 Under frequency protection SAPTUF

6.1.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Under frequency protection	SAPTUF	$f <$	81

6.1.2 Functionality

Under frequency occurs as a result of lack of generation in the network.

Under frequency protection (SAPTUF) is used for load shedding systems, remedial action schemes, gas turbine start-up and so on.

SAPTUF is provided with an under voltage blocking.

6.1.3 Function block

```
        SAPTUF
 U3P*              TRIP
 BLOCK            START
               RESTORE
              BLKDMAGN
```

IEC09000282_1_en.vsd
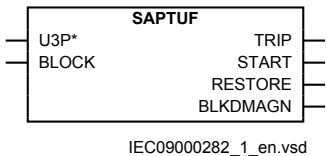
Figure 71: SAPTUF function block

6.1.4 Signals

Table 118: SAPTUF Input signals

Name	Type	Default	Description
U3P	GROUP SIGNAL	-	Three phase group signal for voltage inputs
BLOCK	BOOLEAN	0	Block of function

Table 119:   SAPTUF Output signals

Name	Type	Description
TRIP	BOOLEAN	General trip signal
START	BOOLEAN	General start signal
RESTORE	BOOLEAN	Restore signal for load restoring purposes
BLKDMAGN	BOOLEAN	Measurement blocked due to low voltage amplitude

6.1.5   Settings

Table 120:   SAPTUF Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
StartFrequency	35.00 - 75.00	Hz	0.01	48.80	Frequency set value
tDelay	0.000 - 60.000	s	0.001	0.200	Operate time delay
tRestore	0.000 - 60.000	s	0.001	0.000	Restore time delay
RestoreFreq	45.00 - 65.00	Hz	0.01	49.90	Restore frequency if frequency is above frequency value

6.1.6   Monitored data

Table 121:   SAPTUF Monitored data

Name	Type	Values (Range)	Unit	Description
FREQ	REAL	-	Hz	Measured frequency

6.1.7   Operation principle

Under frequency protection (SAPTUF) function is used to detect low power system frequency. 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 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.

6.1.7.1   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 *MinValFreqMeas* in the SMAI preprocessing function, which is set as a

percentage of a global base voltage parameter, SAPTUF gets blocked, and the output BLKDMAGN is issued. All voltage settings are made in percent of the setting of the global parameter *UBase*.

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

6.1.7.2 Time delay

The time delay for SAPTUF is a settable definite time delay, specified by the setting *tDelay*.

Trip signal issuing requires that the under frequency condition continues for at least the user set time delay. If the START condition, with respect to the measured frequency ceases during the delay time, and is not fulfilled again within a defined reset time, the START output is reset.

On the RESTORE output of SAPTUF a 100 ms pulse is issued, after a time delay corresponding to the setting of *tRestore*, when the measured frequency returns to the level corresponding to the setting *RestoreFreq*.

6.1.7.3 Blocking

It is possible to block Under frequency protection (SAPTUF) completely, by binary input signal:

BLOCK: blocks all outputs

If the measured voltage level decreases below the setting of *MinValFreqMeas* in the preprocessing function, both the START and the TRIP outputs, are blocked.

6.1.7.4 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 systems. When the frequency has returned back to the setting of *RestoreFreq*, the RESTORE output is issued after the time delay *tRestore*. The design of Under frequency protection (SAPTUF) is schematically described in figure 72.

IEC09000034-1.vsd
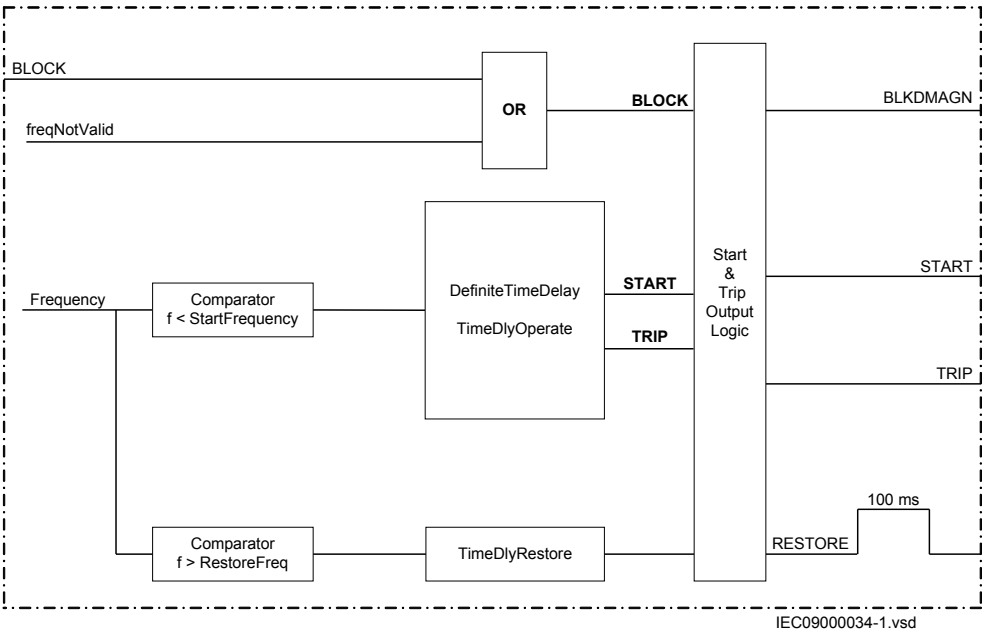
Figure 72:   Schematic design of Under frequency function SAPTUF

6.1.8   Technical data

Table 122:   SAPTUF Technical data

Function	Range or value	Accuracy
Operate value, start function	(35.00-75.00) Hz	± 2.0 mHz
Operate value, restore frequency	(45 - 65) Hz	± 2.0 mHz
Operate time, start function	200 ms typically at f_r to 0.99 x f_{set}	-
Reset time, start function	50 ms typically at 1.01 x f_{set} to f_r	-
Timers	(0.000-60.000)s	± 0.5% + 10 ms

6.2   Over frequency protection SAPTOF

6.2.1   Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Over frequency protection	SAPTOF	$f >$	81

6.2.2   Functionality

Over frequency protection (SAPTOF) function is applicable in all situations, where reliable detection of high fundamental power system frequency is needed.

Over frequency 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 under voltage blocking.

6.2.3   Function block
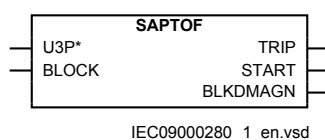
Figure 73:   *SAPTOF function block*

6.2.4   Signals

Table 123:   *SAPTOF Input signals*

Name	Type	Default	Description
U3P	GROUP SIGNAL	-	Three phase group signal for voltage inputs
BLOCK	BOOLEAN	0	Block of function

Table 124:   *SAPTOF Output signals*

Name	Type	Description
TRIP	BOOLEAN	General trip signal
START	BOOLEAN	General start signal
BLKDMAGN	BOOLEAN	Measurement blocked due to low amplitude

6.2.5 Settings

Table 125:   SAPTOF Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
StartFrequency	35.00 - 75.00	Hz	0.01	51.20	Frequency set value
tDelay	0.000 - 60.000	s	0.001	0.200	Operate time delay

6.2.6 Monitored data

Table 126:   SAPTOF Monitored data

Name	Type	Values (Range)	Unit	Description
FREQ	REAL	-	Hz	Measured frequency

6.2.7 Operation principle

Over frequency 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.

6.2.7.1 Measurement principle

The fundamental frequency of the positive sequence voltage is measured continuously, and compared with the set value, *StartFrequency*. Over frequency protection (SAPTOF) is dependent on the voltage magnitude. If the voltage magnitude decreases below the setting *MinValFreqMeas* in the SMAI preprocessing function, which is set as a percentage of a global base voltage parameter *UBase*, SAPTOF is blocked, and the output BLKDMAGN is issued. All voltage settings are made in percent of the global parameter *UBase*. To avoid oscillations of the output START signal, a hysteresis has been included.

6.2.7.2 Time delay

The time delay for SAPTOF is a settable definite time delay, specified by the setting *tDelay*.

TRIP signal issuing requires that the over frequency condition continues for at least the user set time delay. If the START condition, with respect to the measured

frequency ceases during the delay time, and is not fulfilled again within a defined reset time, the START output is reset.

6.2.7.3 Blocking

It is possible to block Over frequency protection (SAPTOF) completely, by binary input signals or by parameter settings, where:

BLOCK: blocks all outputs

If the measured voltage level decreases below the setting of *MinValFreqMeas* in the preprocessing function SMAI, both the START and the TRIP outputs, are blocked.

6.2.7.4 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 design of Over frequency protection (SAPTOF) is schematically described in figure <u>74</u>.
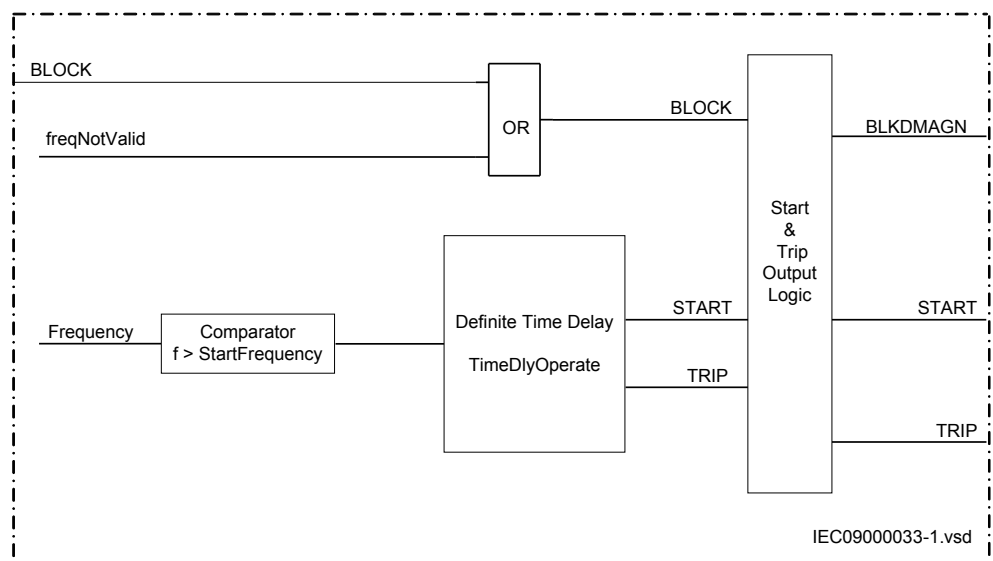
Figure 74:   Schematic design of Over frequency protection (SAPTOF)

6.2.8 Technical data

Table 127: 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	200 ms typically at f_r to 1.01 x f_{set}	-
Reset time, start function	50 ms typically at 1.01 x f_{set} to f_r	-
Timer	(0.000-60.000)s	± 0.5% + 10 ms

6.3 Rate-of-change frequency protection SAPFRC

6.3.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Rate-of-change frequency protection	SAPFRC	$df/dt \gtrless$	81

6.3.2 Functionality

Rate-of-change frequency protection (SAPFRC) function gives an early indication of a main disturbance in the system. It can be used for generation shedding, load shedding, remedial action schemes etc. SAPFRC can discriminate between positive or negative change of frequency.

6.3.3 Function block

IEC09000281_1_en.vsd
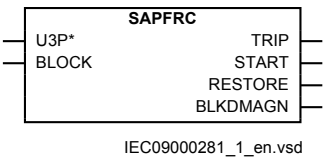
Figure 75: SAPFRC function block

6.3.4 Signals

Table 128: SAPFRC Input signals

Name	Type	Default	Description
U3P	GROUP SIGNAL	-	Three phase group signal for voltage inputs
BLOCK	BOOLEAN	0	Block of function

Table 129: SAPFRC Output signals

Name	Type	Description
TRIP	BOOLEAN	Operate/trip signal for frequency gradient
START	BOOLEAN	Start/pick-up signal for frequency gradient
RESTORE	BOOLEAN	Restore signal for load restoring purposes
BLKDMAGN	BOOLEAN	Blocking indication due to low amplitude

6.3.5 Settings

Table 130: SAPFRC Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
StartFreqGrad	-10.00 - 10.00	Hz/s	0.01	0.50	Frequency gradient start value, the sign defines direction
tTrip	0.000 - 60.000	s	0.001	0.200	Operate time delay in positive / negative frequency gradient mode
RestoreFreq	45.00 - 65.00	Hz	0.01	49.90	Restore is enabled if frequency is above set frequency value
tRestore	0.000 - 60.000	s	0.001	0.000	Restore time delay

6.3.6 Operation principle

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 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. If the frequency recovers, after a frequency decrease, a restore signal is issued.

6.3.6.1 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 *MinValFreqMeas* in the preprocessing function,which is set as a percentage of a global base voltage parameter, SAPFRC is blocked, and the output BLKDMAGN is issued. The sign of the setting *StartFreqGrad*, controls if SAPFRC function 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 function to START and TRIP for frequency increases.

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

6.3.6.2 Time delay

SAPFRC has a settable definite time delay, *tTrip*.

Trip signal issuing requires that SAPFRC 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 defined reset time, the START output is reset after the reset time has elapsed.

The RESTORE output of SAPFRC function 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*.

6.3.6.3　　Design
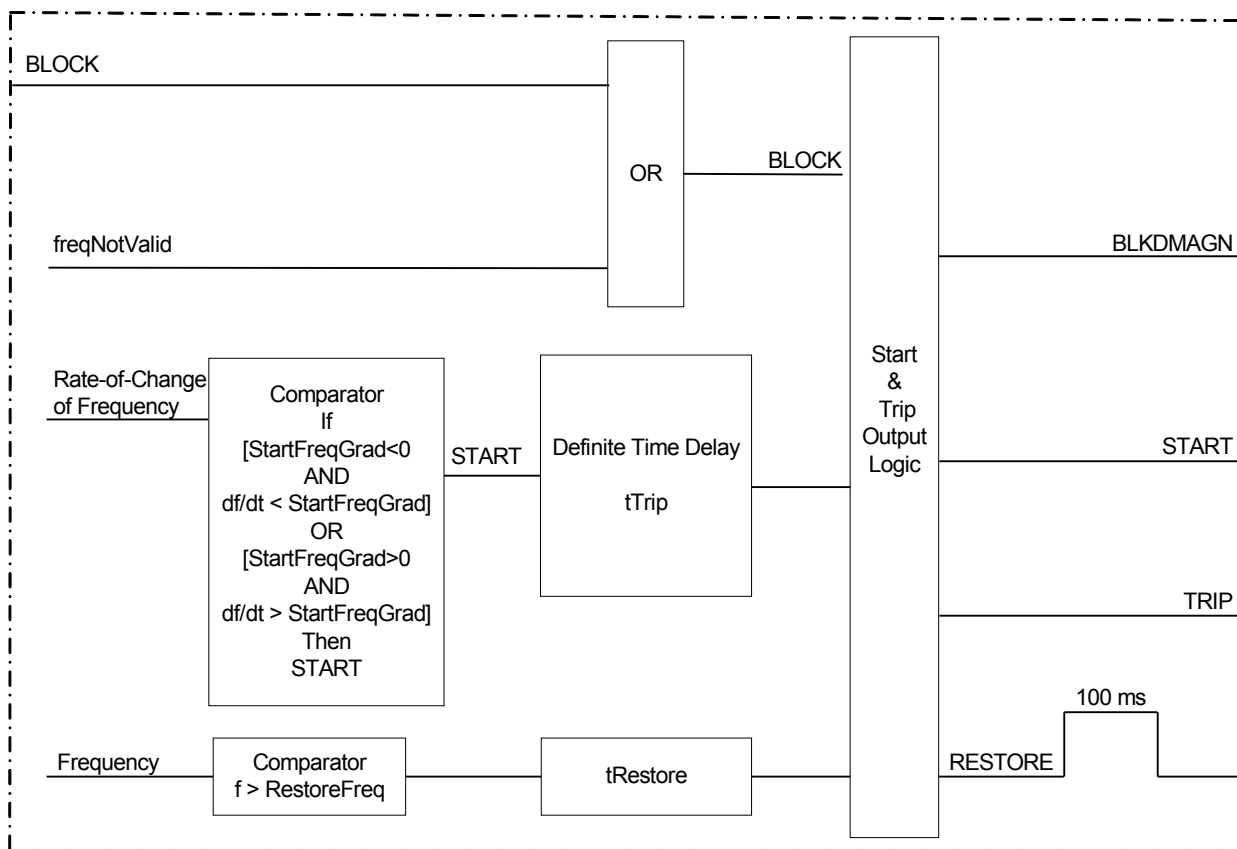
IEC08000009_en_1.vsd

Figure 76:　　Schematic design of Rate-of-change frequency protection (SAPFRC)

6.3.7　　Technical data

Table 131:　　SAPFRC Technical data

Function	Range or value	Accuracy
Operate value, start function	(-10.00-10.00) Hz/s	± 10.0 mHz/s
Operate value, restore enable frequency	(45.00 - 65.00) Hz	
Timers	(0.000 - 60.000) s	± 0.5% + 10 ms
Operate time, start function	100 ms typically	-

Section 7   Secondary system supervision

7.1   Current circuit supervison CCSRDIF

7.1.1   Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Current circuit supervision	CCSRDIF	-	-

7.1.2   Functionality

Open or short circuited current transformer cores can cause unwanted operation of many protection functions such as differential, earth fault current and negative sequence current functions.

It must be remembered that a blocking of protection functions at an occurrence of open CT circuit will mean that the situation will remain and extremely high voltages will stress the secondary circuit.

Current circuit supervision (CCSRDIF) compares the residual current from a three phase set of current transformer cores with the neutral point current on a separate input taken from another set of cores on the current transformer.

A detection of a difference indicates a fault in the circuit and is used as alarm or to block protection functions expected to give unwanted tripping.

7.1.3   Function block

IEC08000055-1-en.vsd
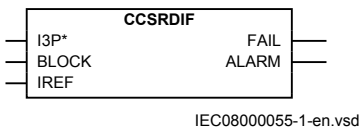
Figure 77:   CCSRDIF function block

7.1.4 Signals

Table 132:   *CCSRDIF Input signals*

Name	Type	Default	Description
I3P	GROUP SIGNAL	-	Three phase group signal for current inputs
IREF	GROUP SIGNAL	-	Group signal for current reference
BLOCK	BOOLEAN	0	Block of function

Table 133:   *CCSRDIF Output signals*

Name	Type	Description
FAIL	BOOLEAN	Detection of current circuit failure
ALARM	BOOLEAN	Alarm for current circuit failure

7.1.5 Settings

Table 134:   *CCSRDIF Group settings (basic)*

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
IMinOp	5 - 200	%IB	1	20	Minimum operate current differential level in % of IBase

Table 135:   *CCSRDIF Group settings (advanced)*

Name	Values (Range)	Unit	Step	Default	Description
Ip>Block	5 - 500	%IB	1	150	Block of the function at high phase current, in % of IBase

Table 136:   *CCSRDIF Non group settings (basic)*

Name	Values (Range)	Unit	Step	Default	Description
GlobalBaseSel	1 - 6	-	1	1	Selection of one of the Global Base Value groups

7.1.6 Operation principle

Current circuit supervison (CCSRDIF) compares the absolute value of the vectorial sum of the three phase currents |ΣIphase| and the numerical value of the residual current |Iref| from another current transformer set, see figure 78.

The FAIL output will be set to a logical one when the following criteria are fulfilled:

- The numerical value of the difference |ΣIphase| – |Iref| is higher than 80% of the numerical value of the sum |ΣIphase| + |Iref|.
- The numerical value of the current |ΣIphase| – |Iref| is equal to or higher than the set operate value *IMinOp*.
- No phase current has exceeded *Ip>Block* during the last 10 ms.
- CCSRDIF is enabled by setting *Operation = On*.

The FAIL output remains activated 100 ms after the AND-gate resets when being activated for more than 20 ms. If the FAIL lasts for more than 150 ms a ALARM will be issued. In this case the FAIL and ALARM will remain activated 1 s after the AND-gate resets. This prevents unwanted resetting of the blocking function when phase current supervision element(s) operate, for example, during a fault.
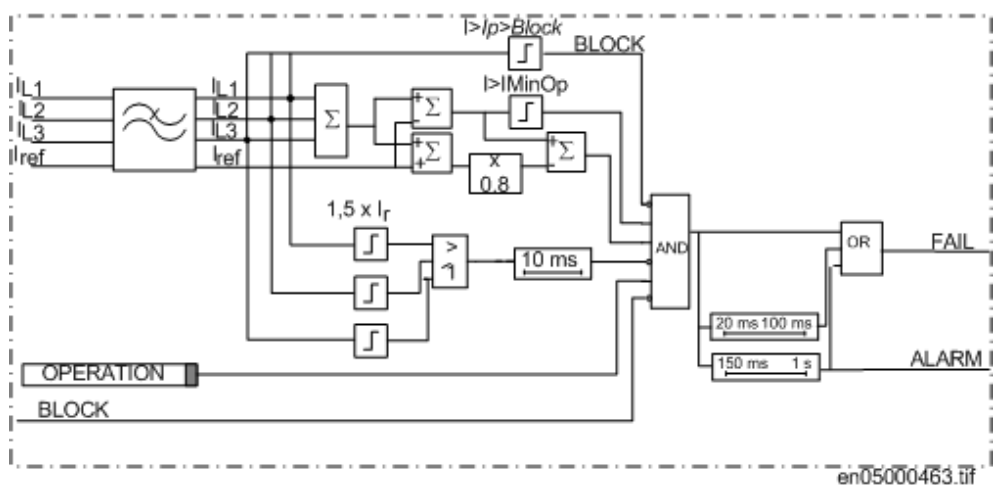
Figure 78:   *Simplified logic diagram for Current circuit supervision (CCSRDIF)*

The operate characteristic is percentage restrained, see figure 79.
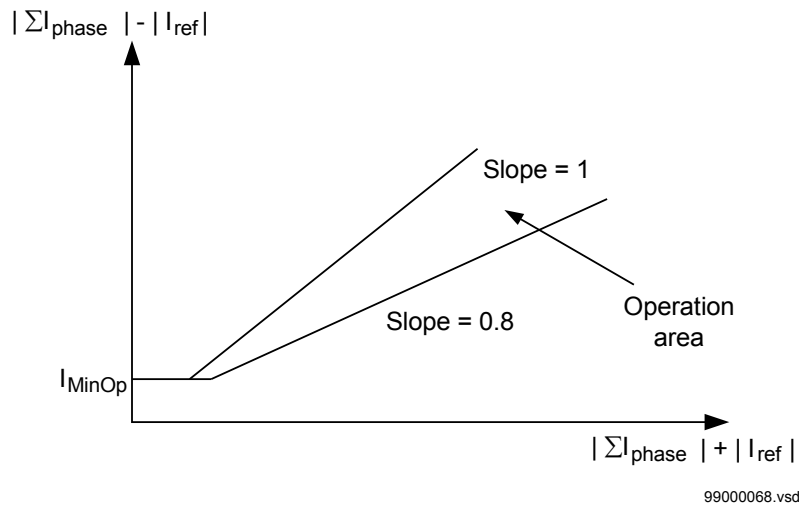
Figure 79:   *Operate characteristics*

Due to the formulas for the axis compared, $|\Sigma\text{Iphase}| - |\text{I ref}|$ and $|\Sigma\text{I phase}| + |\text{I ref}|$ respectively, the slope can not be above 2.

7.1.7   Technical data

Table 137:   *CCSRDIF Technical data*

Function	Range or value	Accuracy
Operate current	(5-200)% of I_r	$\pm$ 10.0% of I_r at $I \leq I_r$ $\pm$ 10.0% of I at $I > I_r$
Block current	(5-500)% of I_r	$\pm$ 5.0% of I_r at $I \leq I_r$ $\pm$ 5.0% of I at $I > I_r$

7.2   Fuse failure supervision SDDRFUF

7.2.1   Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Fuse failure supervision	SDDRFUF	-	-

7.2.2   Functionality

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 two different algorithms, negative sequence and zero sequence based algorithm 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 $3I_0$.

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.

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.

7.2.3 Function block
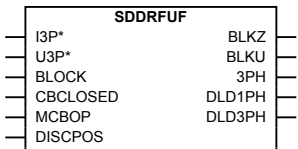
Figure 80:   *SDDRFUF function block*

7.2.4 Signals

Table 138:   *SDDRFUF Input signals*

Name	Type	Default	Description
I3P	GROUP SIGNAL	-	Three phase group signal for current inputs
U3P	GROUP SIGNAL	-	Three phase group signal for voltage inputs
BLOCK	BOOLEAN	0	Block of function
Table continues on next page			

Name	Type	Default	Description
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

Table 139:   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

7.2.5   Settings

Table 140:   SDDRFUF Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	On	Operation Off / On
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

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
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

Table 141:   SDDRFUF Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
GlobalBaseSel	1 - 6	-	1	1	Global Base Selector

7.2.6   Monitored data

Table 142:   SDDRFUF Monitored data

Name	Type	Values (Range)	Unit	Description
3I0	REAL	-	A	Magnitude of zero sequence current
3I2	REAL	-	A	Magnitude of negative sequence current
3U0	REAL	-	kV	Magnitude of zero sequence voltage
3U2	REAL	-	kV	Magnitude of negative sequence voltage

7.2.7   Operation principle

7.2.7.1   Zero sequence

The fuse failure supervision (SDDRFUF) function can be set in five different modes by setting the parameter *OpMode*. The zero sequence function continuously measure the internal currents and voltages in all three phases and calculate:

- the zero-sequence voltage $3U_0$
- the zero-sequence current $3I_0$.

The measured signals are compared with their respective set values *3U0<* and *3I0>*.

The function enable the internal signal fuseFailDetected if the measured zero sequence voltage is higher than the set value *3U0>*, the measured zero sequence current is below the set value *3I0<* and the operation mode selector *(OpMode* is set to 2 (zero sequence mode). This will activate the output signal BLKU, intended to block voltage related protection functions in the IED. The output signal BLKZ will be activated as well if not the internal dead line detection is activated at the same time.

If the fuseFailDetected signal is present for more than 5 seconds at the same time as all phase voltages are below the set value *UPh>* and the setting parameter *SealIn* is set to On, the function will activate the output signals 3PH, BLKU and BLKZ. The same signals will also be activated if all phase voltages are below the value *UPh>*, SealIn=On and any of the phase voltages below the setting value for more than 5 seconds.

It is recommended to always set *SealIn* to *On* since this will secure that no unwanted operation of fuse failure will occur at closing command of breaker when the line is already energized from the other end. The system voltages shall be normal before fuse failure is allowed to be activated and initiate block of different protection functions.

The output signal BLKU can also be activated if no phase voltages is below the setting *UPh>* for more than 60 seconds at the same time as the zero sequence voltage is above the set value *3U0>* 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). This condition covers for fuse failure at open breaker position.

Fuse failure condition is unlatched when the normal voltage conditions are restored.

Fuse failure condition is stored in the non volatile memory in the IED. In the new start-up procedure the IED checks the stored value in its non volatile memory and establishes the corresponding starting conditions.

en08000008.vsd
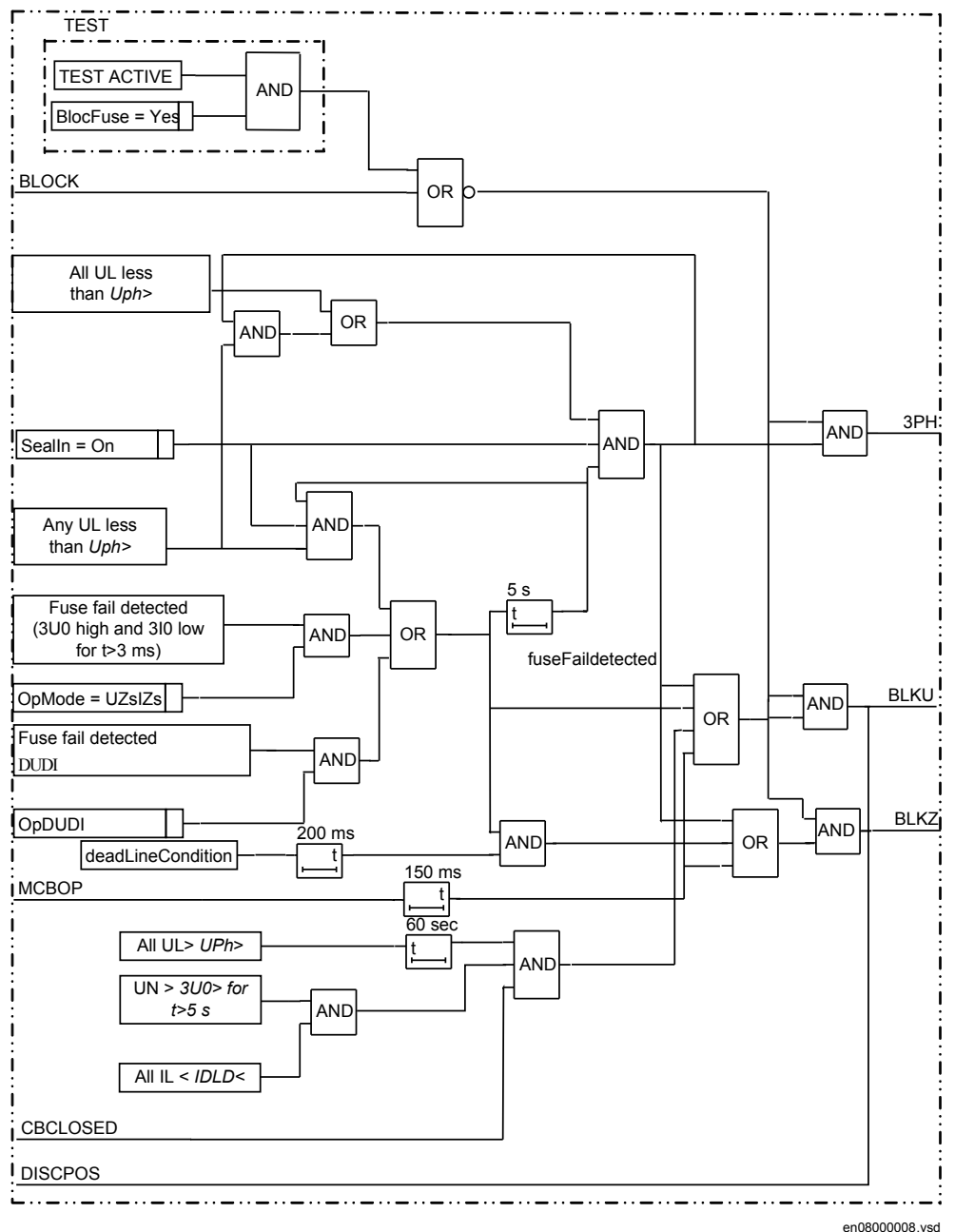
Figure 81:   Simplified logic diagram for fuse failure supervision function, zero sequence based

Input and output signals

The output signals 3PH, BLKU and BLKZ can be blocked in the following conditions:

- The input BLOCK is activated
- 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.

7.2.7.2   Negative sequence

The negative sequence operates in the same way as the zero sequence, but it calculates the negative sequence component of current and voltage.

- the negative sequence current $3I_2$
- the negative sequence voltage $3U_2$

The function enable the internal signal fuseFailDetected if the measured negative sequence voltage is higher than the set value *3U2>*, the measured negative sequence current is below the value *3I2<* and the operation mode selector (*OpMode*) is set to 1 (negative sequence mode).

7.2.7.3   du/dt and di/dt

The delta function can be activated by setting the parameter *OperationDUDI* to *On*. When it is selected *On* it operates in parallel with the sequence based algorithm.

The current and voltage is continuously measured in all three phases and the following quantities are calculated:

- The change of voltage $\Delta U/\Delta t$
- The change of current $\Delta I/\Delta t$

The calculated delta quantities are compared with their respective set values *DI<* and *DU>*.

The delta current and delta voltage algorithm, detects a fuse failure if a sufficient negative change in voltage amplitude without a sufficient change in current amplitude is detected in each phase separately. This check is performed if the circuit breaker is closed. Information about the circuit breaker position is brought to the function input CBCLOSED through a binary input of the IED.

There are two conditions for activating the internal STDU signal and set the latch:

- The magnitude of ΔU is higher than the corresponding setting *DU>* and ΔI is below the setting *DI>* in any phase at the same time as the circuit breaker is closed (CBCLOSED = 1)
- The magnitude ΔU is higher than the setting *DU>* and the magnitude of ΔI is below the setting *DI>* in any phase at the same time as the magnitude of the phase current in the same phase is higher than the setting *IPh>*.

The first 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 second criterion can activate the delta function.

The second criterion means that detection of failure in one phase together with high current for the same phase will set the latch. 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. To prevent that the phase current criterion is introduced.

If a fuse fail is detected (see figure 81), the output BLKU will be activated. If not the internal dead line detection is activated, BLKZ will be activated as well.

If all measured voltages are low (lower than the setting *UPh>*) for more than 5 seconds at the same time as a fuse fail is detected, the output 3PH will be activated. To release this indication all voltages must be over the setting *UPh>* and no fuse fail detected.

7.2.7.4 Operation modes

The fuse failure supervision function can be switched on or off by the setting parameter *Operation* to *On* or *Off*.

Negative and zero sequence algorithm

For increased flexibility and adaptation to system requirements, an operation mode selector, *OperationMode* has been introduced to make it possible to select different operating modes for the negative and zero sequence based algorithm. The different operation modes are:

- *OpMode* = 0, the negative and zero sequence function is switched off
- *OpMode* = 1; Negative sequence is selected
- *OpMode* = 2; Zero sequence is selected
- *OMode* = 3; Both negative and zero sequence is activated and working in parallel in an OR-condition
- *OpMode* = 4; Both negative and zero sequence is activated and working in series (AND-condition for operation)
- *OpMode* = 5; Optimum of negative and zero sequence (the function that has the highest magnitude of measured negative and zero sequence current will be activated).

du/dt and di/dt algorithm

The ΔU and ΔI function can be switched on or off by the setting parameter *OpDUDI* to *On* or *Off*.

Negative and zero sequence algorithm

For increased flexibility and adaptation to system requirements, an operation mode selector, *OperationMode* has been introduced to make it possible to select different operating modes for the negative and zero sequence based algorithm. The different operation modes are:

- *OpMode* = 0, the negative and zero sequence function is switched off
- *OpMode* = 1; Negative sequence is selected
- *OpMode* = 2; Zero sequence is selected

- *OMode* = 3; Both negative and zero sequence is activated and working in parallel in an OR-condition
- *OpMode* = 4; Both negative and zero sequence is activated and working in series (AND-condition for operation)
- *OpMode* = 5; Optimum of negative and zero sequence (the function that has the highest magnitude of measured negative and zero sequence current will be activated).

du/dt and di/dt algorithm

The ΔU and ΔI function can be switched on or off by the setting parameter *OpDUDI* to *On* or *Off*.

7.2.7.5   Dead line detection

The function input signal deadLineCondition (see figure 81) is related to the internal dead line detection function. This signal is activated from the dead line condition function when the voltage and the current in at least one phase is below their respective setting values *UDLD<* and *IDLD<*. It prevents the blocking of the impedance protection by a fuse failure detection during dead line condition (that occurs also during single pole auto-reclosing). The 200 ms drop-off timer prolongs the dead line condition after the line-energization in order to prevent the blocking of the impedance protection for unequal pole closing.

7.2.8   Technical data

Table 143:   *SDDRFUF Technical data*

Function	Range or value	Accuracy
Operate voltage, zero sequence	(1-100)% of UBase	± 0.5% 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

7.3   Breaker close/trip circuit monitoring TCSSCBR

7.3.1   Identification

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

7.3.2　　　　　Functionality

The trip circuit supervision function TCSSCBR is designed to supervise the control circuit of the circuit breaker. The invalidity of a control circuit is detected by using a dedicated output contact that contains the supervision functionality.

The function operates after a predefined operating time and resets when the fault disappears.

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

7.3.3　　　　　Function block

Figure 82:　　　*Function block*

7.3.4　　　　　Signals

Table 144:　　　*TCSSCBR Input signals*

Name	Type	Default	Description
TCS_STATE	BOOLEAN	0	Trip circuit fail indication from I/O-card
BLOCK	BOOLEAN	0	Block of function

Table 145:　　　*TCSSCBR Output signals*

Name	Type	Description
ALARM	BOOLEAN	Trip circuit fault indication

7.3.5　　　　　Settings

Table 146:　　　*TCSSCBR Non group settings (basic)*

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	On	Operation Off/On
tDelay	0.020 - 300.000	s	0.001	3.000	Operate time delay

7.3.6 Monitored data

Table 147: *TCSSCBR Monitored data*

Name	Type	Values (Range)	Unit	Description
ALARM	BOOLEAN	0=FALSE 1=TRUE	-	Trip circuit fault indication

7.3.7 Operation principle

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

The operation of trip circuit supervision can be described by using a module diagram. All the modules in the diagram are explained in the next sections.
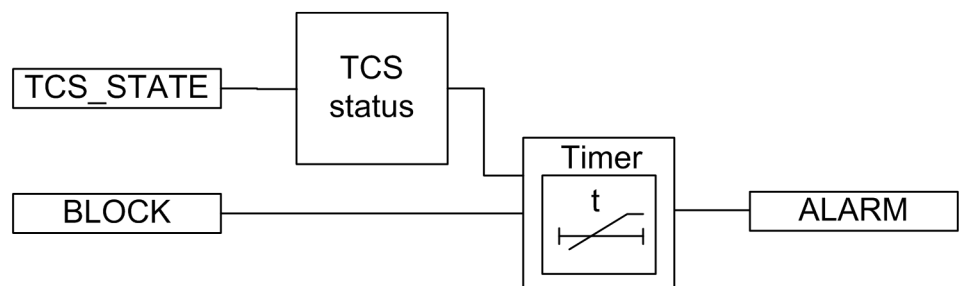
Figure 83: *Functional module diagram*

> Trip circuit supervision generates a current of approximately 1.0 mA through the supervised circuit. It must be ensured that this current will not cause a latch up of the controlled object.

> To protect the trip circuit supervision circuits in the IED, the output contacts are provided with parallel transient voltage suppressors. The breakdown voltage of these suppressors is 400 +/– 20 V DC.

Timer

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

The binary input BLOCK can be used to block the function. The activation of the BLOCK input deactivates the ALARM output and resets the internal timer.

7.3.8 Technical data
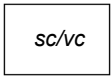
Table 148:   *TCSSCBR Technical data*

Function	Range or value	Accuracy
Operate time delay	(0.020 - 300.000)s	± 0,5% ± 10ms

Section 8   Control

8.1   Synchrocheck, energizing check, and synchronizing SESRSYN

8.1.1   Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Synchrocheck, energizing check, and synchronizing	SESRSYN	*sc/vc*	25

8.1.2   Functionality

The Synchronizing function allows closing of asynchronous networks at the correct moment including the breaker closing time. The systems can thus be reconnected after an auto-reclose or manual closing which improves the network stability.

The Synchrocheck, energizing check function (SESRSYN) checks that the voltages on both sides of the circuit breaker are in synchronism, or with at least one side dead to ensure that closing can be done safely.

The function includes a built-in voltage selection scheme for double bus and 1½ or ring busbar arrangements.

Manual closing as well as automatic reclosing can be checked by the function and can have different settings.

For systems which are running asynchronous a synchronizing function is provided. The main purpose of the synchronizing function is to provide controlled closing of circuit breakers when two asynchronous systems are going to be connected. It is used for slip frequencies that are larger than those for synchrocheck and lower than a set maximum level for the synchronizing function.

> Do not configure inputs LNQOPEN and LNQCLD, since they are not supported in the IED.

8.1.3 Function block


```
              SESRSYN
    U3PBB1              SYNOK
    U3PBB2           AUTOSYOK
    U3PLN1           AUTOENOK
    BLOCK             MANSYOK
    BLKSYNCH          MANENOK
    BLKSC            TSTSYNOK
    BLKENERG          TSTAUTSY
    B1QOPEN           TSTMANSY
    B1QCLD            TSTENOK
    B2QOPEN           USELFAIL
    B2QCLD              B1SEL
    LNQOPEN             B2SEL
    LNQCLD              LNSEL
    UB1OK            SYNPROGR
    UB1FF             SYNFAIL
    UB2OK            FRDIFSYN
    UB2FF            FRDERIVA
    ULNOK              UOKSC
    ULNFF             UDIFFSC
    STARTSYN          FRDIFFA
    TSTSYNCH          PHDIFFA
    TSTSC             FRDIFFM
    TSTENERG          PHDIFFM
    AENMODE           UDIFFME
    MENMODE          FRDIFFME
                     PHDIFFME
                      MODEAEN
                      MODEMEN
```

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Figure 84:   *SESRSYN function block*

8.1.4 Signals

Table 149:   *SESRSYN Input signals*

Name	Type	Default	Description
U3PBB1	GROUP SIGNAL	-	Group Signal for Voltage input Bus Bar 1
U3PBB2	GROUP SIGNAL	-	Group Signal for Voltage input Bus Bar 2
U3PLN1	GROUP SIGNAL	-	Group Signal for Voltage input Line 1
BLOCK	BOOLEAN	0	General block
BLKSYNCH	BOOLEAN	0	Block synchronizing
BLKSC	BOOLEAN	0	Block synchro check
BLKENERG	BOOLEAN	0	Block energizing check
B1QOPEN	BOOLEAN	0	Open status for CB or disconnector connected to bus1
B1QCLD	BOOLEAN	0	Close status for CB or disconnector connected to bus1
B2QOPEN	BOOLEAN	0	Open status for CB or disconnector connected to bus2
B2QCLD	BOOLEAN	0	Close status for CB or disconnector connected to bus2
Table continues on next page			

Name	Type	Default	Description
LNQOPEN	BOOLEAN	0	Open status for CB or disconnector connected to line
LNQCLD	BOOLEAN	0	Close status for CB or disconnector connected to line
UB1OK	BOOLEAN	0	Bus1 voltage transformer OK
UB1FF	BOOLEAN	0	Bus1 voltage transformer fuse failure
UB2OK	BOOLEAN	0	Bus2 voltage transformer OK
UB2FF	BOOLEAN	0	Bus2 voltage transformer fuse failure
ULNOK	BOOLEAN	0	Line voltage transformer OK
ULNFF	BOOLEAN	0	Line voltage transformer fuse failure
STARTSYN	BOOLEAN	0	Start synchronizing
TSTSYNCH	BOOLEAN	0	Set synchronizing in test mode
TSTSC	BOOLEAN	0	Set synchro check in test mode
TSTENERG	BOOLEAN	0	Set energizing check in test mode
AENMODE	INTEGER	0	Input for setting of automatic energizing mode
MENMODE	INTEGER	0	Input for setting of manual energizing mode

Table 150:   SESRSYN Output signals

Name	Type	Description
SYNOK	BOOLEAN	Synchronizing OK output
AUTOSYOK	BOOLEAN	Auto synchro check OK
AUTOENOK	BOOLEAN	Automatic energizing check OK
MANSYOK	BOOLEAN	Manual synchro check OK
MANENOK	BOOLEAN	Manual energizing check OK
TSTSYNOK	BOOLEAN	Synchronizing OK test output
TSTAUTSY	BOOLEAN	Auto synchro check OK test output
TSTMANSY	BOOLEAN	Manual synchro check OK test output
TSTENOK	BOOLEAN	Energizing check OK test output
USELFAIL	BOOLEAN	Selected voltage transformer fuse failed
B1SEL	BOOLEAN	Bus1 selected
B2SEL	BOOLEAN	Bus2 selected
LNSEL	BOOLEAN	Line selected
SYNPROGR	BOOLEAN	Synchronizing in progress
SYNFAIL	BOOLEAN	Synchronizing failed
FRDIFSYN	BOOLEAN	Frequency difference out of limit for synchronizing
FRDERIVA	BOOLEAN	Frequency derivative out of limit for synchronizing
UOKSC	BOOLEAN	Voltage amplitudes above set limits
UDIFFSC	BOOLEAN	Voltage difference out of limit
FRDIFFA	BOOLEAN	Frequency difference out of limit for Auto operation
Table continues on next page		

Name	Type	Description
PHDIFFA	BOOLEAN	Phase angle difference out of limit for Auto operation
FRDIFFM	BOOLEAN	Frequency difference out of limit for Manual operation
PHDIFFM	BOOLEAN	Phase angle difference out of limit for Manual Operation
UDIFFME	REAL	Calculated difference in voltage
FRDIFFME	REAL	Calculated difference in frequency
PHDIFFME	REAL	Calculated difference of phase angle
MODEAEN	INTEGER	Selected mode for automatic energizing
MODEMEN	INTEGER	Selected mode for manual energizing

8.1.5   Settings

Table 151:   *SESRSYN Group settings (basic)*

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
SelPhaseBus1	phase1 phase2 phase3 phase1-phase2 phase2-phase3 phase3-phase1	-	-	phase2	Select phase for bus1
SelPhaseBus2	phase1 phase2 phase3 phase1-phase2 phase2-phase3 phase3-phase1	-	-	phase2	Select phase for bus2
SelPhaseLine	phase1 phase2 phase3 phase1-phase2 phase2-phase3 phase3-phase1	-	-	phase2	Select phase for line
PhaseShift	-180 - 180	Deg	5	0	Phase shift
URatio	0.20 - 5.00	-	0.01	1.00	Voltage ratio
OperationSynch	Off On	-	-	Off	Operation for synchronizing function Off/On
FreqDiffMin	0.003 - 0.250	Hz	0.001	0.010	Minimum frequency difference limit for synchronizing
FreqDiffMax	0.050 - 0.500	Hz	0.001	0.200	Maximum frequency difference limit for synchronizing
FreqRateChange	0.000 - 5.000	Hz/s	0.001	0.300	Maximum allowed frequency rate of change
tBreaker	0.000 - 60.000	s	0.001	0.080	Closing time of the breaker
tClosePulse	0.050 - 60.000	s	0.001	0.200	Breaker closing pulse duration
Table continues on next page					

Name	Values (Range)	Unit	Step	Default	Description
tMaxSynch	0.00 - 6000.00	s	0.01	600.00	Resets synchronization if no close has been made before set time
tMinSynch	0.000 - 60.000	s	0.001	2.000	Minimum time to accept synchronizing conditions
OperationSC	Off On	-	-	On	Operation for synchronism check function Off/On
UDiffSC	2.0 - 50.0	%UB	1.0	15.0	Voltage difference limit in % of UBase
FreqDiffA	0.003 - 1.000	Hz	0.001	0.010	Frequency difference limit between bus and line Auto
FreqDiffM	0.003 - 1.000	Hz	0.001	0.010	Frequency difference limit between bus and line Manual
PhaseDiffA	5.0 - 90.0	Deg	1.0	25.0	Phase angle difference limit between bus and line Auto
PhaseDiffM	5.0 - 90.0	Deg	1.0	25.0	Phase angle difference limit between bus and line Manual
tSCA	0.000 - 60.000	s	0.001	0.100	Time delay for synchrocheck Auto
tSCM	0.000 - 60.000	s	0.001	0.100	Time delay for synchrocheck Manual
AutoEnerg	Off DLLB DBLL Both	-	-	DBLL	Automatic energizing check mode
ManEnerg	Off DLLB DBLL Both	-	-	Both	Manual energizing check mode
ManEnergDBDL	Off On	-	-	Off	Manual dead bus, dead line energizing
tAutoEnerg	0.000 - 60.000	s	0.001	0.100	Time delay for automatic energizing check
tManEnerg	0.000 - 60.000	s	0.001	0.100	Time delay for manual energizing check

Table 152:   *SESRSYN Non group settings (basic)*

Name	Values (Range)	Unit	Step	Default	Description
GlobalBaseSel	1 - 6	-	1	1	Global Base Selector

8.1.6   Monitored data

Table 153:   *SESRSYN Monitored data*

Name	Type	Values (Range)	Unit	Description
UDIFFME	REAL	-	kV	Calculated difference in voltage
FRDIFFME	REAL	-	Hz	Calculated difference in frequency
PHDIFFME	REAL	-	deg	Calculated difference of phase angle

8.1.7 Operation principle

8.1.7.1 Basic functionality

The synchrocheck function measures the conditions across the circuit breaker and compares them to set limits. The output is only given when all measured quantities are simultaneously within their set limits.

The energizing check function measures the bus and line voltages and compares them to both high and low threshold detectors. The output is given only when the actual measured quantities match the set conditions.

The synchronizing function measures the conditions across the circuit breaker, and also determines the angle change occurring during the closing delay of the circuit breaker, from the measured slip frequency. The output is given only when all measured conditions are simultaneously within their set limits. The issue of the output is timed to give closure at the optimal time including the time for the circuit breaker and the closing circuit.

For single circuit breaker arrangements, the SESRSYN function blocks have the capability to make the necessary voltage selection. The selection of correct voltage is made using auxiliary contacts of the bus disconnectors.

The internal logic for each function block as well as, the Input and Outputs, and the settings with default setting and setting ranges is described in this document. For application related information, please refer to the Application manual.

8.1.7.2 Synchrocheck

The voltage difference, frequency difference and phase angle difference values are measured in the IED centrally and are available for the Synchrocheck function for evaluation. If the bus voltage is connected as phase-phase and the line voltage as phase-neutral (or the opposite), this need to be compensated. This is done with a setting, which scales up the line voltage to a level equal to the bus voltage.

When the function is set to *OperationSC = On*, the measuring will start.

The function compares bus and line values with the set values for acceptable frequency, phase angle and voltage difference: FreqDiffA/M, PhaseDiffA/M and UDiffSC. If a compensation factor is set due to the use of different voltages on the bus and line, the factor is deducted from the line voltage before the comparison of the phase angle values.

The frequency on both sides of the circuit breaker is also measured. The frequencies must not deviate from the rated frequency more than +/-5Hz. The frequency difference between the bus frequency and the line frequency is measured and may not exceed the set value.

Two sets of settings for frequency difference and phase angle difference are available and used for the manual closing and Autoreclose functions respectively, as required.

The inputs BLOCK and BLKSC are available for total block of the complete Synchrocheck function and block of the Synchrocheck function respectively. Input TSTSC will allow testing of the function where the fulfilled conditions are connected to a separate test output.

The outputs MANSYOK and AUTOSYOK are activated when the actual measured conditions match the set conditions for the respective output. The output signal can be delayed independently for MANSYOK and AUTOSYOK conditions.

A number of outputs are available as information about fulfilled checking conditions. UOKSC shows that the voltages are high, UDIFFSC, FRDIFFM/A, PHDIFFM/A shows when the voltage difference, frequency difference and phase angle difference conditions are met.

8.1.7.3 Synchronizing

When the function is set to *OperationSynch=On* the measuring will be performed.

The function compares the values for the bus and line voltage which is a supervision that the voltages are both live. If both sides are live, the measured values are compared with the set values for acceptable frequency, rate of change of frequency and phase angle and *FreqDiffMin*.

Measured frequencies between the settings for the maximum and minimum frequency will initiate the measuring and the evaluation of the angle change to allow operation to be sent in the right moment including the set *tBreaker* time. There is a phase angle release internally to block any incorrect closing pulses. At operation the SYNOK output will be activated with a pulse *tClosePulse* and the function reset. The function will also reset if the syncronizing conditions are not fulfilled within the set *tMaxSynch* time. This prevents that the functions are, by mistake, maintained in operation for a long time, waiting for conditions to be fulfilled.

The inputs BLOCK and BLKSYNCH are available for total block of the complete function and of the synchronizing part.TSTSYNCH will allow testing of the function where the fulfilled conditions are connected to a separate output.
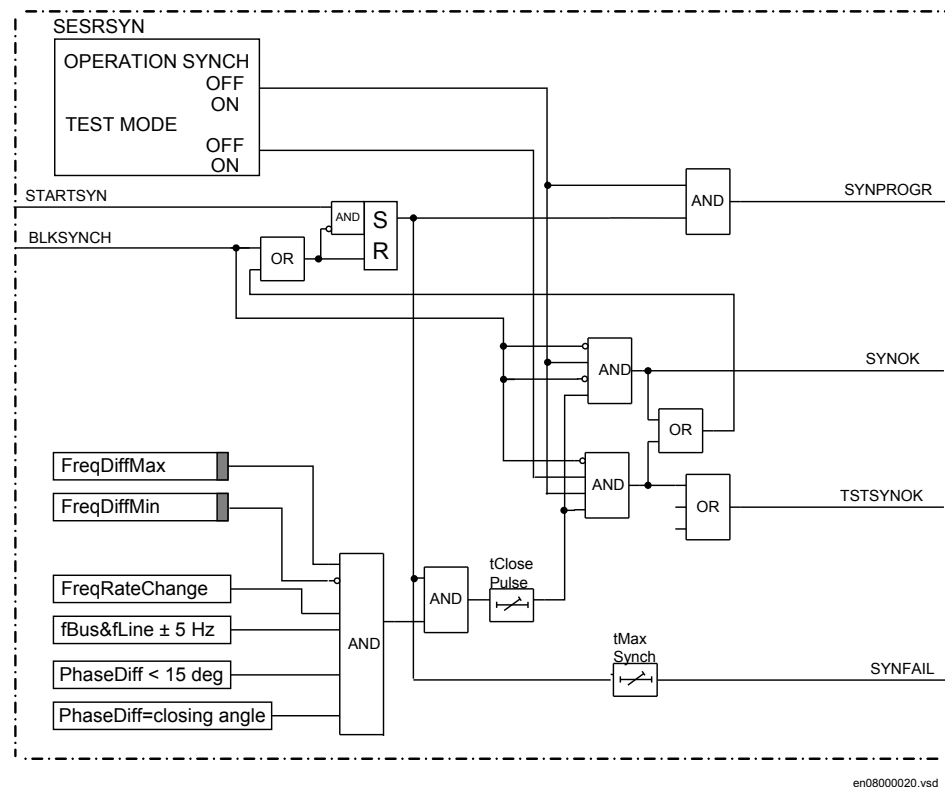
Figure 85:   Simplified logic diagram for the synchronizing function

8.1.7.4   Energizing check

Voltage values are measured in the IED centrally and are available for evaluation by the Energizing check function.

The frequency on both sides of the circuit breaker is also measured. The frequencies must not deviate from the rated frequency more than +/-5Hz.

The Energizing direction can be selected individually for the Manual and the Automatic functions respectively. When the conditions are met the outputs AUTOENOK and MANENOK respectively will be activated if the fuse supervision conditions are fulfilled. The output signal can be delayed independently for MANENOK and AUTOENOK conditions. The Energizing direction can also be selected by an integer input AENMODE and MENMODE, which for example, can be connected to a Binary to Integer function block (B16I). Integers supplied shall be 1=off, 2=DLLB, 3=DBLL and 4= Both. Not connected input with connection of INTZERO output from Fixed Signals function block will mean that the setting is done from PST tool. The active position can be read on outputs MODEAEN resp MODEMEN. The modes are 0=OFF, 1=DLLB, 2=DBLL and 3=Both.

The inputs BLOCK and BLKENERG are available for total block of the complete Synchronizing function and block of the Energizing check function. TSTENERG

will allow testing of the function where the fulfilled conditions are connected to a separate test output.
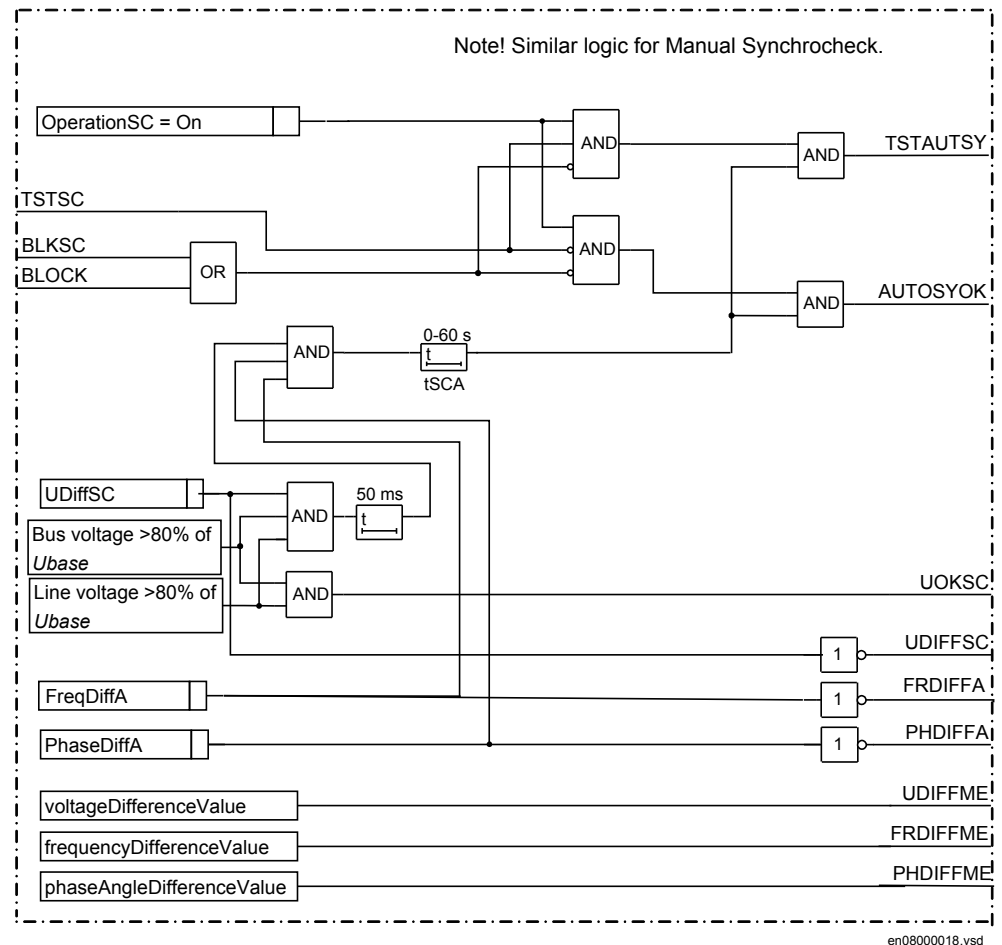
Figure 86:   *Simplified logic diagram for the Synchrocheck function*

8.1.7.5   Voltage selection

The voltage selection module including supervision of included voltage transformer fuses for the different arrangements is a basic part of the Synchronizing function and determines the parameters fed to the Synchronizing, Synchrocheck and Energizing check functions. This includes the selection of the appropriate Line and Bus voltages and fuse supervision.

The default voltages used will be ULine1 and UBus1. This is also the case when external voltage selection is provided. Fuse failure supervision for the used inputs must also be connected.

The voltage selection function, selected voltages, and fuse conditions are the Synchronizing, Synchrocheck and Energizing check inputs.

For the disconnector positions it is advisable to use (NO) a and (NC) b type contacts to supply Disconnector Open and Closed positions but, it is also possible to use an inverter for one of the positions.

8.1.7.6 Fuse failure supervision

External fuse-failure signals or signals from a tripped fuse switch/MCB are connected to binary inputs that are configured to the inputs of the Synchronizing functions in the IED. Alternatively, the internal signals from fuse failure supervision can be used when available. There are two alternative connection possibilities. Inputs labelled OK must be connected if the available contact indicates that the voltage circuit is healthy. Inputs labelled FF must be connected if the available contact indicates that the voltage circuit is faulty.

The UB1OK/UB2OK and UB1FF/UB2FF inputs are related to the busbar voltage and theULNOK and ULNFF inputs are related to the line voltage. Configure them to the binary inputs or function outputs that indicate the status of the external fuse failure of the busbar and line voltages. In the event of a fuse failure, the energizing check functions are blocked. The Synchronizing and the Synchrocheck function requires full voltage on both sides and will be blocked automatically in the event of fuse failures.

8.1.7.7 Voltage selection for a single circuit breaker with double busbars

This function uses the binary input from the disconnectors auxiliary contacts B1QOPEN-B1QCLD for Bus 1, and B2QOPEN-B2QCLD for Bus 2 to select between bus 1 and bus 2 voltages. If the disconnector connected to bus 2 is closed and the disconnector connected to bus 1 is opened the bus 2 voltage is used. All other combinations use the bus 1 voltage. The Outputs B1SEL and B2SEL respectively indicate the selected Bus voltage.

The function checks the fuse-failure signals for bus 1, bus 2 and line voltage transformers. Inputs UB1OK-UB1FF supervise the fuse for Bus 1. UB2OK-UB2FF supervises the fuse for Bus 2 and ULNOK-ULNFF supervises the fuse for the Line voltage transformer. The inputs fail (FF) or healthy (OK) can alternatively be used dependent on the available signal. If a fuse-failure is detected in the selected voltage source an output signal USELFAIL is set. This output signal is true if the selected bus or line voltages have a fuse failure. This output as well as the function can be blocked with the input signal BLOCK. The function logic diagram is shown in figure .

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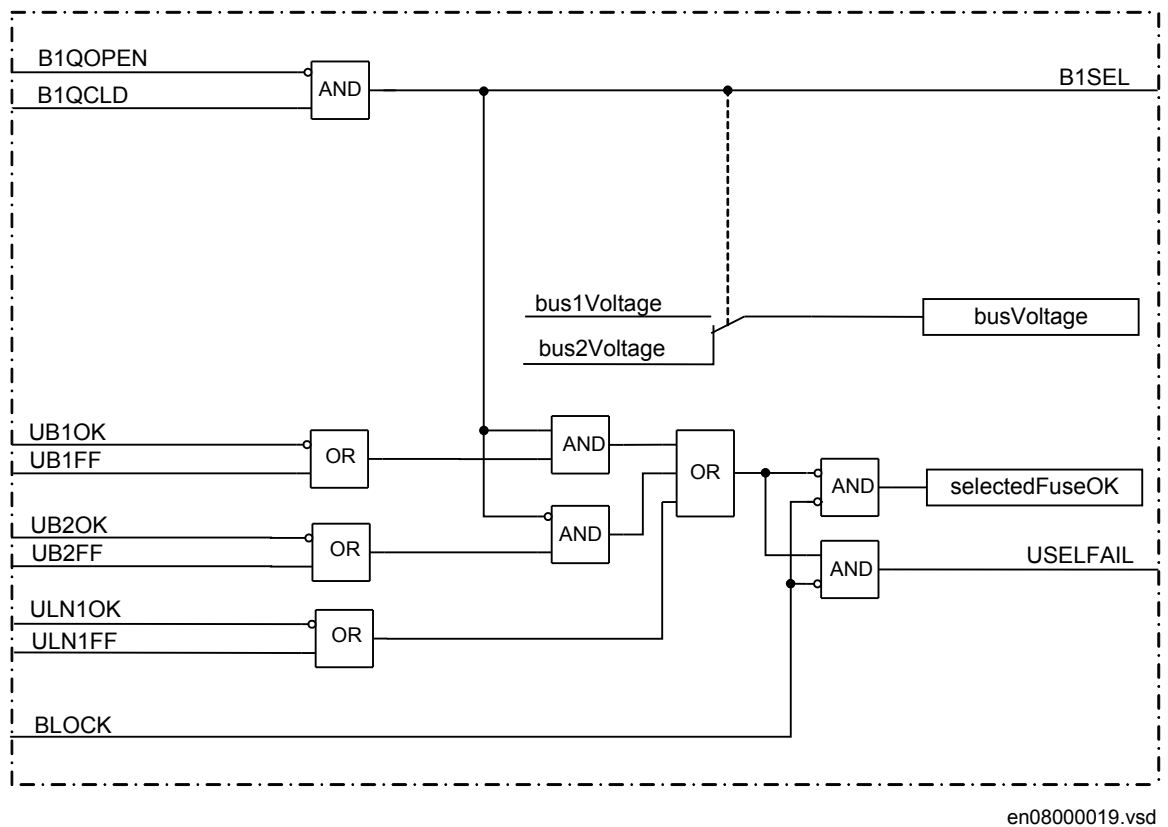
Figure 87: *Logic diagram for the voltage selection function of a single circuit breaker with double busbars*

8.1.8 Technical data

Table 154: *SESRSYN Technical data*
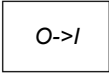
Function	Range or value	Accuracy
Phase shift, φ_{line} - φ_{bus}	(-180 to 180) degrees	-
Voltage ratio, U_{bus}/U_{line}	0.20-5.00	-
Frequency difference limit between bus and line	(0.003-1.000) Hz	± 2.0 mHz
Phase angle difference limit between bus and line	(5.0-90.0) degrees	± 2.0 degrees
Voltage difference limit between bus and line	(2.0-50.0)% of Ubase	± 0.5% of U_r
Time delay output for synchrocheck	(0.000-60.000) s	± 0.5% ± 10 ms
Time delay for energizing check	(0.000-60.000) s	± 0.5% ± 10 ms
Operate time for synchrocheck function	160 ms typically	-
Operate time for energizing function	80 ms typically	-

8.2 Autorecloser SMBRREC

8.2.1 Identification

Function Description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Autorecloser	SMBRREC	O->I	79

8.2.2 Functionality

The autoreclosing function provides high-speed and/or delayed auto-reclosing for single breaker applications.

Up to five reclosing attempts can be programmed.

The autoreclosing function can be configured to co-operate with a synchrocheck function.

8.2.3 Function block


```
          SMBRREC
—  ON            BLOCKED  —
—  OFF            SETON   —
—  BLKON          READY   —
—  BLKOFF        ACTIVE   —
—  RESET          SUCCL   —
—  INHIBIT       UNSUCCL  —
—  START         INPROGR  —
—  TRSOTF          3PT1   —
—  ZONESTEP        3PT2   —
—  THOLHOLD        3PT3   —
—  CBREADY         3PT4   —
—  CBPOS           3PT5   —
—  SYNC         CLOSECB   —
—  WAIT        WFMASTER   —
—  RSTCOUNT    COUNT3P1   —
               COUNT3P2   —
               COUNT3P3   —
               COUNT3P4   —
               COUNT3P5   —
                COUNTAR   —
```

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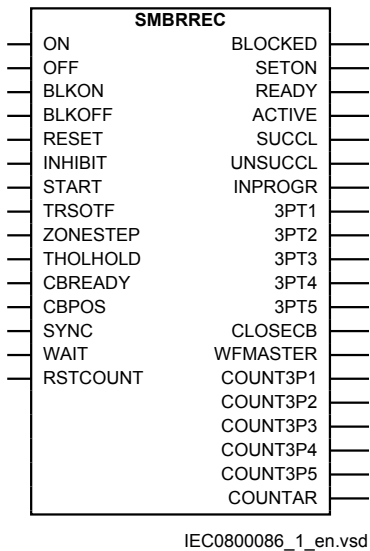
Figure 88: SMBRREC function block

8.2.4 Signals

Table 155:   SMBRREC Input signals

Name	Type	Default	Description
ON	BOOLEAN	0	Switches AR On when Operation = ExternalCtrl
OFF	BOOLEAN	0	Switches AR Off when Operation = ExternalCtrl
BLKON	BOOLEAN	0	Sets AR in blocked state
BLKOFF	BOOLEAN	0	Releases AR from blocked state
RESET	BOOLEAN	0	Resets AR to initial conditions
INHIBIT	BOOLEAN	0	Interrupts and inhibits reclosing sequence
START	BOOLEAN	0	Reclosing sequence starts by a protection trip signal
TRSOTF	BOOLEAN	0	Makes AR to continue to shots 2-5 at a trip from SOTF
ZONESTEP	BOOLEAN	0	Coordination between local AR and down stream devices
THOLHOLD	BOOLEAN	0	Holds 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
SYNC	BOOLEAN	0	Synchronizing check fulfilled for 3Ph closing attempts
WAIT	BOOLEAN	0	Wait for master in Multi-breaker arrangements
RSTCOUNT	BOOLEAN	0	Resets all counters

Table 156:   SMBRREC Output signals

Name	Type	Description
BLOCKED	BOOLEAN	AR is in blocked state
SETON	BOOLEAN	AR operation is switched on
READY	BOOLEAN	Indicates that AR 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
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
CLOSECB	BOOLEAN	Closing command for CB
Table continues on next page		

Name	Type	Description
WFMASTER	BOOLEAN	Signal to Slave issued by Master for sequential reclosing
COUNT3P1	INTEGER	Counting the number of three-phase reclosing shot 1
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

8.2.5 Settings

Table 157:   SMBRREC Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off External ctrl On	-	-	External ctrl	Off / ExternalCtrl / On
t1 3Ph	0.000 - 60.000	s	0.001	6.000	Open time for shot 1, delayed 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
tCBClosedMin	0.00 - 6000.00	s	0.01	5.00	Minimum 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 158:   SMBRREC Group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
NoOfShots	1 2 3 4 5	-	-	1	Maximum 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 CB auxilary contact type NC/NO for CBPOS input
CBReadyType	CO OCO	-	-	CO	Select type of circuit breaker ready signal CO/OCO
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
tInhibit	0.000 - 60.000	s	0.001	5.000	Inhibit reclosing reset time
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 protection unit's AR

8.2.6   Operation principle

8.2.6.1   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).

8.2.6.2 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.

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 89. 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 etc.
- 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. 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.
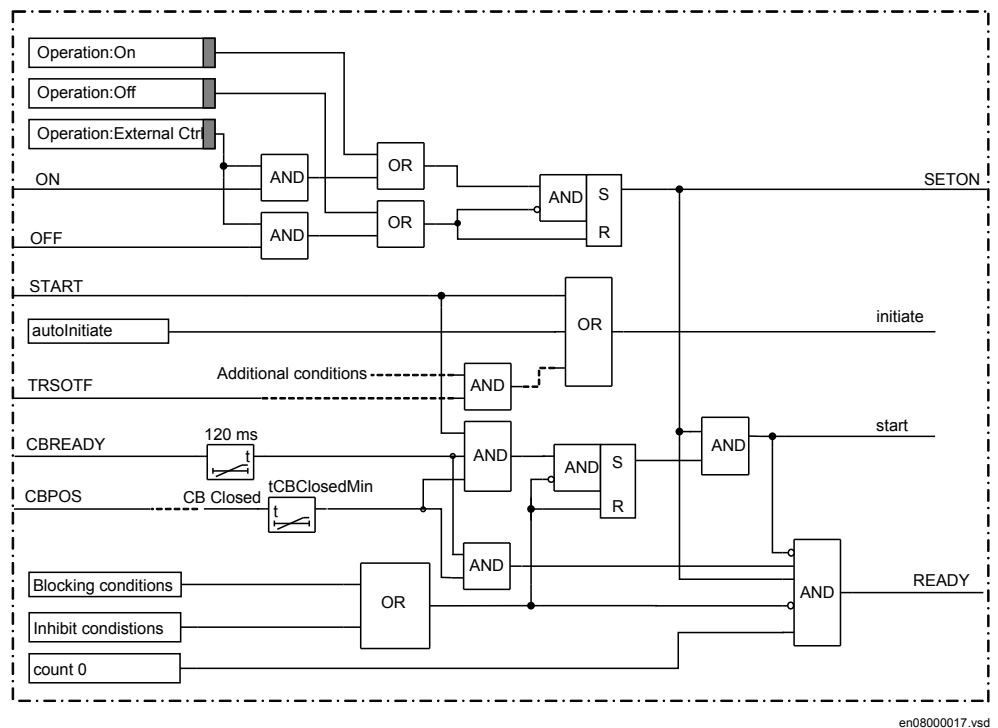
Figure 89:   Auto-reclosing Off/On and start

8.2.6.3   Control of the auto-reclosing open time

There are settings for three-phase auto-reclosing open time, *t1 3Ph to t5 3Ph*.

8.2.6.4   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*. A long trip signal interrupts the reclosing sequence in the same way as a signal to input INHIBIT.

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 synchro-check 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, the signal passes on.

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.
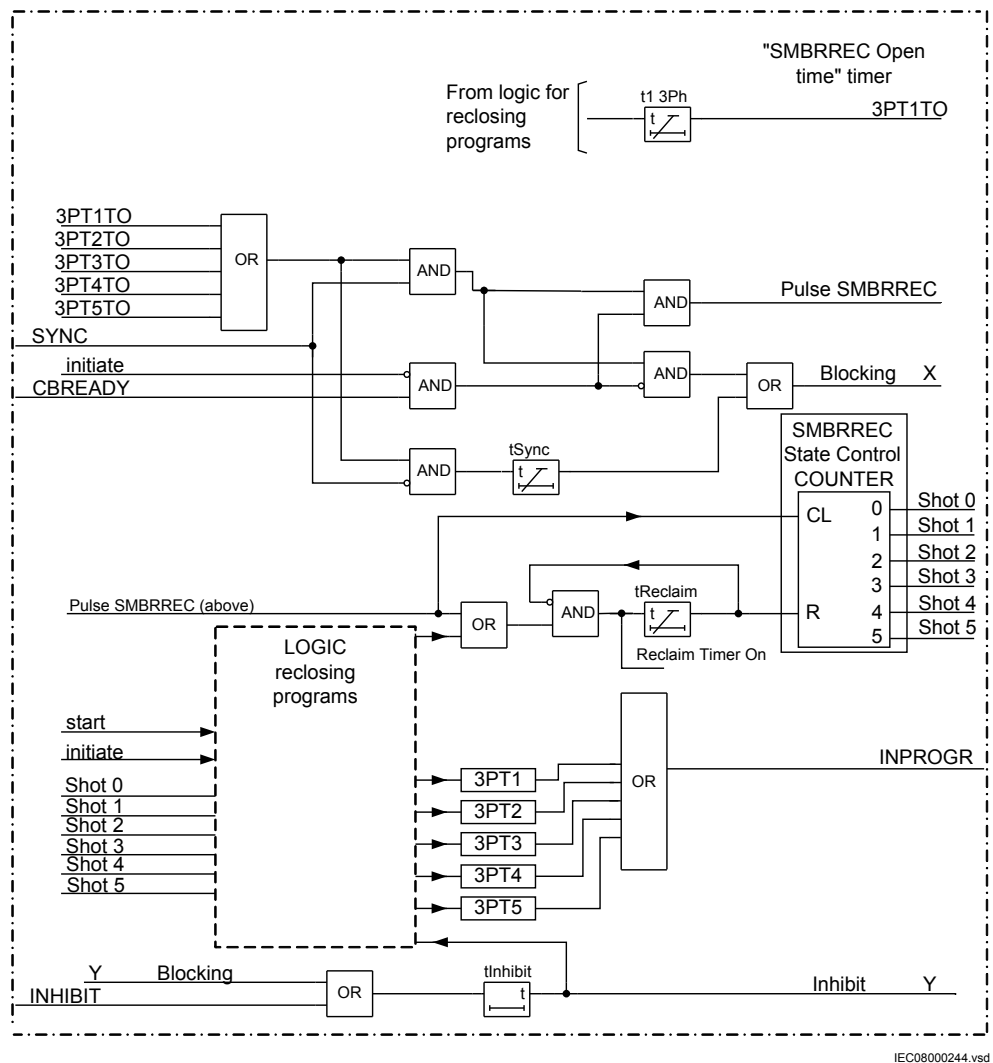
Figure 90:   Reclosing Reclaim and Inhibit timers

Pulsing of the CB closing command

The duration of the pulse is fixed 200 ms. See figure 91

When a reclosing command is issued, the appropriate reclosing operation counter is incremented. There is a counter for each reclosing shot and one for the total number of reclosing commands issued.

en08000245.vsd
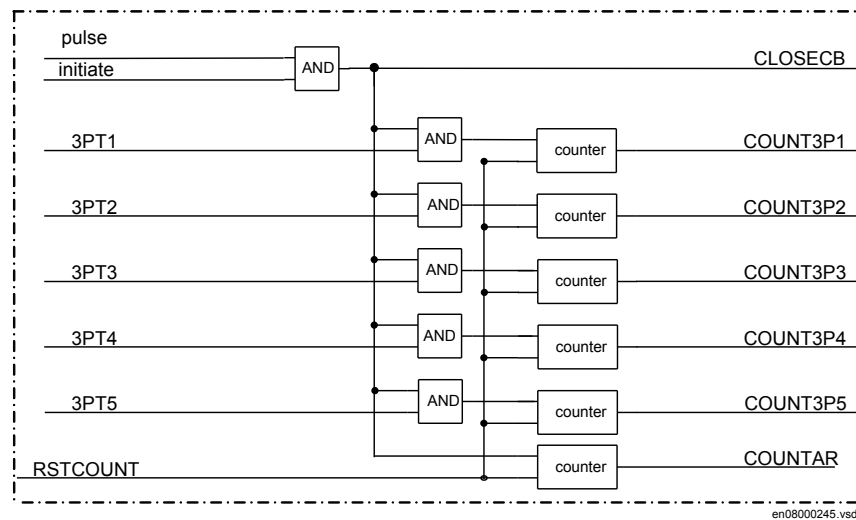
Figure 91: Pulsing of closing command and driving the operation counters

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*.

IEC09000203_1_en.vsd
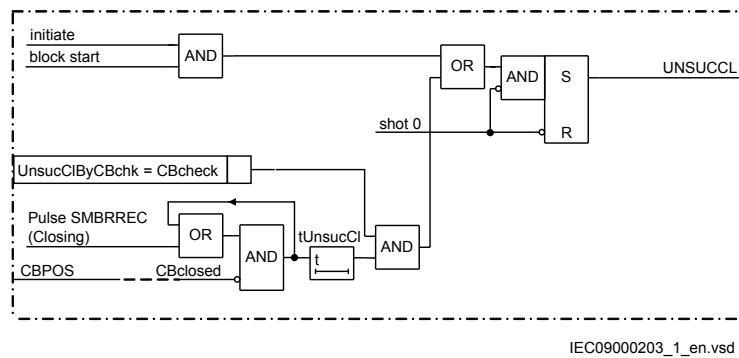
Figure 92:   *Issue of signal UNSUCCL, unsuccessful reclosing*

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.

en05000787.vsd
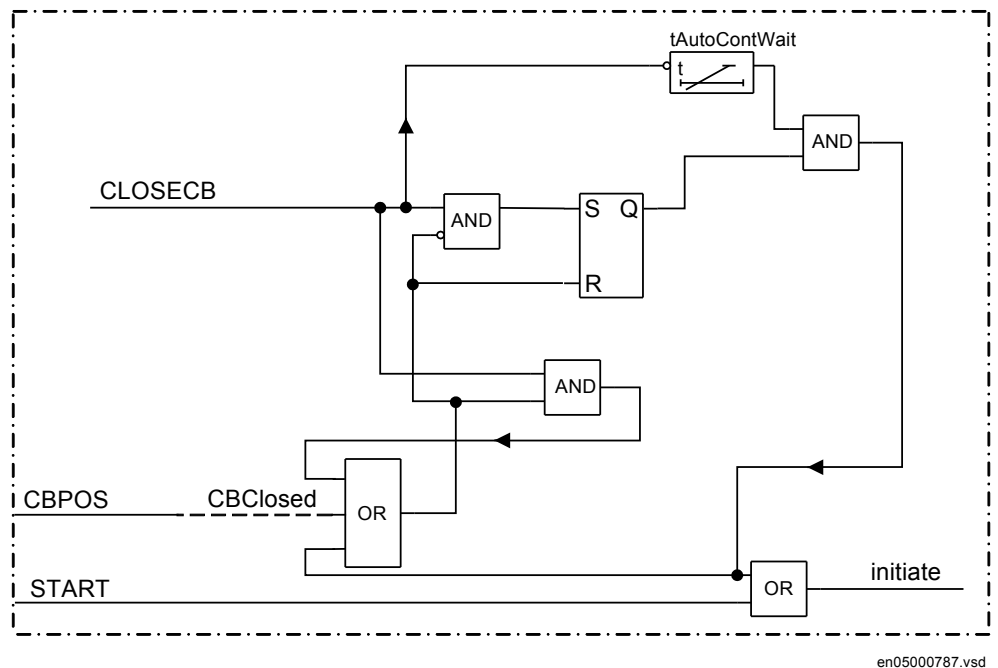
Figure 93:   *Automatic proceeding of shot 2 to 5*

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.

en08000078.vsd
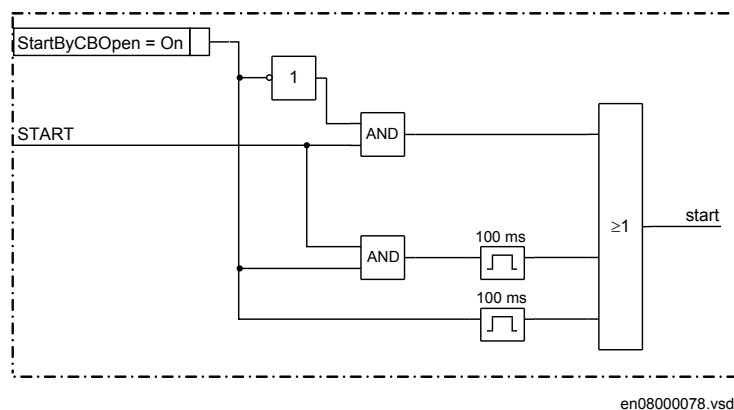
Figure 94:   Pulsing of the start inputs

8.2.7   Technical data

Table 159:   SMBRREC Technical data

Function	Range or value	Accuracy
Number of autoreclosing shots	1 - 5	-
Autoreclosing open time: shot 1 - t1 3Ph	(0.000-60.000) s	± 0.5% ± 10 ms
shot 2 - t2 3Ph shot 3 - t3 3Ph shot 4 - t4 3Ph shot 5 - t5 3Ph	(0.00-6000.00) 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	
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	

8.3   Apparatus control APC

8.3.1   Functionality

The apparatus control is a function 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.

8.3.2   Switch controller SCSWI

8.3.2.1   Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Switch controller	SCSWI	-	-

8.3.2.2   Functionality

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.

8.3.2.3   Function block


```
            SCSWI
 ─── BLOCK          EXE_OP ───
 ─── PSTO           EXE_CL ───
 ─── L_SEL        SELECTED ───
 ─── L_OPEN       START_SY ───
 ─── L_CLOSE      POSITION ───
 ─── AU_OPEN       OPENPOS ───
 ─── AU_CLOSE     CLOSEPOS ───
 ─── BL_CMD        CMD_BLK ───
 ─── RES_EXT       L_CAUSE ───
 ─── SY_INPRO     POS_INTR ───
 ─── SYNC_OK          XOUT ───
 ─── EN_OPEN
 ─── EN_CLOSE
 ─── XPOS*
```

IEC09000087_1_en.vsd
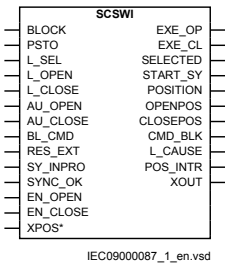
Figure 95:   SCSWI function block

8.3.2.4   Signals

Table 160:   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
Table continues on next page			

Name	Type	Default	Description
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_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
XPOS	GROUP SIGNAL	-	Group signal from XCBR/XSWI

Table 161:　　*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
START_SY	BOOLEAN	Starts the synchronizing function
POSITION	INTEGER	Position indication
OPENPOS	BOOLEAN	Open position indication
CLOSEPOS	BOOLEAN	Closed position indication
CMD_BLK	BOOLEAN	Commands are blocked
L_CAUSE	INTEGER	Latest value of the error indication during command
POS_INTR	BOOLEAN	Stopped in intermediate position
XOUT	BOOLEAN	Execution information to XCBR/XSWI

8.3.2.5　　Settings

Table 162:　　*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	0.000 - 60.000	s	0.001	30.000	Maximum time between select and execute signals
Table continues on next page					

Name	Values (Range)	Unit	Step	Default	Description
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

8.3.3 Circuit breaker SXCBR

8.3.3.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Circuit breaker	SXCBR	-	-

8.3.3.2 Functionality

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.

8.3.3.3 Function block

IEC09000089_1_en.vsd
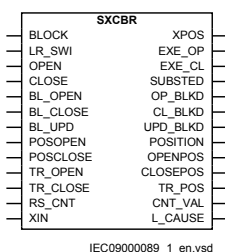
Figure 96:   SXCBR function block

8.3.3.4 Signals

Table 163:   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
Table continues on next page			

Name	Type	Default	Description
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 164:   SXCBR Output signals

Name	Type	Description
XPOS	GROUP SIGNAL	Group connection to CSWI
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
TR_POS	INTEGER	Truck position indication
CNT_VAL	INTEGER	Operation counter value
L_CAUSE	INTEGER	Latest value of the error indication during command

8.3.3.5   Settings

Table 165:   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

8.3.4 Circuit switch SXSWI

8.3.4.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Circuit switch	SXSWI	-	-

8.3.4.2 Functionality

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.

8.3.4.3 Function block


```
          SXSWI
  BLOCK            XPOS
  LR_SWI          EXE_OP
  OPEN            EXE_CL
  CLOSE          SUBSTED
  BL_OPEN        OP_BLKD
  BL_CLOSE       CL_BLKD
  BL_UPD        UPD_BLKD
  POSOPEN       POSITION
  POSCLOSE      OPENPOS
  TR_OPEN       CLOSEPOS
  TR_CLOSE       TR_POS
  RS_CNT         CNT_VAL
  XIN           L_CAUSE
```

IEC09000092_1_en.vsd
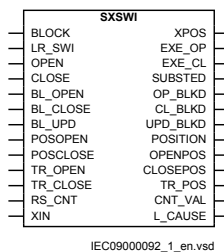
Figure 97:   SXSWI function block

8.3.4.4 Signals

Table 166:   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
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 167:   *SXSWI Output signals*

Name	Type	Description
XPOS	GROUP SIGNAL	Group connection to CSWI
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
TR_POS	INTEGER	Truck position indication
CNT_VAL	INTEGER	Operation counter value
L_CAUSE	INTEGER	Latest value of the error indication during command

8.3.4.5   Settings

Table 168:   *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

8.3.5   Bay control QCBAY

8.3.5.1   Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Bay control	QCBAY	-	-

8.3.5.2   Functionality

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.

8.3.5.3   Function block
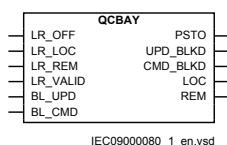
Figure 98:   *QCBAY function block*

8.3.5.4   Signals

Table 169:   *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 170:   *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

8.3.5.5   Settings

Table 171:   *QCBAY Non group settings (basic)*

Name	Values (Range)	Unit	Step	Default	Description
AllPSTOValid	Priority No priority	-	-	Priority	Priority of originators

8.3.6 Local remote LOCREM

8.3.6.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Local remote	LOCREM	-	-

8.3.6.2 Functionality

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.

8.3.6.3 Function block

```
            LOCREM
—  CTRLOFF           OFF   —
—  LOCCTRL         LOCAL   —
—  REMCTRL        REMOTE   —
—  LHMICTRL        VALID   —
        IEC09000076_1_en.vsd
```
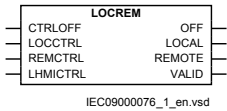
Figure 99:   LOCREM function block

8.3.6.4 Signals

Table 172:   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 173:   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

8.3.6.5 Settings

Table 174: *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

8.3.7 Local remote control LOCREMCTRL

8.3.7.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Local remote control	LOCREMCTRL	-	-

8.3.7.2 Functionality

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.

8.3.7.3 Function block


```
          LOCREMCTRL
    ^PSTO1          ^HMICTR1
    ^PSTO2          ^HMICTR2
    ^PSTO3          ^HMICTR3
    ^PSTO4          ^HMICTR4
    ^PSTO5          ^HMICTR5
    ^PSTO6          ^HMICTR6
    ^PSTO7          ^HMICTR7
    ^PSTO8          ^HMICTR8
    ^PSTO9          ^HMICTR9
    ^PSTO10         ^HMICTR10
    ^PSTO11         ^HMICTR11
    ^PSTO12         ^HMICTR12
```

IEC09000074_1_en.vsd
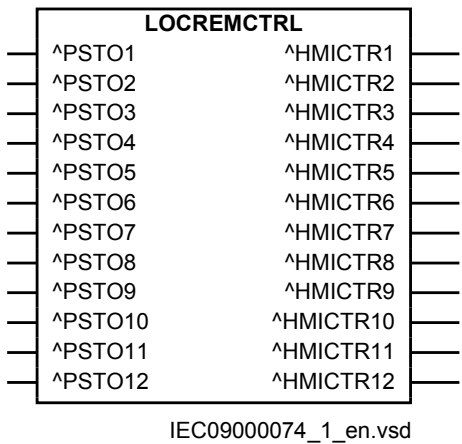
Figure 100: *LOCREMCTRL function block*

8.3.7.4 Signals

Table 175:   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 176:   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

8.3.7.5 Settings

The function does not have any parameters available in Local HMI or Protection and Control IED Manager (PCM600).

8.3.8 Select release SELGGIO

8.3.8.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Select release	SELGGIO	-	-

8.3.8.2 Function block

IEC09000084_1_en.vsd
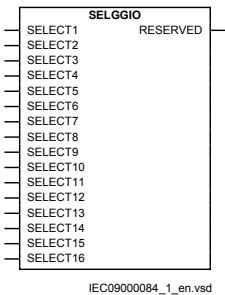
Figure 101:   SELGGIO function block

8.3.8.3 Signals

Table 177:   SELGGIO Input signals

Name	Type	Default	Description
SELECT1	BOOLEAN	0	Select signal of control 1
SELECT2	BOOLEAN	0	Select signal of control 2
SELECT3	BOOLEAN	0	Select signal of control 3
SELECT4	BOOLEAN	0	Select signal of control 4
SELECT5	BOOLEAN	0	Select signal of control 5
SELECT6	BOOLEAN	0	Select signal of control 6
SELECT7	BOOLEAN	0	Select signal of control 7
SELECT8	BOOLEAN	0	Select signal of control 8
SELECT9	BOOLEAN	0	Select signal of control 9
SELECT10	BOOLEAN	0	Select signal of control 10
SELECT11	BOOLEAN	0	Select signal of control 11
SELECT12	BOOLEAN	0	Select signal of control 12
SELECT13	BOOLEAN	0	Select signal of control 13
SELECT14	BOOLEAN	0	Select signal of control 14
SELECT15	BOOLEAN	0	Select signal of control 15
SELECT16	BOOLEAN	0	Select signal of control 16

Table 178:   *SELGGIO Output signals*

Name	Type	Description
RESERVED	BOOLEAN	Reserved indication from bay/apparatus

8.3.8.4   Settings

The function does not have any parameters available in Local HMI or Protection and Control IED Manager (PCM600).

8.3.9   Operation principle

8.3.9.1   Switch controller SCSWI

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.

Command handling

Two types of command models can be used. The two command models are "direct with normal security" and "SBO (Select-Before-Operate) with enhanced security". The parameter *CtlModel* defines which one of the two command models is used. The command 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. The meaning of the cause signals can be found in table 2.

> ℹ️ 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

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.

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 the 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, the switch controller 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 102. 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 104.

IEC09000209_1_en.vsd
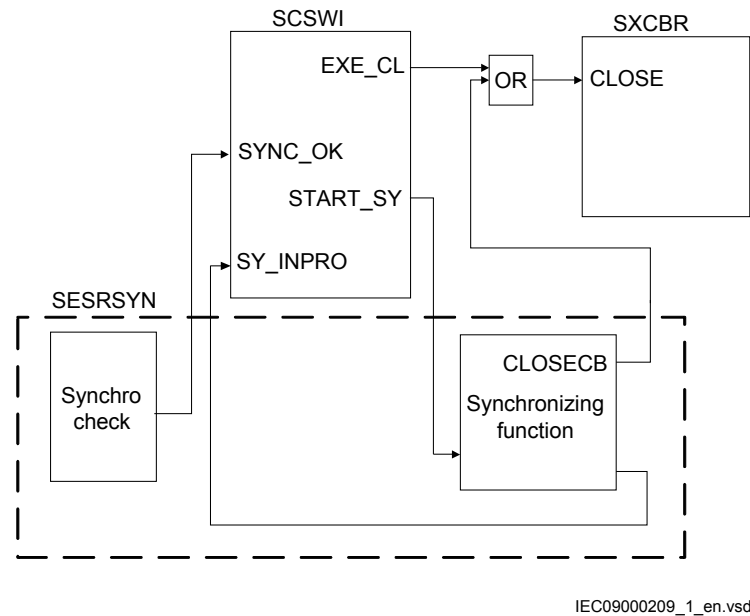
Figure 102:   Example of interaction between SCSWI, SESRSYN (synchrocheck and synchronizing function) and SXCBR function

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.

en05000092.vsd
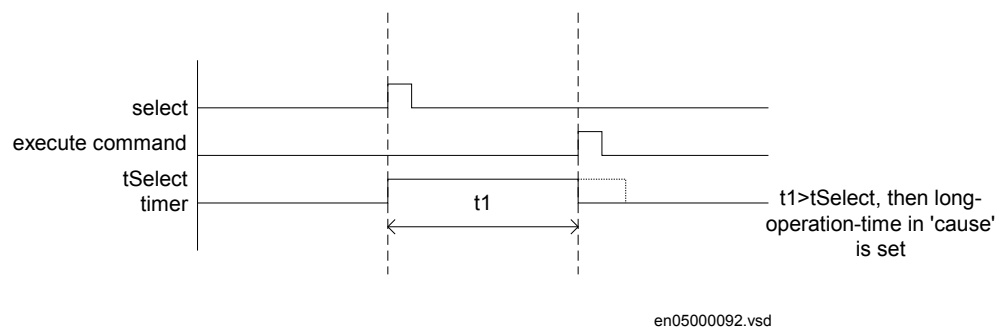
Figure 103:   tSelect

The timer *tExecutionFB* supervises the time between the execute command and the command termination, see figure __"".

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.
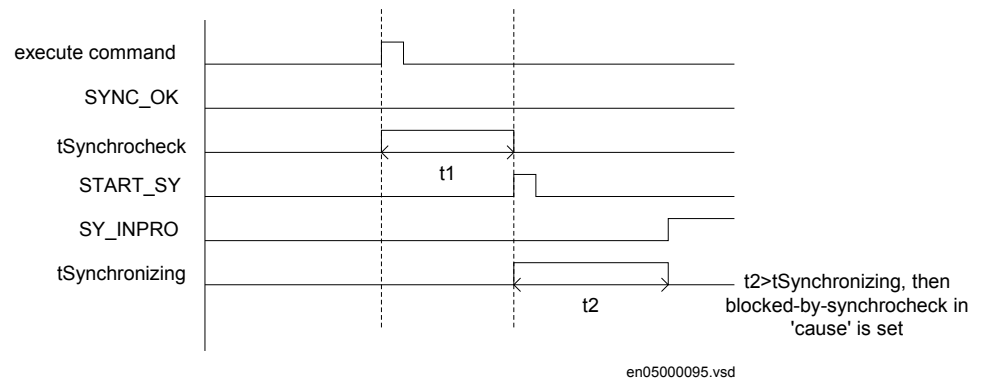
Figure 104:   *tSynchroCheck and tSynchronizing*

Error handling

Depending on the error that occurs during the command sequence, the error signal will be set with a value. Table 179 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 indicates the latest value of the error during the command.

Table 179:   *Values for "cause" signal in priority order*

Apparatus control function	Description
–22	wrongCTLModel
–23	blockedForCommand
–24	blocked-for-open-command
–25	blocked-for-close-command
–30	longOperationTime
–31	switch-not-start-moving
–32	persistent-intermediate-state
–33	switch-returned-to-initial-position
–34	switch-in-bad-state
–35	not-expected-final-position

8.3.9.2   Circuit breaker SXCBR

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The intended user of the Circuit breaker (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, evaluate block conditions and evaluate 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 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 105.

Figure 105:   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 etc.

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 . 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 106 explains these two timers during the execute phase.
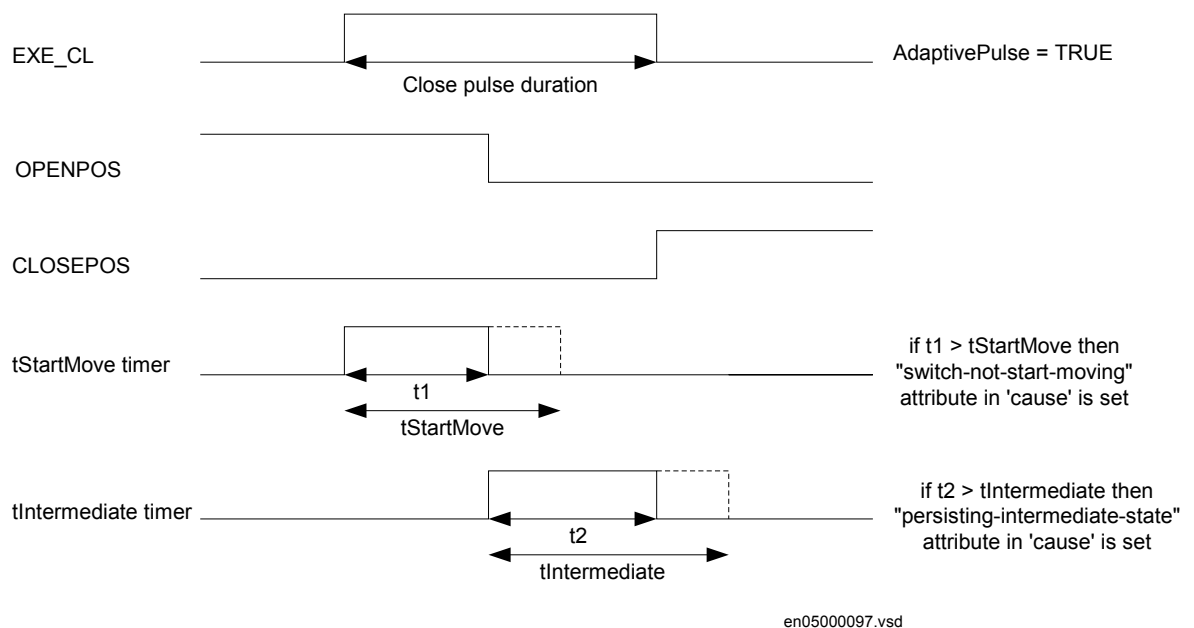
Figure 106:   *The timers tStartMove and tIntermediate*

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 107 shows the principle of the execute output pulse. The *AdaptivePulse* parameter will have affect on both execute output pulses.
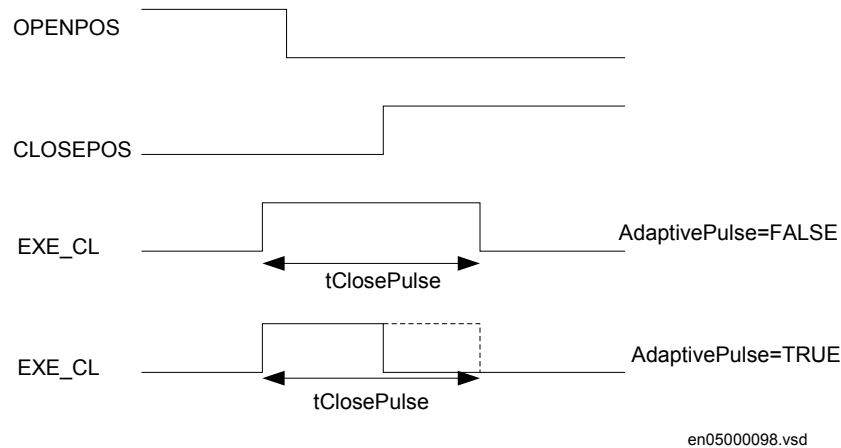
Figure 107:   Execute output pulse

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 108 .

OPENPOS

CLOSEPOS

EXE_OP   AdaptivePulse=FALSE
        tOpenPulse

EXE_OP   AdaptivePulse=TRUE
        tOpenPulse

tStartMove timer

en05000099.vsd
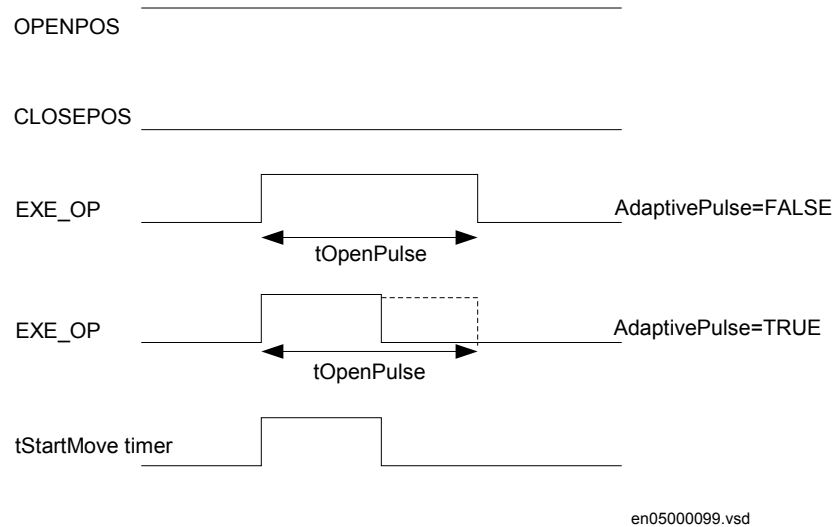
Figure 108:   Open command with open position indication

Error handling

Depending on the error that occurs during the command sequence the error signal will be set with a value. Table 180 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 indicates the latest value of the error during the command.

Table 180:   Vendor specific cause values for Apparatus control in priority order

Apparatus control function	Description
–22	wrongCTLModel
–23	blockedForCommand
–24	blocked-for-open-command
–25	blocked-for-close-command
–30	longOperationTime
–31	switch-not-start-moving
–32	persistent-intermediate-state
–33	switch-returned-to-initial-position
–34	switch-in-bad-state
–35	not-expected-final-position

8.3.9.3   Circuit switch SXSWI

The intended user of 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,

evaluate block conditions and evaluate 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 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 109.

en05000096.vsd
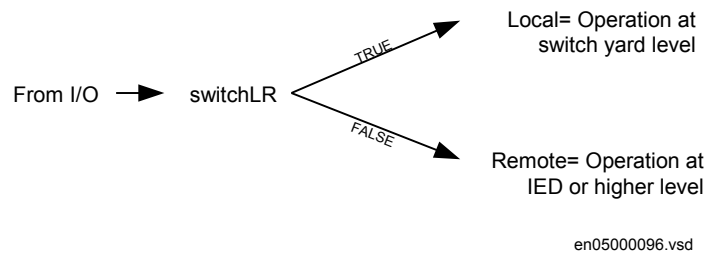
Figure 109:   Local/Remote switch

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 etc.

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 . 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 110 explains these two timers during the execute phase.
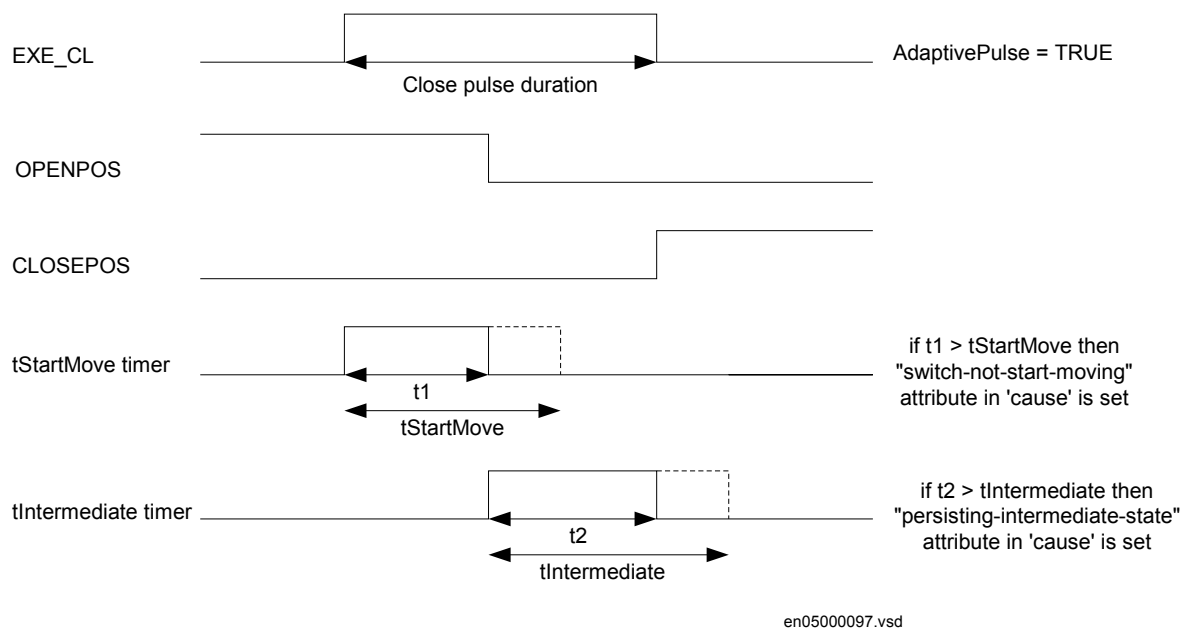
Figure 110: *The timers tStartMove and tIntermediate*

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 111 shows the principle of the execute output pulse. The *AdaptivePulse* parameter will have affect on both execute output pulses.
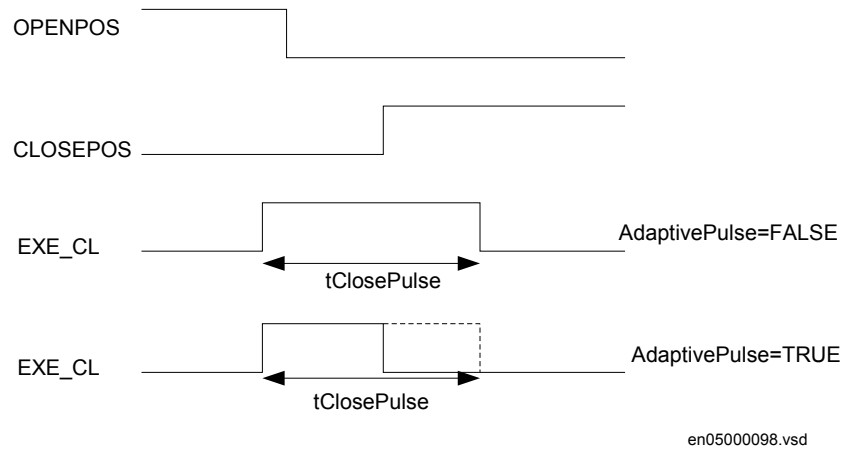
Figure 111:   *Execute output pulse*

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, i.e. *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.

> 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 when a primary device is open and an open command is executed is shown in figure 112.

en05000099.vsd
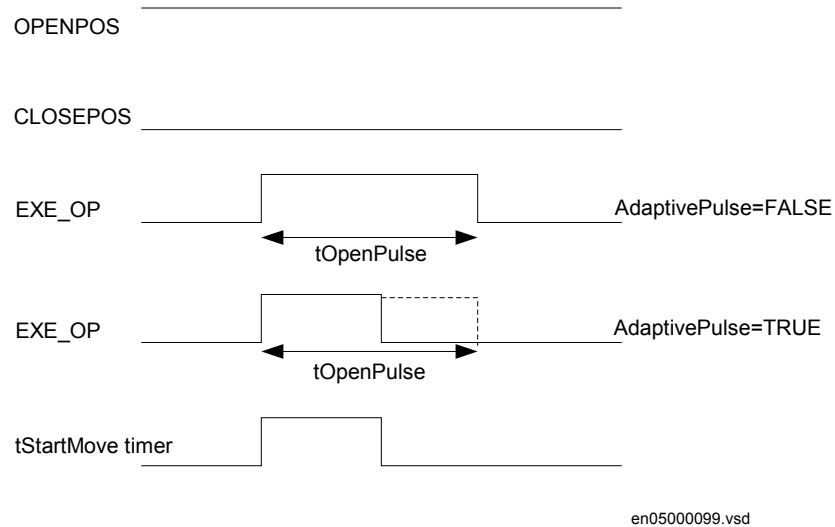
Figure 112: *Open command with open position indication*

Error handling

Depending on the error that occurs during the command sequence the error signal
will be set with a value. Table 181 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 indicates the latest value of the error
during the command.

Table 181: *Values for "cause" signal in priority order*

Apparatus control function	Description
–22	wrongCTLModel
–23	blockedForCommand
–24	blocked-for-open-command
–25	blocked-for-close-command
–30	longOperationTime
–31	switch-not-start-moving
–32	persistent-intermediate-state
–33	switch-returned-to-initial-position
–34	switch-in-bad-state
–35	not-expected-final-position

8.3.9.4   Bay control QCBAY

The functionality of the Bay control (QCBAY) function is not defined in the IEC
61850–8–1 standard, which means that the function is a vendor specific logical node.

The function sends information about the Permitted Source To Operate (PSTO) and blocking conditions to other functions within the bay for example, switch control functions, voltage control functions and measurement functions.

Local panel switch

The local panel switch is a switch that defines the operator place selection. The switch connected to this function can have three positions remote/local/off. The positions are here defined so that remote means that operation is allowed from station/ remote level and local from the IED level. The local/remote switch is normally situated on the control/protection IED itself, which means that the position of the switch and its validity information are connected internally, and not via I/O boards. When the switch is mounted separately on the IED the signals are connected to the function via I/O boards.

When the local panel switch is in Off position all commands from remote and local level will be ignored. If the position for the local/remote switch is not valid the PSTO output will always be set to faulty state (3), which means no possibility to operate.

To adapt the signals from the local HMI or from an external local/remote switch, the function blocks LOCREM and LOCREMCTRL are needed and connected to QCBAY.

Permitted Source To Operate (PSTO)

The actual state of the operator place is presented by the value of the Permitted Source To Operate, PSTO signal. The PSTO value is evaluated from the local/ remote switch position according to table 182. In addition, there is one configuration parameter that affects the value of the PSTO signal. If the parameter *AllPSTOValid* is set and LR-switch position is in Local or Remote state, the PSTO value is set to 5 (all), that is, it is permitted to operate from both local and remote level without any priority. When the external panel switch is in Off position the PSTO value shows the actual state of switch that is, 0. In this case it is not possible to control anything.

Table 182: *PSTO values for different Local panel switch positions*

Local panel switch positions	PSTO value	AllPSTOValid (configuration parameter)	Possible locations that shall be able to operate
0 = Off	0	--	Not possible to operate
1 = Local	1	FALSE	Local Panel
1 = Local	5	TRUE	Local or Remote level without any priority
2 = Remote	2	FALSE	Remote level
2 = Remote	5	TRUE	Local or Remote level without any priority
3 = Faulty	3	--	Not possible to operate

Blockings

The blocking states for position indications and commands are intended to provide the possibility for the user to make common blockings for the functions configured within a complete bay.

The blocking facilities provided by the bay control function are the following:

- Blocking of position indications, BL_UPD. This input will block all inputs related to apparatus positions for all configured functions within the bay.
- Blocking of commands, BL_CMD. This input will block all commands for all configured functions within the bay.
- Blocking of function, BLOCK, signal from DO (Data Object) Behavior (IEC 61850–8–1). 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 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.

8.3.9.5   Local remote/Local remote control LOCREM/LOCREMCTRL

The function block Local remote (LOCREM) handles the signals coming from the local/remote switch. The connections are seen in figure 113, 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).

IEC09000208_1_en.vsd
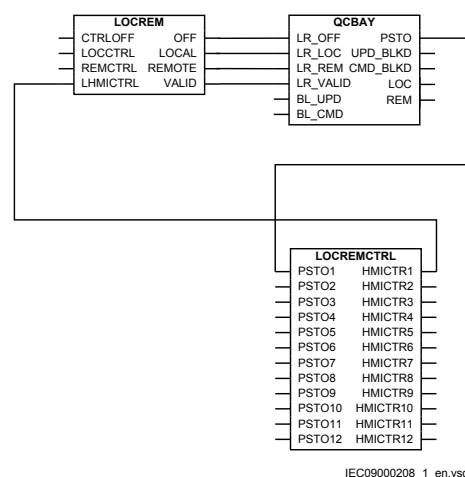
Figure 113:   Configuration for the local/remote handling for a local HMI with two bays and two screen pages

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.

8.4 Interlocking

8.4.1 Functionality

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.

8.4.2 Logical node for interlocking SCILO

8.4.2.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Logical node for interlocking	SCILO	-	-

8.4.2.2 Functionality

The Logical node for interlocking (SCILO) function is used to enable a switching operation if the interlocking conditions permit. The function itself does not provide any interlocking functionality. The interlocking conditions are generated in separate function blocks containing the interlocking logic.

8.4.2.3 Function block
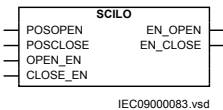
Figure 114:   SCILO function block

8.4.2.4 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.
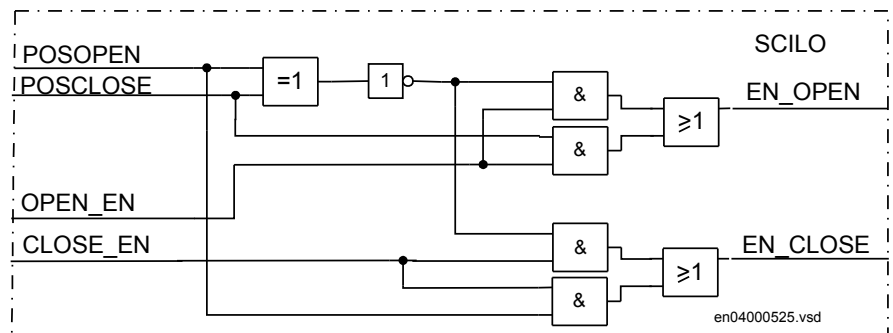
Figure 115:   SCILO function logic diagram

8.4.2.5 Signals

Table 183:   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 184:   SCILO Output signals

Name	Type	Description
EN_OPEN	BOOLEAN	Open operation at closed or intermediate or bad position is enabled
EN_CLOSE	BOOLEAN	Close operation at open or intermediate or bad position is enabled

8.4.2.6 Settings

The function does not have any settings available in Local HMI or Protection and Control IED Manager (PCM600).

8.4.3 Interlocking for busbar earthing switch BB_ES

8.4.3.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Interlocking for busbar earthing switch	BB_ES	-	-

8.4.3.2 Functionality

The Interlocking for busbar earthing switch (BB_ES) module is used for one busbar earthing switch on any busbar parts according to figure 116.

QC

en04000504.vsd
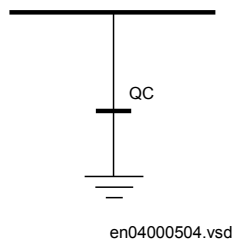
Figure 116: *Switchyard layout BB_ES*

8.4.3.3 Function block

BB_ES
QC_OP   QCREL
QC_CL   QCITL
BB_DC_OP   BBESOPTR
VP_BB_DC   BBESCLTR
EXDU_BB

IEC09000071_1_en.vsd
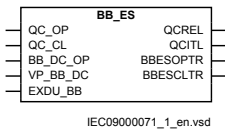
Figure 117: *BB_ES function block*

8.4.3.4 Logic diagram

BB_ES

VP_BB_DC   QCREL
BB_DC_OP   &   QCITL
EXDU_BB   1

QC_OP   BBESOPTR
QC_CL   BBESCLTR
en04000546.vsd
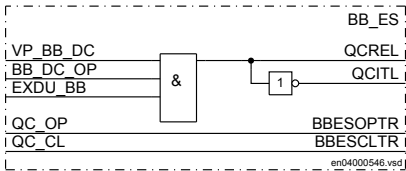
8.4.3.5 Signals

Table 185: 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 transmission error from any bay containing all disconnectors on this busbar part

Table 186: 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

8.4.3.6 Settings

The function does not have any settings available in Local HMI or Protection and Control IED Manager (PCM600).

8.4.4 Interlocking for bus-section breaker A1A2_BS

8.4.4.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Interlocking for bus-section breaker	A1A2_BS	-	-

8.4.4.2 Functionality

The Interlocking for bus-section breaker (A1A2_BS) module is used for one bus-section circuit breaker between section 1 and 2 according to figure 118. The module can be used for different busbars, which includes a bus-section circuit breaker.
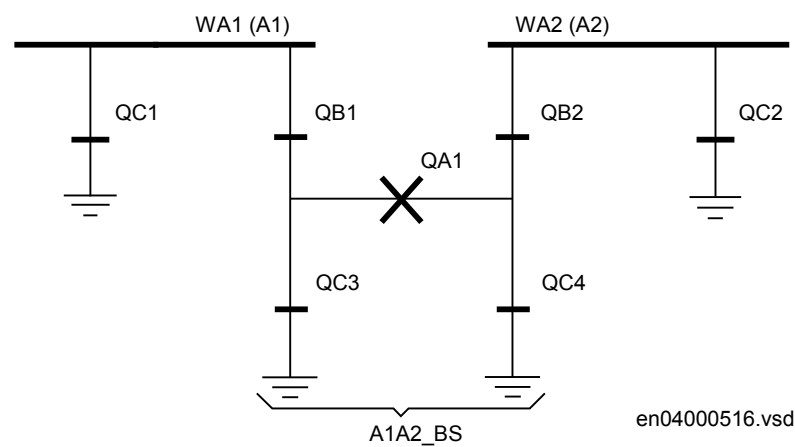
Figure 118: Switchyard layout A1A2_BS

8.4.4.3 Function block
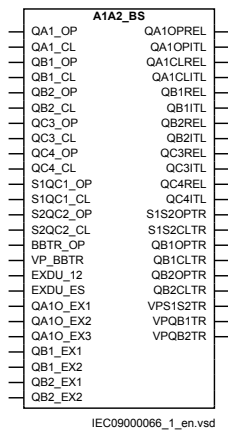
Figure 119: A1A2_BS function block

8.4.4.4 Logic diagram

en04000542.vsd

en04000543.vsd
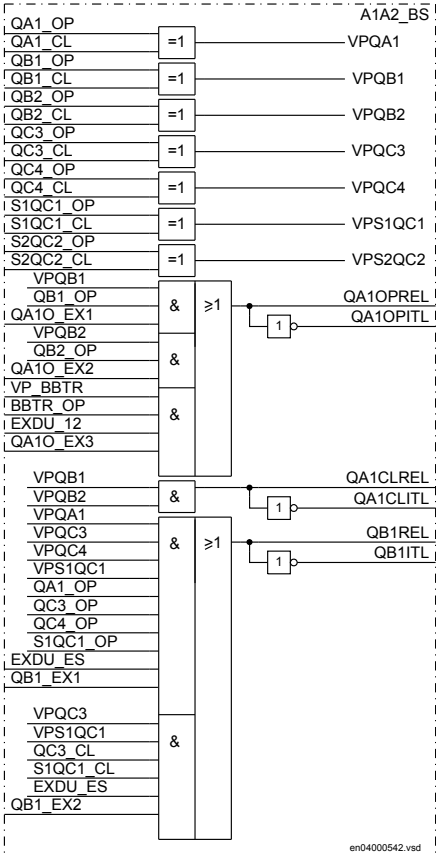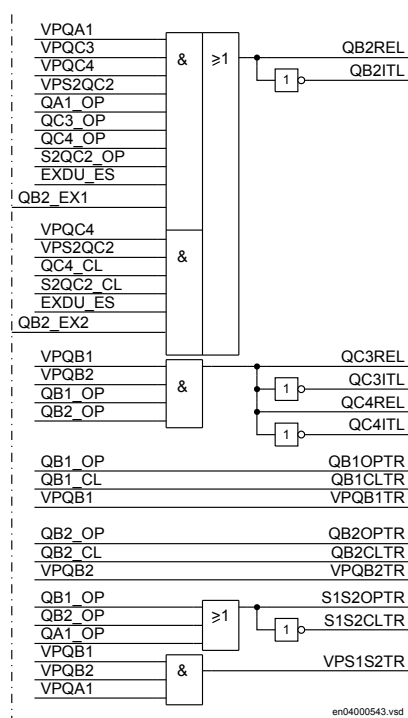
8.4.4.5 Signals

Table 187: *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 apparatuses involved in the busbar transfer
Table continues on next page			

Name	Type	Default	Description
EXDU_12	BOOLEAN	0	No transmission error from any bay connected to busbar 1 and 2
EXDU_ES	BOOLEAN	0	No transmission error from bays containing earthing switches 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 188:   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 apparatuses 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)

8.4.4.6 Settings

The function does not have any settings available in Local HMI or Protection and Control IED Manager (PCM600).

8.4.5 Interlocking for bus-section disconnector A1A2_DC

8.4.5.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Interlocking for bus-section disconnector	A1A2_DC	-	-

8.4.5.2 Functionality

The Interlocking for bus-section disconnector (A1A2_DC) module is used for one bus-section disconnector between section 1 and 2 according to figure 120. The module can be used for different busbars, which includes a bus-section disconnector.
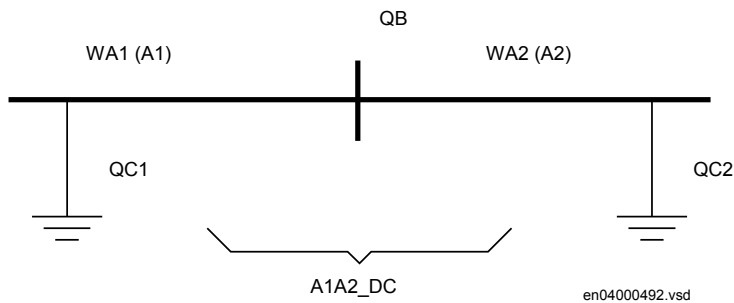
Figure 120:   Switchyard layout A1A2_DC

8.4.5.3 Function block
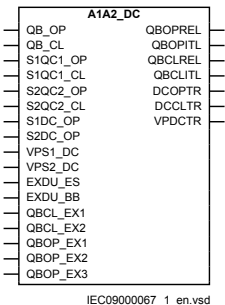
Figure 121:   A1A2_DC function block

8.4.5.4 Logic diagram

en04000544.vsd

en04000545.vsd
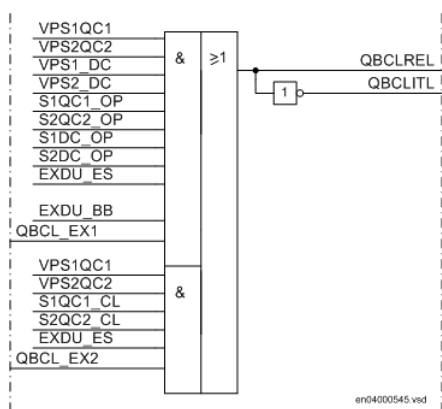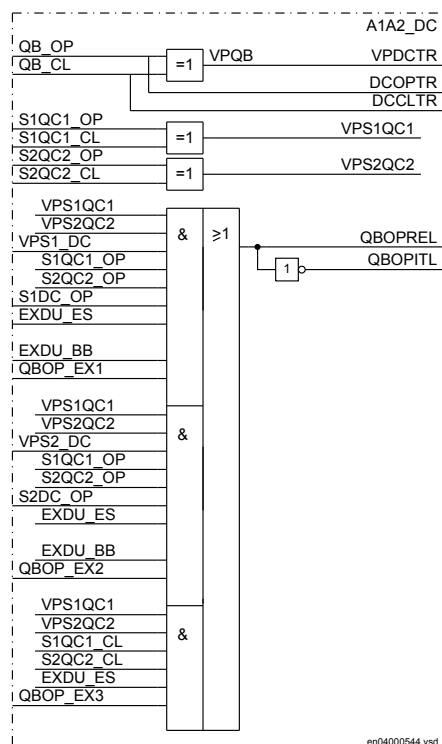
8.4.5.5 Signals

Table 189:   *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 transmission error from bays containing earthing switches QC1 or QC2
EXDU_BB	BOOLEAN	0	No transmission error from bays with disconnectors connected to sections 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 190:   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)

8.4.5.6   Settings

The function does not have any settings available in Local HMI or Protection and Control IED Manager (PCM600).

8.4.6 Interlocking for bus-coupler bay ABC_BC

8.4.6.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Interlocking for bus-coupler bay	ABC_BC	-	-

8.4.6.2 Functionality

The Interlocking for bus-coupler bay (ABC_BC) module is used for a bus-coupler bay connected to a double busbar arrangement according to figure 122. The module can also be used for a single busbar arrangement with transfer busbar or double busbar arrangement without transfer busbar.
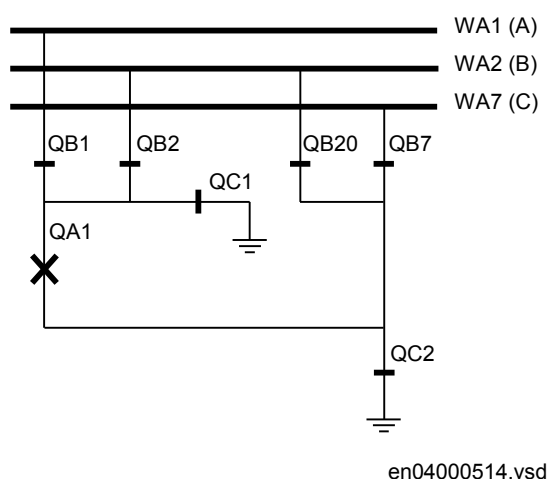
Figure 122:   Switchyard layout ABC_BC

The interlocking functionality in 650 series can not handle the transfer bus (WA7)C.

8.4.6.3   Function block

| ABC_BC |
QA1_OP	QA1OPREL
QA1_CL	QA1OPITL
QB1_OP	QA1CLREL
QB1_CL	QA1CLITL
QB2_OP	QB1REL
QB2_CL	QB1ITL
QB7_OP	QB2REL
QB7_CL	QB2ITL
QB20_OP	QB7REL
QB20_CL	QB7ITL
QC1_OP	QB20REL
QC1_CL	QB20ITL
QC2_OP	QC1REL
QC2_CL	QC1ITL
QC11_OP	QC2REL
QC11_CL	QC2ITL
QC21_OP	QB1OPTR
QC21_CL	QB1CLTR
QC71_OP	QB220OTR
QC71_CL	QB220CTR
BBTR_OP	QB7OPTR
BC_12_CL	QB7CLTR
VP_BBTR	QB12OPTR
VP_BC_12	QB12CLTR
EXDU_ES	BC12OPTR
EXDU_12	BC12CLTR
EXDU_BC	BC17OPTR
QA1O_EX1	BC17CLTR
QA1O_EX2	BC27OPTR
QA1O_EX3	BC27CLTR
QB1_EX1	VPQB1TR
QB1_EX2	VQB220TR
QB1_EX3	VPQB7TR
QB2_EX1	VPQB12TR
QB2_EX2	VPBC12TR
QB2_EX3	VPBC17TR
QB20_EX1	VPBC27TR
QB20_EX2	
QB7_EX1	
QB7_EX2	

IEC09000069_1_en.vsd

Figure 123:   ABC_BC function block

8.4.6.4   Logic diagram

en04000533.vsd

```
VPQA1
VPQB2
VPQC1        &    ≥1              QB1REL
VPQC2                             QB1ITL
VPQC11                    1
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
QB1_EX3
                 en04000534.vsd
```



```
VPQA1
VPQB1
VPQC1        &    ≥1              QB2REL
VPQC2                             QB2ITL
VPQC21                    1
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
                 en04000535.vsd
```

en04000536.vsd

en04000537.vsd

8.4.6.5 Signals

Table 191:   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
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	Bus coupler connection exists between busbar WA1 and WA2
VP_BBTR	BOOLEAN	0	Status are valid for apparatuses involved in the busbar transfer
VP_BC_12	BOOLEAN	0	Status of the bus coupler apparatuses between WA1 and WA2 are valid
EXDU_ES	BOOLEAN	0	No transmission error from any bay containing earthing switches
EXDU_12	BOOLEAN	0	No transmission 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
Table continues on next page			

Name	Type	Default	Description
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 192:   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
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
QB22OOTR	BOOLEAN	QB2 and QB20 are in open position
QB22OCTR	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
Table continues on next page		

Name	Type	Description
BC12OPTR	BOOLEAN	No connection via the own bus coupler between WA1 and WA2
BC12CLTR	BOOLEAN	Connection 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	Connection 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	Connection 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 apparatuses between WA1 and WA2 are valid
VPBC17TR	BOOLEAN	Status of the bus coupler apparatuses between WA1 and WA7 are valid
VPBC27TR	BOOLEAN	Status of the bus coupler apparatuses between WA2 and WA7 are valid

8.4.6.6　　　　　Settings

The function does not have any settings available in Local HMI or Protection and Control IED Manager (PCM600).

8.4.7　　　　Interlocking for 1 1/2 breaker diameter

8.4.7.1　　　　Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Interlocking for 1 1/2 breaker diameter	BH_CONN	-	-
Interlocking for 1 1/2 breaker diameter	BH_LINE_A	-	-
Interlocking for 1 1/2 breaker diameter	BH_LINE_B	-	-

8.4.7.2　　　　Functionality

The Interlocking for 1 1/2 breaker diameter (BH_CONN, BH_LINE_A, BH_LINE_B) modules are used for lines connected to a 1 1/2 breaker diameter according to figure 124.
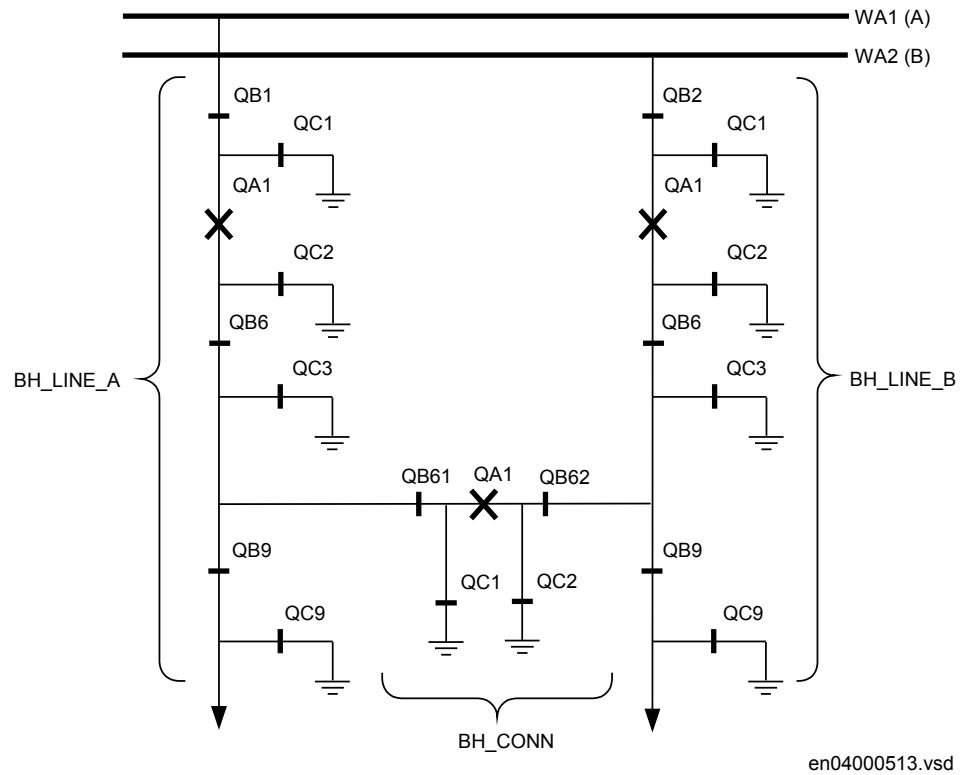
Figure 124: *Switchyard layout 1 1/2 breaker*

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.

8.4.7.3 Function block
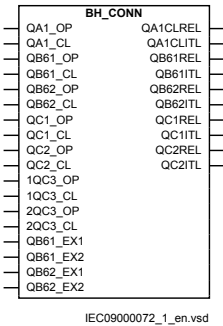
Figure 125: *BH_CONN function block*

```
                  BH_LINE_A
        QA1_OP          QA1CLREL
        QA1_CL          QA1CLITL
        QB6_OP           QB6REL
        QB6_CL           QB6ITL
        QB1_OP           QB1REL
        QB1_CL           QB1ITL
        QC1_OP           QC1REL
        QC1_CL           QC1ITL
        QC2_OP           QC2REL
        QC2_CL           QC2ITL
        QC3_OP           QC3REL
        QC3_CL           QC3ITL
        QB9_OP           QB9REL
        QB9_CL           QB9ITL
        QC9_OP           QC9REL
        QC9_CL           QC9ITL
        CQA1_OP         QB1OPTR
        CQA1_CL         QB1CLTR
        CQB61_OP        VPQB1TR
        CQB61_CL
        CQC1_OP
        CQC1_CL
        CQC2_OP
        CQC2_CL
        QC11_OP
        QC11_CL
        VOLT_OFF
        VOLT_ON
        EXDU_ES
        QB6_EX1
        QB6_EX2
        QB1_EX1
        QB1_EX2
        QB9_EX1
        QB9_EX2
        QB9_EX3
        QB9_EX4
        QB9_EX5
        QB9_EX6
        QB9_EX7
                  IEC09000073_1_en.vsd
```

Figure 126:   BH_LINE_A function block

```
                  BH_LINE_B
        QA1_OP          QA1CLREL
        QA1_CL          QA1CLITL
        QB6_OP           QB6REL
        QB6_CL           QB6ITL
        QB2_OP           QB2REL
        QB2_CL           QB2ITL
        QC1_OP           QC1REL
        QC1_CL           QC1ITL
        QC2_OP           QC2REL
        QC2_CL           QC2ITL
        QC3_OP           QC3REL
        QC3_CL           QC3ITL
        QB9_OP           QB9REL
        QB9_CL           QB9ITL
        QC9_OP           QC9REL
        QC9_CL           QC9ITL
        CQA1_OP         QB2OPTR
        CQA1_CL         QB2CLTR
        CQB62_OP        VPQB2TR
        CQB62_CL
        CQC1_OP
        CQC1_CL
        CQC2_OP
        CQC2_CL
        QC21_OP
        QC21_CL
        VOLT_OFF
        VOLT_ON
        EXDU_ES
        QB6_EX1
        QB6_EX2
        QB2_EX1
        QB2_EX2
        QB9_EX1
        QB9_EX2
        QB9_EX3
        QB9_EX4
        QB9_EX5
        QB9_EX6
        QB9_EX7
                  IEC09000081_1_en.vsd
```

Figure 127:   BH_LINE_B function block

8.4.7.4 Logic diagrams

en04000560.vsd

en04000554.vsd

en04000555.vsd

en04000556.vsd

en04000557.vsd

en04000558.vsd

en04000559.vsd
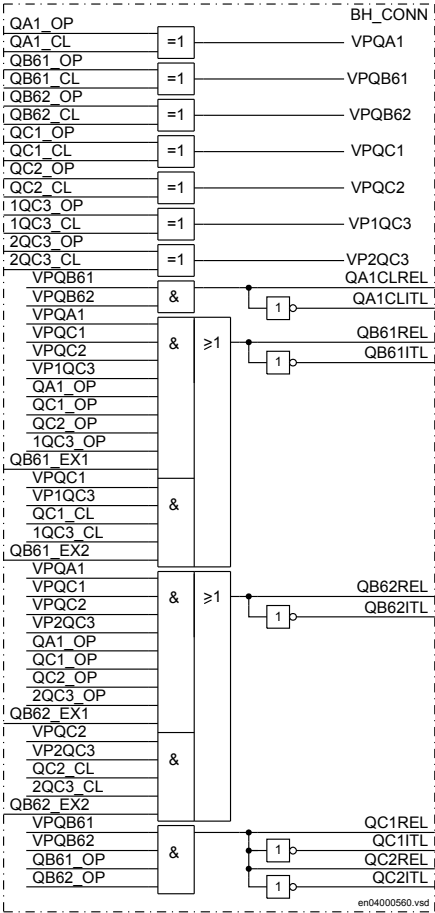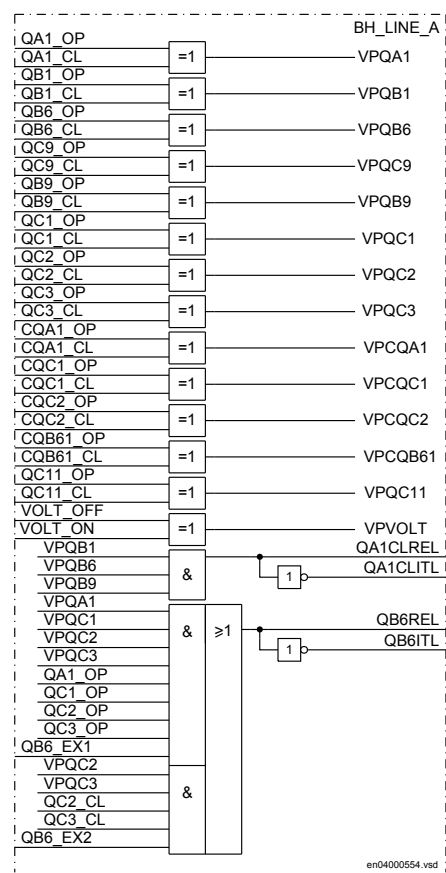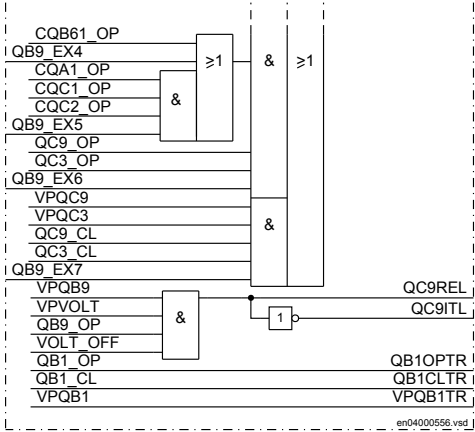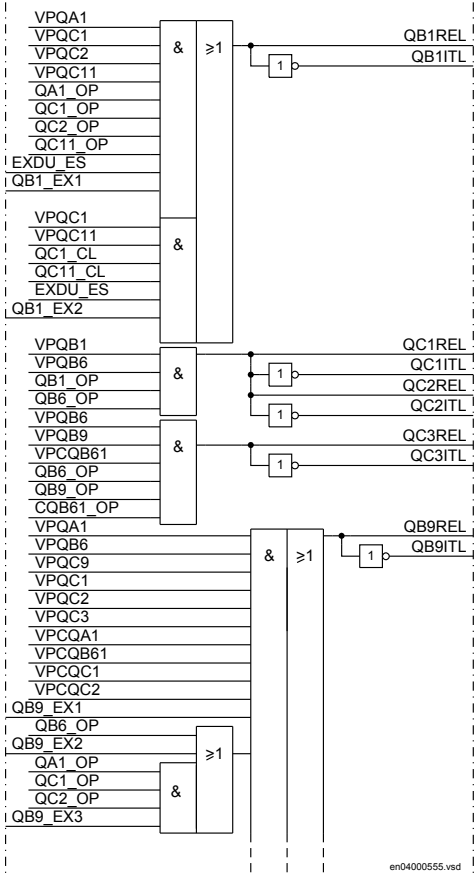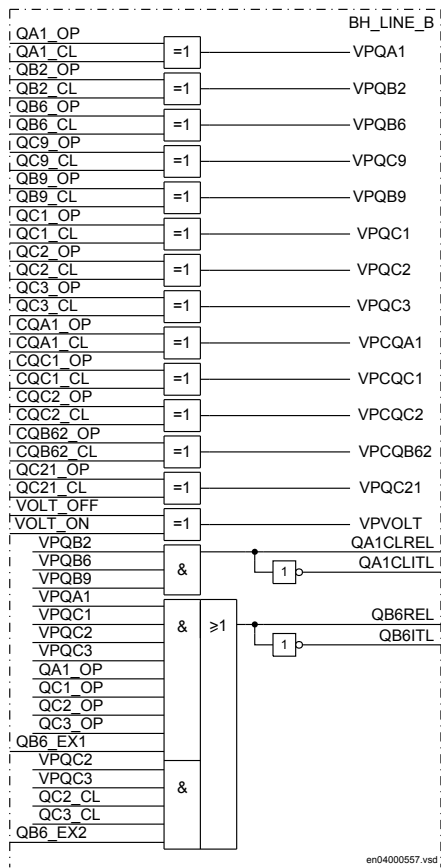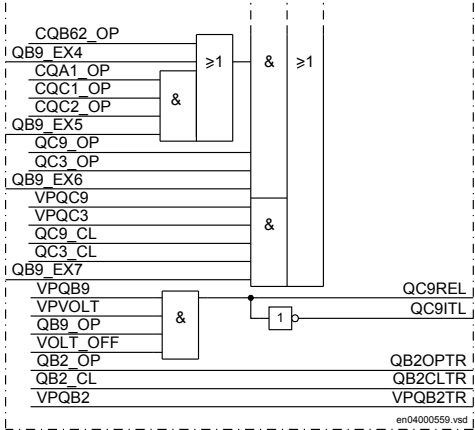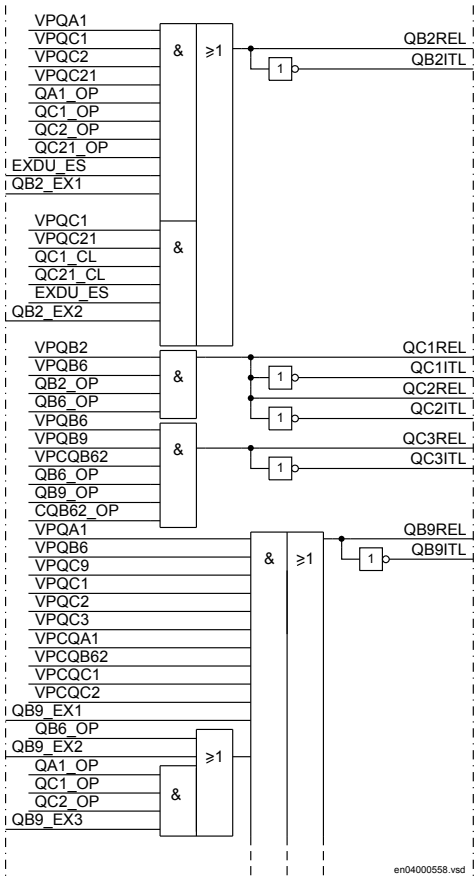
8.4.7.5 Signals

Table 193: *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
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 194: *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
Table continues on next page			

Name	Type	Default	Description
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 transmission 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
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 195: *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
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
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 transmission 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 196:   *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

Table 197:   *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 198:   *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)

8.4.7.6   Settings

The function does not have any settings available in Local HMI or Protection and
Control IED Manager (PCM600).

8.4.8   Interlocking for double CB bay

8.4.8.1   Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Interlocking for double CB bay	DB_BUS_A	-	-
Interlocking for double CB bay	DB_BUS_B	-	-
Interlocking for double CB bay	DB_LINE	-	-

8.4.8.2   Functionality

The Interlocking for 1 1/2 breaker diameter (DB_BUS_A, DB_BUS_B, DB_LINE) modules are used for a line connected to a double circuit breaker arrangement according to figure 128.
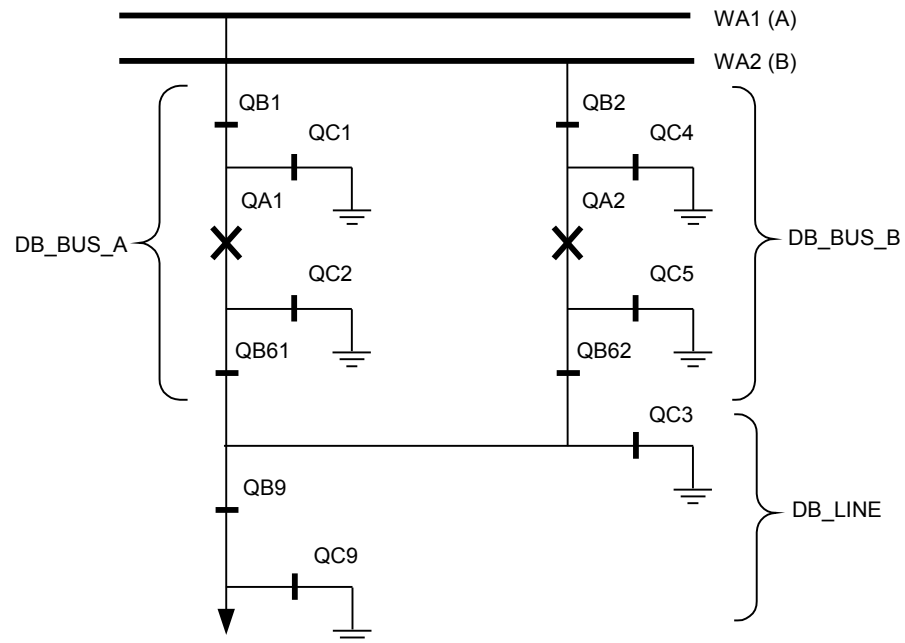
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Figure 128:   Switchyard layout double circuit breaker.

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.

8.4.8.3   Function block
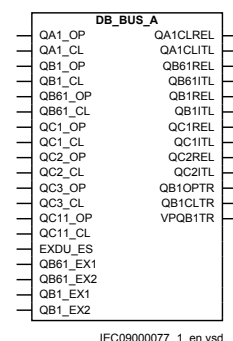
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Figure 129:   DB_BUS_A function block

```
                    ┌─────────────────────┐
                    │      DB_BUS_B       │
                  ──┤ QA2_OP      QA2CLREL ├──
                  ──┤ QA2_CL      QA2CLITL ├──
                  ──┤ QB2_OP       QB62REL ├──
                  ──┤ QB2_CL       QB62ITL ├──
                  ──┤ QB62_OP       QB2REL ├──
                  ──┤ QB62_CL       QB2ITL ├──
                  ──┤ QC4_OP        QC4REL ├──
                  ──┤ QC4_CL        QC4ITL ├──
                  ──┤ QC5_OP        QC5REL ├──
                  ──┤ QC5_CL        QC5ITL ├──
                  ──┤ QC3_OP       QB2OPTR ├──
                  ──┤ QC3_CL       QB2CLTR ├──
                  ──┤ QC21_OP       VPQB2TR ├──
                  ──┤ QC21_CL              │
                  ──┤ EXDU_ES             │
                  ──┤ QB62_EX1            │
                  ──┤ QB62_EX2            │
                  ──┤ QB2_EX1             │
                  ──┤ QB2_EX2             │
                    └─────────────────────┘
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```
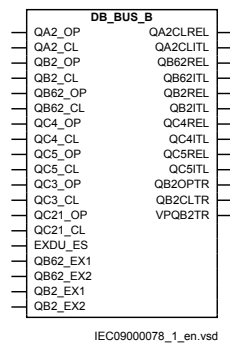
Figure 130:   DB_BUS_B function block

```
                    ┌─────────────────────┐
                    │       DB_LINE       │
                  ──┤ QA1_OP        QB9REL ├──
                  ──┤ QA1_CL        QB9ITL ├──
                  ──┤ QA2_OP        QC3REL ├──
                  ──┤ QA2_CL        QC3ITL ├──
                  ──┤ QB61_OP       QC9REL ├──
                  ──┤ QB61_CL       QC9ITL ├──
                  ──┤ QC1_OP              │
                  ──┤ QC1_CL              │
                  ──┤ QC2_OP              │
                  ──┤ QC2_CL              │
                  ──┤ QB62_OP             │
                  ──┤ QB62_CL             │
                  ──┤ QC4_OP              │
                  ──┤ QC4_CL              │
                  ──┤ QC5_OP              │
                  ──┤ QC5_CL              │
                  ──┤ QB9_OP              │
                  ──┤ QB9_CL              │
                  ──┤ QC3_OP              │
                  ──┤ QC3_CL              │
                  ──┤ QC9_OP              │
                  ──┤ QC9_CL              │
                  ──┤ VOLT_OFF            │
                  ──┤ VOLT_ON             │
                  ──┤ QB9_EX1             │
                  ──┤ QB9_EX2             │
                  ──┤ QB9_EX3             │
                  ──┤ QB9_EX4             │
                  ──┤ QB9_EX5             │
                    └─────────────────────┘
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```
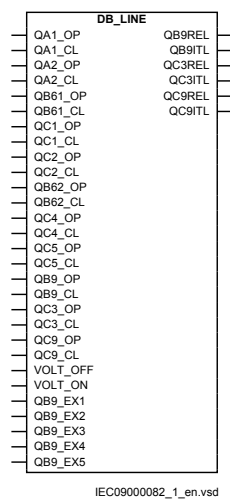
Figure 131:   DB_LINE function block

8.4.8.4 Logic diagrams

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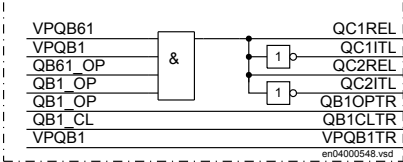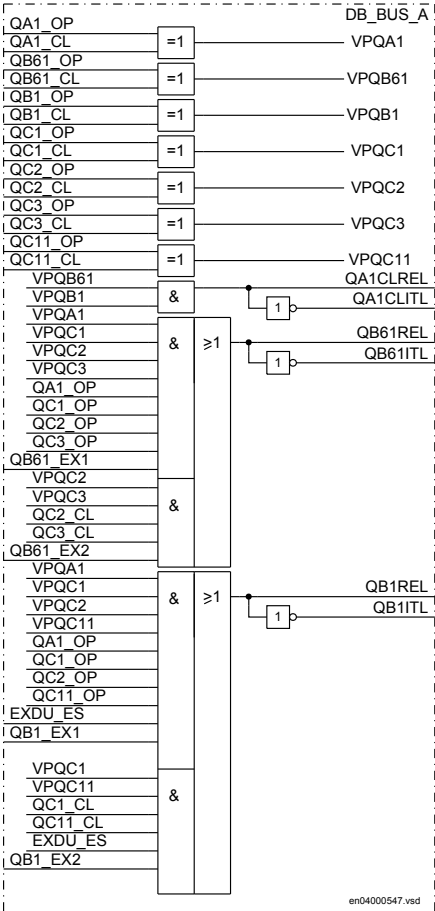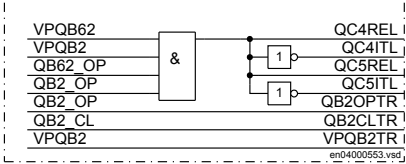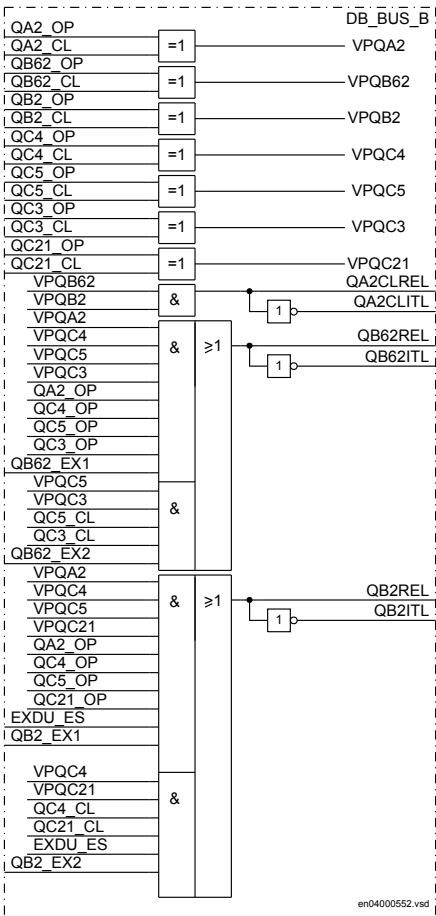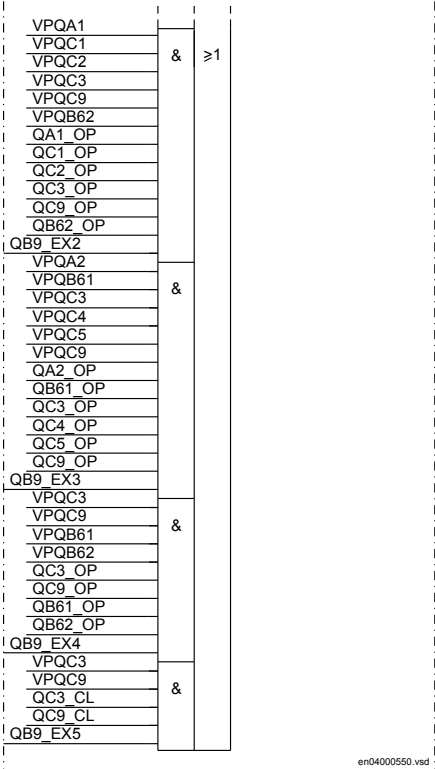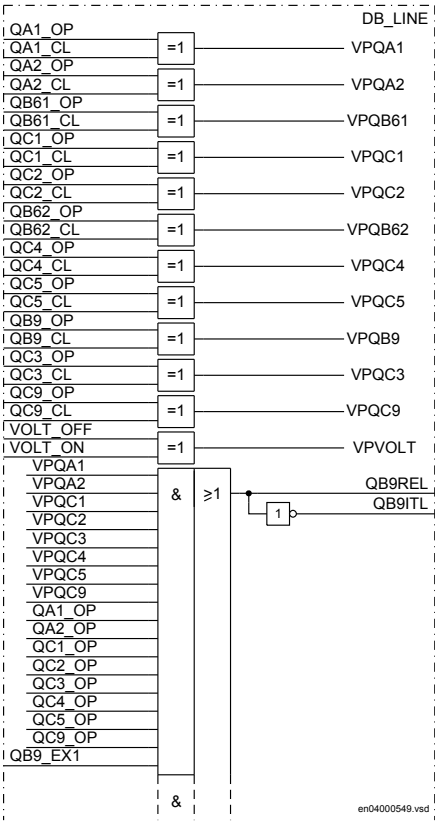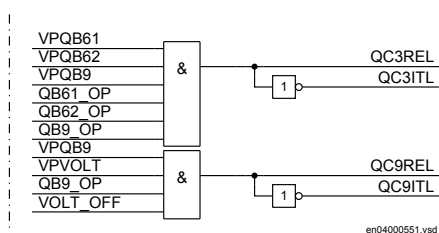
8.4.8.5 Signals

Table 199:   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 transmission 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 200:   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
Table continues on next page			

Name	Type	Default	Description
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 transmission 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 201:   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
Table continues on next page			

Name	Type	Default	Description
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
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 202:   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
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 203:   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
Table continues on next page		

Name	Type	Description
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)

Table 204:   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

8.4.8.6   Settings

The function does not have any settings available in Local HMI or Protection and Control IED Manager (PCM600).

8.4.9   Interlocking for line bay ABC_LINE

8.4.9.1   Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Interlocking for line bay	ABC_LINE	-	-

8.4.9.2   Functionality

Interlocking for line bay (ABC_LINE) module is used for a line connected to a double busbar arrangement with a transfer busbar according to figure 132. The module can also be used for a double busbar arrangement without transfer busbar or a single busbar arrangement with/without transfer busbar.

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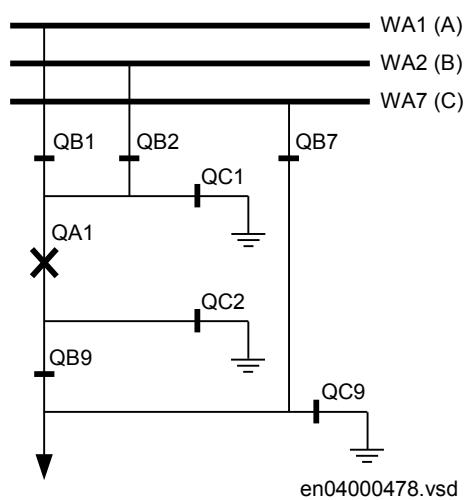
Figure 132: *Switchyard layout ABC_LINE*

The interlocking functionality in 650 series can not handle the transfer bus (WA7)C.
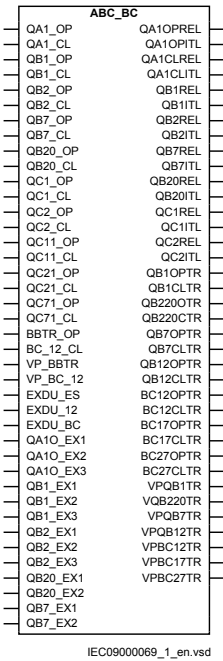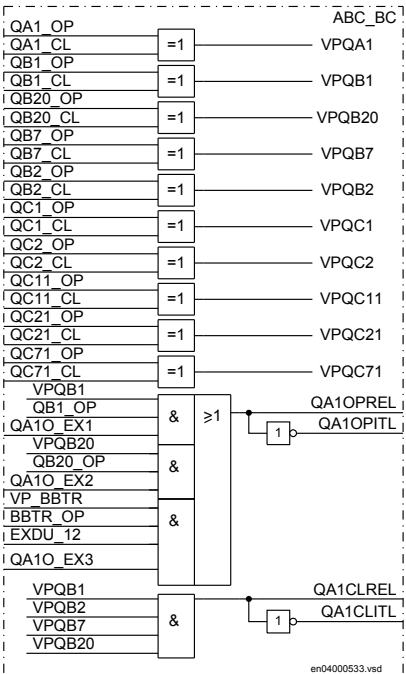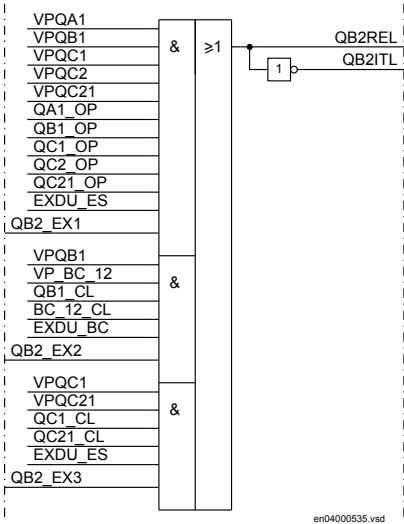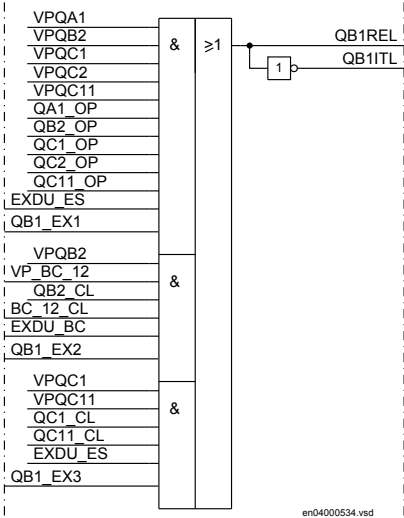
8.4.9.3 Function block


```
                    ABC_LINE
     — QA1_OP            QA1CLREL —
     — QA1_CL            QA1CLITL —
     — QB9_OP              QB9REL —
     — QB9_CL              QB9ITL —
     — QB1_OP              QB1REL —
     — QB1_CL              QB1ITL —
     — QB2_OP              QB2REL —
     — QB2_CL              QB2ITL —
     — QB7_OP              QB7REL —
     — QB7_CL              QB7ITL —
     — QC1_OP              QC1REL —
     — QC1_CL              QC1ITL —
     — QC2_OP              QC2REL —
     — QC2_CL              QC2ITL —
     — QC9_OP              QC9REL —
     — QC9_CL              QC9ITL —
     — QC11_OP            QB1OPTR —
     — QC11_CL            QB1CLTR —
     — QC21_OP            QB2OPTR —
     — QC21_CL            QB2CLTR —
     — QC71_OP            QB7OPTR —
     — QC71_CL            QB7CLTR —
     — BB7_D_OP          QB12OPTR —
     — BC_12_CL          QB12CLTR —
     — BC_17_OP           VPQB1TR —
     — BC_17_CL           VPQB2TR —
     — BC_27_OP           VPQB7TR —
     — BC_27_CL          VPQB12TR —
     — VOLT_OFF
     — VOLT_ON
     — VP_BB7_D
     — VP_BC_12
     — VP_BC_17
     — VP_BC_27
     — EXDU_ES
     — EXDU_BPB
     — EXDU_BC
     — QB9_EX1
     — QB9_EX2
     — QB1_EX1
     — QB1_EX2
     — QB1_EX3
     — QB2_EX1
     — QB2_EX2
     — QB2_EX3
     — QB7_EX1
     — QB7_EX2
     — QB7_EX3
     — QB7_EX4

            IEC09000070_1_en.vsd
```

Figure 133:   ABC_LINE function block

8.4.9.4 Logic diagram

en04000527.vsd

en04000528.vsd

en04000529.vsd

en04000531.vsd
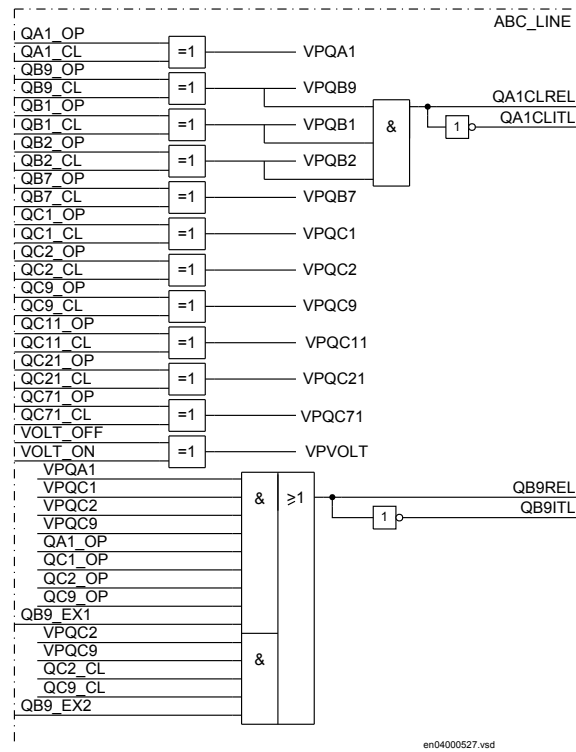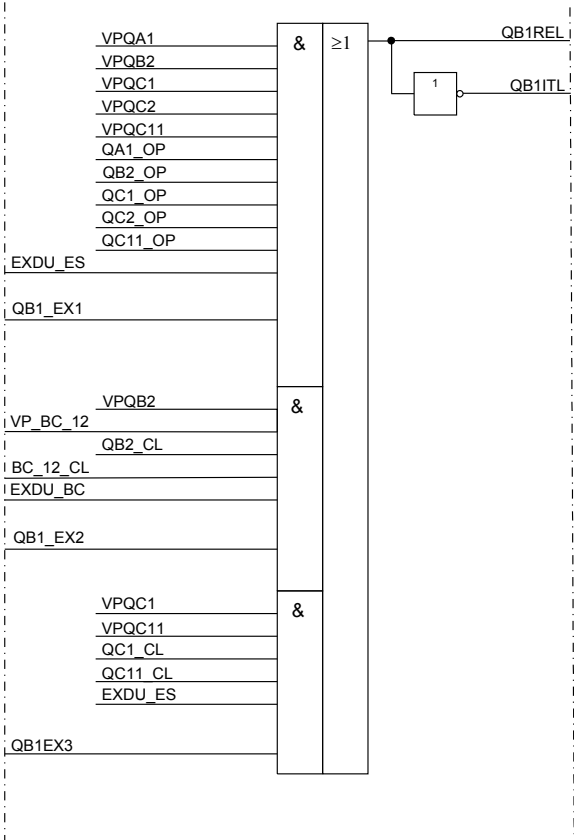
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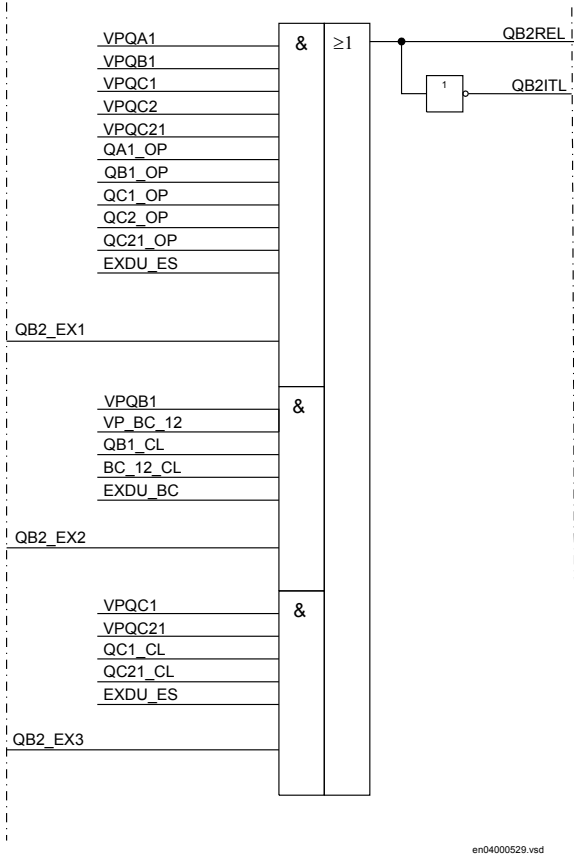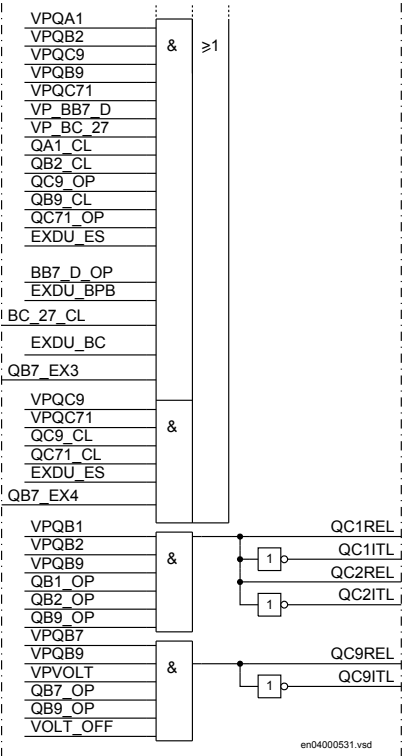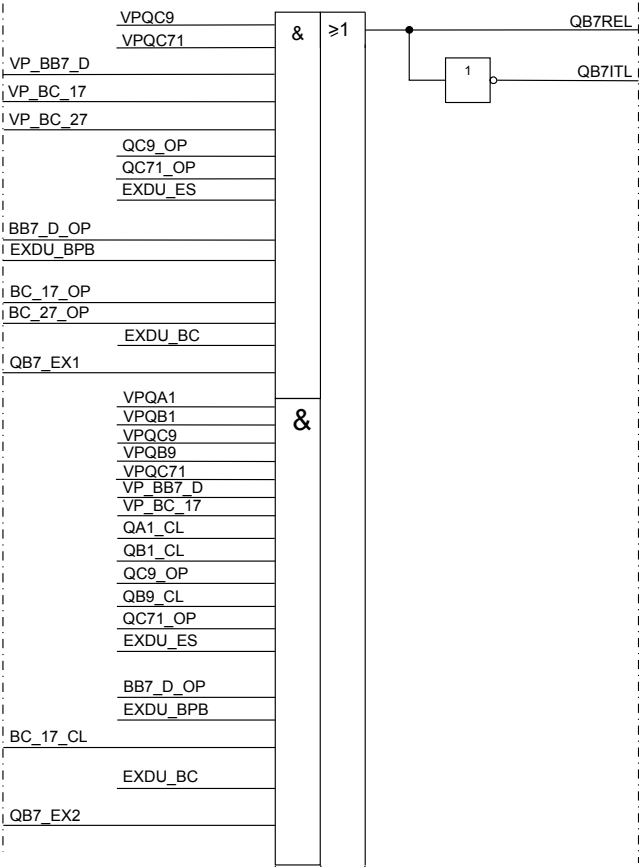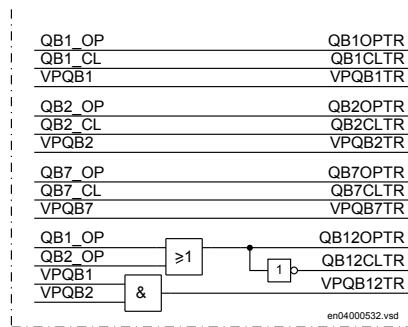
8.4.9.5 Signals

Table 205: *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
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
Table continues on next page			

Name	Type	Default	Description
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 apparatuses between WA1 and WA2 are valid
VP_BC_17	BOOLEAN	0	Status of the bus coupler apparatuses between WA1 and WA7 are valid
VP_BC_27	BOOLEAN	0	Status of the bus coupler apparatus between WA2 and WA7 are valid
EXDU_ES	BOOLEAN	0	No transmission error from any bay containing earthing switches
EXDU_BPB	BOOLEAN	0	No transmission 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
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 206: 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)

8.4.9.6   Settings

The function does not have any settings available in Local HMI or Protection and Control IED Manager (PCM600).

8.4.10   Interlocking for transformer bay AB_TRAFO

8.4.10.1   Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Interlocking for transformer bay	AB_TRAFO	-	-

8.4.10.2   Functionality

The Interlocking for transformer bay (AB_TRAFO) module is used for a transformer bay connected to a double busbar arrangement according to figure 134. The module is used when there is no disconnector between circuit breaker and transformer. Otherwise, the Interlocking for line bay (ABC_LINE) module can be used. This module can also be used in single busbar arrangements.

en04000515.vsd
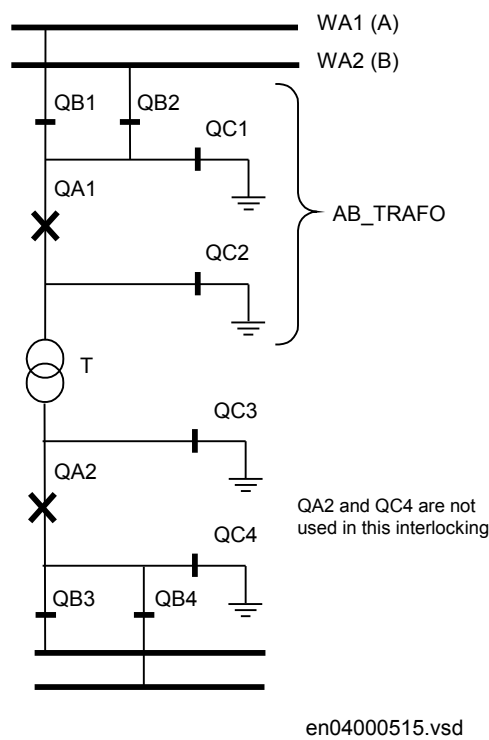
Figure 134:   Switchyard layout AB_TRAFO

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8.4.10.3 Function block
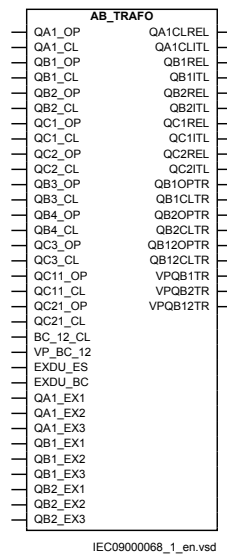
Figure 135:   AB_TRAFO function block

8.4.10.4 Logic diagram

en04000539.vsd

en04000540.vsd

en04000541.vsd
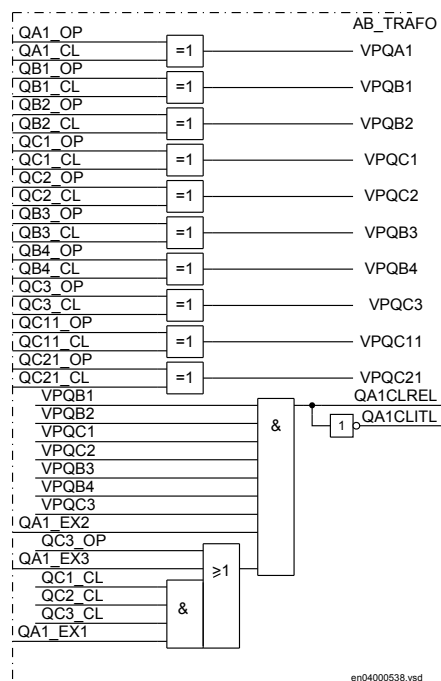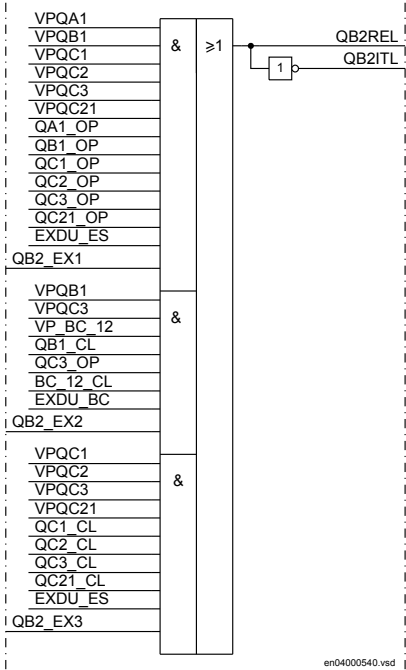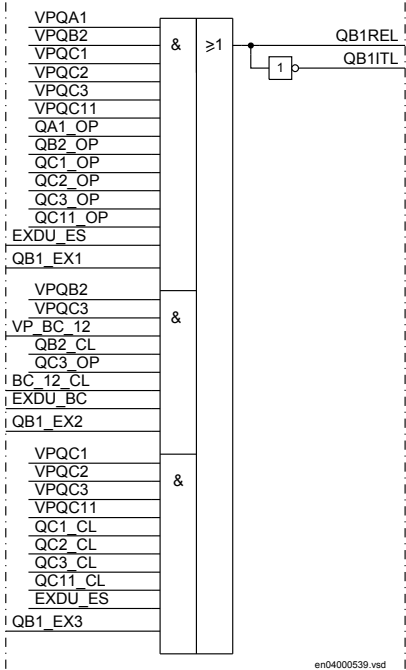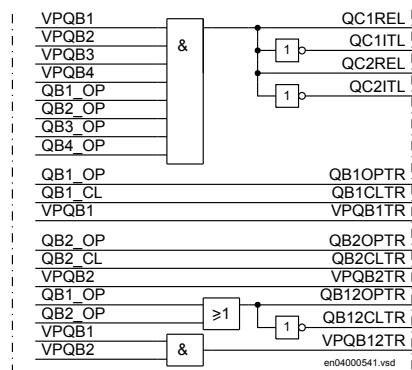
8.4.10.5 Signals

Table 207: *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
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 apparatuses between WA1 and WA2 are valid
EXDU_ES	BOOLEAN	0	No transmission error from any bay containing earthing switches
EXDU_BC	BOOLEAN	0	No transmission error from any bus coupler bay
Table continues on next page			

Name	Type	Default	Description
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 208: 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
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)

8.4.10.6   Settings

The function does not have any settings available in Local HMI or Protection and Control IED Manager (PCM600).

8.4.11 Position evaluation POS_EVAL

8.4.11.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Position evaluation	POS_EVAL	-	-

8.4.11.2 Functionality

Position evaluation (POS_EVAL) function converts the input position data signal POSITION, consisting of value, time and signal status, to binary signals POSOPEN or POSCLOSE.

The output signals are used by other functions in the interlocking scheme.

8.4.11.3 Function block


```
        POS_EVAL
── POSITION     OPENPOS ──
                CLOSEPOS ──
     IEC09000079_1_en.vsd
```
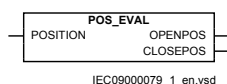
Figure 136:   POS_EVAL function block

8.4.11.4 Logic diagram
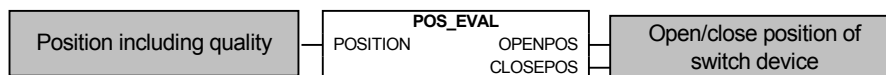

```
                          POS_EVAL
┌──────────────────────┐ ┌───────────────────┐ ┌──────────────────────┐
│ Position including   │─│ POSITION  OPENPOS │─│ Open/close position of│
│ quality              │ │           CLOSEPOS│ │ switch device         │
└──────────────────────┘ └───────────────────┘ └──────────────────────┘
                                              IEC08000469-1-en.vsd
```

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

8.4.11.5 Signals

Table 209: *POS_EVAL Input signals*

Name	Type	Default	Description
POSITION	INTEGER	0	Position status including quality

Table 210: *POS_EVAL Output signals*

Name	Type	Description
OPENPOS	BOOLEAN	Open position
CLOSEPOS	BOOLEAN	Close position

8.4.11.6 Settings

The function does not have any settings available in Local HMI or Protection and Control IED Manager (PCM600).

8.4.12 Operation principle

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 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 137.
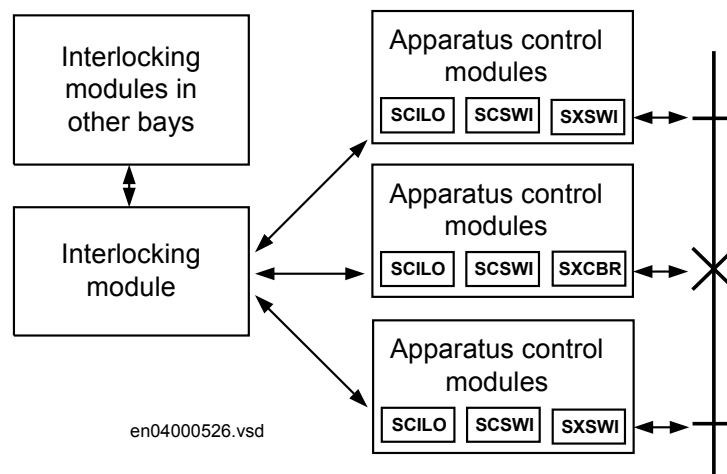
Figure 137:   Interlocking module on bay level.

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 138 illustrates the data exchange principle.
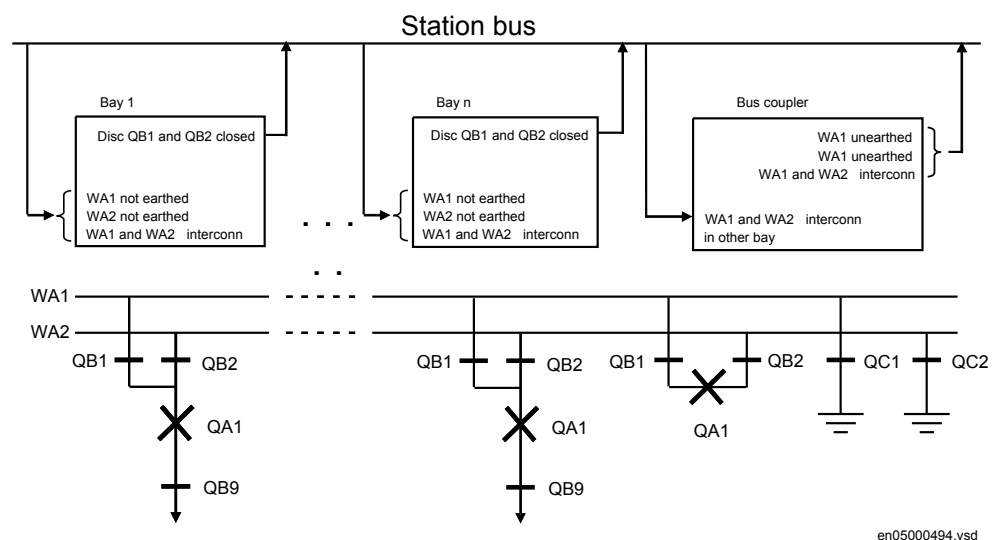
Figure 138:   Data exchange between interlocking modules.

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 station 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, i.e. 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 customers 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.

8.5 Logic rotating switch for function selection and LHMI presentation SLGGIO

8.5.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Logic rotating switch for function selection and LHMI presentation	SLGGIO	-	-

8.5.2 Functionality

The Logic rotating switch for function selection and LHMI presentation (SLGGIO) function block (or the selector switch function block) is used within the ACT tool in order to get a selector switch functionality similar with 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 extended purchase portfolio. The virtual selector switches eliminate all these problems.

8.5.3   Function block
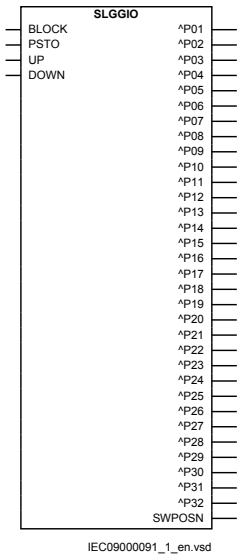
Figure 139:   *SLGGIO function block*

8.5.4   Signals

Table 211:   *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 212:   *SLGGIO Output signals*

Name	Type	Description
P01	BOOLEAN	Selector switch position 1
P02	BOOLEAN	Selector switch position 2
P03	BOOLEAN	Selector switch position 3
P04	BOOLEAN	Selector switch position 4
P05	BOOLEAN	Selector switch position 5
P06	BOOLEAN	Selector switch position 6
P07	BOOLEAN	Selector switch position 7
P08	BOOLEAN	Selector switch position 8
P09	BOOLEAN	Selector switch position 9
P10	BOOLEAN	Selector switch position 10
P11	BOOLEAN	Selector switch position 11
Table continues on next page		

Name	Type	Description
P12	BOOLEAN	Selector switch position 12
P13	BOOLEAN	Selector switch position 13
P14	BOOLEAN	Selector switch position 14
P15	BOOLEAN	Selector switch position 15
P16	BOOLEAN	Selector switch position 16
P17	BOOLEAN	Selector switch position 17
P18	BOOLEAN	Selector switch position 18
P19	BOOLEAN	Selector switch position 19
P20	BOOLEAN	Selector switch position 20
P21	BOOLEAN	Selector switch position 21
P22	BOOLEAN	Selector switch position 22
P23	BOOLEAN	Selector switch position 23
P24	BOOLEAN	Selector switch position 24
P25	BOOLEAN	Selector switch position 25
P26	BOOLEAN	Selector switch position 26
P27	BOOLEAN	Selector switch position 27
P28	BOOLEAN	Selector switch position 28
P29	BOOLEAN	Selector switch position 29
P30	BOOLEAN	Selector switch position 30
P31	BOOLEAN	Selector switch position 31
P32	BOOLEAN	Selector switch position 32
SWPOSN	INTEGER	Switch position as integer value

8.5.5 Settings

Table 213: 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
tPulse	0.000 - 60.000	s	0.001	0.200	Operate pulse duration
tDelay	0.000 - 60000.000	s	0.010	0.000	Output time delay
StopAtExtremes	Disabled Enabled	-	-	Disabled	Stop when min or max position is reached

8.5.6   Monitored data

Table 214:   *SLGGIO Monitored data*

Name	Type	Values (Range)	Unit	Description
SWPOSN	INTEGER	-	-	Switch position as integer value

8.5.7   Operation principle

The Logic rotating switch for function selection and LHMI presentation (SLGGIO) 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 ACT 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. The 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.

8.6   Selector mini switch VSGGIO

8.6.1   Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Selector mini switch	VSGGIO	-	-

8.6.2   Functionality

Selector mini switch (VSGGIO) function block is a multipurpose function used in the configuration tool in PCM600 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.

8.6.3   Function block

IEC09000341-1-en.vsd
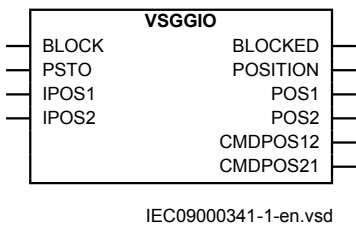
8.6.4   Signals

Table 215:   *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 216:   *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
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

8.6.5 Settings

Table 217: *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

8.6.6 Operation principle

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

8.7 IEC 61850 generic communication I/O functions DPGGIO

8.7.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
IEC 61850 generic communication I/O functions	DPGGIO	-	-

8.7.2 Functionality

The IEC 61850 generic communication I/O functions (DPGGIO) function block is used to send three logical signals to other systems or equipment in the substation. It is especially used in the interlocking and reservation station-wide logics.

8.7.3 Function block


```
          DPGGIO
— OPEN          POSITION —
— CLOSE
— VALID
      IEC09000075_1_en.vsd
```
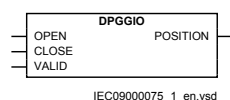
Figure 140:   *DPGGIO function block*

8.7.4 Signals

Table 218:   *DPGGIO Input signals*

Name	Type	Default	Description
OPEN	BOOLEAN	0	Open indication
CLOSE	BOOLEAN	0	Close indication
VALID	BOOLEAN	0	Valid indication

Table 219:   *DPGGIO Output signals*

Name	Type	Description
POSITION	INTEGER	Double point indication

8.7.5   Settings

The function does not have any parameters available in Local HMI or Protection and Control IED Manager (PCM600).

8.7.6   Operation principle

Upon receiving the input signals, the IEC 61850 generic communication I/O functions (DPGGIO) function block will send the signals over IEC 61850-8-1 to the equipment or system that requests these signals. To be able to get the signals, PCM600 must be used to define which function block in which equipment or system should receive this information.

8.8   Single point generic control 8 signals SPC8GGIO

8.8.1   Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Single point generic control 8 signals	SPC8GGIO	-	-

8.8.2   Functionality

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 complicated function blocks that have the capability to receive commands (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.

8.8.3   Function block


```
         SPC8GGIO
 ── BLOCK          ^OUT1 ──
 ── PSTO           ^OUT2 ──
                   ^OUT3 ──
                   ^OUT4 ──
                   ^OUT5 ──
                   ^OUT6 ──
                   ^OUT7 ──
                   ^OUT8 ──
```
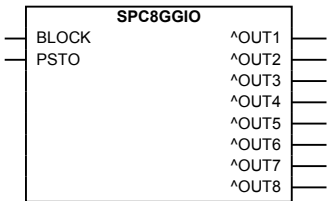
IEC09000086_1_en.vsd

Figure 141:   SPC8GGIO function block

8.8.4 Signals

Table 220:   SPC8GGIO Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of function
PSTO	INTEGER	2	Operator place selection

Table 221:   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

8.8.5 Settings

Table 222:   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
Table continues on next page					

Name	Values (Range)	Unit	Step	Default	Description
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

8.8.6 Operation principle

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 SP8GGIO function block is REMOTE.

8.9 Automation bits AUTOBITS

8.9.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Automation bits	AUTOBITS	-	-

8.9.2 Functionality

Automation bits function (AUTOBITS) is used within PCM600 in order to get into the configuration of the commands coming through the DNP3 protocol.

8.9.3   Function block

```
            AUTOBITS
  ──| BLOCK        ^CMDBIT1  |──
  ──| PSTO         ^CMDBIT2  |──
                   ^CMDBIT3  |──
                   ^CMDBIT4  |──
                   ^CMDBIT5  |──
                   ^CMDBIT6  |──
                   ^CMDBIT7  |──
                   ^CMDBIT8  |──
                   ^CMDBIT9  |──
                   ^CMDBIT10 |──
                   ^CMDBIT11 |──
                   ^CMDBIT12 |──
                   ^CMDBIT13 |──
                   ^CMDBIT14 |──
                   ^CMDBIT15 |──
                   ^CMDBIT16 |──
                   ^CMDBIT17 |──
                   ^CMDBIT18 |──
                   ^CMDBIT19 |──
                   ^CMDBIT20 |──
                   ^CMDBIT21 |──
                   ^CMDBIT22 |──
                   ^CMDBIT23 |──
                   ^CMDBIT24 |──
                   ^CMDBIT25 |──
                   ^CMDBIT26 |──
                   ^CMDBIT27 |──
                   ^CMDBIT28 |──
                   ^CMDBIT29 |──
                   ^CMDBIT30 |──
                   ^CMDBIT31 |──
                   ^CMDBIT32 |──

          IEC09000030-1-en.vsd
```
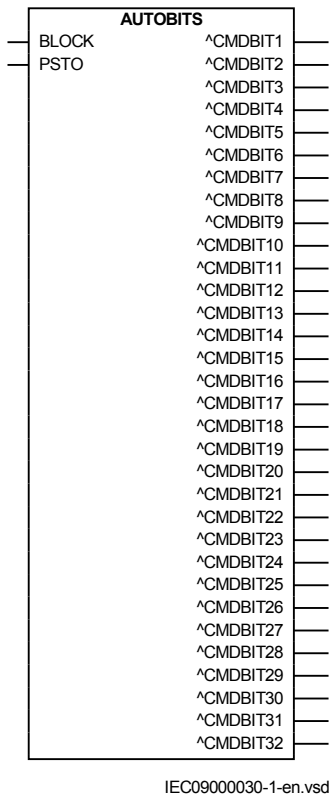
Figure 142:   AUTOBITS function block

8.9.4   Signals

Table 223:   AUTOBITS Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of function
PSTO	INTEGER	0	Operator place selection

Table 224:   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
Table continues on next page		

Name	Type	Description
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

8.9.5 Settings

Table 225:   *AUTOBITS Non group settings (basic)*

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On

8.9.6 Operation principle

Automation bits function (AUTOBITS) has 32 individual outputs which each can be mapped as a Binary Output point in DNP. 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 the 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.

See DNP3 communication protocol manual for description of the DNP3 protocol implementation.

Section 9   Logic

9.1   Tripping logic SMPPTRC

9.1.1   Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Tripping logic	SMPPRTC	*I->O*	94

9.1.2   Functionality

A function block for protection tripping is provided for each circuit breaker involved in the tripping of the fault. It provides the pulse prolongation to ensure a trip pulse of sufficient length, as well as all functionality necessary for correct co-operation with autoreclosing functions.

The trip function block includes functionality for breaker lock-out.

9.1.3   Function block
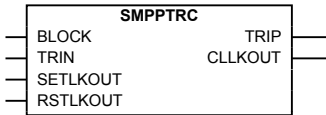
IEC09000284_1_en.vsd

Figure 143:   SMPPTRC function block

9.1.4 Signals

Table 226:   *SMPPTRC Input signals*

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of function
TRIN	BOOLEAN	0	Trip all phases
SETLKOUT	BOOLEAN	0	Input for setting the circuit breaker lockout function
RSTLKOUT	BOOLEAN	0	Input for resetting the circuit breaker lockout function

Table 227:   *SMPPTRC Output signals*

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

9.1.5 Settings

Table 228:   *SMPPTRC Group settings (basic)*

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	On	Operation Off / On
tTripMin	0.000 - 60.000	s	0.001	0.150	Minimum duration of trip output signal

Table 229:   *SMPPTRC Group settings (advanced)*

Name	Values (Range)	Unit	Step	Default	Description
TripLockout	Off On	-	-	Off	On: Activate output (CLLKOUT) and trip latch, Off: Only output
AutoLock	Off On	-	-	Off	On: Lockout from input (SETLKOUT) and trip, Off: Only input

9.1.6 Operation principle

The duration of a trip output signal from tripping logic (SMPPTRC) function is settable (*tTripMin*). The pulse length should be long enough to secure the breaker opening.

For three-phase tripping, SMPPTRC function has a single input (TRIN) through which all trip output signals from the protection functions within the IED, or from external protection functions via one or more of the IEDs binary inputs, are routed. It has a single trip output (TRIP) for connection to one or more of the IEDs binary outputs, as well as to other functions within the IED requiring this signal.

en05000789.vsd
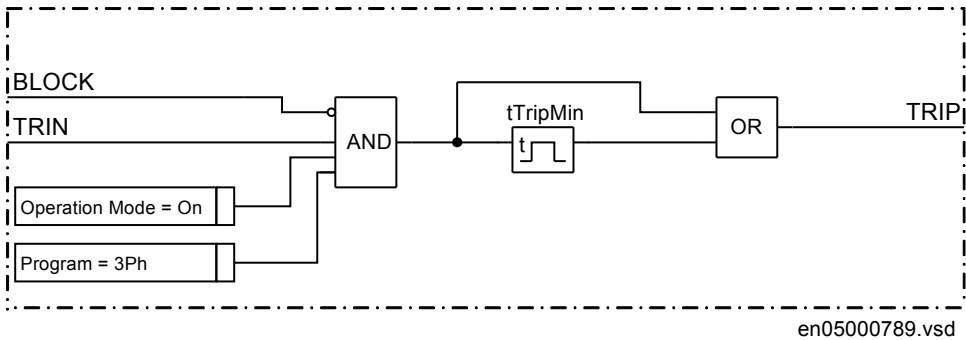
Figure 144:   Simplified logic diagram for three phase trip

In multi-breaker arrangements, one SMPPTRC function block is used for each breaker.

The breaker close lockout function can be activated from an external trip signal from another protection function via input (SETLKOUT) or internally at a three-phase trip, if desired.

It is possible to lockout seal in the tripping output signals or use blocking of closing only the choice is by setting *TripLockout*.

9.1.7 Technical data

Table 230:   SMPPTRC Technical data

Function	Range or value	Accuracy
Trip action	3-ph	-
Minimum trip pulse length	(0.000-60.000) s	± 0.5% ± 10 ms

9.2 Trip matrix logic TMAGGIO

9.2.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Trip matrix logic	TMAGGIO	-	-

9.2.2 Functionality

Trip matrix logic (TMAGGIO) function is used to route trip signals and/or other logical output signals to different output contacts on the IED.

TMAGGIO output signals and the physical outputs are available in PCM600 and this allows the user to adapt the signals to the physical tripping outputs according to the specific application needs.

9.2.3 Function block
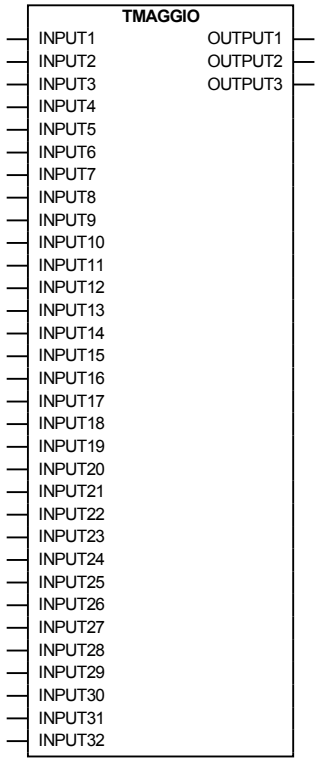
Figure 145:   TMAGGIO function block

9.2.4 Signals

Table 231:   TMAGGIO Input signals

Name	Type	Default	Description
INPUT1	BOOLEAN	0	Binary input 1
INPUT2	BOOLEAN	0	Binary input 2
INPUT3	BOOLEAN	0	Binary input 3
INPUT4	BOOLEAN	0	Binary input 4
INPUT5	BOOLEAN	0	Binary input 5
INPUT6	BOOLEAN	0	Binary input 6
INPUT7	BOOLEAN	0	Binary input 7
INPUT8	BOOLEAN	0	Binary input 8
INPUT9	BOOLEAN	0	Binary input 9
INPUT10	BOOLEAN	0	Binary input 10
Table continues on next page			

Name	Type	Default	Description
INPUT11	BOOLEAN	0	Binary input 11
INPUT12	BOOLEAN	0	Binary input 12
INPUT13	BOOLEAN	0	Binary input 13
INPUT14	BOOLEAN	0	Binary input 14
INPUT15	BOOLEAN	0	Binary input 15
INPUT16	BOOLEAN	0	Binary input 16
INPUT17	BOOLEAN	0	Binary input 17
INPUT18	BOOLEAN	0	Binary input 18
INPUT19	BOOLEAN	0	Binary input 19
INPUT20	BOOLEAN	0	Binary input 20
INPUT21	BOOLEAN	0	Binary input 21
INPUT22	BOOLEAN	0	Binary input 22
INPUT23	BOOLEAN	0	Binary input 23
INPUT24	BOOLEAN	0	Binary input 24
INPUT25	BOOLEAN	0	Binary input 25
INPUT26	BOOLEAN	0	Binary input 26
INPUT27	BOOLEAN	0	Binary input 27
INPUT28	BOOLEAN	0	Binary input 28
INPUT29	BOOLEAN	0	Binary input 29
INPUT30	BOOLEAN	0	Binary input 30
INPUT31	BOOLEAN	0	Binary input 31
INPUT32	BOOLEAN	0	Binary input 32

Table 232:   TMAGGIO Output signals

Name	Type	Description
OUTPUT1	BOOLEAN	OR function betweeen inputs 1 to 16
OUTPUT2	BOOLEAN	OR function between inputs 17 to 32
OUTPUT3	BOOLEAN	OR function between inputs 1 to 32

9.2.5   Settings

Table 233:   TMAGGIO Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	On	Operation Off / On
PulseTime	0.050 - 60.000	s	0.001	0.150	Output pulse time
OnDelay	0.000 - 60.000	s	0.001	0.000	Output on delay time
OffDelay	0.000 - 60.000	s	0.001	0.000	Output off delay time
Table continues on next page					

Name	Values (Range)	Unit	Step	Default	Description
ModeOutput1	Steady Pulsed	-	-	Steady	Mode for output 1, steady or pulsed
ModeOutput2	Steady Pulsed	-	-	Steady	Mode for output 2, steady or pulsed
ModeOutput3	Steady Pulsed	-	-	Steady	Mode for output 3, steady or pulsed

9.2.6 Operation principle

Trip matrix logic (TMAGGIO) block is provided with 32 input signals and 3 output signals. The function block incorporates internal logic OR gates in order to provide the necessary grouping of connected input signals (e.g. for tripping and alarming purposes) to the three output signals from the function block.

Internal built-in OR logic is made in accordance with the following three rules:

1. when any one of first 16 inputs signals (INPUT1 to INPUT16) has logical value 1 (TRUE) the first output signal (OUTPUT1) will get logical value 1 (TRUE).
2. when any one of second 16 inputs signals (INPUT17 to INPUT32) has logical value 1 (TRUE) the second output signal (OUTPUT2) will get logical value 1 (TRUE).
3. when any one of all 32 input signals (INPUT1 to INPUT32) has logical value 1 (TRUE) the third output signal (OUTPUT3) will get logical value 1 (TRUE).

By use of the settings *ModeOutput1, ModeOutput2, ModeOutput3, PulseTime, OnDelay* and *OffDelay* the behaviour of each output can be customized. The *OnDelay* is always active and will delay the input to output transition by the set time. The *ModeOutput* for respective output decides wether the output shall be steady with an drop-off delay as set by *OffDelay* or if it shall give a pulse with duration set by *PulseTime*. Note that for pulsed operation since the inputs are connected in an OR-function a new pulse will only be given on the output if all related inputs are reset and then one is activated again. And for steady operation the of delay will start when all related inputs have reset. Detailed logical diagram is shown in figure 146

IEC09000612_1_en.vsd
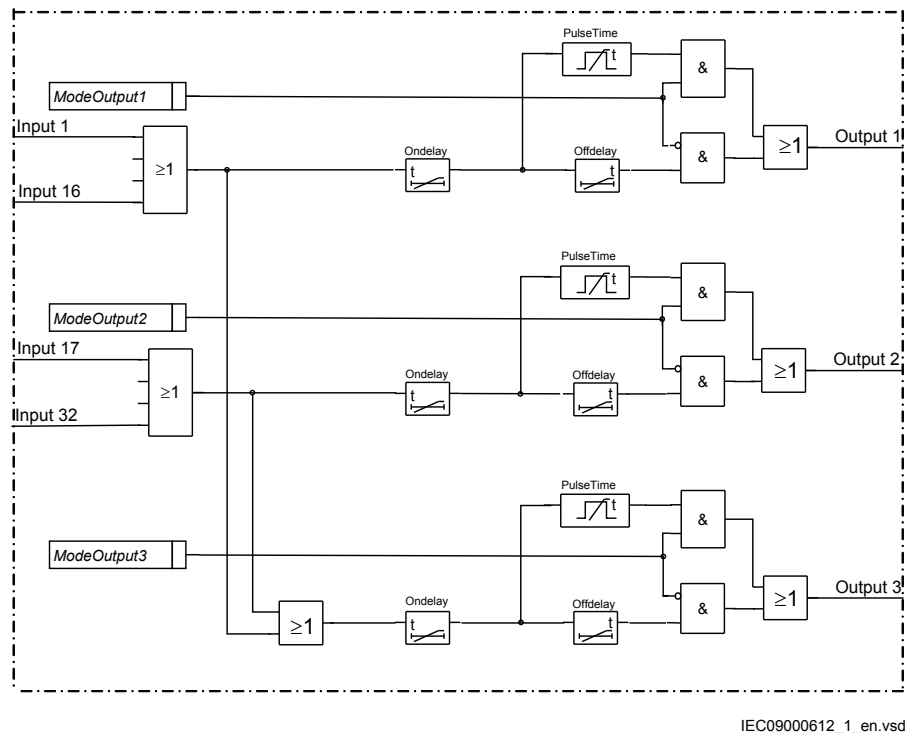
Figure 146:   Trip matrix internal logic

Output signals from TMAGGIO are typically connected to other logic blocks or directly to output contacts in the IED. When used for direct tripping of the circuit breaker(s) the pulse time delay shall be set to approximately 0.150 seconds in order to obtain satisfactory minimum duration of the trip pulse to the circuit breaker trip coils.

9.3   Configurable logic blocks

9.3.1   Standard configurable logic blocks

9.3.1.1   Functionality

A number of logic blocks and timers are available for 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 controlling if a signal should be able to pass from the input to the output or not depending on a setting.

• **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 after a power interruption should return to the state before the interruption, or be reset. 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 after a power interruption should return to the state before the interruption, or be reset. Reset input has priority.

Configurable logic Q/T

A number of logic blocks and timers with the capability to propagate timestamp and quality of the input signals are available. The function blocks assist the user to adapt the IEDs configuration to the specific application needs.

• **ORQT** function block that also propagates timestamp and quality of input signals.

• **INVERTERQT** function block that inverts the input signal and propagates timestamp and quality of input signal.

• **PULSETIMERQT** function block can be used, for example, for pulse extensions or limiting of operation of outputs. The function also propagates timestamp and quality of input signal.

• **XORQT** function block. The function also propagates timestamp and quality of input signals.

• **TIMERSETQT** function has pick-up and drop-out delayed outputs related to the input signal. The timer has a settable time delay. The function also propagates timestamp and quality of input signal.

- **ANDQT** function block. The function also propagates timestamp and quality of input signals.

- **SRMEMORYQT** 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 after a power interruption should return to the state before the interruption, or be reset. The function also propagates timestamp and quality of input signal.

- **RSMEMORYQT** 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 after a power interruption should return to the state before the interruption, or be reset. The function also propagates timestamp and quality of input signal.

- **INVALIDQT** function which sets quality invalid of outputs according to a "valid" input. Inputs are copied to outputs. If input VALID is 0, or if its quality invalid bit is set, all outputs invalid quality bit will be set to invalid. The timestamp of an output will be set to the latest timestamp of INPUT and VALID inputs.

- **INDCOMBSPQT** combines single input signals to group signal. Single position input is copied to value part of SP_OUT output. TIME input is copied to time part of SP_OUT output. State input bits are copied to the corresponding state part of SP_OUT output. If the state or value on the SP_OUT output changes, the Event bit in the state part is toggled. The function also propagates timestamp and quality of input signals.

- **INDEXTSPQT** extracts individual signals from a group signal input. Value part of single position input is copied to SI_OUT output. Time part of single position input is copied to TIME output. State bits in common part and indication part of inputs signal is copied to the corresponding state output. The function also propagates timestamp and quality of input signal.

9.3.1.2 OR function block

Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
OR Function block	OR	-	-

Functionality

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.

Function block

```
            OR
 ──  INPUT1         OUT   ──
 ──  INPUT2        NOUT   ──
 ──  INPUT3
 ──  INPUT4
 ──  INPUT5
 ──  INPUT6
```

IEC09000288-1-en.vsd

Signals

Table 234:   OR Input signals

Name	Type	Default	Description
INPUT1	BOOLEAN	0	Input signal 1
INPUT2	BOOLEAN	0	Input signal 2
INPUT3	BOOLEAN	0	Input signal 3
INPUT4	BOOLEAN	0	Input signal 4
INPUT5	BOOLEAN	0	Input signal 5
INPUT6	BOOLEAN	0	Input signal 6

Table 235:   OR Output signals

Name	Type	Description
OUT	BOOLEAN	Output signal
NOUT	BOOLEAN	Inverted output signal

Settings

The function does not have any parameters available in Local HMI or Protection and Control IED Manager (PCM600).

9.3.1.3   Inverter function block INVERTER

Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Inverter function block	INVERTER	-	-

Function block

```
                  INVERTER
  ─ INPUT                    OUT ─
```
IEC09000287-1-en.vsd
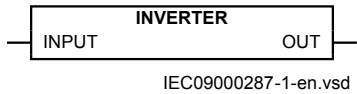
Signals

Table 236:   INVERTER Input signals

Name	Type	Default	Description
INPUT	BOOLEAN	0	Input signal

Table 237:   INVERTER Output signals

Name	Type	Description
OUT	BOOLEAN	Output signal

Settings

The function does not have any parameters available in Local HMI or Protection and Control IED Manager (PCM600).

9.3.1.4   PULSETIMER function block

Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
PULSETIMER function block	PULSETIMER	-	-

Functionality

The pulse function can be used, for example for pulse extensions or limiting of operation of outputs. The PULSETIMER has a settable length.

Function block

```
                  PULSETIMER
  ─ INPUT                    OUT ─
```
IEC09000291-1-en.vsd
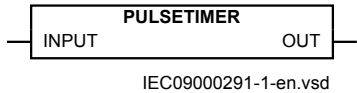
Signals

Table 238:   PULSETIMER Input signals

Name	Type	Default	Description
INPUT	BOOLEAN	0	Input signal

Table 239: *PULSETIMER Output signals*

Name	Type	Description
OUT	BOOLEAN	Output signal

Settings

Table 240: *PULSETIMER Non group settings (basic)*

Name	Values (Range)	Unit	Step	Default	Description
t	0.000 - 90000.000	s	0.001	0.010	Pulse time length

9.3.1.5 Controllable gate function block GATE

Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Controllable gate function block	GATE	-	-

Functionality

The GATE function block is used for controlling if a signal should pass from the input to the output or not, depending on setting.

Function block

IEC09000295-1-en.vsd
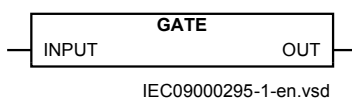
Signals

Table 241: *GATE Input signals*

Name	Type	Default	Description
INPUT	BOOLEAN	0	Input signal

Table 242: *GATE Output signals*

Name	Type	Description
OUT	BOOLEAN	Output signal

Settings

Table 243:   *GATE Group settings (basic)*

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off/On

9.3.1.6   Exclusive OR function block XOR

Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Exclusive OR function block	XOR	-	-

Functionality

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

Function block

```
            XOR
  INPUT1          OUT
  INPUT2          NOUT
```
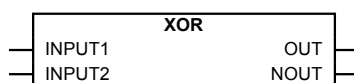
IEC09000292-1-en.vsd

Signals

Table 244:   *XOR Input signals*

Name	Type	Default	Description
INPUT1	BOOLEAN	0	Input signal 1
INPUT2	BOOLEAN	0	Input signal 2

Table 245:   *XOR Output signals*

Name	Type	Description
OUT	BOOLEAN	Output signal
NOUT	BOOLEAN	Inverted output signal

Settings

The function does not have any parameters available in Local HMI or Protection and Control IED Manager (PCM600).

9.3.1.7 Loop delay function block LOOPDELAY

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Logic loop delay function block	LOOPDELAY	-	-

The LOOPDELAY function is used to delay the output signal one execution cycle.

Function block

IEC09000296-1-en.vsd
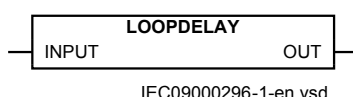
Signals

Table 246:   *LOOPDELAY Input signals*

Name	Type	Default	Description
INPUT	BOOLEAN	0	Input signal

Table 247:   *LOOPDELAY Output signals*

Name	Type	Description
OUT	BOOLEAN	Output signal, signal is delayed one execution cycle

Settings

The function does not have any parameters available in Local HMI or Protection and Control IED Manager (PCM600).

9.3.1.8 Timer function block TIMERSET

Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Timer function block	TIMERSET	-	-

Functionality

The function block TIMERSET has pick-up and drop-out delayed outputs related to the input signal. The timer has a settable time delay (*t*).
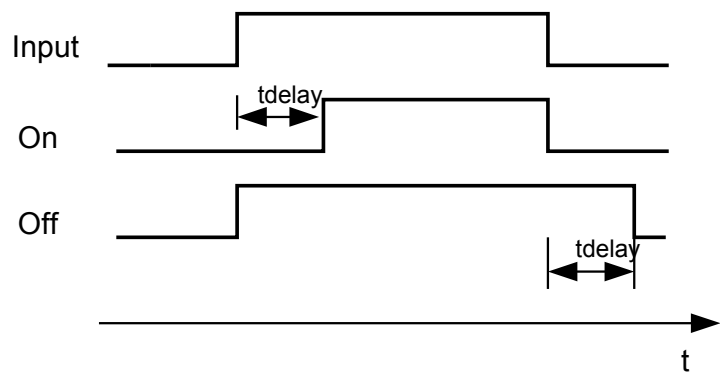
en08000289-2-en.vsd

Figure 147: TIMERSET Status diagram

Function block

IEC09000290-1-en.vsd

Signals

Table 248: TIMERSET Input signals

Name	Type	Default	Description
INPUT	BOOLEAN	0	Input signal

Table 249: TIMERSET Output signals

Name	Type	Description
ON	BOOLEAN	Output signal, pick-up delayed
OFF	BOOLEAN	Output signal, drop-out delayed

Settings

Table 250: 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

9.3.1.9 AND function block

Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
AND function block	AND	-	-

Functionality

The AND function is used to form general combinatory expressions with boolean variables. The AND function block has four inputs and two outputs.

Default value on all four inputs are logical 1 which makes it possible for the user to just use the required number of inputs and leave the rest un-connected. The output OUT has a default value 0 initially, which suppresses one cycle pulse if the function has been put in the wrong execution order.

Function block

```
            AND
  ─│ INPUT1        OUT │─
  ─│ INPUT2       NOUT │─
  ─│ INPUT3            │
  ─│ INPUT4            │
```
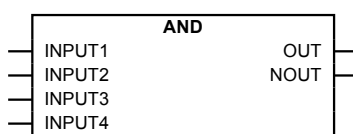
IEC09000289-1-en.vsd

Signals

Table 251: *AND Input signals*

Name	Type	Default	Description
INPUT1	BOOLEAN	1	Input signal 1
INPUT2	BOOLEAN	1	Input signal 2
INPUT3	BOOLEAN	1	Input signal 3
INPUT4	BOOLEAN	1	Input signal 4

Table 252: *AND Output signals*

Name	Type	Description
OUT	BOOLEAN	Output signal
NOUT	BOOLEAN	Inverted output signal

Settings

The function does not have any parameters available in Local HMI or Protection and Control IED Manager (PCM600).
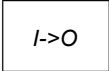
9.3.1.10

Set-reset memory function block SRMEMORY

Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Set-reset memory function block	SRMEMORY	-	-

Functionality

The Set-Reset function 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. For a Set-Reset flip-flop, SET input has higher priority over RESET input.

Table 253:   *Truth table for the Set-Reset (SRMEMORY) function block*

SET	RESET	OUT	NOUT
1	0	1	0
0	1	0	1
1	1	1	0
0	0	0	1

Function block

```
        SRMEMORY
 ─ SET            OUT ─
 ─ RESET         NOUT ─
```

IEC09000293-1-en.vsd

Signals

Table 254:   *SRMEMORY Input signals*

Name	Type	Default	Description
SET	BOOLEAN	0	Input signal to set
RESET	BOOLEAN	0	Input signal to reset

Table 255:   *SRMEMORY Output signals*

Name	Type	Description
OUT	BOOLEAN	Output signal
NOUT	BOOLEAN	Inverted output signal

Settings

Table 256:   SRMEMORY Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Memory	Off On	-	-	On	Operating mode of the memory function

9.3.1.11   Reset-set with memory function block RSMEMORY

Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Reset-set with memory function block	RSMEMORY	-	-

Functionality

The Reset-Set function 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 257:   Truth table for the Reset-Set (RSMEMORY) function block

SET	RESET	OUT	NOUT
1	0	1	0
0	1	0	1
1	1	0	1
0	0	0	1

Function block


```
              RSMEMORY
   ──  SET              OUT  ──
   ──  RESET          NOUT  ──
```
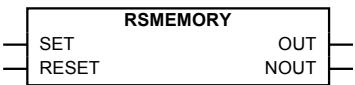
IEC09000294-1-en.vsd

Signals

Table 258:   RSMEMORY Input signals

Name	Type	Default	Description
SET	BOOLEAN	0	Input signal to set
RESET	BOOLEAN	0	Input signal to reset

Table 259: RSMEMORY Output signals

Name	Type	Description
OUT	BOOLEAN	Output signal
NOUT	BOOLEAN	Inverted output signal

Settings

Table 260: RSMEMORY Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Memory	Off On	-	-	On	Operating mode of the memory function

9.3.2 Configurable logic Q/T

9.3.2.1 Functionality

A number of logic blocks and timers with the capability to propagate timestamp and quality of the input signals are available. The function blocks assist the user to adapt the IEDs configuration to the specific application needs.

9.3.2.2 ORQT function block

Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
ORQT function block	ORQT	-	-

Functionality

The ORQT function is used to form general combinatory expressions with boolean variables. The ORQT function block has six inputs and two outputs. One of the outputs is inverted.

Function block

IEC09000298-1-en.vsd
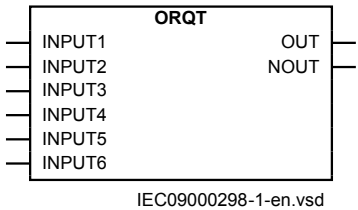
Signals

Table 261:   ORQT Input signals

Name	Type	Default	Description
INPUT1	BOOLEAN	0	Input signal 1
INPUT2	BOOLEAN	0	Input signal 2
INPUT3	BOOLEAN	0	Input signal 3
INPUT4	BOOLEAN	0	Input signal 4
INPUT5	BOOLEAN	0	Input signal 5
INPUT6	BOOLEAN	0	Input signal 6

Table 262:   ORQT Output signals

Name	Type	Description
OUT	BOOLEAN	Output signal
NOUT	BOOLEAN	Inverted output signal

Settings

The function does not have any parameters available in Local HMI or Protection and Control IED Manager (PCM600).

9.3.2.3   INVERTERQT function block

Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
INVERTERQT function block	INVERTERQT	-	-

Function block

INVERTERQT
INPUT   OUT

IEC09000299-1-en.vsd

Signals

Table 263:   INVERTERQT Input signals

Name	Type	Default	Description
INPUT	BOOLEAN	0	Input signal

Table 264:   *INVERTERQT Output signals*

Name	Type	Description
OUT	BOOLEAN	Output signal

Settings

The function does not have any parameters available in Local HMI or Protection and Control IED Manager (PCM600).

9.3.2.4   Pulse timer function block PULSTIMERQT

Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Pulse timer function block	PULSTIMERQT	-	-

Functionality

The PULSETIMERQT function can be used, for example, for pulse extensions or limiting of operation of outputs. The pulse timer has a settable length and will also propagate quality and time.

When the input goes to 1 the output will be 1 for the time set by the Time delay parameter. Then return to 0.

When the output changes value, the timestamp of the output signal is updated.

The supported "quality" state bits are propagated from the input each execution to the output. A change of these bits will not lead to an updated timestamp on the output.

Function block

```
              PULSETIMERQT
        ┌───────────────────────┐
    ────┤ INPUT           OUT   ├────
        └───────────────────────┘
```

IEC09000304-1-en.vsd
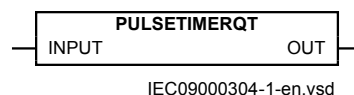
Signals

Table 265:   *PULSETIMERQT Input signals*

Name	Type	Default	Description
INPUT	BOOLEAN	0	Input signal

Table 266:   *PULSETIMERQT Output signals*

Name	Type	Description
OUT	BOOLEAN	Output signal

Settings

Table 267:   PULSETIMERQT Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
t	0.000 - 90000.000	s	0.001	0.010	Pulse time length

9.3.2.5   XORQT function block

Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
XORQT function block	XORQT	-	-

Functionality

The exclusive OR function XORQT is used to generate combinatory expressions with boolean variables. The function block XORQT 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.

Function block
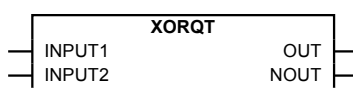
IEC09000300-1-en.vsd

Signals

Table 268:   XORQT Input signals

Name	Type	Default	Description
INPUT1	BOOLEAN	0	Input signal 1
INPUT2	BOOLEAN	0	Input signal 2

Table 269:   XORQT Output signals

Name	Type	Description
OUT	BOOLEAN	Output signal
NOUT	BOOLEAN	Inverted output signal

Settings

The function does not have any parameters available in Local HMI or Protection and Control IED Manager (PCM600).

9.3.2.6

Settable timer function block TIMERSETQT

Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Settable timer function block	TIMERSETQT	-	-

Functionality

The function block TIMERSETQT has pick-up and drop-out delayed outputs related to the input signal. The timer has a settable time delay (*t*).

When the output changes value the timestamp of the output signal is updated. The supported "quality" state bits are propagated from the input each execution to the output. A change of these bits will not lead to an updated timestamp on the output.

en08000289-2-en.vsd
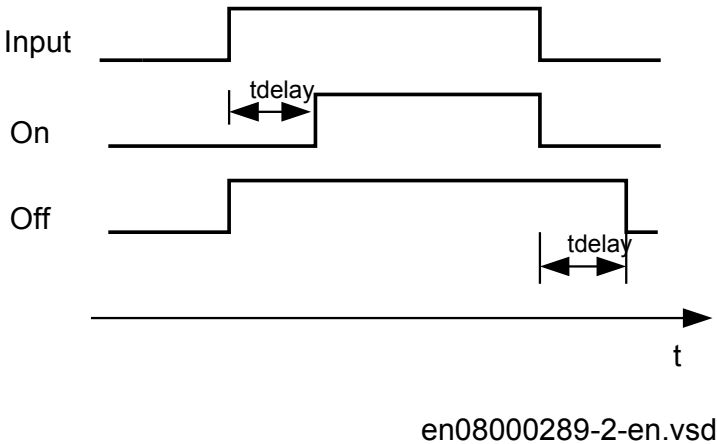
Figure 148:   TIMERSETQT function

Function block

IEC09000303-1-en.vsd
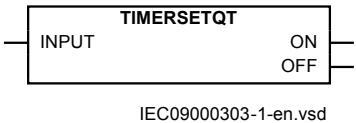
Signals

Table 270:   TIMERSETQT Input signals

Name	Type	Default	Description
INPUT	BOOLEAN	0	Input signal

Table 271:   *TIMERSETQT Output signals*

Name	Type	Description
ON	BOOLEAN	Output signal, pick-up delayed
OFF	BOOLEAN	Output signal, drop-out delayed

Settings

Table 272:   *TIMERSETQT 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

9.3.2.7   ANDQT function block

Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
ANDQT function block	ANDQT	-	-

Functionality

The ANDQT function is used to form general combinatory expressions with boolean variables. The ANDQT function block has four inputs and two outputs.

Default value on all four inputs are logical 1 which makes it possible for the user to just use the required number of inputs and leave the rest un-connected. The output OUT has a default value 0 initially, which will suppress one cycle pulse if the function has been put in the wrong execution order.
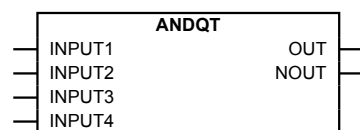
IEC09000297-1-en.vsd

Signals

Table 273:   *ANDQT Input signals*

Name	Type	Default	Description
INPUT1	BOOLEAN	1	Input signal 1
INPUT2	BOOLEAN	1	Input signal 2
INPUT3	BOOLEAN	1	Input signal 3
INPUT4	BOOLEAN	1	Input signal 4

Table 274:   *ANDQT Output signals*

Name	Type	Description
OUT	BOOLEAN	Output signal
NOUT	BOOLEAN	Inverted output signal

Settings

The function does not have any parameters available in Local HMI or Protection and Control IED Manager (PCM600).

9.3.2.8   Set-reset function block SRMEMORYQT

Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Set/reset logic component	SRMEMORYQT	-	-

Functionality

The Set-Reset function SRMEMORYQT is a flip-flop with memory that can set or reset an output from two inputs respectively. Each SRMEMORYQT 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.

The SRMEMORYQT propagates quality and time as well as value.

Table 275:   *SRMEMORYQT functionality*

SET	RESET	OUT	NOUT
1	0	1	0
0	1	0	1
1	1	1	0
0	0	0	1

If *Memory* parameter is *On*, the output result is stored in semi-retained memory.

Function block


```
          SRMEMORYQT
 ─── SET              OUT ───
 ─── RESET           NOUT ───
```
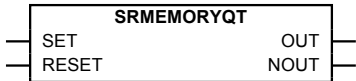
IEC09000301-1-en.vsd

Signals

Table 276:   *SRMEMORYQT Input signals*

Name	Type	Default	Description
SET	BOOLEAN	0	Input signal to set
RESET	BOOLEAN	0	Input signal to reset

Table 277:   *SRMEMORYQT Output signals*

Name	Type	Description
OUT	BOOLEAN	Output signal
NOUT	BOOLEAN	Inverted output signal

Settings

Table 278:   *SRMEMORYQT Group settings (basic)*

Name	Values (Range)	Unit	Step	Default	Description
Memory	Off On	-	-	On	Operating mode of the memory function

9.3.2.9   Reset-set function block RSMEMORYQT

Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Reset/set logic component	RSMEMORYQT	-	-

Functionality

The Reset-Set function RSMEMORYQT is a flip-flop with memory that can reset or set an output from two inputs respectively. Each RSMEMORYQT 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 279:   *RSMEMORYQT functionality*

SET	RESET	OUT	NOUT
1	0	1	0
0	1	0	1
1	1	0	1
0	0	0	1

Function block

```
                RSMEMORYQT
        SET                OUT
        RESET              NOUT
```

IEC09000302-1-en.vsd
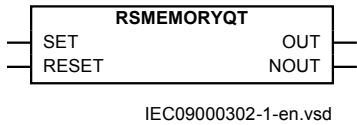
Signals

Table 280:   RSMEMORYQT Input signals

Name	Type	Default	Description
SET	BOOLEAN	0	Input signal to set
RESET	BOOLEAN	0	Input signal to reset

Table 281:   RSMEMORYQT Output signals

Name	Type	Description
OUT	BOOLEAN	Output signal
NOUT	BOOLEAN	Inverted output signal

Settings

Table 282:   RSMEMORYQT Group settings (basic)

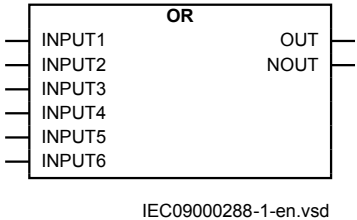| Name	Values (Range)	Unit	Step	Default	Description
Memory	Off On	-	-	On	Operating mode of the memory function

9.3.2.10   INVALIDQT function block

Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
INVALIDQT function block	INVALIDQT	-	-

Function block
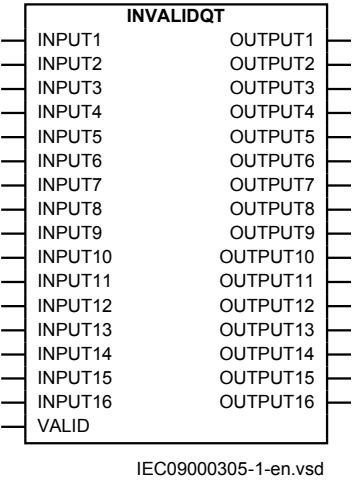
IEC09000305-1-en.vsd

Function which sets quality invalid of outputs according to a "valid" input.

Inputs are copied to outputs. If input VALID is 0, or if its quality invalid bit is set, all outputs invalid quality bit will be set. The timestamp of an output will be set to the latest timestamp of INPUT and VALID input.

Signals

Table 283: *INVALIDQT Input signals*

Name	Type	Default	Description
INPUT1	BOOLEAN	0	Indication input 1
INPUT2	BOOLEAN	0	Indication input 2
INPUT3	BOOLEAN	0	Indication input 3
INPUT4	BOOLEAN	0	Indication input 4
INPUT5	BOOLEAN	0	Indication input 5
INPUT6	BOOLEAN	0	Indication input 6
INPUT7	BOOLEAN	0	Indication input 7
INPUT8	BOOLEAN	0	Indication input 8
INPUT9	BOOLEAN	0	Indication input 9
INPUT10	BOOLEAN	0	Indication input 10
INPUT11	BOOLEAN	0	Indication input 11
INPUT12	BOOLEAN	0	Indication input 12
INPUT13	BOOLEAN	0	Indication input 13
INPUT14	BOOLEAN	0	Indication input 14
INPUT15	BOOLEAN	0	Indication input 15
INPUT16	BOOLEAN	0	Indication input 16
VALID	BOOLEAN	1	Inputs are valid or not

Table 284:   INVALIDQT Output signals

Name	Type	Description
OUTPUT1	BOOLEAN	Indication output 1
OUTPUT2	BOOLEAN	Indication output 2
OUTPUT3	BOOLEAN	Indication output 3
OUTPUT4	BOOLEAN	Indication output 4
OUTPUT5	BOOLEAN	Indication output 5
OUTPUT6	BOOLEAN	Indication output 6
OUTPUT7	BOOLEAN	Indication output 7
OUTPUT8	BOOLEAN	Indication output 8
OUTPUT9	BOOLEAN	Indication output 9
OUTPUT10	BOOLEAN	Indication output 10
OUTPUT11	BOOLEAN	Indication output 11
OUTPUT12	BOOLEAN	Indication output 12
OUTPUT13	BOOLEAN	Indication output 13
OUTPUT14	BOOLEAN	Indication output 14
OUTPUT15	BOOLEAN	Indication output 15
OUTPUT16	BOOLEAN	Indication output 16

Settings

The function does not have any parameters available in Local HMI or Protection and Control IED Manager (PCM600).

9.3.2.11   Indication combining single position function block INDCOMBSPQT

Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Single indication signal combining function block	INDCOMBSPQT	-	-

Functionality

Single position input is copied to value part of SP_OUT output. TIME input is copied to time part of SP_OUT output. State input bits are copied to the corresponding state part of SP_OUT output. If the state or value on the SP_OUT output changes, the Event bit in the state part is toggled.

Function block

```
         INDCOMBSPQT
 — SP_IN*           SP_OUT —
 — TIME*
 — BLOCKED*
 — SUBST*
 — INVALID*
 — TEST*
```
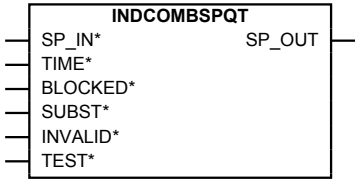
IEC09000306-1-en.vsd

Signals

Table 285:   *INDCOMBSPQT Input signals*

Name	Type	Default	Description
SP_IN	BOOLEAN	0	Single point indication
TIME	GROUP SIGNAL	0	Timestamp
BLOCKED	BOOLEAN	0	Blocked for update
SUBST	BOOLEAN	0	Substitued
INVALID	BOOLEAN	0	Invalid value
TEST	BOOLEAN	0	Testmode

Table 286:   *INDCOMBSPQT Output signals*

Name	Type	Description
SP_OUT	BOOLEAN	Single point indication

Settings

The function does not have any parameters available in Local HMI or Protection and Control IED Manager (PCM600).

### 9.3.2.12   Indication extractor single position function block INDEXTSPQT

Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Single indication signal extractor function block	INDEXTSPQT	-	-

Functionality

Value part of single position input is copied to SI_OUT output.

Time part of single position input is copied to TIME output.

State bits in common part and indication part of inputs signal is copied to the corresponding state output.

Function block

```
                INDEXTSPQT
     SI_IN*                    SI_OUT
                                 TIME
                              BLOCKED
                                SUBST
                              INVALID
                                 TEST
```

IEC09000307-1-en.vsd
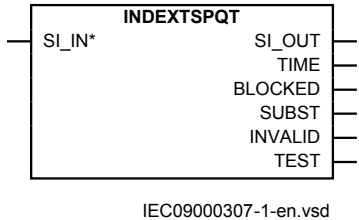
Signals

Table 287:   INDEXTSPQT Input signals

Name	Type	Default	Description
SI_IN	BOOLEAN	0	Single indication

Table 288:   INDEXTSPQT Output signals

Name	Type	Description
SI_OUT	BOOLEAN	Single indication
TIME	GROUP SIGNAL	Timestamp of input
BLOCKED	BOOLEAN	Blocked for update
SUBST	BOOLEAN	Substituted
INVALID	BOOLEAN	Invalid value
TEST	BOOLEAN	Testmode

Settings

The function does not have any parameters available in Local HMI or Protection and Control IED Manager (PCM600).

9.3.3   Technical data

Table 289:   Configurable logic blocks

Logic block	Quantity with cycle time			Range or value	Accuracy
	5 ms	20 ms	100 ms		
LogicAND	60	60	160	-	-
LogicOR	60	60	160	-	-
LogicXOR	10	10	20	-	-
LogicInverter	30	30	80	-	-
LogicSRMemory	10	10	20	-	-
LogicGate	10	10	20	-	-
Table continues on next page					

Logic block	Quantity with cycle time			Range or value	Accuracy
	5 ms	20 ms	100 ms		
LogicPulseTimer	10	10	20	(0.000–90000.000) s	± 0.5% ± 10 ms
LogicTimerSet	10	10	20	(0.000–90000.000) s	± 0.5% ± 10 ms
LogicLoopDelay	10	10	20		

Table 290:   Configurable logic Q/T

Logic block	Quantity with cycle time		Range or value	Accuracy
	20 ms	100 ms		
LogicAND	20	100	-	-
LogicOR	20	100	-	-
LogicXOR	10	30	-	-
LogicInverter	20	100	-	-
LogicRSMemoryQT	10	30	-	-
LogicSRMemory	15	10	-	-
LogicPulseTimer	10	30	(0.000–90000.000) s	± 0.5% ± 10 ms
LogicTimerSet	10	30	(0.000–90000.000) s	± 0.5% ± 10 ms
INVALIDQT	6	6	-	-
INDCOMBSPQT	10	10	-	-
INDCOMBSPQT	10	10	-	-

9.4   Fixed signals FXDSIGN

9.4.1   Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Fixed signals	FXDSIGN	-	-

9.4.2   Functionality

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 a certain logic.

9.4.3 Function block

IEC09000037.vsd
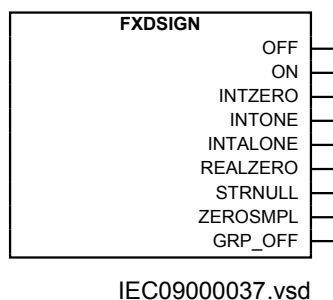
Figure 149: FXDSIGN function block

9.4.4 Signals

Table 291: 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

9.4.5 Settings

The function does not have any settings available in Local HMI or Protection and Control IED Manager (PCM600).

9.4.6 Operation principle

There are nine outputs from the 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
- 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

9.5 Boolean 16 to integer conversion B16I

9.5.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Boolean 16 to integer conversion	B16I	-	-

9.5.2 Functionality

Boolean 16 to integer conversion function (B16I) is used to transform a set of 16 binary (logical) signals into an integer.

9.5.3 Function block
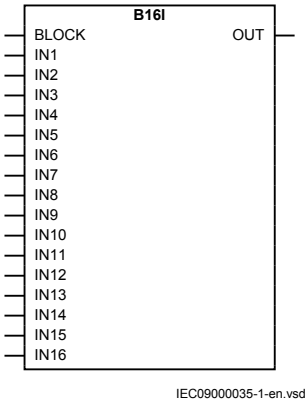
Figure 150:   B16I function block

9.5.4 Signals

Table 292:   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
Table continues on next page			

Name	Type	Default	Description
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 293:   B16I Output signals

Name	Type	Description
OUT	INTEGER	Output value

9.5.5   Settings

The function does not have any parameters available in local HMI or Protection and Control IED Manager (PCM600)

9.5.6   Monitored data

Table 294:   B16I Monitored data

Name	Type	Values (Range)	Unit	Description
OUT	INTEGER	-	-	Output value

9.5.7   Operation principle

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.

9.6 Boolean 16 to integer conversion with logic node representation B16IFCVI

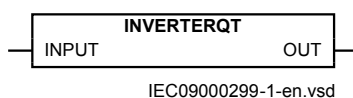### 9.6.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Boolean 16 to integer conversion with logic node representation	B16IFCVI	-	-

9.6.2 Functionality

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.

9.6.3 Function block


```
           B16IFCVI
──  BLOCK              OUT  ──
──  IN1
──  IN2
──  IN3
──  IN4
──  IN5
──  IN6
──  IN7
──  IN8
──  IN9
──  IN10
──  IN11
──  IN12
──  IN13
──  IN14
──  IN15
──  IN16
```

IEC09000624-1-en.vsd
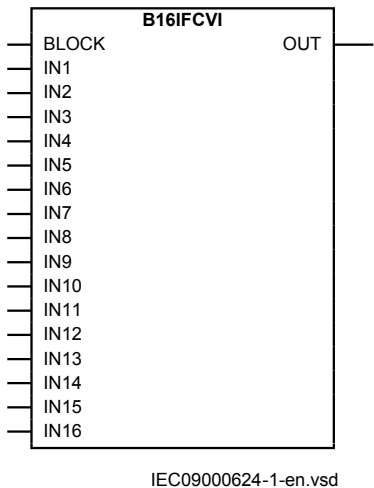
Figure 151:   B16IFCVI function block

9.6.4 Signals

Table 295:   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
Table continues on next page			

Name	Type	Default	Description
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 296:   B16IFCVI Output signals

Name	Type	Description
OUT	INTEGER	Output value

9.6.5   Settings

The function does not have any parameters available in local HMI or Protection and Control IED Manager (PCM600)

9.6.6   Monitored data

Table 297:   B16IFCVI Monitored data

Name	Type	Values (Range)	Unit	Description
OUT	INTEGER	-	-	Output value

9.6.7   Operation principle

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.

9.7 Integer to boolean 16 conversion IB16A

9.7.1 Identification

| Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Integer to boolean 16 conversion	IB16A	-	-

9.7.2 Functionality

Integer to boolean 16 conversion function (IB16A) is used to transform an integer into a set of 16 binary (logical) signals.

9.7.3 Function block

IEC09000036-1-en.vsd
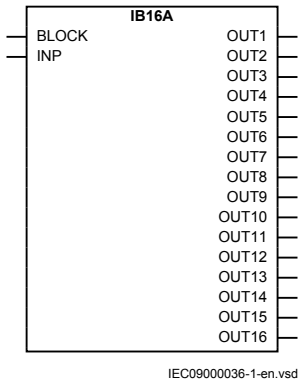
Figure 152:   IB16A function block

9.7.4 Signals

Table 298:   IB16A Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of function
INP	INTEGER	0	Integer Input

Table 299:   IB16A Output signals

Name	Type	Description
OUT1	BOOLEAN	Output 1
OUT2	BOOLEAN	Output 2
OUT3	BOOLEAN	Output 3
OUT4	BOOLEAN	Output 4
Table continues on next page		

Name	Type	Description
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

9.7.5   Settings

The function does not have any parameters available in local HMI or Protection and Control IED Manager (PCM600)

9.7.6   Operation principle

Integer to boolean 16 conversion function (IB16A) is used to transform an integer into a set of 16 binary (logical) signals. IB16A function is designed for receiving the integer input locally. The BLOCK input will freeze the logical outputs at the last value.

9.8   Integer to boolean 16 conversion with logic node representation IB16FCVB

9.8.1   Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Integer to boolean 16 conversion with logic node representation	IB16FCVB	-	-

9.8.2   Functionality

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 IEC 61850 depending on the
operator position input (PSTO).

9.8.3 Function block

```
          IB16FCVB
   ─ BLOCK        OUT1  ─
   ─ PSTO         OUT2  ─
                  OUT3  ─
                  OUT4  ─
                  OUT5  ─
                  OUT6  ─
                  OUT7  ─
                  OUT8  ─
                  OUT9  ─
                 OUT10  ─
                 OUT11  ─
                 OUT12  ─
                 OUT13  ─
                 OUT14  ─
                 OUT15  ─
                 OUT16  ─
```

IEC09000399-1-en.vsd
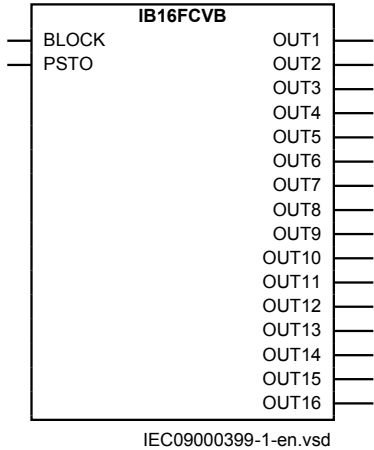
Figure 153:   IB16FCVB function block

9.8.4 Signals

Table 300:   IB16FCVB Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of function
PSTO	INTEGER	1	Operator place selection

Table 301:   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
Table continues on next page		

Name	Type	Description
OUT13	BOOLEAN	Output 13
OUT14	BOOLEAN	Output 14
OUT15	BOOLEAN	Output 15
OUT16	BOOLEAN	Output 16

9.8.5 Settings

The function does not have any parameters available in local HMI or Protection and Control IED Manager (PCM600)

9.8.6 Operation principle

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.

Section 10 Monitoring

10.1 IEC 61850 generic communication I/O functions SPGGIO

10.1.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
IEC 61850 generic communication I/O functions	SPGGIO	-	-

10.1.2 Functionality

IEC 61850 generic communication I/O functions (SPGGIO) is used to send one single logical signal to other systems or equipment in the substation.

10.1.3 Function block
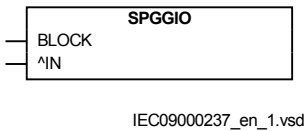
Figure 154: *SPGGIO function block*

10.1.4 Signals

Table 302: *SPGGIO Input signals*

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of function
IN	BOOLEAN	0	Input status

10.1.5 Settings

The function does not have any parameters available in Local HMI or Protection and Control IED Manager (PCM600).

10.1.6　Operation principle

Upon receiving a signal at its input, IEC 61850 generic communication I/O functions (SPGGIO) function sends the signal over IEC 61850-8-1 to the equipment or system that requests this signal. To be able to get the signal, one must use other tools, described in the Engineering manual and define which function block in which equipment or system should receive this information.

10.2　IEC 61850 generic communication I/O functions 16 inputs SP16GGIO

10.2.1　Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
IEC 61850 generic communication I/O functions 16 inputs	SP16GGIO	-	-

10.2.2　Functionality

IEC 61850 generic communication I/O functions 16 inputs (SP16GGIO) function is used to send up to 16 logical signals to other systems or equipment in the substation.

10.2.3　Function block

IEC09000238_en_1.vsd
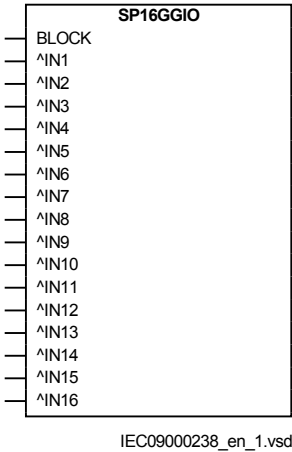
Figure 155: SP16GGIO function block

10.2.4   Signals

Table 303:   *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

10.2.5   Settings

The function does not have any parameters available in Local HMI or Protection
and Control IED Manager (PCM600).

10.2.6   Operation principle

Upon receiving signals at its inputs, IEC 61850 generic communication I/O
functions 16 inputs (SP16GGIO) function will send the signals over IEC 61850-8-1
to the equipment or system that requests this signals. To be able to get the signal,
one must use other tools, described in the Engineering manual and define which
function block in which equipment or system should receive this information.

There are also 16 output signals that show the input status for each input as well as
an OR type output combined for all 16 input signals. These output signals are
handled in PST.

10.3 IEC 61850 generic communication I/O functions MVGGIO

10.3.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
IEC 61850 generic communication I/O functions	MVGGIO	-	-

10.3.2 Functionality

IEC 61850 generic communication I/O functions (MVGGIO) function is used to send the instantaneous value of an analog output to other systems or equipment in the substation. It can also be used inside the same IED, to attach a RANGE aspect to an analog value and to permit measurement supervision on that value.

10.3.3 Function block

MVGGIO
BLOCK   VALUE
IN   RANGE
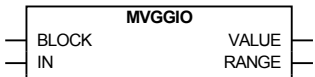
IEC09000239_en.vsd

10.3.4 Signals

Table 304:   MVGGIO Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of function
IN	REAL	0	Analog input value

Table 305:   MVGGIO Output signals

Name	Type	Description
VALUE	REAL	Magnitude of deadband value
RANGE	INTEGER	Range

10.3.5   Settings

Table 306:   MVGGIO Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
BaseValue	0.001 - 99.000	-	0.001	1.000	Base value multiplied by prefix value is used as base for all level settings
Prefix	micro milli unit kilo Mega Giga Tera	-	-	unit	Prefix (multiplication factor) for base value setting
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	-5000.00 - 5000.00	%Base	0.01	500.00	High High limit
MV hLim	-5000.00 - 5000.00	%Base	0.01	200.00	High limit
MV lLim	-5000.00 - 5000.00	%Base	0.01	-200.00	Low limit
MV llLim	-5000.00 - 5000.00	%Base	0.01	-500.00	Low Low limit
MV min	-5000.00 - 5000.00	%Base	0.01	-1000.00	Minimum value
MV max	-5000.00 - 5000.00	%Base	0.01	1000.00	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)

10.3.6   Monitored data

Table 307:   MVGGIO Monitored data

Name	Type	Values (Range)	Unit	Description
VALUE	REAL	-	-	Magnitude of deadband value
RANGE	INTEGER	0=Normal 1=High 2=Low 3=High-High 4=Low-Low	-	Range

10.3.7   Operation principle

Upon receiving an analog signal at its input, IEC 61850 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.

10.4 Measurements

10.4.1 Functionality

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 & VTs). During normal service by periodic comparison of the measured value from the IED with other independent meters the proper operation of the IED analogue 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. There are no interconnections regarding any settings or parameters, neither between functions nor between signals within each function.

Zero clampings are handled by *ZeroDb* for each signal separately for each of the functions. For example, the zero clamping of U12 is handled by *UL12ZeroDb* in VMMXU, zero clamping of I1 is handled by *ILZeroDb* in CMMXU.

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

The output values are displayed in the local HMI under **Main menu/Tests/ Function status/Monitoring/CVMMXN/Outputs**

The measuring functions CMMXU, VNMMXU and VMMXU provides 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 provides 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.

10.4.2 Measurements CVMMXN

10.4.2.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Measurements	CVMMXN	P, Q, S, I, U, f	-

10.4.2.2 Function block

The available function blocks of an IED are depending on the actual hardware (TRM) and the logic configuration made in PCM600.
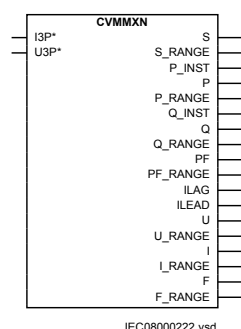
Figure 156: *CVMMXN function block*

10.4.2.3 Signals

Table 308: *CVMMXN Input signals*

Name	Type	Default	Description
I3P	GROUP SIGNAL	-	Three phase group signal for current inputs
U3P	GROUP SIGNAL	-	Three phase group signal for voltage inputs

Table 309: *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	Calculated voltage magnitude of deadband value
U_RANGE	INTEGER	Calcuated 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

10.4.2.4 Settings

Table 310: CVMMXN Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
GlobalBaseSel	1 - 6	-	1	1	Selection of one of the Global Base Value groups
Mode	L1, L2, L3 Arone Pos Seq L1L2 L2L3 L3L1 L1 L2 L3	-	-	L1, L2, L3	Selection of measured current and voltage
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	0.00 - 1.00	-	0.01	0.00	Low pass filter coefficient for power measurement
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
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
Table continues on next page					

Name	Values (Range)	Unit	Step	Default	Description
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

Table 311:   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
PHiHiLim	-2000.0 - 2000.0	%SB	0.1	150.0	High 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
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
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
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)

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
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)
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
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
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
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)
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

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
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

10.4.2.5 Monitored data

Table 312:   CVMMXN Monitored data
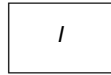
Name	Type	Values (Range)	Unit	Description
S	REAL	-	MVA	Apparent power magnitude of deadband value
P	REAL	-	MW	Active power magnitude of deadband value
Q	REAL	-	MVAr	Reactive power magnitude of deadband value
PF	REAL	-	-	Power factor magnitude of deadband value
U	REAL	-	kV	Calculated voltage magnitude of deadband value
I	REAL	-	A	Calculated current magnitude of deadband value
F	REAL	-	Hz	System frequency magnitude of deadband value

10.4.3 Phase current measurement CMMXU

10.4.3.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Phase current measurement	CMMXU	*I*	-

10.4.3.2 Function block

The available function blocks of an IED are depending on the actual hardware (TRM) and the logic configuration made in PCM600.

```
            CMMXU
  ┌──────────────────────────┐
──┤ I3P              IL1      ├──
  │               IL1RANG     ├──
  │               IL1ANGL     ├──
  │                  IL2      ├──
  │               IL2RANG     ├──
  │               IL2ANGL     ├──
  │                  IL3      ├──
  │               IL3RANG     ├──
  │               IL3ANGL     ├──
  └──────────────────────────┘
```

Figure 157:   *CMMXU function block*

10.4.3.3   Signals

Table 313:   *CMMXU Input signals*

Name	Type	Default	Description
I3P	GROUP SIGNAL	-	Three phase group signal for current inputs

Table 314:   *CMMXU Output signals*

Name	Type	Description
IL1	REAL	IL1 Amplitude
IL1RANG	INTEGER	IL1 Amplitude range
IL1ANGL	REAL	IL1 Angle
IL2	REAL	IL2 Amplitude
IL2RANG	INTEGER	IL2 Amplitude range
IL2ANGL	REAL	IL2 Angle
IL3	REAL	IL3 Amplitude
IL3RANG	INTEGER	IL3 Amplitude range
IL3ANGL	REAL	IL3 Angle

10.4.3.4   Settings

Table 315:   *CMMXU Non group settings (basic)*

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
GlobalBaseSel	1 - 6	-	1	1	Global Base Selector
ILDbRepInt	1 - 300	s,%,%s	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s
ILMax	0 - 500000	A	1	1300	Maximum value
ILRepTyp	Cyclic Dead band Int deadband	-	-	Dead band	Reporting type
ILAngDbRepInt	1 - 300	s,%,%s	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s

Table 316:   *CMMXU Non group settings (advanced)*

Name	Values (Range)	Unit	Step	Default	Description
ILZeroDb	0 - 100000	1/1000%	1	500	Zero point clamping
ILHiHiLim	0 - 500000	A	1	1200	High High limit (physical value)
ILHiLim	0 - 500000	A	1	1100	High limit (physical value)
ILLowLim	0 - 500000	A	1	0	Low limit (physical value)
ILLowLowLim	0 - 500000	A	1	00	Low Low limit (physical value)
ILMin	0 - 500000	A	1	0	Minimum value
ILLimHys	0.000 - 100.000	%	0.001	5.000	Hysteresis value in % of range and is common for all limits
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

10.4.3.5   Monitored data

Table 317:   *CMMXU Monitored data*

Name	Type	Values (Range)	Unit	Description
IL1	REAL	-	A	IL1 Amplitude
IL1ANGL	REAL	-	deg	IL1 Angle
IL2	REAL	-	A	IL2 Amplitude
IL2ANGL	REAL	-	deg	IL2 Angle
IL3	REAL	-	A	IL3 Amplitude
IL3ANGL	REAL	-	deg	IL3 Angle

10.4.4   Phase-phase voltage measurement VMMXU

10.4.4.1   Identification

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

10.4.4.2   Function block

The available function blocks of an IED are depending on the actual hardware (TRM) and the logic configuration made in PCM600.


```
        VMMXU
  U3P            UL12
              UL12RANG
              UL12ANGL
                 UL23
              UL23RANG
              UL23ANGL
                 UL31
              UL31RANG
              UL31ANGL
```
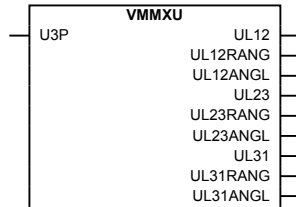
Figure 158:   *VMMXU function block*

10.4.4.3   Signals

Table 318:   *VMMXU Input signals*

Name	Type	Default	Description
U3P	GROUP SIGNAL	-	Three phase group signal for voltage inputs

Table 319:   *VMMXU Output signals*

Name	Type	Description
UL12	REAL	UL12 Amplitude
UL12RANG	INTEGER	UL12 Amplitude range
UL12ANGL	REAL	UL12 Angle
UL23	REAL	UL23 Amplitude
UL23RANG	INTEGER	UL23 Amplitude range
UL23ANGL	REAL	UL23 Angle
UL31	REAL	UL31 Amplitude
UL31RANG	INTEGER	UL31Amplitude range
UL31ANGL	REAL	UL31 Angle

10.4.4.4   Settings

Table 320:   *VMMXU Non group settings (basic)*

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
GlobalBaseSel	1 - 6	-	1	1	Global Base Selector
ULDbRepInt	1 - 300	s,%,%s	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
ULMax	0 - 4000000	V	1	170000	Maximum value
ULRepTyp	Cyclic Dead band Int deadband	-	-	Dead band	Reporting type
ULAngDbRepInt	1 - 300	s,%,%s	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s

Table 321:   *VMMXU Non group settings (advanced)*

Name	Values (Range)	Unit	Step	Default	Description
ULZeroDb	0 - 100000	1/1000%	1	500	Zero point clamping
ULHiHiLim	0 - 4000000	V	1	160000	High High limit (physical value)
ULHiLim	0 - 4000000	V	1	150000	High limit (physical value)
ULLowLim	0 - 4000000	V	1	125000	Low limit (physical value)
ULLowLowLim	0 - 4000000	V	1	115000	Low Low limit (physical value)
ULMin	0 - 4000000	V	1	0	Minimum value
ULLimHys	0.000 - 100.000	V	0.001	5.0000	Hysteresis value in % of range and is common for all limits

10.4.4.5   Monitored data

Table 322:   *VMMXU Monitored data*

Name	Type	Values (Range)	Unit	Description
UL12	REAL	-	kV	UL12 Amplitude
UL12ANGL	REAL	-	deg	UL12 Angle
UL23	REAL	-	kV	UL23 Amplitude
UL23ANGL	REAL	-	deg	UL23 Angle
UL31	REAL	-	kV	UL31 Amplitude
UL31ANGL	REAL	-	deg	UL31 Angle

10.4.5   Current sequence component measurement CMSQI

10.4.5.1   Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Current sequence component measurement	CMSQI	*I1, I2, I0*	-

10.4.5.2 Function block

The available function blocks of an IED are depending on the actual hardware (TRM) and the logic configuration made in PCM600.

```
        ┌─────────────────┐
        │      CMSQI      │
      ──┤ I3P        3I0  ├──
        │         3I0RANG ├──
        │         3I0ANGL ├──
        │             I1  ├──
        │          I1RANG ├──
        │          I1ANGL ├──
        │             I2  ├──
        │          I2RANG ├──
        │          I2ANGL ├──
        └─────────────────┘
```
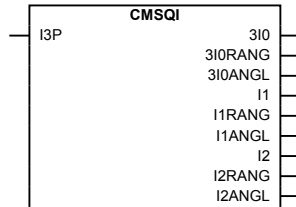
Figure 159:   *CMSQI function block*

10.4.5.3 Signals

Table 323:   *CMSQI Input signals*

Name	Type	Default	Description
I3P	GROUP SIGNAL	-	Three phase group signal for current inputs

Table 324:   *CMSQI Output signals*

Name	Type	Description
3I0	REAL	3I0 Amplitude
3I0RANG	INTEGER	3I0 Amplitude range
3I0ANGL	REAL	3I0 Angle
I1	REAL	I1 Amplitude
I1RANG	INTEGER	I1Amplitude range
I1ANGL	REAL	I1 Angle
I2	REAL	I2 Amplitude
I2RANG	INTEGER	I2 Amplitude range
I2ANGL	REAL	I2Angle

10.4.5.4 Settings

Table 325:   *CMSQI Non group settings (basic)*

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
3I0DbRepInt	1 - 300	s,%,%s	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s
3I0Min	0 - 500000	A	1	0	Minimum value
3I0Max	0 - 500000	A	1	3300	Maximum value
Table continues on next page					

Name	Values (Range)	Unit	Step	Default	Description
3I0RepTyp	Cyclic Dead band Int deadband	-	-	Dead band	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	s,%,%s	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s
I1DbRepInt	1 - 300	s,%,%s	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s
I1Min	0 - 500000	A	1	0	Minimum value
I1Max	0 - 500000	A	1	1300	Maximum value
I1RepTyp	Cyclic Dead band Int deadband	-	-	Dead band	Reporting type
I1AngDbRepInt	1 - 300	s,%,%s	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s
I2DbRepInt	1 - 300	s,%,%s	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s
I2Min	0 - 500000	A	1	0	Minimum value
I2Max	0 - 500000	A	1	1300	Maximum value
I2RepTyp	Cyclic Dead band Int deadband	-	-	Dead band	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	s,%,%s	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s

Table 326:   CMSQI Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
3I0ZeroDb	0 - 100000	1/1000%	1	500	Zero point clamping
3I0HiHiLim	0 - 500000	A	1	3600	High High limit (physical value)
3I0HiLim	0 - 500000	A	1	3300	High limit (physical value)
3I0LowLim	0 - 500000	A	1	0	Low limit (physical value)
3I0LowLowLim	0 - 500000	A	1	0	Low Low limit (physical value)
I1ZeroDb	0 - 100000	1/1000%	1	500	Zero point clamping
I1HiHiLim	0 - 500000	A	1	1200	High High limit (physical value)
I1HiLim	0 - 500000	A	1	1100	High limit (physical value)
I1LowLim	0 - 500000	A	1	0	Low limit (physical value)
I1LowLowLim	0 - 500000	A	1	0	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
I2ZeroDb	0 - 100000	1/1000%	1	500	Zero point clamping
I2HiHiLim	0 - 500000	A	1	1200	High High limit (physical value)

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
I2HiLim	0 - 500000	A	1	1100	High limit (physical value)
I2LowLim	0 - 500000	A	1	0	Low limit (physical value)
I2LowLowLim	0 - 500000	A	1	0	Low Low limit (physical value)

10.4.5.5 Monitored data

Table 327: CMSQI Monitored data

Name	Type	Values (Range)	Unit	Description
3I0	REAL	-	A	3I0 Amplitude
3I0ANGL	REAL	-	deg	3I0 Angle
I1	REAL	-	A	I1 Amplitude
I1ANGL	REAL	-	deg	I1 Angle
I2	REAL	-	A	I2 Amplitude
I2ANGL	REAL	-	deg	I2Angle

10.4.6 Voltage sequence measurement VMSQI

10.4.6.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Voltage sequence measurement	VMSQI	*U1, U2, U0*	-

10.4.6.2 Function block

The available function blocks of an IED are depending on the actual hardware (TRM) and the logic configuration made in PCM600.


```
        VMSQI
  U3P            3U0
             3U0RANG
             3U0ANGL
                  U1
               U1RANG
               U1ANGL
                  U2
               U2RANG
               U2ANGL
```
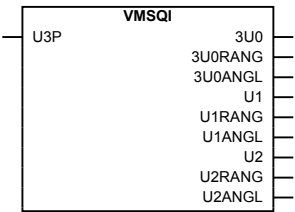
Figure 160: VMSQI function block

10.4.6.3 Signals

Table 328:   *VMSQI Input signals*

Name	Type	Default	Description
U3P	GROUP SIGNAL	-	Three phase group signal for voltage inputs

Table 329:   *VMSQI Output signals*

Name	Type	Description
3U0	REAL	3U0 Amplitude
3U0RANG	INTEGER	3U0 Amplitude range
3U0ANGL	REAL	3U0 Angle
U1	REAL	U1 Amplitude
U1RANG	INTEGER	U1 Amplitude range
U1ANGL	REAL	U1 Angle
U2	REAL	U2 Amplitude
U2RANG	INTEGER	U2 Amplitude range
U2ANGL	REAL	U2 Angle

10.4.6.4 Settings

Table 330:   *VMSQI Non group settings (basic)*

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
3U0DbRepInt	1 - 300	s,%,%s	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s
3U0Min	0 - 2000000	V	1	0	Minimum value
3U0Max	0 - 2000000	V	1	318000	Maximum value
3U0RepTyp	Cyclic Dead band Int deadband	-	-	Dead band	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	s,%,%s	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s
U1DbRepInt	1 - 300	s,%,%s	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s
U1Min	0 - 2000000	V	1	0	Minimum value
U1Max	0 - 2000000	V	1	106000	Maximum value
U1RepTyp	Cyclic Dead band Int deadband	-	-	Dead band	Reporting type
Table continues on next page					

Name	Values (Range)	Unit	Step	Default	Description
U1AngDbRepInt	1 - 300	s,%,%s	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s
U2DbRepInt	1 - 300	s,%,%s	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s
U2Min	0 - 2000000	V	1	0	Minimum value
U2Max	0 - 2000000	V	1	106000	Maximum value
U2RepTyp	Cyclic Dead band Int deadband	-	-	Dead band	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	s,%,%s	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s

Table 331:   *VMSQI Non group settings (advanced)*

Name	Values (Range)	Unit	Step	Default	Description
3U0ZeroDb	0 - 100000	1/1000%	1	500	Zero point clamping
3U0HiHiLim	0 - 2000000	V	1	288000	High High limit (physical value)
3U0HiLim	0 - 2000000	V	1	258000	High limit (physical value)
3U0LowLim	0 - 2000000	V	1	213000	Low limit (physical value)
3U0LowLowLim	0 - 2000000	V	1	198000	Low Low limit (physical value)
U1ZeroDb	0 - 100000	1/1000%	1	500	Zero point clamping
U1HiHiLim	0 - 2000000	V	1	96000	High High limit (physical value)
U1HiLim	0 - 2000000	V	1	86000	High limit (physical value)
U1LowLim	0 - 2000000	V	1	71000	Low limit (physical value)
U1LowLowLim	0 - 2000000	V	1	66000	Low Low limit (physical value)
U1LimHys	0.000 - 100.000	%	0.001	5.000	Hysteresis value in % of range and is common for all limits
U2ZeroDb	0 - 100000	1/1000%	1	500	Zero point clamping
U2HiHiLim	0 - 2000000	V	1	96000	High High limit (physical value)
U2HiLim	0 - 2000000	V	1	86000	High limit (physical value)
U2LowLim	0 - 2000000	V	1	71000	Low limit (physical value)
U2LowLowLim	0 - 2000000	V	1	66000	Low Low limit (physical value)

10.4.6.5   Monitored data

Table 332:   *VMSQI Monitored data*

Name	Type	Values (Range)	Unit	Description
3U0	REAL	-	kV	3U0 Amplitude
3U0ANGL	REAL	-	deg	3U0 Angle
U1	REAL	-	kV	U1 Amplitude
Table continues on next page				

Name	Type	Values (Range)	Unit	Description
U1ANGL	REAL	-	deg	U1 Angle
U2	REAL	-	kV	U2 Amplitude
U2ANGL	REAL	-	deg	U2 Angle

10.4.7 Phase-neutral voltage measurement VNMMXU

10.4.7.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Phase-neutral voltage measurement	VNMMXU	U	-

10.4.7.2 Function block

The available function blocks of an IED are depending on the actual hardware (TRM) and the logic configuration made in PCM600.
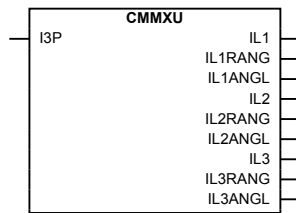
```
        VNMMXU
 ─┤ U3P         UL1 ├─
             UL1RANG ├─
             UL1ANGL ├─
                 UL2 ├─
             UL2RANG ├─
             UL2ANGL ├─
                 UL3 ├─
             UL3RANG ├─
             UL3ANGL ├─
```
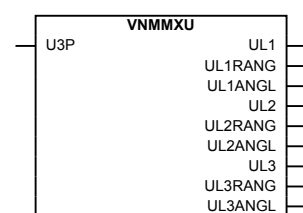
Figure 161:   VNMMXU function block

10.4.7.3 Signals

Table 333:   VNMMXU Input signals

Name	Type	Default	Description
U3P	GROUP SIGNAL	-	Three phase group signal for voltage inputs

Table 334:   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
Table continues on next page		

Name	Type	Description
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

10.4.7.4　　　　Settings

Table 335:　　　VNMMXU Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Mode On / Off
GlobalBaseSel	1 - 6	-	1	1	Global Base Selector
UDbRepInt	1 - 300	s,%,%s	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s
UMax	0 - 2000000	V	1	106000	Maximum value
URepTyp	Cyclic Dead band Int deadband	-	-	Dead band	Reporting type
ULimHys	0.000 - 100.000	V	0.001	5.0000	Hysteresis value in % of range and is common for all limits
UAngDbRepInt	1 - 300	s,%,%s	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s

Table 336:　　　VNMMXU Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
UZeroDb	0 - 100000	1/1000%	1	500	Zero point clamping in 0,001% of range
UHiHiLim	0 - 2000000	V	1	96000	High High limit (physical value)
UHiLim	0 - 2000000	V	1	86000	High limit (physical value)
ULowLim	0 - 2000000	V	1	71000	Low limit (physical value)
ULowLowLim	0 - 2000000	V	1	66000	Low Low limit (physical value)
UMin	0 - 2000000	V	1	0	Minimum value

10.4.7.5 Monitored data

Table 337:   *VNMMXU Monitored data*

Name	Type	Values (Range)	Unit	Description
UL1	REAL	-	kV	UL1 Amplitude, magnitude of reported value
UL1ANGL	REAL	-	deg	UL1 Angle, magnitude of reported value
UL2	REAL	-	kV	UL2 Amplitude, magnitude of reported value
UL2ANGL	REAL	-	deg	UL2 Angle, magnitude of reported value
UL3	REAL	-	kV	UL3 Amplitude, magnitude of reported value
UL3ANGL	REAL	-	deg	UL3 Angle, magnitude of reported value

10.4.8 Operation principle

10.4.8.1 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. The *PhaseAngleRef* is set in local HMI under: **Configuration/Analog modules/Reference** channel service values.

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 CVMMXN.

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 162. 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 162.
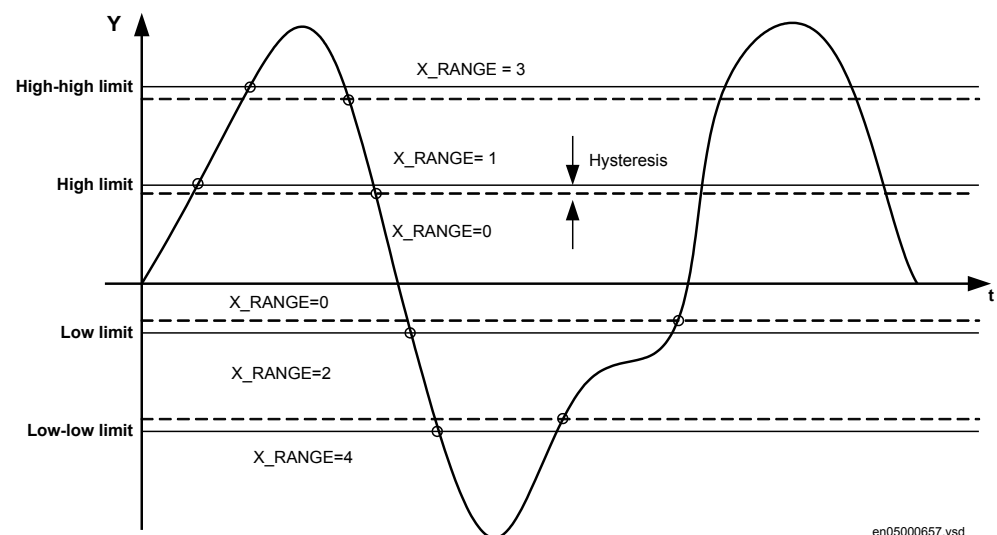
Figure 162:   Presentation of operating limits

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 162.

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.
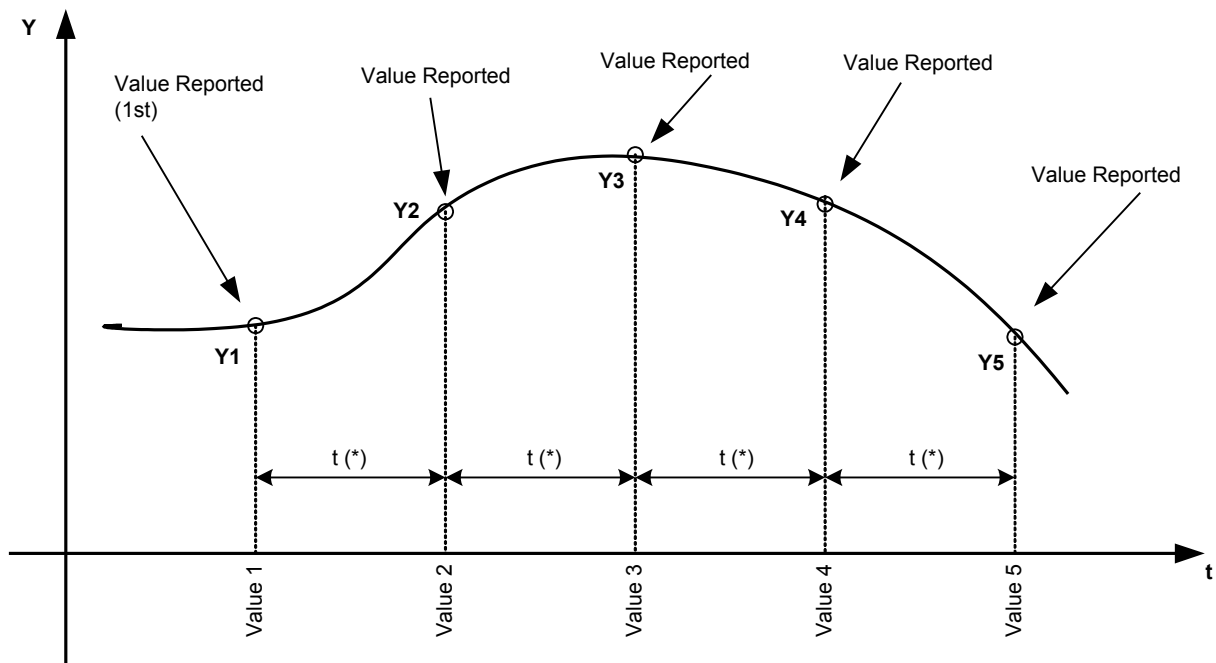
(*)Set value for t: XDbRepInt

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Figure 163:   *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 $\pm\Delta Y$ 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 164 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.
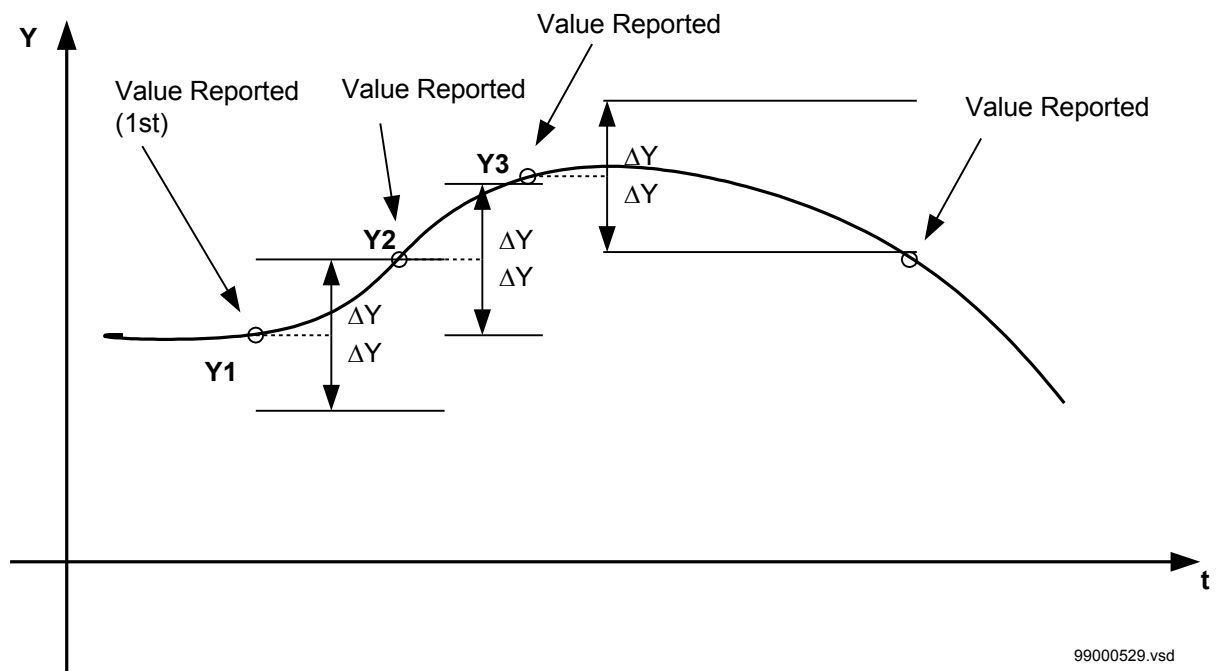
Figure 164:   Amplitude dead-band supervision reporting

After the new value is reported, the $\pm\Delta Y$ 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 $\pm\Delta Y$ 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 165, 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 165 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.

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Figure 165:   Reporting with integral dead-band supervision

10.4.8.2   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	$\overline{S} = \overline{U_{L1}} \cdot \overline{I_{L1}^*} + \overline{U_{L2}} \cdot \overline{I_{L2}^*} + \overline{U_{L3}} \cdot \overline{I_{L3}^*}$	$U = (\left|\overline{U_{L1}}\right| + \left|\overline{U_{L2}}\right| + \left|\overline{U_{L3}}\right|)/\sqrt{3}$ $I = (\left|\overline{I_{L1}}\right| + \left|\overline{I_{L2}}\right| + \left|\overline{I_{L3}}\right|)/3$	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 39)	$U = (\left|\overline{U_{L1L2}}\right| + \left|\overline{U_{L2L3}}\right|)/2$ $I = (\left|\overline{I_{L1}}\right| + \left|\overline{I_{L3}}\right|)/2$ (Equation 40)	Used when three two phase-to-phase voltages are available
3	PosSeq	$\overline{S} = 3 \cdot \overline{U_{PosSeq}} \cdot \overline{I_{PosSeq}^*}$ (Equation 41)	$U = \sqrt{3} \cdot \left|\overline{U_{PosSeq}}\right|$ $I = \left|\overline{I_{PosSeq}}\right|$ (Equation 42)	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 43)	$U = \left| \overline{U_{L1L2}} \right|$ $I = (\left| \overline{I_{L1}} \right| + \left| \overline{I_{L2}} \right|) / 2$ (Equation 44)	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 45)	$U = \left| \overline{U_{L2L3}} \right|$ $I = (\left| \overline{I_{L2}} \right| + \left| \overline{I_{L3}} \right|) / 2$ (Equation 46)	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 47)	$U = \left| \overline{U_{L3L1}} \right|$ $I = (\left| \overline{I_{L3}} \right| + \left| \overline{I_{L1}} \right|) / 2$ (Equation 48)	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 49)	$U = \sqrt{3} \cdot \left| \overline{U_{L1}} \right|$ $I = \left| \overline{I_{L1}} \right|$ (Equation 50)	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 51)	$U = \sqrt{3} \cdot \left| \overline{U_{L2}} \right|$ $I = \left| \overline{I_{L2}} \right|$ (Equation 52)	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 53)	$U = \sqrt{3} \cdot \left| \overline{U_{L3}} \right|$ $I = \left| \overline{I_{L3}} \right|$ (Equation 54)	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:

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

(Equation 55)

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

<div align="right">(Equation 56)</div>

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

<div align="right">(Equation 57)</div>

$$PF = \cos\varphi = \frac{P}{S}$$

<div align="right">(Equation 58)</div>

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 analogue 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 166.

% of Ir   Amplitude compensation

+10

IAmpComp5   Measured current
IAmpComp30

IAmpComp100

5   30   100   % of Ir

-10

0-5%:   Constant
5-30-100%: Linear
>100%:   Constant

Degrees   Angle compensation

+10

IAngComp30   Measured current
IAngComp5
IAngComp100

5   30   100   % of Ir

-10
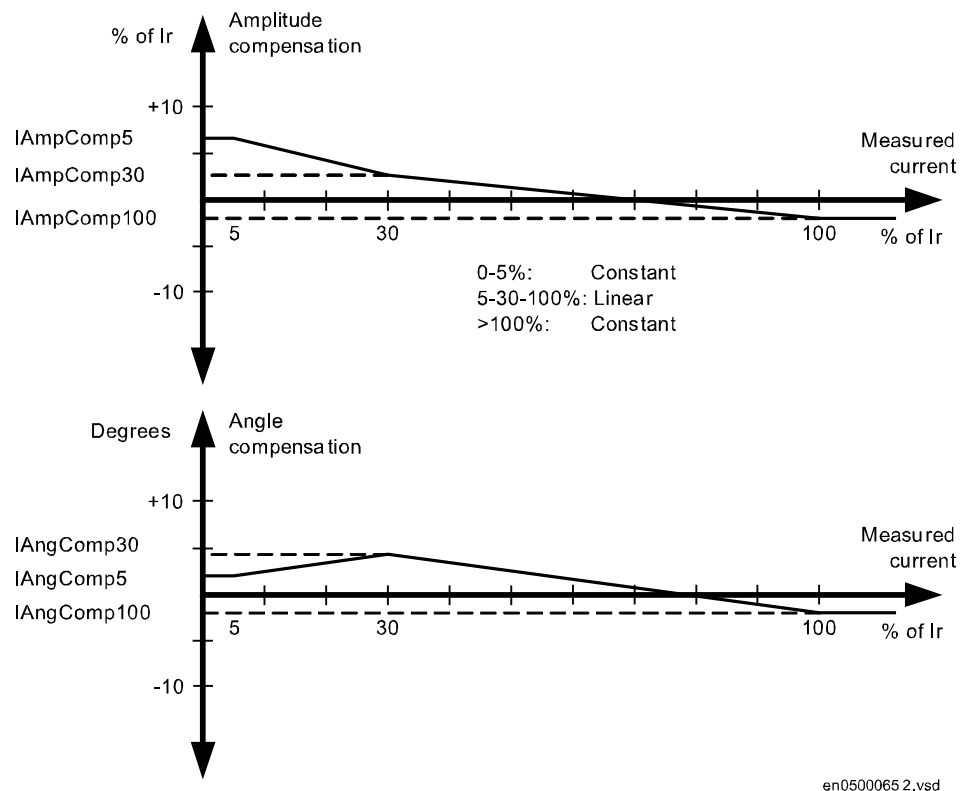
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Figure 166:   *Calibration curves*

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 59)

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, the amplitude level for current and voltage measurement is forced to zero. When either current or voltage measurement is forced to zero automatically the measured values for power (P, Q & S) and power factor are forced to zero as well. Since the measurement supervision functionality, included in the CVMMXN function, 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 etc.) 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

CTStartPoint defines if the CTs earthing point is located towards or from the protected object under observation. If everything is properly set power is always measured towards protection object.
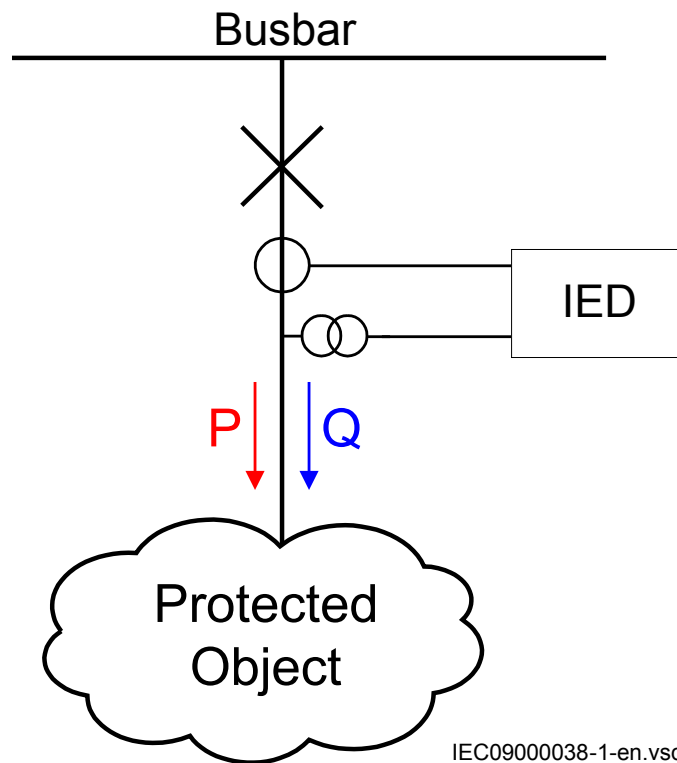
Figure 167: Internal IED directionality convention for P & Q measurements

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.

10.4.8.3   Phase current measurement CMMXU

The 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 166 above.

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".

10.4.8.4 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".

10.4.8.5 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".
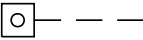
10.4.9 Technical data

Table 338: CVMMXN Tehcnical data

Function	Range or value	Accuracy
Frequency	$(0.95\text{-}1.05) \times f_r$	$\pm$ 2.0 mHz
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 $I > I_r$

10.5   Event Counter CNTGGIO

10.5.1   Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Event counter	CNTGGIO	○— — —	-

10.5.2   Functionality

Event counter (CNTGGIO) has six counters which are used for storing the number of times each counter input has been activated.

10.5.3   Function block

IEC09000090_1_en.vsd
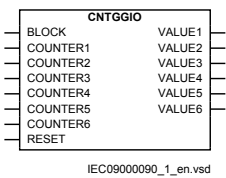
Figure 168:   CNTGGIO function block

10.5.4   Signals

Table 339:   CNTGGIO Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of function
COUNTER1	BOOLEAN	0	Input for counter 1
COUNTER2	BOOLEAN	0	Input for counter 2
COUNTER3	BOOLEAN	0	Input for counter 3
COUNTER4	BOOLEAN	0	Input for counter 4
COUNTER5	BOOLEAN	0	Input for counter 5
COUNTER6	BOOLEAN	0	Input for counter 6
RESET	BOOLEAN	0	Reset of function

Table 340:   *CNTGGIO Output signals*

Name	Type	Description
VALUE1	INTEGER	Output of counter 1
VALUE2	INTEGER	Output of counter 2
VALUE3	INTEGER	Output of counter 3
VALUE4	INTEGER	Output of counter 4
VALUE5	INTEGER	Output of counter 5
VALUE6	INTEGER	Output of counter 6

10.5.5   Settings

Table 341:   *CNTGGIO Group settings (basic)*

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On

10.5.6   Monitored data

Table 342:   *CNTGGIO Monitored data*

Name	Type	Values (Range)	Unit	Description
VALUE1	INTEGER	-	-	Output of counter 1
VALUE2	INTEGER	-	-	Output of counter 2
VALUE3	INTEGER	-	-	Output of counter 3
VALUE4	INTEGER	-	-	Output of counter 4
VALUE5	INTEGER	-	-	Output of counter 5
VALUE6	INTEGER	-	-	Output of counter 6

10.5.7   Operation principle

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.

The 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 PCM 600.

10.5.7.1 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.

10.5.8 Technical data

Table 343:   CNTGGIO Technical data

Function	Range or value	Accuracy
Counter value	0-10000	-
Max. count up speed	10 pulses/s	-

10.6 Disturbance report

10.6.1 Functionality

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, always included in the IED, acquires sampled data of all selected analog input and binary signals connected to the function block that is, maximum 40 analog and 96 binary signals.

Disturbance report functionality is a common name for several functions:

- Event List
- Indications
- Event recorder
- Trip Value recorder
- Disturbance recorder

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 in the AxRADR or BxRBDR function blocks which is 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, but the disturbance report files may be uploaded to PCM600 (Protection and Control IED Manager) and further analysis using the disturbance handling tool.

10.6.2 Disturbance report DRPRDRE

10.6.2.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Disturbance report	DRPRDRE	-	-

10.6.2.2 Function block

IEC09000346-1-en.vsd
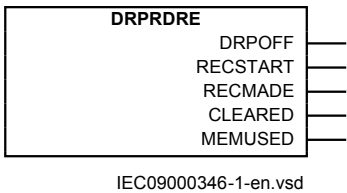
Figure 169: DRPRDRE function block

10.6.2.3 Signals

Table 344: 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

10.6.2.4   Settings

Table 345:   DRPRDRE Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off/On
PreFaultRecT	0.05 - 1.00	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)
MaxNoStoreRec	10 - 100	-	1	100	Maximum number of stored disturbances
ZeroAngleRef	1 - 30	Ch	1	1	Trip value recorder, phasor reference channel
OpModeTest	Off On	-	-	Off	Operation mode during test mode

10.6.2.5   Monitored data

Table 346:   DRPRDRE Monitored data

Name	Type	Values (Range)	Unit	Description
MemoryUsed	INTEGER	-	%	Memory usage (0-100%)
UnTrigStatCh1	BOOLEAN	-	-	Under level trig for analog channel 1 activated
OvTrigStatCh1	BOOLEAN	-	-	Over level trig for analog channel 1 activated
UnTrigStatCh2	BOOLEAN	-	-	Under level trig for analog channel 2 activated
OvTrigStatCh2	BOOLEAN	-	-	Over level trig for analog channel 2 activated
UnTrigStatCh3	BOOLEAN	-	-	Under level trig for analog channel 3 activated
OvTrigStatCh3	BOOLEAN	-	-	Over level trig for analog channel 3 activated
UnTrigStatCh4	BOOLEAN	-	-	Under level trig for analog channel 4 activated
OvTrigStatCh4	BOOLEAN	-	-	Over level trig for analog channel 4 activated
UnTrigStatCh5	BOOLEAN	-	-	Under level trig for analog channel 5 activated
OvTrigStatCh5	BOOLEAN	-	-	Over level trig for analog channel 5 activated
Table continues on next page				

Name	Type	Values (Range)	Unit	Description
UnTrigStatCh6	BOOLEAN	-	-	Under level trig for analog channel 6 activated
OvTrigStatCh6	BOOLEAN	-	-	Over level trig for analog channel 6 activated
UnTrigStatCh7	BOOLEAN	-	-	Under level trig for analog channel 7 activated
OvTrigStatCh7	BOOLEAN	-	-	Over level trig for analog channel 7 activated
UnTrigStatCh8	BOOLEAN	-	-	Under level trig for analog channel 8 activated
OvTrigStatCh8	BOOLEAN	-	-	Over level trig for analog channel 8 activated
UnTrigStatCh9	BOOLEAN	-	-	Under level trig for analog channel 9 activated
OvTrigStatCh9	BOOLEAN	-	-	Over level trig for analog channel 9 activated
UnTrigStatCh10	BOOLEAN	-	-	Under level trig for analog channel 10 activated
OvTrigStatCh10	BOOLEAN	-	-	Over level trig for analog channel 10 activated
UnTrigStatCh11	BOOLEAN	-	-	Under level trig for analog channel 11 activated
OvTrigStatCh11	BOOLEAN	-	-	Over level trig for analog channel 11 activated
UnTrigStatCh12	BOOLEAN	-	-	Under level trig for analog channel 12 activated
OvTrigStatCh12	BOOLEAN	-	-	Over level trig for analog channel 12 activated
UnTrigStatCh13	BOOLEAN	-	-	Under level trig for analog channel 13 activated
OvTrigStatCh13	BOOLEAN	-	-	Over level trig for analog channel 13 activated
UnTrigStatCh14	BOOLEAN	-	-	Under level trig for analog channel 14 activated
OvTrigStatCh14	BOOLEAN	-	-	Over level trig for analog channel 14 activated
UnTrigStatCh15	BOOLEAN	-	-	Under level trig for analog channel 15 activated
OvTrigStatCh15	BOOLEAN	-	-	Over level trig for analog channel 15 activated
Table continues on next page				

Name	Type	Values (Range)	Unit	Description
UnTrigStatCh16	BOOLEAN	-	-	Under level trig for analog channel 16 activated
OvTrigStatCh16	BOOLEAN	-	-	Over level trig for analog channel 16 activated
UnTrigStatCh17	BOOLEAN	-	-	Under level trig for analog channel 17 activated
OvTrigStatCh17	BOOLEAN	-	-	Over level trig for analog channel 17 activated
UnTrigStatCh18	BOOLEAN	-	-	Under level trig for analog channel 18 activated
OvTrigStatCh18	BOOLEAN	-	-	Over level trig for analog channel 18 activated
UnTrigStatCh19	BOOLEAN	-	-	Under level trig for analog channel 19 activated
OvTrigStatCh19	BOOLEAN	-	-	Over level trig for analog channel 19 activated
UnTrigStatCh20	BOOLEAN	-	-	Under level trig for analog channel 20 activated
OvTrigStatCh20	BOOLEAN	-	-	Over level trig for analog channel 20 activated
UnTrigStatCh21	BOOLEAN	-	-	Under level trig for analog channel 21 activated
OvTrigStatCh21	BOOLEAN	-	-	Over level trig for analog channel 21 activated
UnTrigStatCh22	BOOLEAN	-	-	Under level trig for analog channel 22 activated
OvTrigStatCh22	BOOLEAN	-	-	Over level trig for analog channel 22 activated
UnTrigStatCh23	BOOLEAN	-	-	Under level trig for analog channel 23 activated
OvTrigStatCh23	BOOLEAN	-	-	Over level trig for analog channel 23 activated
UnTrigStatCh24	BOOLEAN	-	-	Under level trig for analog channel 24 activated
OvTrigStatCh24	BOOLEAN	-	-	Over level trig for analog channel 24 activated
UnTrigStatCh25	BOOLEAN	-	-	Under level trig for analog channel 25 activated
OvTrigStatCh25	BOOLEAN	-	-	Over level trig for analog channel 25 activated
Table continues on next page				

Name	Type	Values (Range)	Unit	Description
UnTrigStatCh26	BOOLEAN	-	-	Under level trig for analog channel 26 activated
OvTrigStatCh26	BOOLEAN	-	-	Over level trig for analog channel 26 activated
UnTrigStatCh27	BOOLEAN	-	-	Under level trig for analog channel 27 activated
OvTrigStatCh27	BOOLEAN	-	-	Over level trig for analog channel 27 activated
UnTrigStatCh28	BOOLEAN	-	-	Under level trig for analog channel 28 activated
OvTrigStatCh28	BOOLEAN	-	-	Over level trig for analog channel 28 activated
UnTrigStatCh29	BOOLEAN	-	-	Under level trig for analog channel 29 activated
OvTrigStatCh29	BOOLEAN	-	-	Over level trig for analog channel 29 activated
UnTrigStatCh30	BOOLEAN	-	-	Under level trig for analog channel 30 activated
OvTrigStatCh30	BOOLEAN	-	-	Over level trig for analog channel 30 activated
UnTrigStatCh31	BOOLEAN	-	-	Under level trig for analog channel 31 activated
OvTrigStatCh31	BOOLEAN	-	-	Over level trig for analog channel 31 activated
UnTrigStatCh32	BOOLEAN	-	-	Under level trig for analog channel 32 activated
OvTrigStatCh32	BOOLEAN	-	-	Over level trig for analog channel 32 activated
UnTrigStatCh33	BOOLEAN	-	-	Under level trig for analog channel 33 activated
OvTrigStatCh33	BOOLEAN	-	-	Over level trig for analog channel 33 activated
UnTrigStatCh34	BOOLEAN	-	-	Under level trig for analog channel 34 activated
OvTrigStatCh34	BOOLEAN	-	-	Over level trig for analog channel 34 activated
UnTrigStatCh35	BOOLEAN	-	-	Under level trig for analog channel 35 activated
OvTrigStatCh35	BOOLEAN	-	-	Over level trig for analog channel 35 activated
Table continues on next page				

Name	Type	Values (Range)	Unit	Description
UnTrigStatCh36	BOOLEAN	-	-	Under level trig for analog channel 36 activated
OvTrigStatCh36	BOOLEAN	-	-	Over level trig for analog channel 36 activated
UnTrigStatCh37	BOOLEAN	-	-	Under level trig for analog channel 37 activated
OvTrigStatCh37	BOOLEAN	-	-	Over level trig for analog channel 37 activated
UnTrigStatCh38	BOOLEAN	-	-	Under level trig for analog channel 38 activated
OvTrigStatCh38	BOOLEAN	-	-	Over level trig for analog channel 38 activated
UnTrigStatCh39	BOOLEAN	-	-	Under level trig for analog channel 39 activated
OvTrigStatCh39	BOOLEAN	-	-	Over level trig for analog channel 39 activated
UnTrigStatCh40	BOOLEAN	-	-	Under level trig for analog channel 40 activated
OvTrigStatCh40	BOOLEAN	-	-	Over level trig for analog channel 40 activated
FaultNumber	INTEGER	-	-	Disturbance fault number

10.6.2.6 Measured values

Table 347: DRPRDRE Measured values

Name	Type	Default	Description
ManTrig	BOOLEAN	0	Manual trig of disturbance report
ClearDist	BOOLEAN	0	Clear all disturbances
ClearProcessEv	BOOLEAN	0	Clear all process events

10.6.3 Analog input signals AxRADR

10.6.3.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Analog input signals	A1RADR	-	-
Analog input signals	A2RADR	-	-
Analog input signals	A3RADR	-	-

10.6.3.2 Function block
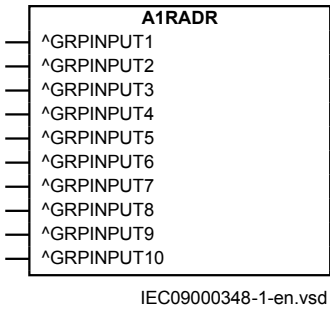
Figure 170:   *A1RADR function block, analog inputs, example for A1RADR, A2RADR and A3RADR*

10.6.3.3 Signals

A1RADR - A3RADR Input signals

Tables for input signals for A1RADR, A2RADR and A3RADR are similar except for GRPINPUT number.

- A1RADR, GRPINPUT1 - GRPINPUT10
- A2RADR, GRPINPUT11 - GRPINPUT20
- A3RADR, GRPINPUT21 - GRPINPUT30

Table 348:   A1RADR Input signals

Name	Type	Default	Description
GRPINPUT1	GROUP SIGNAL	-	Group signal for input 1
GRPINPUT2	GROUP SIGNAL	-	Group signal for input 2
GRPINPUT3	GROUP SIGNAL	-	Group signal for input 3
GRPINPUT4	GROUP SIGNAL	-	Group signal for input 4
GRPINPUT5	GROUP SIGNAL	-	Group signal for input 5
GRPINPUT6	GROUP SIGNAL	-	Group signal for input 6
GRPINPUT7	GROUP SIGNAL	-	Group signal for input 7
GRPINPUT8	GROUP SIGNAL	-	Group signal for input 8
GRPINPUT9	GROUP SIGNAL	-	Group signal for input 9
GRPINPUT10	GROUP SIGNAL	-	Group signal for input 10

10.6.3.4 Settings

A1RADR - A3RADR Settings

Setting tables for A1RADR, A2RADR and A3RADR are similar except for channel numbers.

- A1RADR, channel01 - channel10
- A2RADR, channel11 - channel20
- A3RADR, channel21 - channel30

Table 349:   *A1RADR Non group settings (basic)*

Name	Values (Range)	Unit	Step	Default	Description
Operation01	Off On	-	-	Off	Operation On/Off
Operation02	Off On	-	-	Off	Operation On/Off
Operation03	Off On	-	-	Off	Operation On/Off
Operation04	Off On	-	-	Off	Operation On/Off
Operation05	Off On	-	-	Off	Operation On/Off
Operation06	Off On	-	-	Off	Operation On/Off
Operation07	Off On	-	-	Off	Operation On/Off
Operation08	Off On	-	-	Off	Operation On/Off
Operation09	Off On	-	-	Off	Operation On/Off
Operation10	Off On	-	-	Off	Operation On/Off

Table 350:   *A1RADR Non group settings (advanced)*

Name	Values (Range)	Unit	Step	Default	Description
NomValue01	0.0 - 999999.9	-	0.1	0.0	Nominal value for analog channel 1
UnderTrigOp01	Off On	-	-	Off	Use under level trigger for analog channel 1 (on) or not (off)
UnderTrigLe01	0 - 200	%	1	50	Under trigger level for analog channel 1 in % of signal
OverTrigOp01	Off On	-	-	Off	Use over level trigger for analog channel 1 (on) or not (off)
OverTrigLe01	0 - 5000	%	1	200	Over trigger level for analog channel 1 in % of signal
NomValue02	0.0 - 999999.9	-	0.1	0.0	Nominal value for analog channel 2
UnderTrigOp02	Off On	-	-	Off	Use under level trigger for analog channel 2 (on) or not (off)
Table continues on next page					

Name	Values (Range)	Unit	Step	Default	Description
UnderTrigLe02	0 - 200	%	1	50	Under trigger level for analog channel 2 in % of signal
OverTrigOp02	Off On	-	-	Off	Use over level trigger for analog channel 2 (on) or not (off)
OverTrigLe02	0 - 5000	%	1	200	Over trigger level for analog channel 2 in % of signal
NomValue03	0.0 - 999999.9	-	0.1	0.0	Nominal value for analog channel 3
UnderTrigOp03	Off On	-	-	Off	Use under level trigger for analog channel 3 (on) or not (off)
UnderTrigLe03	0 - 200	%	1	50	Under trigger level for analog channel 3 in % of signal
OverTrigOp03	Off On	-	-	Off	Use over level trigger for analog channel 3 (on) or not (off)
OverTrigLe03	0 - 5000	%	1	200	Overtrigger level for analog channel 3 in % of signal
NomValue04	0.0 - 999999.9	-	0.1	0.0	Nominal value for analog channel 4
UnderTrigOp04	Off On	-	-	Off	Use under level trigger for analog channel 4 (on) or not (off)
UnderTrigLe04	0 - 200	%	1	50	Under trigger level for analog channel 4 in % of signal
OverTrigOp04	Off On	-	-	Off	Use over level trigger for analog channel 4 (on) or not (off)
OverTrigLe04	0 - 5000	%	1	200	Over trigger level for analog channel 4 in % of signal
NomValue05	0.0 - 999999.9	-	0.1	0.0	Nominal value for analog channel 5
UnderTrigOp05	Off On	-	-	Off	Use under level trigger for analog channel 5 (on) or not (off)
UnderTrigLe05	0 - 200	%	1	50	Under trigger level for analog channel 5 in % of signal
OverTrigOp05	Off On	-	-	Off	Use over level trigger for analog channel 5 (on) or not (off)
OverTrigLe05	0 - 5000	%	1	200	Over trigger level for analog channel 5 in % of signal
NomValue06	0.0 - 999999.9	-	0.1	0.0	Nominal value for analog channel 6
UnderTrigOp06	Off On	-	-	Off	Use under level trigger for analog channel 6 (on) or not (off)
UnderTrigLe06	0 - 200	%	1	50	Under trigger level for analog channel 6 in % of signal
OverTrigOp06	Off On	-	-	Off	Use over level trigger for analog channel 6 (on) or not (off)
OverTrigLe06	0 - 5000	%	1	200	Over trigger level for analog channel 6 in % of signal
NomValue07	0.0 - 999999.9	-	0.1	0.0	Nominal value for analog channel 7
UnderTrigOp07	Off On	-	-	Off	Use under level trigger for analog channel 7 (on) or not (off)
UnderTrigLe07	0 - 200	%	1	50	Under trigger level for analog channel 7 in % of signal
Table continues on next page					

Name	Values (Range)	Unit	Step	Default	Description
OverTrigOp07	Off On	-	-	Off	Use over level trigger for analog channel 7 (on) or not (off)
OverTrigLe07	0 - 5000	%	1	200	Over trigger level for analog channel 7 in % of signal
NomValue08	0.0 - 999999.9	-	0.1	0.0	Nominal value for analog channel 8
UnderTrigOp08	Off On	-	-	Off	Use under level trigger for analog channel 8 (on) or not (off)
UnderTrigLe08	0 - 200	%	1	50	Under trigger level for analog channel 8 in % of signal
OverTrigOp08	Off On	-	-	Off	Use over level trigger for analog channel 8 (on) or not (off)
OverTrigLe08	0 - 5000	%	1	200	Over trigger level for analog channel 8 in % of signal
NomValue09	0.0 - 999999.9	-	0.1	0.0	Nominal value for analog channel 9
UnderTrigOp09	Off On	-	-	Off	Use under level trigger for analog channel 9 (on) or not (off)
UnderTrigLe09	0 - 200	%	1	50	Under trigger level for analog channel 9 in % of signal
OverTrigOp09	Off On	-	-	Off	Use over level trigger for analog channel 9 (on) or not (off)
OverTrigLe09	0 - 5000	%	1	200	Over trigger level for analog channel 9 in % of signal
NomValue10	0.0 - 999999.9	-	0.1	0.0	Nominal value for analog channel 10
UnderTrigOp10	Off On	-	-	Off	Use under level trigger for analog channel 10 (on) or not (off)
UnderTrigLe10	0 - 200	%	1	50	Under trigger level for analog channel 10 in % of signal
OverTrigOp10	Off On	-	-	Off	Use over level trigger for analog channel 10 (on) or not (off)
OverTrigLe10	0 - 5000	%	1	200	Over trigger level for analog channel 10 in % of signal

10.6.4   Analog input signals A4RADR

10.6.4.1   Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Analog input signals	A41RADR	-	-

10.6.4.2   Function block

```
          A4RADR
  ——— ^INPUT31
  ——— ^INPUT32
  ——— ^INPUT33
  ——— ^INPUT34
  ——— ^INPUT35
  ——— ^INPUT36
  ——— ^INPUT37
  ——— ^INPUT38
  ——— ^INPUT39
  ——— ^INPUT40
```

IEC09000350-1-en.vsd
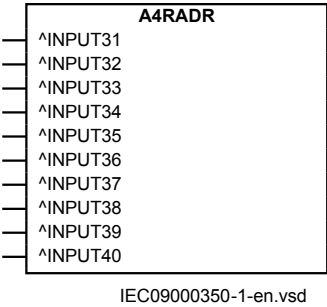
Figure 171:   A4RADR function block, derived analog inputs

10.6.4.3   Signals

Table 351:   A4RADR Input signals

Name	Type	Default	Description
INPUT31	REAL	0	Analog channel 31
INPUT32	REAL	0	Analog channel 32
INPUT33	REAL	0	Analog channel 33
INPUT34	REAL	0	Analog channel 34
INPUT35	REAL	0	Analog channel 35
INPUT36	REAL	0	Analog channel 36
INPUT37	REAL	0	Analog channel 37
INPUT38	REAL	0	Analog channel 38
INPUT39	REAL	0	Analog channel 39
INPUT40	REAL	0	Analog channel 40

10.6.4.4   Settings

Table 352:   A4RADR Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation31	Off On	-	-	Off	Operation On/off
Operation32	Off On	-	-	Off	Operation On/off
Operation33	Off On	-	-	Off	Operation On/off
Operation34	Off On	-	-	Off	Operation On/off
Operation35	Off On	-	-	Off	Operation On/off
Table continues on next page					

Name	Values (Range)	Unit	Step	Default	Description
Operation36	Off On	-	-	Off	Operation On/off
Operation37	Off On	-	-	Off	Operation On/off
Operation38	Off On	-	-	Off	Operation On/off
Operation39	Off On	-	-	Off	Operation On/off
Operation40	Off On	-	-	Off	Operation On/off

Table 353:   A4RADR Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
NomValue31	0.0 - 999999.9	-	0.1	0.0	Nominal value for analog channel 31
UnderTrigOp31	Off On	-	-	Off	Use under level trigger for analog channel 31 (on) or not (off)
UnderTrigLe31	0 - 200	%	1	50	Under trigger level for analog channel 31 in % of signal
OverTrigOp31	Off On	-	-	Off	Use over level trigger for analog channel 31 (on) or not (off)
OverTrigLe31	0 - 5000	%	1	200	Over trigger level for analog channel 31 in % of signal
NomValue32	0.0 - 999999.9	-	0.1	0.0	Nominal value for analog channel 32
UnderTrigOp32	Off On	-	-	Off	Use under level trigger for analog channel 32 (on) or not (off)
UnderTrigLe32	0 - 200	%	1	50	Under trigger level for analog channel 32 in % of signal
OverTrigOp32	Off On	-	-	Off	Use over level trigger for analog channel 32 (on) or not (off)
OverTrigLe32	0 - 5000	%	1	200	Over trigger level for analog channel 32 in % of signal
NomValue33	0.0 - 999999.9	-	0.1	0.0	Nominal value for analog channel 33
UnderTrigOp33	Off On	-	-	Off	Use under level trigger for analog channel 33 (on) or not (off)
UnderTrigLe33	0 - 200	%	1	50	Under trigger level for analog channel 33 in % of signal
OverTrigOp33	Off On	-	-	Off	Use over level trigger for analog channel 33 (on) or not (off)
OverTrigLe33	0 - 5000	%	1	200	Overtrigger level for analog channel 33 in % of signal
NomValue34	0.0 - 999999.9	-	0.1	0.0	Nominal value for analog channel 34
UnderTrigOp34	Off On	-	-	Off	Use under level trigger for analog channel 34 (on) or not (off)
UnderTrigLe34	0 - 200	%	1	50	Under trigger level for analog channel 34 in % of signal
OverTrigOp34	Off On	-	-	Off	Use over level trigger for analog channel 34 (on) or not (off)
Table continues on next page					

Name	Values (Range)	Unit	Step	Default	Description
OverTrigLe34	0 - 5000	%	1	200	Over trigger level for analog channel 34 in % of signal
NomValue35	0.0 - 999999.9	-	0.1	0.0	Nominal value for analog channel 35
UnderTrigOp35	Off On	-	-	Off	Use under level trigger for analog channel 35 (on) or not (off)
UnderTrigLe35	0 - 200	%	1	50	Under trigger level for analog channel 35 in % of signal
OverTrigOp35	Off On	-	-	Off	Use over level trigger for analog channel 35 (on) or not (off)
OverTrigLe35	0 - 5000	%	1	200	Over trigger level for analog channel 35 in % of signal
NomValue36	0.0 - 999999.9	-	0.1	0.0	Nominal value for analog channel 36
UnderTrigOp36	Off On	-	-	Off	Use under level trigger for analog channel 36 (on) or not (off)
UnderTrigLe36	0 - 200	%	1	50	Under trigger level for analog channel 36 in % of signal
OverTrigOp36	Off On	-	-	Off	Use over level trigger for analog channel 36 (on) or not (off)
OverTrigLe36	0 - 5000	%	1	200	Over trigger level for analog channel 36 in % of signal
NomValue37	0.0 - 999999.9	-	0.1	0.0	Nominal value for analog channel 37
UnderTrigOp37	Off On	-	-	Off	Use under level trigger for analog channel 37 (on) or not (off)
UnderTrigLe37	0 - 200	%	1	50	Under trigger level for analog channel 37 in % of signal
OverTrigOp37	Off On	-	-	Off	Use over level trigger for analog channel 37 (on) or not (off)
OverTrigLe37	0 - 5000	%	1	200	Over trigger level for analog channel 37 in % of signal
NomValue38	0.0 - 999999.9	-	0.1	0.0	Nominal value for analog channel 38
UnderTrigOp38	Off On	-	-	Off	Use under level trigger for analog channel 38 (on) or not (off)
UnderTrigLe38	0 - 200	%	1	50	Under trigger level for analog channel 38 in % of signal
OverTrigOp38	Off On	-	-	Off	Use over level trigger for analog channel 38 (on) or not (off)
OverTrigLe38	0 - 5000	%	1	200	Over trigger level for analog channel 38 in % of signal
NomValue39	0.0 - 999999.9	-	0.1	0.0	Nominal value for analog channel 39
UnderTrigOp39	Off On	-	-	Off	Use under level trigger for analog channel 39 (on) or not (off)
UnderTrigLe39	0 - 200	%	1	50	Under trigger level for analog channel 39 in % of signal
OverTrigOp39	Off On	-	-	Off	Use over level trigger for analog channel 39 (on) or not (off)
OverTrigLe39	0 - 5000	%	1	200	Over trigger level for analog channel 39 in % of signal
NomValue40	0.0 - 999999.9	-	0.1	0.0	Nominal value for analog channel 40

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
UnderTrigOp40	Off On	-	-	Off	Use under level trigger for analog channel 40 (on) or not (off)
UnderTrigLe40	0 - 200	%	1	50	Under trigger level for analog channel 40 in % of signal
OverTrigOp40	Off On	-	-	Off	Use over level trigger for analog channel 40 (on) or not (off)
OverTrigLe40	0 - 5000	%	1	200	Over trigger level for analog channel 40 in % of signal

10.6.5   Binary input signals BxRBDR

10.6.5.1   Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Binary input signals	B1RBDR	-	-
Binary input signals	B2RBDR	-	-
Binary input signals	B3RBDR	-	-
Binary input signals	B4RBDR	-	-
Binary input signals	B5RBDR	-	-
Binary input signals	B6RBDR	-	-

10.6.5.2   Function block

```
              B1RBDR
    —  ^INPUT1
    —  ^INPUT2
    —  ^INPUT3
    —  ^INPUT4
    —  ^INPUT5
    —  ^INPUT6
    —  ^INPUT7
    —  ^INPUT8
    —  ^INPUT9
    —  ^INPUT10
    —  ^INPUT11
    —  ^INPUT12
    —  ^INPUT13
    —  ^INPUT14
    —  ^INPUT15
    —  ^INPUT16
```
IEC09000352-1-en.vsd
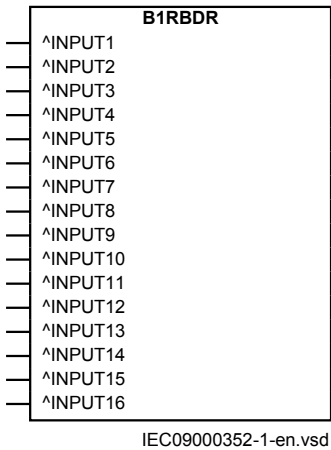
Figure 172:   B1RBDR function block, binary inputs, example for B1RBDR - B6RBDR

10.6.5.3   Signals

B1RBDR - B6RBDR Input signals
Tables for input signals for B1RBDR - B6RBDR are all similar except for INPUT
and description number.

- B1RBDR, INPUT1 - INPUT16
- B2RBDR, INPUT17 - INPUT32
- B3RBDR, INPUT33 - INPUT48
- B4RBDR, INPUT49 - INPUT64
- B5RBDR, INPUT65 - INPUT80
- B6RBDR, INPUT81 - INPUT96

Table 354:   *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

10.6.5.4   Settings

B1RBDR - B6RBDR Settings
Setting tables for B1RBDR - B6RBDR are all similar except for binary channel
and description numbers.

- B1RBDR, channel1 - channel16
- B2RBDR, channel17 - channel32
- B3RBDR, channel33 - channel48
- B4RBDR, channel49 - channel64
- B5RBDR, channel65 - channel80
- B6RBDR, channel81 - channel96

Table 355:   *B1RBDR Non group settings (basic)*

Name	Values (Range)	Unit	Step	Default	Description
TrigDR01	Off On	-	-	Off	Trigger operation On/Off
SetLED01	Off Start Trip Start and Trip	-	-	Off	Set LED on HMI for binary channel 1
TrigDR02	Off On	-	-	Off	Trigger operation On/Off
SetLED02	Off Start Trip Start and Trip	-	-	Off	Set LED on HMI for binary channel 2
TrigDR03	Off On	-	-	Off	Trigger operation On/Off
SetLED03	Off Start Trip Start and Trip	-	-	Off	Set LED on HMI for binary channel 3
TrigDR04	Off On	-	-	Off	Trigger operation On/Off
SetLED04	Off Start Trip Start and Trip	-	-	Off	Set LED on HMI for binary channel 4
TrigDR05	Off On	-	-	Off	Trigger operation On/Off
SetLED05	Off Start Trip Start and Trip	-	-	Off	Set LED on HMI for binary channel 5
TrigDR06	Off On	-	-	Off	Trigger operation On/Off
SetLED06	Off Start Trip Start and Trip	-	-	Off	Set LED on HMI for binary channel 6
TrigDR07	Off On	-	-	Off	Trigger operation On/Off
SetLED07	Off Start Trip Start and Trip	-	-	Off	Set LED on HMI for binary channel 7
TrigDR08	Off On	-	-	Off	Trigger operation On/Off
SetLED08	Off Start Trip Start and Trip	-	-	Off	Set LED on HMI for binary channel 8
TrigDR09	Off On	-	-	Off	Trigger operation On/Off
Table continues on next page					

Name	Values (Range)	Unit	Step	Default	Description
SetLED09	Off Start Trip Start and Trip	-	-	Off	Set LED on HMI for binary channel 9
TrigDR10	Off On	-	-	Off	Trigger operation On/Off
SetLED10	Off Start Trip Start and Trip	-	-	Off	Set LED on HMI for binary channel 10
TrigDR11	Off On	-	-	Off	Trigger operation On/Off
SetLED11	Off Start Trip Start and Trip	-	-	Off	Set LED on HMI for binary channel 11
TrigDR12	Off On	-	-	Off	Trigger operation On/Off
SetLED12	Off Start Trip Start and Trip	-	-	Off	Set LED on HMI for binary input 12
TrigDR13	Off On	-	-	Off	Trigger operation On/Off
SetLED13	Off Start Trip Start and Trip	-	-	Off	Set LED on HMI for binary channel 13
TrigDR14	Off On	-	-	Off	Trigger operation On/Off
SetLED14	Off Start Trip Start and Trip	-	-	Off	Set LED on HMI for binary channel 14
TrigDR15	Off On	-	-	Off	Trigger operation On/Off
SetLED15	Off Start Trip Start and Trip	-	-	Off	Set LED on HMI for binary channel 15
TrigDR16	Off On	-	-	Off	Trigger operation On/Off
SetLED16	Off Start Trip Start and Trip	-	-	Off	Set LED on HMI for binary channel 16

Table 356:   *B1RBDR Non group settings (advanced)*

Name	Values (Range)	Unit	Step	Default	Description
TrigLevel01	Trig on 0 Trig on 1	-	-	Trig on 1	Trigger on positive (1) or negative (0) slope for binary input 1
IndicationMa01	Hide Show	-	-	Hide	Indication mask for binary channel 1
TrigLevel02	Trig on 0 Trig on 1	-	-	Trig on 1	Trigger on positive (1) or negative (0) slope for binary input 2
IndicationMa02	Hide Show	-	-	Hide	Indication mask for binary channel 2
TrigLevel03	Trig on 0 Trig on 1	-	-	Trig on 1	Trigger on positive (1) or negative (0) slope for binary input 3
IndicationMa03	Hide Show	-	-	Hide	Indication mask for binary channel 3
TrigLevel04	Trig on 0 Trig on 1	-	-	Trig on 1	Trigger on positive (1) or negative (0) slope for binary input 4
IndicationMa04	Hide Show	-	-	Hide	Indication mask for binary channel 4
TrigLevel05	Trig on 0 Trig on 1	-	-	Trig on 1	Trigger on positive (1) or negative (0) slope for binary input 5
IndicationMa05	Hide Show	-	-	Hide	Indication mask for binary channel 5
TrigLevel06	Trig on 0 Trig on 1	-	-	Trig on 1	Trigger on positive (1) or negative (0) slope for binary input 6
IndicationMa06	Hide Show	-	-	Hide	Indication mask for binary channel 6
TrigLevel07	Trig on 0 Trig on 1	-	-	Trig on 1	Trigger on positive (1) or negative (0) slope for binary input 7
IndicationMa07	Hide Show	-	-	Hide	Indication mask for binary channel 7
TrigLevel08	Trig on 0 Trig on 1	-	-	Trig on 1	Trigger on positive (1) or negative (0) slope for binary input 8
IndicationMa08	Hide Show	-	-	Hide	Indication mask for binary channel 8
TrigLevel09	Trig on 0 Trig on 1	-	-	Trig on 1	Trigger on positive (1) or negative (0) slope for binary input 9
IndicationMa09	Hide Show	-	-	Hide	Indication mask for binary channel 9
TrigLevel10	Trig on 0 Trig on 1	-	-	Trig on 1	Trigger on positive (1) or negative (0) slope for binary input 10
IndicationMa10	Hide Show	-	-	Hide	Indication mask for binary channel 10
TrigLevel11	Trig on 0 Trig on 1	-	-	Trig on 1	Trigger on positive (1) or negative (0) slope for binary input 11
IndicationMa11	Hide Show	-	-	Hide	Indication mask for binary channel 11
TrigLevel12	Trig on 0 Trig on 1	-	-	Trig on 1	Trigger on positive (1) or negative (0) slope for binary input 12
IndicationMa12	Hide Show	-	-	Hide	Indication mask for binary channel 12
Table continues on next page					

Name	Values (Range)	Unit	Step	Default	Description
TrigLevel13	Trig on 0 Trig on 1	-	-	Trig on 1	Trigger on positive (1) or negative (0) slope for binary input 13
IndicationMa13	Hide Show	-	-	Hide	Indication mask for binary channel 13
TrigLevel14	Trig on 0 Trig on 1	-	-	Trig on 1	Trigger on positive (1) or negative (0) slope for binary input 14
IndicationMa14	Hide Show	-	-	Hide	Indication mask for binary channel 14
TrigLevel15	Trig on 0 Trig on 1	-	-	Trig on 1	Trigger on positive (1) or negative (0) slope for binary input 15
IndicationMa15	Hide Show	-	-	Hide	Indication mask for binary channel 15
TrigLevel16	Trig on 0 Trig on 1	-	-	Trig on 1	Trigger on positive (1) or negative (0) slope for binary input 16
IndicationMa16	Hide Show	-	-	Hide	Indication mask for binary channel 16

10.6.6 Operation principle

Disturbance report is a common name for several functions to supply the operator, analysis engineer, etc. with sufficient information about events in the system.

The functions included in the disturbance report are:

- General disturbance information
- Indications
- Event recorder
- Event list
- Trip value recorder
- Disturbance recorder

Figure 173 shows the relations between Disturbance Report, included functions and function blocks. Event list, Event recorder and Indications uses information from the binary input function blocks (BxRBDR). Trip value recorder uses analog information from the analog input function blocks (AxRADR). Disturbance recorder function acquires information from both AxRADR and BxRBDR.
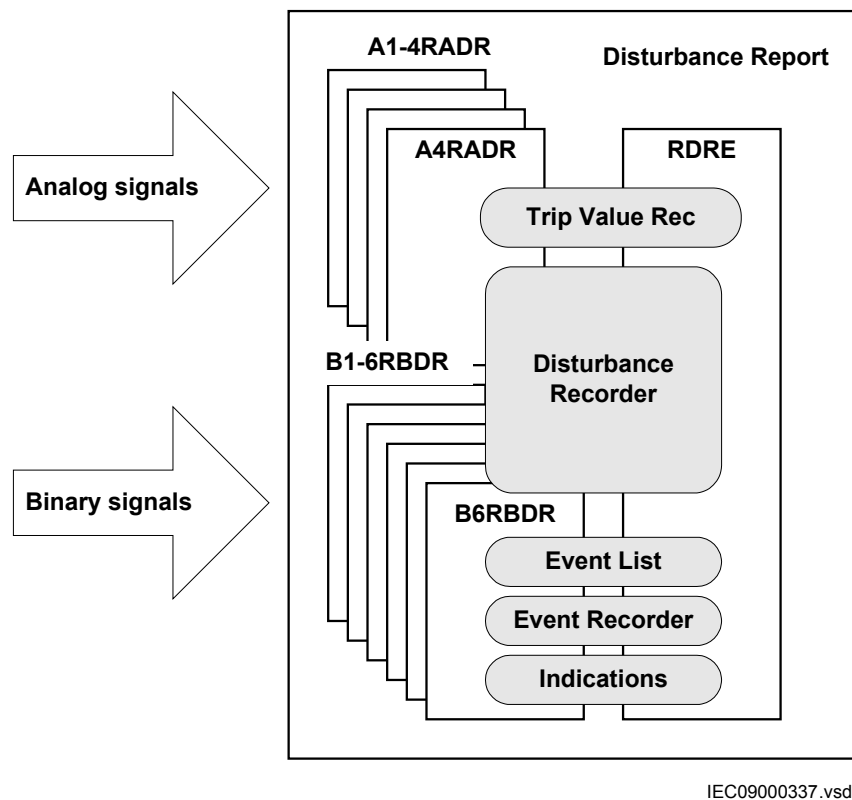
Figure 173:   Disturbance report functions and related function blocks

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 etc. 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.
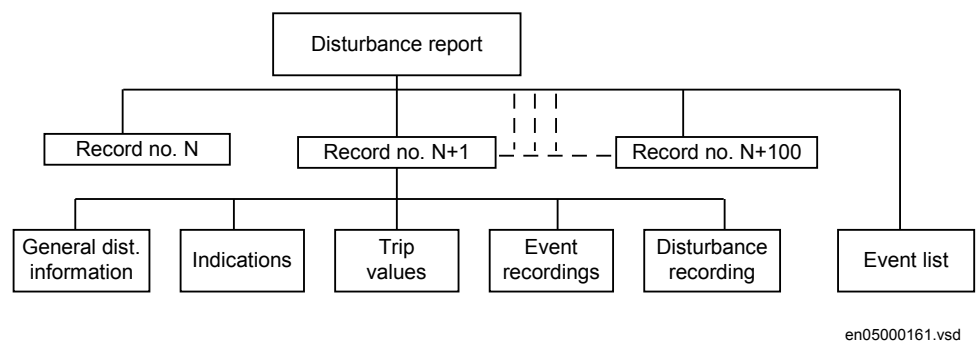
Figure 174:   Disturbance report structure

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 over-written 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. In

a 50 Hz system it's possible to record 100 where the maximum recording time is 3.4 seconds. The memory limit does not affect the rest of the disturbance report (Event list, Event recorder, Indications and Trip value recorder).

10.6.6.1 Disturbance information

Date and time of the disturbance, the indications, events, fault location and the trip values are available on the local human-machine interface (LHMI). To acquire a complete disturbance report the use of a PC and PCM600 is required. The PC may be connected to the IED-front, rear or remotely via the station bus (Ethernet ports).

10.6.6.2 Indications

Indications is a list of signals that were activated during the total recording time of the disturbance (not time-tagged). See Indication section for detailed information.

10.6.6.3 Event recorder

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 Event recorder section for detailed information.

10.6.6.4 Event list

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 Event list section for detailed information.

10.6.6.5 Trip value recorder

The recorded trip values include phasors of selected analog signals before the fault and during the fault. See Trip value recorder section for detailed information.

10.6.6.6 Disturbance recorder

Disturbance recorder records analog and binary signal data before, during and after the fault. See Disturbance recorder section for detailed information.

10.6.6.7 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

10.6.6.8   Recording times

Disturbance report records information about a disturbance during a settable time frame. The recording times are valid for the whole disturbance report. Disturbance recorder , event recorder 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
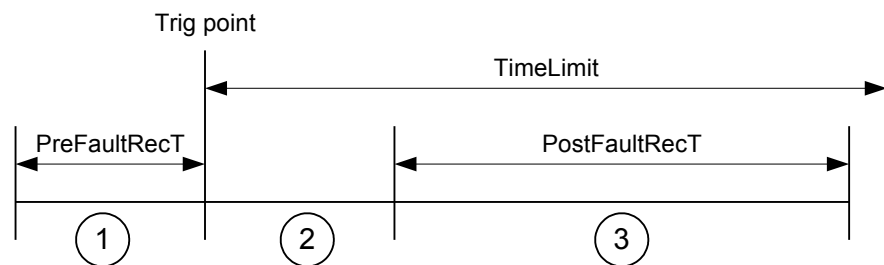
en05000487.vsd

Figure 175:   *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.

10.6.6.9   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 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 (phase differential currents, bias currents etc.).
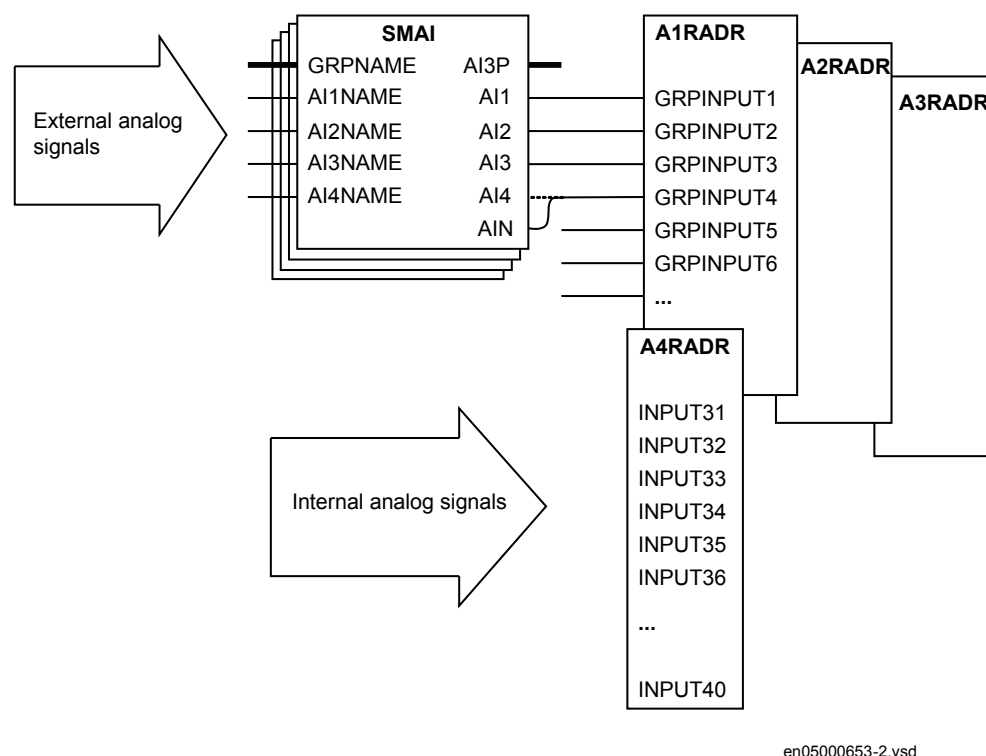
en05000653-2.vsd

Figure 176: *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.

Application configuration tool (ACT) is used for analog configuration of the Disturbance report.

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 a input signal the corresponding information is available on the non-calculated output (AI4) on the SMAI-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* l, 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.

10.6.6.10 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=ON/OFF*). A binary signal can be selected to activate the yellow (START) and red (TRIP) LED on the local HMI (*SetLED=Off/Start/Trip/Start and Trip*).

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*.

10.6.6.11 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.

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 local HMI and PCM600 .

10.6.6.12 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 (*PostRetrigPost-retrig = 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.

10.6.7   Technical data

Table 357:   DRPRDRE Technical data

Function	Range or value	Accuracy
Current recording	-	± 1,0% of I_r at $I \leq I_r$ ± 1,0% of I at I > Ir
Voltage recording	-	± 1,0% of U_r at $U \leq U_r$ ± 1,0% of U at U > U_r
Pre-fault time	(0.05–3.00) s	-
Post-fault time	(0.1–10.0) s	-
Limit time	(0.5–8.0) s	-
Maximum number of recordings	100	-
Time tagging resolution	1 ms	See time synchronization technical data
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	-

10.7   Indications

10.7.1   Functionality

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.

The indication information is available for each of the recorded disturbances in the IED and the user may use the local HMI to get the information.

10.7.2 Function block

The Indications function has no function block of it's own. .

10.7.3 Signals

10.7.3.1 Input signals

The Indications function may log the same binary input signals as the Disturbance report function.

10.7.4 Operation principle

The LED indications display this information:

Green LED:

Steady light	In Service
Flashing light	Internal fail
Dark	No power supply

Yellow LED:

Function controlled by *SetLEDn* setting in Disturbance report function.

Red LED:

Function controlled by *SetLEDn* setting in Disturbance report function.

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 BxRBDR function block
- the DRPRDRE parameter *Operation* must be set *On*
- the DRPRDRE must be trigged (binary or analog)
- the input signal must change state from logical 0 to 1 during the recording time.

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 , indications and event recorder function .

10.7.5   Technical data

Table 358:   *DRPRDRE Technical data*

Function		Value
Buffer capacity	Maximum number of indications presented for single disturbance	96
	Maximum number of recorded disturbances	100

10.8   Event recorder

10.8.1   Functionality

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 information may be uploaded to the PCM600 and further analyzed using the Disturbance handling tool.

The event recording information is an integrated part of the disturbance record (Comtrade file).

10.8.2   Function block

The Event recorder has no function block of it's own.

10.8.3 Signals

10.8.3.1 Input signals

The Event recorder function logs the same binary input signals as the Disturbance report function.

10.8.4 Operation principle

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 , indications and event recorder function .

The event record is stored as a part of the disturbance report information and managed via the local HMI or PCM600.

10.8.5 Technical data

Table 359:   DRPRDRE 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

10.9 Event list

10.9.1 Functionality

Continuous event-logging is useful for monitoring of 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 of up to 1000 time-tagged events stored in a ring-buffer.

The event list information is available in the IED and is reported to higher control systems via the station bus together with other logged events in the IED. The local HMI can be used to view the event list.

To view events that occurs during the time while the event list is displayed in the local HMI, the list has to be closed and reopened.

10.9.2 Function block

The Event list has no function block of it's own.

10.9.3 Signals

10.9.3.1 Input signals

The Event list logs the same binary input signals as configured for the Disturbance report function.

10.9.4 Operation principle

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 , indications and the event recorder function .

The event list is stored and managed separate from the disturbance report information .

10.9.5 Technical data

Table 360:   DRPRDRE Technical data

Function		Value
Buffer capacity	Maximum number of events in the list	1000
Resolution		1 ms
Accuracy		Depending on time synchronizing

10.10 Trip value recorder

10.10.1 Functionality

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 information may be uploaded to the PCM600 and further analyzed using the Disturbance Handling tool.

The trip value recorder information is an integrated part of the disturbance record (Comtrade file).

10.10.2 Function block

The Trip value recorder has no function block of it's own.

10.10.3 Signals

10.10.3.1 Input signals

The trip value recorder function uses analog input signals connected to (not).

10.10.4 Operation principle

Trip value recorder 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 .

The trip value record is stored as a part of the disturbance report information and managed in via the local HMI or PCM600.

10.10.5 Technical data

Table 361: *DRPRDRE Technical data*

Function		Value
Buffer capacity	Maximum number of analog inputs	30
	Maximum number of disturbance reports	100

10.11 Disturbance recorder

10.11.1 Functionality

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 all selected analog input and binary signals connected to the Disturbance report function (maximum 40 analog and 96 binary signals). The binary signals are the same signals as available under 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.

The disturbance recorder information for the last 100 disturbances are saved in the IED and the local HMI is used to view the list of recordings.

The disturbance recording information can be uploaded to the PCM600 and further analyzed using the Disturbance handling tool.

10.11.2   Function block

The Disturbance recorder has no function block of it's own.

10.11.3   Signals

10.11.3.1   Input and output signals

See Disturbance report for input and output signals.

10.11.4   Setting parameters

See Disturbance report for settings.

10.11.5   Operation principle

Disturbance recording 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) through the Signal Matrix Analog Input (SMAI) and possible summation (Sum3Ph) function blocks and some internally derived analog signals. .

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.

10.11.5.1   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 . 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.

10.11.6 Technical data

Table 362: DRPRDRE 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

10.12 Measured value expander block MVEXP

10.12.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Measured value expander block	MVEXP	-	-

10.12.2 Functionality

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, that is low-low limit, low limit, high limit and high-high limit. The measure value expander block has been introduced to be able to translate the integer output signal from the measuring functions to 5 binary signals, that is 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.

10.12.3 Function block

IEC09000215-1-en.vsd
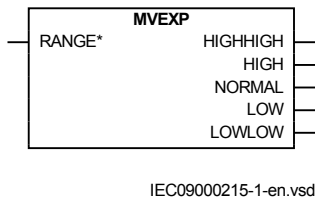
Figure 177:   MVEXP function block

10.12.4 Signals

Table 363:   MVEXP Input signals

Name	Type	Default	Description
RANGE	INTEGER	0	Measured value range

Table 364:   MVEXP 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

10.12.5 Settings

The function does not have any parameters available in Local HMI or Protection and Control IED Manager (PCM600).

Common base IED values for primary current (setting *IBase*), primary voltage (setting *UBase*) and primary power (setting *SBase*) are set in a Global base values for settings function GBASVAL. Setting *GlobalBaseSel* is used to select a GBASVAL function for reference of base values.

10.12.6 Operation principle

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 365.

Table 365:   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

10.13   Station battery supervision SPVNZBAT

10.13.1   Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Station battery supervision function	SPVNZBAT	U<>	-

10.13.2   Functionality

The station battery supervision function SPVNZBAT is used for monitoring battery terminal voltage.

SPVNZBAT activates the start and alarm outputs when the battery terminal voltage exceeds the set upper limit or drops below the set lower limit. A time delay for the overvoltage and undervoltage alarms can be set according to definite time characteristics.

In the definite time (DT) mode, SPVNZBAT operates after a predefined operate time and resets when the battery undervoltage or overvoltage condition disappears.

10.13.3   Function block

Figure 178:   Function block

10.13.4 Signals

Table 366:   *SPVNZBAT Input signals*

Name	Type	Default	Description
U_BATT	REAL	0.00	Battery terminal voltage that has to be supervised
BLOCK	BOOLEAN	0	Blocks all the output signals of the function

Table 367:   *SPVNZBAT Output signals*

Name	Type	Description
AL_ULOW	BOOLEAN	Alarm when voltage has been below low limit for a set time
AL_UHI	BOOLEAN	Alarm when voltage has exceeded high limit for a set time
ST_ULOW	BOOLEAN	Start signal when battery voltage drops below lower limit
ST_UHI	BOOLEAN	Start signal when battery voltage exceeds upper limit

10.13.5 Settings

Table 368:   *SPVNZBAT Non group settings (basic)*

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	On	Operation mode Off / On
RtdBattVolt	20.00 - 250.00	V	1.00	110.00	Battery rated voltage
BattVoltLowLim	60 - 140	%Ubat	1	70	Lower limit for the battery terminal voltage
BattVoltHiLim	60 - 140	%Ubat	1	120	Upper limit for the battery terminal voltage
tDelay	0.000 - 60.000	s	0.001	0.200	Delay time for alarm
tReset	0.000 - 60.000	s	0.001	0.000	Time delay for reset of alarm

10.13.6 Monitored data

Table 369:   *SPVNZBAT Monitored data*

Name	Type	Values (Range)	Unit	Description
BATTVOLT	REAL	-	kV	Service value of the battery terminal voltage

10.13.7 Operation principle

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

The function execution requires that at least one of the function outputs is connected in configuration.

The operation of station battery supervision function can be described by using a module diagram. All the modules in the diagram are explained in the next sections.
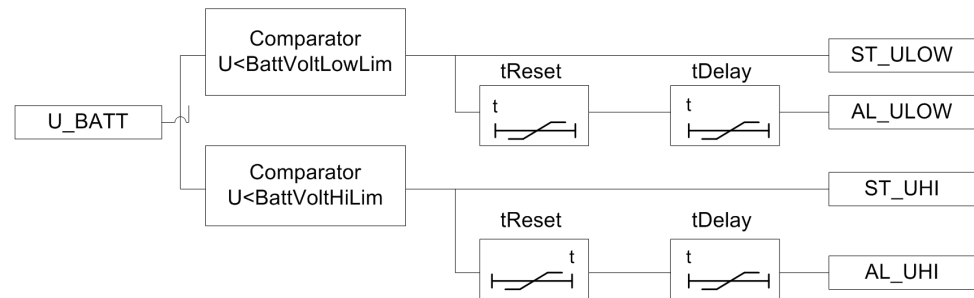
Figure 179:   Functional module diagram

The battery rated voltage is set with the *RtdBattVolt* setting. The value of the *BattVoltLowLim* and *BattVoltHiLim* settings are given in relative per unit to the *RtdBattVolt* setting.

It is possible to block the function outputs by the `BLOCK` input.

Low level detector

The level detector compares the battery voltage `U_BATT` with the set value of the *BattVoltLowLim* setting. If the value of the `U_BATT` input drops below the set value of the *BattVoltLowLim* setting, the start signal `ST_ULOW` is activated.

The measured voltage between the battery terminals `U_BATT` is available through the Monitored data view.

High level detector

The level detector compares the battery voltage `U_BATT` with the set value of the *BattVoltHiLim* setting. If the value of the `U_BATT` input exceeds the set value of the *BattVoltHiLim* setting, the start signal `ST_UHI` is activated.

Time delay

When the operate timer has reached the value set by the *tDelay* setting, the `AL_ULOW` and `AL_UHI` outputs are activated. If the voltage returns to the normal value before the module operates, the reset timer is activated. If the reset timer reaches the value set by *tReset*, the operate timer resets and the `ST_ULOW` and `ST_UHI` outputs are deactivated.

Function	Range or value	Accuracy
Lower limit for the battery terminal voltage	(60-140) % of Ubat	± 0,5% of set battery voltage
Reset ratio, lower limit	<105 %	-
Upper limit for the battery terminal voltage	(60-140) % of Ubat	± 0,5% of set battery voltage
Reset ratio, upper limit	>95 %	-
Timers	(0.000-60.000) s	± 0.5% ± 10 ms

10.14 Insulation gas monitoring function SSIMG

10.14.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Insulation gas monitoring function	SSIMG	-	63

10.14.2 Functionality

Insulation gas monitoring function (SSIMG) is used for monitoring the circuit breaker condition. Binary information based on the gas pressure in the circuit breaker is used as input signals to the function. In addition to that, the function generates alarms based on received information.

10.14.3 Function block

```
            SSIMG
─ BLOCK          PRESSURE  ─
─ BLK_ALM        PRES_ALM  ─
─ PRESSURE        PRES_LO  ─
─ TEMP               TEMP  ─
─ PRES_ALM       TEMP_ALM  ─
─ PRES_LO         TEMP_LO  ─
─ SET_P_LO
─ SET_T_LO
─ RESET_LO
```
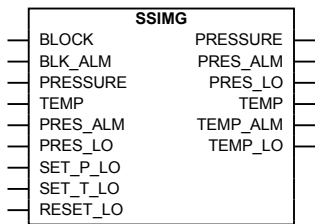
IEC09000129-1-en.vsd

Figure 180: SSIMG function block

10.14.4 Signals

ℹ️ Inputs PRESSURE and TEMP together with settings
PressAlmLimit, *PressLOLimit*, *TempAlarmLimit* and *TempLOLimit*
are not supported in first release of 650 series.

Table 371: SSIMG Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of function
BLK_ALM	BOOLEAN	0	Block all the alarms
PRESSURE	REAL	0.0	Pressure input from CB
TEMP	REAL	0.0	Temperature of the insulation medium from CB
PRES_ALM	BOOLEAN	0	Pressure alarm signal
PRES_LO	BOOLEAN	0	Pressure lockout signal
SET_P_LO	BOOLEAN	0	Set pressure lockout
SET_T_LO	BOOLEAN	0	Set temperature lockout
RESET_LO	BOOLEAN	0	Reset pressure and temperature lockout

Table 372: SSIMG Output signals

Name	Type	Description
PRESSURE	REAL	Pressure service value
PRES_ALM	BOOLEAN	Pressure below alarm level
PRES_LO	BOOLEAN	Pressure below lockout level
TEMP	REAL	Temperature of the insulation medium
TEMP_ALM	BOOLEAN	Temperature above alarm level
TEMP_LO	BOOLEAN	Temperature above lockout level

10.14.5 Settings

Table 373: SSIMG Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
PressAlmLimit	0.00 - 25.00	-	0.01	5.00	Alarm setting for pressure
PressLOLimit	0.00 - 25.00	-	0.01	3.00	Pressure lockout setting
TempAlarmLimit	-40.00 - 200.00	-	0.01	30.00	Temperature alarm level setting of the medium
TempLOLimit	-40.00 - 200.00	-	0.01	30.00	Temperature lockout level of the medium
tPressureAlarm	0.000 - 60.000	s	0.001	0.000	Time delay for pressure alarm
tPressureLO	0.000 - 60.000	s	0.001	0.000	Time delay for pressure lockout indication
Table continues on next page					

Name	Values (Range)	Unit	Step	Default	Description
tTempAlarm	0.000 - 60.000	s	0.001	0.000	Time delay for temperature alarm
tTempLockOut	0.000 - 60.000	s	0.001	0.000	Time delay for temperture lockout
tResetPressAlm	0.000 - 60.000	s	0.001	0.000	Reset time delay for pressure alarm
tResetPressLO	0.000 - 60.000	s	0.001	0.000	Reset time delay for pressure lockout
tResetTempAlm	0.000 - 60.000	s	0.001	0.000	Reset time delay for temperture alarm
tResetTempLO	0.000 - 60.000	s	0.001	0.000	Reset time delay for temperture lockout

10.14.6 Operation principle

Insulation gas monitoring function (SSIMG) is used to monitor gas pressure in the circuit breaker. Two binary output signals are used from the circuit breaker to initiate alarm signals, pressure below alarm level and pressure below lockout level. If the input signal PRES_ALM is high, which indicate that the gas pressure in the circuit breaker is below alarm level, the function initiates output signal PRES_ALM, pressure below alarm level, after a set time delay and indicate that maintenance of the circuit breaker is required. Similarly, if the input signal PRES_LO is high, which indicate gas pressure in the circuit breaker is below lockout level, the function initiates output signal PRES_LO, after a time delay. The two time delay settings, *tPressureAlarm* and *tPressureLO*, are included in order not to initiate any alarm for short sudden changes in the gas pressure. If the gas pressure in the circuit breaker goes below the levels for more than the set time delays the corresponding signals, PRES_ALM, pressure below alarm level and PRES_LO, pressure below lockout level alarm will be obtained.

The input signal BLK_ALM is used to block the two alarms and the input signal BLOCK to block both alarms and the function.

10.14.7 Technical data

Table 374: SSIMG Technical data

Function	Range or value	Accuracy
Pressure alarm	0.00-25.00	-
Pressure lockout	0.00-25.00	-
Temperature alarm	-40.00-200.00	-
Temperature lockout	-40.00-200.00	-
Timers	(0.000-60.000) s	± 0.5% ± 10 ms

10.15 Insulation liquid monitoring function SSIML

10.15.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Insulation liquid monitoring function	SSIML	-	71

10.15.2 Functionality

Insulation liquid monitoring function (SSIML) is used for monitoring the circuit breaker condition. Binary information based on the oil level in the circuit breaker is used as input signals to the function. In addition to that, the function generates alarms based on received information.

10.15.3 Function block
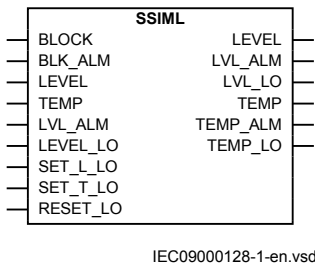
Figure 181: SSIML function block

10.15.4 Signals

Inputs LEVEL and TEMP together with settings *LevelAlmLimit*, *LevelLOLimit*, *TempAlarmLimit* and *TempLOLimit* are not supported in first release of 650 series.

Table 375: SSIML Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of function
BLK_ALM	BOOLEAN	0	Block all the alarms
LEVEL	REAL	0.0	Level input from CB
TEMP	REAL	0.0	Temperature of the insulation medium from CB
LVL_ALM	BOOLEAN	0	Level alarm signal
LEVEL_LO	BOOLEAN	0	Level lockout signal
Table continues on next page			

Name	Type	Default	Description
SET_L_LO	BOOLEAN	0	Set level lockout
SET_T_LO	BOOLEAN	0	Set temperature lockout
RESET_LO	BOOLEAN	0	Reset level and temperature lockout

Table 376:   SSIML Output signals

Name	Type	Description
LEVEL	REAL	Level service value
LVL_ALM	BOOLEAN	Level below alarm level
LVL_LO	BOOLEAN	Level below lockout level
TEMP	REAL	Temperature of the insulation medium
TEMP_ALM	BOOLEAN	Temperature above alarm level
TEMP_LO	BOOLEAN	Temperature above lockout level

10.15.5   Settings

Table 377:   SSIML Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
LevelAlmLimit	0.00 - 25.00	-	0.01	5.00	Alarm setting for level
LevelLOLimit	0.00 - 25.00	-	0.01	3.00	Level lockout setting
TempAlarmLimit	-40.00 - 200.00	-	0.01	30.00	Temperature alarm level setting of the medium
TempLOLimit	-40.00 - 200.00	-	0.01	30.00	Temperature lockout level of the medium
tLevelAlarm	0.000 - 60.000	s	0.001	0.000	Time delay for level alarm
tLevelLockOut	0.000 - 60.000	s	0.001	0.000	Time delay for level lockout indication
tTempAlarm	0.000 - 60.000	s	0.001	0.000	Time delay for temperature alarm
tTempLockOut	0.000 - 60.000	s	0.001	0.000	Time delay for temperture lockout
tResetLevelAlm	0.000 - 60.000	s	0.001	0.000	Reset time delay for level alarm
tResetLevelLO	0.000 - 60.000	s	0.001	0.000	Reset time delay for level lockout
tResetTempLO	0.000 - 60.000	s	0.001	0.000	Reset time delay for temperture lockout
tResetTempAlm	0.000 - 60.000	s	0.001	0.000	Reset time delay for temperture alarm

10.15.6   Operation principle

Insulation liquid monitoring function (SSIML) is used to monitor oil level in the circuit breaker. Two binary output signals are used from the circuit breaker to initiate alarm signals, level below alarm level and level below lockout level. If the input signal LVL_ALM is high, which indicate that the oil level in the circuit breaker is below alarm level, the output signal LVL_ALM, level below alarm

level, will be initiated after a set time delay and indicate that maintenance of the circuit breaker is required. Similarly, if the input signal LVL_LO is high, which indicate oil level in the circuit breaker is below lockout level, the output signal LVL_LO, will be initiated after a time delay. The two time delay settings, *tLevelAlarm* and *tLevelLockOut*, are included in order not to initiate any alarm for short sudden changes in the oil level. If the oil level in the circuit breaker goes below the levels for more than the set time delays the corresponding signals, LVL_ALM, level below alarm level and LVL_LO, level below lockout level alarm will be obtained.

The input signal BLK_ALM is used to block the two alarms and the input signal BLOCK to block both alarms and the function.

10.15.7 Technical data

Table 378:   SSIML Technical data

Function	Range or value	Accuracy
Alarm, oil level	0.00-25.00	-
Oil level lockout	0.00-25.00	-
Temperature alarm	-40.00-200.00	-
Temperature lockout	-40.00-200.00	-
Timers	(0.000-60.000) s	± 0.5% ± 10 ms

10.16 Circuit breaker condition monitoring SSCBR

10.16.1 Identification

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

10.16.2 Functionality

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

The function contains a blocking functionality. It is possible to block the function outputs, if desired.

10.16.3   Function block

```
           SSCBR
—  I3P*           TRVTOAL  —
—  BLOCK          TRVTCAL  —
—  BLK_ALM        SPRCHRAL —
—  POSOPEN         OPRALM  —
—  POSCLOSE       OPRLOALM —
—  ALMPRES         IACCALM —
—  LOPRES         IACCLOAL —
—  SPRCHRGN        CBLIFEAL —
—  SPRCHRGD       NOOPRALM —
—  CBCNTRST        PRESALM —
—  IACCRST          PRESLO —
—  SPCHTRST         CBOPEN —
—  TRVTRST        CBINVPOS —
                  CBCLOSED —
```
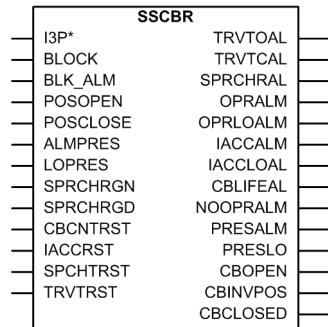
10.16.4   Signals

Table 379:   SSCBR Input signals

Name	Type	Default	Description
I3P	GROUP SIGNAL	-	Three phase group signal for current inputs
BLOCK	BOOLEAN	0	Block of function
BLK_ALM	BOOLEAN	0	Block all the alarms
POSOPEN	BOOLEAN	0	Signal for open position of apparatus from I/O
POSCLOSE	BOOLEAN	0	Signal for close position of apparatus from I/O
ALMPRES	BOOLEAN	0	Binary pressure alarm input
LOPRES	BOOLEAN	0	Binary pressure input for lockout indication
SPRCHRGN	BOOLEAN	0	CB spring charging started input
SPRCHRGD	BOOLEAN	0	CB spring charged input
CBCNTRST	BOOLEAN	0	Reset input for CB remaining life and operation counter
IACCRST	BOOLEAN	0	Reset accumulated currents power
SPCHTRST	BOOLEAN	0	Reset spring charge time
TRVTRST	BOOLEAN	0	Reset travel time

Table 380:   SSCBR Output signals

Name	Type	Description
TRVTOAL	BOOLEAN	CB open travel time exceeded set value
TRVTCAL	BOOLEAN	CB close travel time exceeded set value
SPRCHRAL	BOOLEAN	Spring charging time has crossed the set value
OPRALM	BOOLEAN	Number of CB operations exceeds alarm limit
OPRLOALM	BOOLEAN	Number of CB operations exceeds lockout limit
IACCALM	BOOLEAN	Accumulated currents power (Iyt),exceeded alarm limit
Table continues on next page		

Name	Type	Description
IACCLOAL	BOOLEAN	Accumulated currents power (Iyt),exceeded lockout limit
CBLIFEAL	BOOLEAN	Remaining life of CB exceeded alarm limit
NOOPRALM	BOOLEAN	CB 'not operated for long time' alarm
PRESALM	BOOLEAN	Pressure below alarm level
PRESLO	BOOLEAN	Pressure below lockout level
CBOPEN	BOOLEAN	CB is in open position
CBINVPOS	BOOLEAN	CB is in intermediate position
CBCLOSED	BOOLEAN	CB is in closed position

10.16.5   Settings

Table 381:   *SSCBR Non group settings (basic)*

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	On	Operation Off / On
AccDisLevel	5.00 - 500.00	A	0.01	10.00	RMS current setting below which energy accumulation stops
CurrExp	0.00 - 2.00	-	0.01	2.00	Current exponent setting for energy calculation
RatedFaultCurr	500.00 - 75000.00	A	0.01	5000.00	Rated fault current of the breaker
RatedOpCurr	100.00 - 5000.00	A	0.01	1000.00	Rated operating current of the breaker
AccCurrAlmLvl	0.00 - 20000.00	-	0.01	2500.00	Setting of alarm level for accumulated currents power
AccCurrLO	0.00 - 20000.00	-	0.01	2500.00	Lockout limit setting for accumulated currents power
DirCoef	-3.00 - -0.50	-	0.01	-1.50	Directional coefficient for CB life calculation
LifeAlmLevel	0 - 99999	-	1	5000	Alarm level for CB remaining life
OpNumRatCurr	1 - 99999	-	1	10000	Number of operations possible at rated current
OpNumFaultCurr	1 - 10000	-	1	1000	Number of operations possible at rated fault current
OpNumAlm	0 - 9999	-	1	200	Alarm limit for number of operations
OpNumLO	0 - 9999	-	1	300	Lockout limit for number of operations
tOpenAlm	0 - 200	ms	1	40	Alarm level setting for open travel time
tCloseAlm	0 - 200	ms	1	40	Alarm level setting for close travel time
OpenTimeCorr	0 - 100	ms	1	10	Correction factor for open travel time
CloseTimeCorr	0 - 100	ms	1	10	Correction factor for CB close travel time
DifTimeCorr	-10 - 10	ms	1	5	Correction factor for time difference in auxiliary and main contacts open time
tSprngChrgAlm	0.00 - 60.00	s	0.01	1.00	Setting of alarm for spring charging time
tPressAlm	0.00 - 60.00	s	0.01	0.10	Time delay for gas pressure alarm
Table continues on next page					

Name	Values (Range)	Unit	Step	Default	Description
TPressLO	0.00 - 60.00	s	0.01	0.10	Time delay for gas pressure lockout
AccEnerInitVal	0.00 - 9999.99	-	0.01	0.00	Accumulation energy initial value
CountInitVal	0 - 9999	-	1	0	Operation numbers counter initialization value
CBRemLife	0 - 9999	-	1	5000	Initial value for the CB remaining life estimates
InactDayAlm	0 - 9999	Day	1	2000	Alarm limit value of the inactive days counter
InactDayInit	0 - 9999	Day	1	0	Initial value of the inactive days counter
InactHourAlm	0 - 23	Hour	1	0	Alarm time of the inactive days counter in hours

10.16.6 Monitored data

Table 382: SSCBR Monitored data

Name	Type	Values (Range)	Unit	Description
CBOTRVT	REAL	-	ms	Travel time of the CB during opening operation
CBCLTRVT	REAL	-	ms	Travel time of the CB during closing operation
SPRCHRT	REAL	-	s	The charging time of the CB spring
NO_OPR	INTEGER	-	-	Number of CB operation cycle
NOOPRDAY	INTEGER	-	-	The number of days CB has been inactive
CBLIFEL1	INTEGER	-	-	CB Remaining life phase L1
CBLIFEL2	INTEGER	-	-	CB Remaining life phase L2
CBLIFEL3	INTEGER	-	-	CB Remaining life phase L3
IACCL1	REAL	-	-	Accumulated currents power (Iyt), phase L1
IACCL2	REAL	-	-	Accumulated currents power (Iyt), phase L2
IACCL3	REAL	-	-	Accumulated currents power (Iyt), phase L3

10.16.7 Operation principle

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

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

Figure 182:   Functional module diagram

10.16.7.1   Circuit breaker status

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

operation of the breaker status monitoring can be described by using a module diagram. All the modules in the diagram are explained in the next sections.

Figure 183:   *Functional module diagram for monitoring circuit breaker status*

Phase current check

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

Contact position indicator

The circuit breaker status is open if the auxiliary input contact POSCLOSE is low, the POSOPEN input is high and the current is zero. The circuit breaker is closed when the POSOPEN input is low and the POSCLOSE input is high. The breaker is in the intermediate position if both the auxiliary contacts have the same value, that is, both are in the logical level "0", or if the auxiliary input contact POSCLOSE is low and the POSOPEN input is high, but the current is not zero.

The status of the breaker is indicated with the binary outputs CBOPEN, CBINVPOS, and CBCLOSED for open, intermediate, and closed position respectively.

10.16.7.2   Circuit breaker operation monitoring

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

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

Figure 184:   *Functional module diagram for calculating inactive days and alarm for circuit breaker operation monitoring*

Inactivity timer

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

The inactive days NOOPRDAY is available through the Monitored data view. It is also possible to set the initial inactive days by using the *InactDayInit* parameter.

Alarm limit check

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

10.16.7.3   Breaker contact travel time

The breaker contact travel time module calculates the breaker contact travel time for the closing and opening operation. The operation of the breaker contact travel time measurement can be described by using a module diagram. All the modules in the diagram are explained in the next sections.
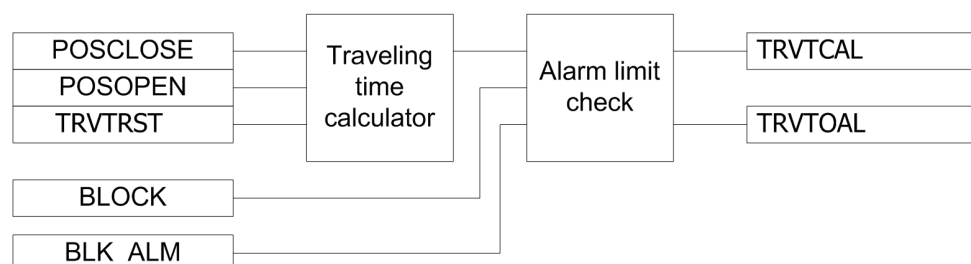
Figure 185:   Functional module diagram for breaker contact travel time

Traveling time calculator

The contact travel time of the breaker is calculated from the time between auxiliary contacts' state change. The open travel time is measured between the opening of the POSCLOSE auxiliary contact and the closing of the POSOPEN auxiliary contact. Travel time is also measured between the opening of the POSOPEN auxiliary contact and the closing of the POSCLOSE auxiliary contact.

$$tTravelOpen = t_{open} + t_1 + t_2 \qquad\qquad tTravelClose = t_{close} + t_3 + t_4$$
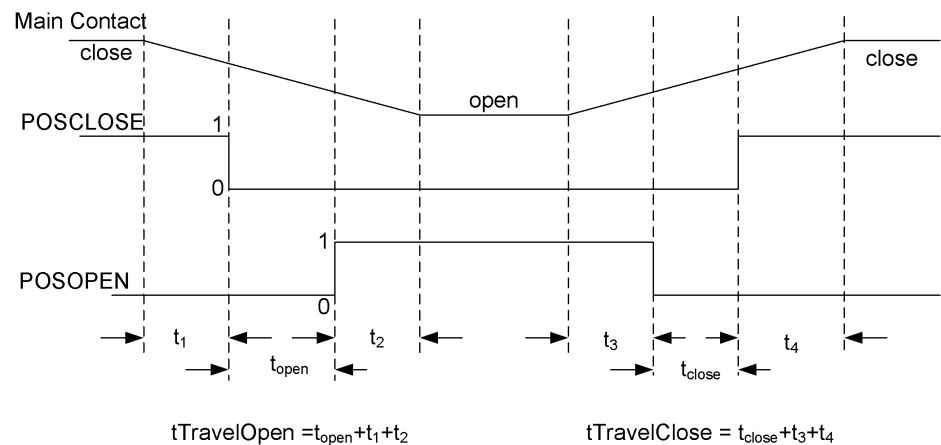
There is a time difference t_1 between the start of the main contact opening and the opening of the `POSCLOSE` auxiliary contact. Similarly, there is a time gap t_2 between the time when the `POSOPEN` auxiliary contact opens and the main contact is completely open. Therefore, in order to incorporate the time $t_1 + t_2$, a correction factor needs to be added with 10 to get the actual opening time. This factor is added with the *OpenTimeCorr* ($= t_1 + t_2$). The closing time is calculated by adding the value set with the *CloseTimeCorr* ($t_3 + t_4$) setting to the measured closing time.

The last measured opening travel time `tTravelOpen` and the closing travel time `tTravelClose` are available through the Monitored data view on the LHMI or through tools via communications.

Alarm limit check

When the measured open travel time is longer than the value set with the *tOpenAlm* setting, the `TRVTOAL` output is activated. Respectively, when the measured close travel time is longer than the value set with the *tCloseAlm* setting, the , the `TRVTCAL` output is activated.

It is also possible to block the `TRVTCAL` and `TRVTOAL` alarm signals by activating the `BLOCK` input.

10.16.7.4 Operation counter

The operation counter subfunction calculates the number of breaker operation cycles. Both open and close operations are included in one operation cycle. The operation counter value is updated after each open operation.

The operation of the subfunction can be described by using a module diagram. All the modules in the diagram are explained in the next sections.
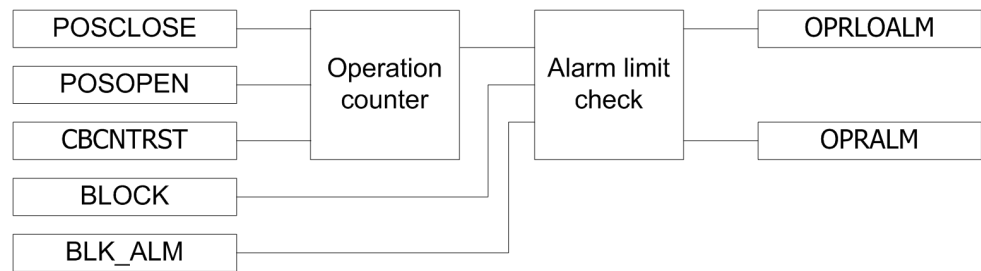
Figure 186:   Functional module diagram for counting circuit breaker operations

Operation counter

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

The number of operations NO_OPR is available through the Monitored data view on the LHMI or through tools via communications. The old circuit breaker operation counter value can be taken into use by writing the value to the *CountInitVal* parameter and can be reset by *Clear CB wear* in the clear menu from LHMI.

Alarm limit check

The OPRALM operation alarm is generated when the number of operations exceeds the value set with the *OpNumAlm* threshold setting. However, if the number of operations increases further and exceeds the limit value set with the *OpNumLO* setting, the OPRLOALM output is activated.

The binary outputs OPRLOALM and OPRALM are deactivated when the BLOCK input is activated.

10.16.7.5   Accumulation of I^{y}t

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

The operation of the module can be described by using a module diagram. All the modules in the diagram are explained in the next sections.
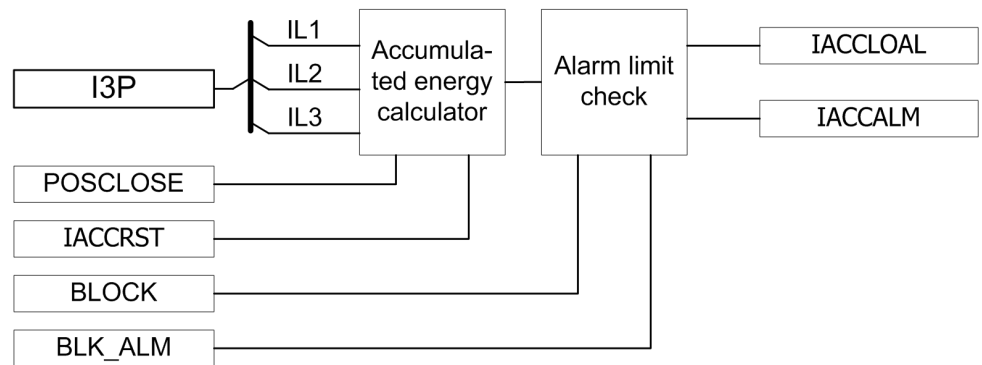
Figure 187: Functional module diagram for calculating accumulative energy and alarm

Accumulated energy calculator

This module calculates the accumulated energy $I^y t$. The factor y is set with the *CurrExp* setting.

The calculation is initiated with the POSCLOSE input open events. It ends when the RMS current becomes lower than the *AccDisLevel* setting value.
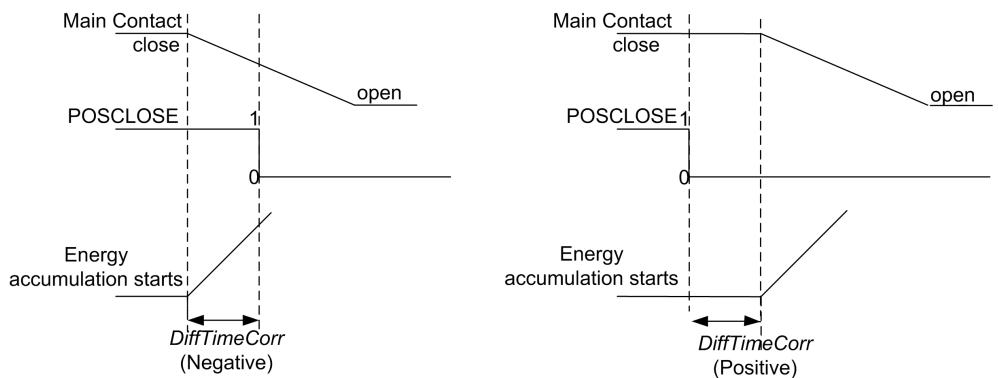
Figure 188: Significance of theDiffTimeCorr setting

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

The accumulated energy outputs IACCL1 (L2, L3) are available through the Monitored data view on the LHMI or through tools via communications. The values can be reset by setting the *Clear accum. breaking curr* setting to true in the clear menu from LHMI.

Alarm limit check

The `IACCALM` alarm is activated when the accumulated energy exceeds the value set with the *AccCurrAlmLvl* threshold setting. However, when the energy exceeds the limit value set with the *AccCurrLO* threshold setting, the `IACCLOAL` output is activated.

The `IACCALM` and `IACCLOAL` outputs can be blocked by activating the binary input `BLOCK`.

10.16.7.6   Remaining life of the circuit breaker

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

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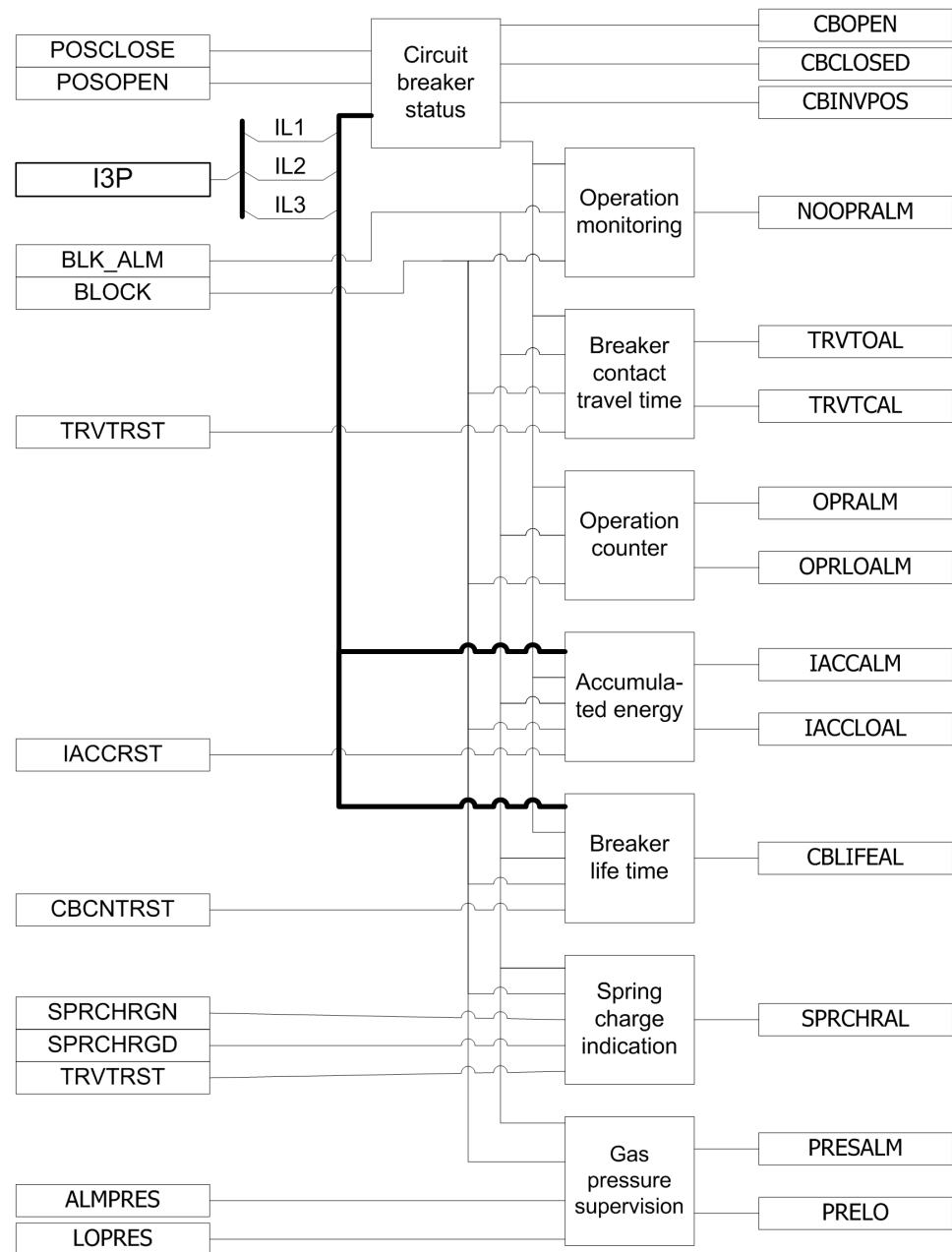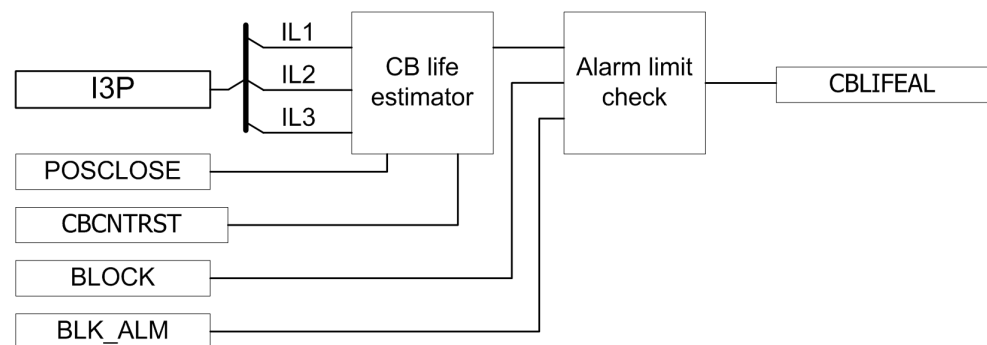

Figure 189:   *Functional module diagram for estimating the life of the circuit breaker*

Circuit breaker life estimator

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

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

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

The remaining life is calculated separately for all three phases and it is available as a monitored data value `CBLIFEL1 (L2, L3)`.

Alarm limit check

When the remaining life of any phase drops below the *LifeAlmLevel* threshold setting, the corresponding circuit breaker life alarm `CBLIFEAL` is activated.

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

It is possible to deactivate the `CBLIFEAL` alarm signal by activating the binary input `BLOCK`.

10.16.7.7 Circuit breaker spring charged indication

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

The operation of the subfunction can be described by using a module diagram. All the modules in the diagram are explained in the next sections.
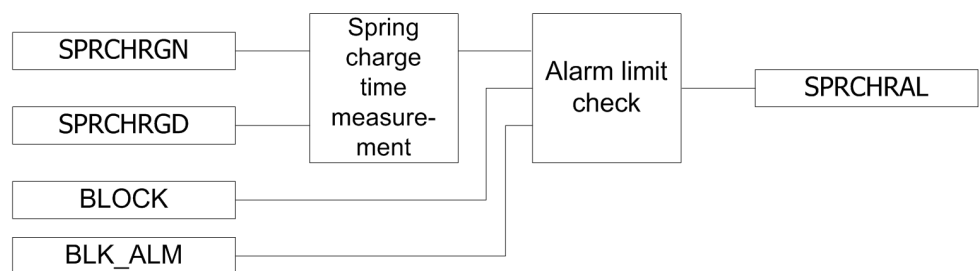
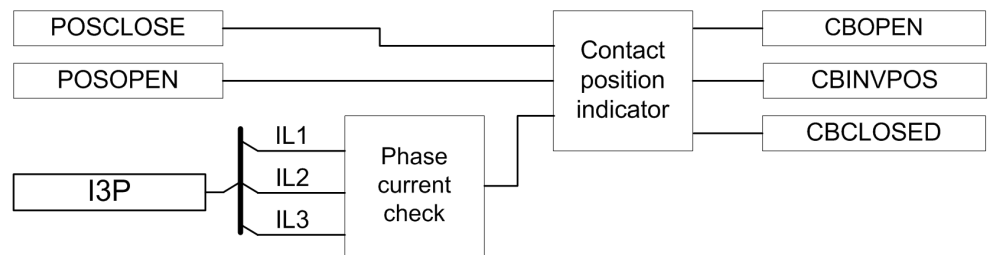*Figure 190:* *Functional module diagram for circuit breaker spring charged indication and alarm*

Spring charge time measurement

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

The spring charging time `SPRCHRT` is available through the Monitored data view .

Alarm limit check

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

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

10.16.7.8   Gas pressure supervision

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

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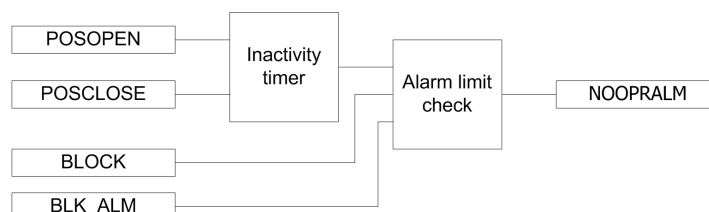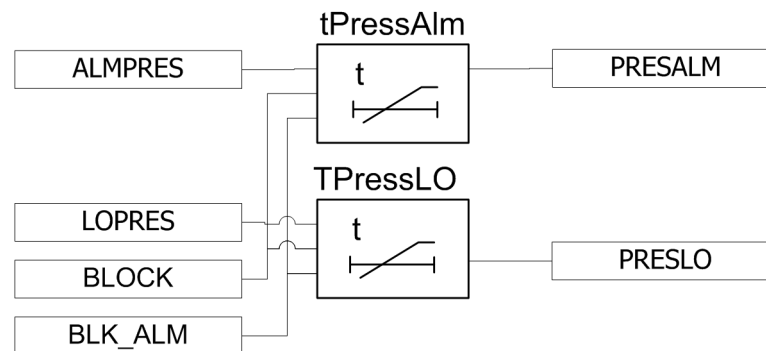

Figure 191:   Functional module diagram for circuit breaker gas pressure alarm

The gas pressure is monitored through the binary input signals `LOPRES` and `ALMPRES`.

Pressure alarm time delay

When the `ALMPRES` binary input is activated, the `PRESALM` alarm is activated after a time delay set with the *tPressAlm* setting. The `PRESALM` alarm can be blocked by activating the `BLOCK` input.

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

The binary input `BLOCK` can be used to block the function. The activation of the `BLOCK` input deactivates all outputs and resets internal timers. The alarm signals from the function can be blocked by activating the binary input `BLK_ALM`.

10.16.8   Technical data
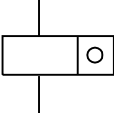
Table 383:   *SSCBR Technical data*

Function	Range or value	Accuracy
RMS current setting below which energy accumulation stops	(5.00-500.00) A	$\pm$ 1.0% of I_r at $I{\leq}I_r$ $\pm$ 1.0% of I at $I{>}I_r$
Alarm level for accumulated energy	0.00-20000.00	< $\pm$ 5.0% of set value
Lockout limit for accumulated energy	0.00-20000.00	< $\pm$ 5.0% of set value
Alarm levels for open and close travel time	(0-200) ms	$\pm$ 0.5% $\pm$ 10ms
Setting of alarm for spring charging time	(0.00-60.00) s	$\pm$ 0.5% $\pm$ 10ms
Time delay for gas pressure alarm	(0.00-60.00) s	$\pm$ 0.5% $\pm$ 10ms
Time delay for gas pressure lockout	(0.00-60.00) s	$\pm$ 0.5% $\pm$ 10ms

Section 11   Metering

11.1   Pulse counter PCGGIO

11.1.1   Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Pulse counter	PCGGIO		-

11.1.2   Functionality

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 BIO (binary input/output) module and then read by the PCGGIO function. A scaled service value is available over the station bus.

11.1.3   Function block

```
        PCGGIO
── BLOCK          INVALID ──
── READ_VAL       RESTART ──
── BI_PULSE*      BLOCKED ──
── RS_CNT         NEW_VAL ──
                 ^SCAL_VAL ──
```
IEC09000335-1-en.vsd
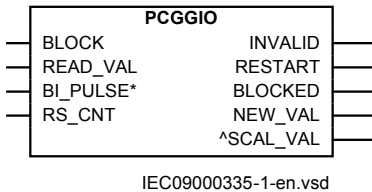
Figure 192:   PCGGIO function block

11.1.4   Signals

Table 384:   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 385:   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

11.1.5   Settings

Table 386:   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	1 - 3600	s	1	60	Cycle time for reporting of counter value

11.1.6   Monitored data

Table 387:   PCGGIO Monitored data

Name	Type	Values (Range)	Unit	Description
CNT_VAL	INTEGER	-	-	Actual pulse counter value
SCAL_VAL	REAL	-	-	Scaled value with time and status information

11.1.7   Operation principle

The registration of pulses is done according to setting of *CountCriteria* parameter on one of the 9 binary input channels located on the BIO module. 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 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 value is stored in semiretain memory.

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 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 time tagged, and transmitted to the station HMI. This time corresponds to the time when the value was frozen by the function.

The BLOCK and READ_VAL inputs can be connected to 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 readings according to the setting of parameter *CountCriteria*. 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 output module (BIO).

The RS_CNT input is used for resetting the counter.

Each PCGGIO function block has four binary output signals that can be used for for event recording: INVALID, RESTART, BLOCKED and NEW_VAL. These signals and the SCAL_VAL signal are accessible over IEC 61850.

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.

11.1.8 Technical data

Table 388: PCGGIO Technical data

Function	Setting range	Accuracy
Cycle time for report of counter value	(1–3600) s	-

11.2 Energy calculation and demand handling ETPMMTR

11.2.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Energy calculation and demand handling	ETPMMTR	-	-

11.2.2 Functionality

Outputs from Measurements (CVMMXN) function can be used to calculate energy. 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.

11.2.3   Function block

```
        ETPMMTR
— P                  ACCST —
— Q               EAFPULSE —
— STACC           EARPULSE —
— RSTACC          ERFPULSE —
— RSTDMD          ERRPULSE —
                    EAFALM —
                    EARALM —
                    ERFALM —
                    ERRALM —
                    EAFACC —
                    EARACC —
                    ERFACC —
                    ERRACC —
                   MAXPAFD —
                   MAXPARD —
                   MAXPRFD —
                   MAXPRRD —
```
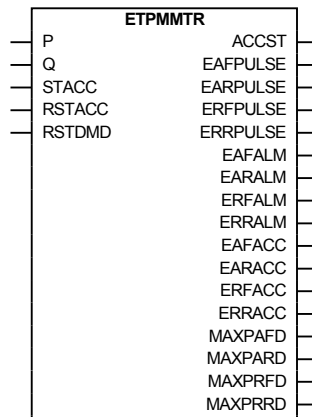
Figure 193:   ETPMMTR function block

11.2.4   Signals

Table 389:   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 390:   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
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
Table continues on next page		

Name	Type	Description
EARACC	REAL	Accumulated reverse active energy value
ERFACC	REAL	Accumulated forward reactive energy value
ERRACC	REAL	Accumulated reverse reactive energy value
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

11.2.5 Settings

Table 391: 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
tEnergyOffPls	0.000 - 60.000	s	0.001	0.500	Energy accumulated pulse OFF time
EAFAccPlsQty	0.001 - 10000.000	MWh	0.001	100.000	Pulse quantity for active forward accumulated energy value
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
ERRAccPlsQty	0.001 - 10000.000	MVArh	0.001	100.000	Pulse quantity for reactive reverse accumulated energy value

Table 392: 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
EnZeroClamp	Off On	-	-	On	Enable of zero point clamping detection function
Table continues on next page					

Name	Values (Range)	Unit	Step	Default	Description
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
DirEnergyAct	Forward Reverse	-	-	Forward	Direction of active energy flow Forward/ Reverse
DirEnergyReac	Forward Reverse	-	-	Forward	Direction of reactive energy flow Forward/ Reverse
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
ERRPresetVal	0.000 - 10000.000	MVArh	0.001	0.000	Preset Initial value for reverse reactive energy

11.2.6 Monitored data

Table 393:   ETPMMTR Monitored data

Name	Type	Values (Range)	Unit	Description
EAFACC	REAL	-	MWh	Accumulated forward active energy value
EARACC	REAL	-	MWh	Accumulated reverse active energy value
ERFACC	REAL	-	MVArh	Accumulated forward reactive energy value
ERRACC	REAL	-	MVArh	Accumulated reverse reactive energy value
MAXPAFD	REAL	-	MW	Maximum forward active power demand value for set interval
MAXPARD	REAL	-	MW	Maximum reverse active power demand value for set interval
MAXPRFD	REAL	-	MVAr	Maximum forward reactive power demand value for set interval
MAXPRRD	REAL	-	MVAr	Maximum reactive power demand value in reverse direction

11.2.7 Operation principle

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.

IEC09000106.vsd
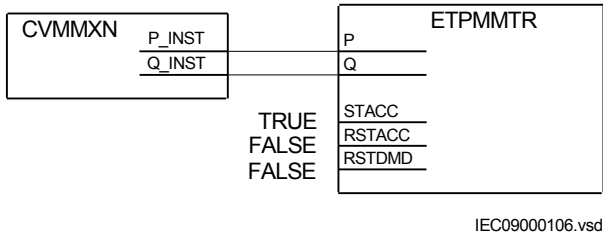
Figure 194:   *Connection of Energy calculation and demand handling function (ETPMMTR) to the Measurements function (CVMMXN)*

11.2.8   Technical data

Table 394:   *ETPMMTRTechnical data*

Function	Range or value	Accuracy
Energy metering	kWh Export/Import, kvarh Export/Import	Input from MMXU. No extra error at steady load

Section 12 Station communication

12.1 DNP3 protocol

DNP3 (Distributed Network Protocol) is a set of communications protocols used to communicate data between components in process automation systems. For a detailed description of the DNP3 protocol, see the DNP3 Communication protocol manual.

12.2 IEC 61850-8-1 communication protocol

12.2.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
IEC 61850-8-1 communication protocol	IEC 61850-8-1	-	-

12.2.2 Functionality

The IED supports communication protocols IEC 61850-8-1 and DNP3 over TCP/IP. All operational information and controls are available through these protocols. However, some communication functionality, for example, horizontal communication (GOOSE) between the IEDs, is only enabled by the IEC 61850-8-1 communication protocol.

The IED is equipped an optical Ethernet rear port for substation communication standard IEC 61850-8-1. IEC 61850-8-1 communication is also possible from the optical Ethernet front port. IEC 61850-8-1 protocol allows intelligent 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.

Disturbance files are accessed using the IEC 61850-8-1 protocol. Disturbance files are available to any Ethernet based application in the standard COMTRADE format. Further, the IED sends and receives binary signals from other IEDs using the IEC 61850-8-1 GOOSE profile. The IED meets the GOOSE performance requirements for tripping applications in substations, as defined by the IEC 61850 standard. The IED interoperates with other IEC 61850 compliant IEDs, tools and systems and simultaneously reports events to five different clients on the IEC 61850 station bus.

All communication connectors, except for the front port connector, are placed on integrated communication modules. The IED is connected to Ethernet-based communication systems via the fibre-optic multimode LC connector (100BASE-FX).

The IED supports SNTP and IRIG-B time synchronization methods with a time-stamping resolution of 1 ms.

- Ethernet based: SNTP and DNP3
- With time synchronization wiring: IRIG-B

Table 395:   *Supported communication interface and protocol alternatives*

Interfaces/Protocols	Ethernet 100BASE-FX LC
IEC 61850-8-1	●
DNP3	●
● = Supported	

12.2.3   Settings

Table 396:   *IEC 61850-8-1 Non group settings (basic)*

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off/On
GOOSE	Front LAN1	-	-	LAN1	Port for GOOSE communication

12.2.4   Technical data

Table 397:   *IEC 61850-8-1 communication protocol*

Function	Value
Protocol	IEC 61850-8-1
Communication speed for the IEDs	100BASE-FX

12.3   Horizontal communication via GOOSE for interlocking

12.3.1   Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Horizontal communication via GOOSE for interlocking	GOOSEINTLKR CV	-	-

12.3.2   Function block

```
        GOOSEINTLKRCV
  BLOCK            ^RESREQ
               ^RESGRANT
                 ^APP1_OP
                 ^APP1_CL
                  APP1VAL
                 ^APP2_OP
                 ^APP2_CL
                  APP2VAL
                 ^APP3_OP
                 ^APP3_CL
                  APP3VAL
                 ^APP4_OP
                 ^APP4_CL
                  APP4VAL
                 ^APP5_OP
                 ^APP5_CL
                  APP5VAL
                 ^APP6_OP
                 ^APP6_CL
                  APP6VAL
                 ^APP7_OP
                 ^APP7_CL
                  APP7VAL
                 ^APP8_OP
                 ^APP8_CL
                  APP8VAL
                 ^APP9_OP
                 ^APP9_CL
                  APP9VAL
                ^APP10_OP
                ^APP10_CL
                 APP10VAL
                ^APP11_OP
                ^APP11_CL
                 APP11VAL
                ^APP12_OP
                ^APP12_CL
                 APP12VAL
                ^APP13_OP
                ^APP13_CL
                 APP13VAL
                ^APP14_OP
                ^APP14_CL
                 APP14VAL
                ^APP15_OP
                ^APP15_CL
                 APP15VAL
                  COM_VAL
```

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Figure 195:   *GOOSEINTLKRCV function block*

12.3.3   Signals

Table 398:   *GOOSEINTLKRCV Input signals*

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of output signals

Table 399:   *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
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
Table continues on next page		

Name	Type	Description
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

12.3.4　　Settings

Table 400:　　　GOOSEINTLKRCV Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off/On

12.4　　Goose binary receive GOOSEBINRCV

12.4.1　　Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Goose binary receive	GOOSEBINRCV	-	-

12.4.2 Function block
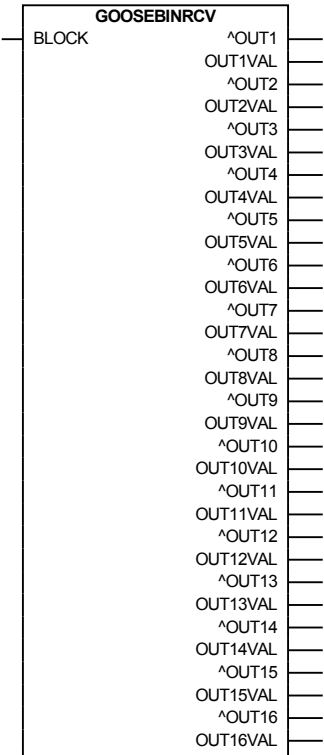
IEC09000236_en.vsd

Figure 196:   GOOSEBINRCV function block

12.4.3 Signals

Table 401:   GOOSEBINRCV Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of output signals

Table 402:   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
OUT4	BOOLEAN	Binary output 4
OUT4VAL	BOOLEAN	Valid data on binary output 4
Table continues on next page		

Name	Type	Description
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

12.4.4   Settings

Table 403:   GOOSEBINRCV Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off/On

Section 13   Basic IED functions

13.1   Self supervision with internal event list

13.1.1   Functionality

Self supervision with internal event list (INTERRSIG and SELFSUPEVLST) 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.

13.1.2   Internal error signals INTERRSIG

13.1.2.1   Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Internal error signal	INTERRSIG	-	-

13.1.2.2   Function block

```
      INTERRSIG
              FAIL ──
           WARNING ──
          TSYNCERR ──
            RTCERR ──
```

IEC09000334-1-en.vsd
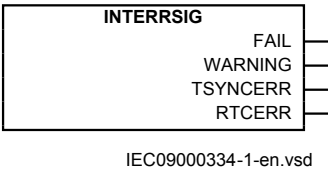
Figure 197:   INTERRSIG function block

13.1.2.3   Signals

Table 404:   INTERRSIG Output signals

Name	Type	Description
FAIL	BOOLEAN	Internal fail
WARNING	BOOLEAN	Internal warning
TSYNCERR	BOOLEAN	Time synchronization error
RTCERR	BOOLEAN	Real time clock error

13.1.2.4   Settings

The function does not have any settings available in Local HMI or Protection and Control IED Manager (PCM600).

13.1.3   Internal event list SELFSUPEVLST

13.1.3.1   Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Internal event list	SELFSUPEVLST	-	-

13.1.3.2   Settings

The function does not have any settings available in Local HMI or Protection and Control IED Manager (PCM600).

13.1.4   Operation principle

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 SELFSUPEVLST function status can be monitored from the local HMI, PCM Event viewer, or 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 **Diagnostics/Internal events** or **Diagnostics/IED status/General**. The information from self supervision function is also available in 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. This output relay is activated (no fault) and deactivated (fault) by the Internal Fail signal, see figure 198. Also the software watchdog timeout and the undervoltage detection of the PSM will deactivate the relay.
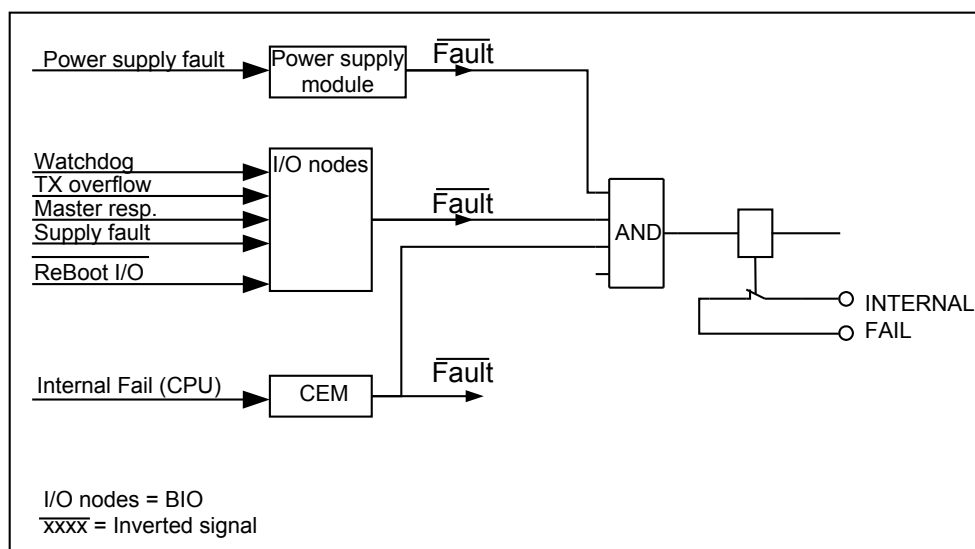
IEC09000390-1-en.vsd

Figure 198:   *Hardware self-supervision, potential-free contact*
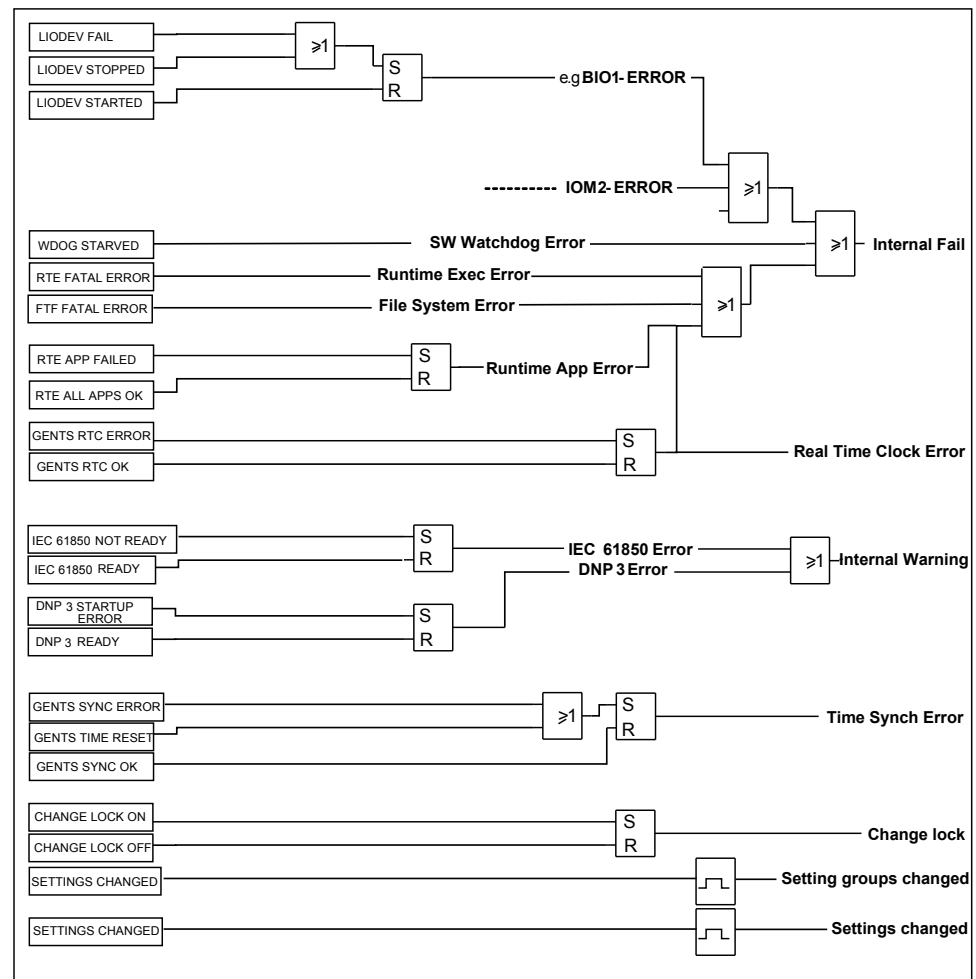
IEC09000381-1-en.vsd

Figure 199:   Self supervision, function block internal signals

Some signals are available from the INTERRSIG function block. The signals from INTERRSIG 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 INTERSIG.

13.1.4.1   Internal signals

SELFSUPEVLST function 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. One group handles signals that are always present in the IED; standard signals. Another group handles signals that are collected depending on the hardware configuration. The standard signals are listed in table 405. The hardware dependent internal signals are listed in table 406. Explanations of internal signals are listed in table 407.

Table 405:   SELFSUPEVLST standard internal signals

Name of signal	Description
Internal Fail	Internal Fail status
Internal Warning	Internal Warning status
Real Time Clock Error	Real Time Clock status
Time Synch Error	Time Synchronization status
Runtime App Error	Runtime Application Error status
Runtime Exec Error	Runtime Execution Error status
IEC61850 Error	IEC 61850 Error status
SW Watchdog Error	SW Watchdog Error status
Settings Changed	Settings Changed
Setting Group Changed	Setting Groups Changed
Change Lock	Change Lock status
File System Error	Fault tolerant filesystem status
DNP3 Error	DNP3 error status

Table 406:   Self-supervision's HW dependent internal signals

Card	Name of signal	Description
PSM	PSM-Error	Power Supply Module Error status
TRM	TRM-Error	Transformator Module Error status
COM	COM-Error	Communication Module Error status
BIO	BIO-Error	Binary Input / Output Module Error status
AIM	AIM-Error	Analog Input Module Error status

Table 407:   Explanations of internal signals

Name of signal	Reasons for activation
Internal Fail	This signal will be active if one or more of the following internal signals are active; Real Time Clock Error, Runtime App Error, Runtime Exec Error, SW Watchdog Error, File System Error
Internal Warning	This signal will be active if one or more of the following internal signals are active; IEC 61850 Error, DNP3 Error
Real Time Clock Error	This signal will be active if there is a hardware error with the real time clock.
Time Synch Error	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.
Table continues on next page	

Name of signal	Reasons for activation
Runtime Exec Error	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.
IEC61850 Error	This signal will be active if the IEC61850 stack did not succeed in some actions like reading IEC61850 configuration, startup etc.
SW Watchdog Error	This signal will be activated when the IED has been under too heavy load for at least 5 minutes. The operating systems background task is used for the measurements.
Runtime App Error	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, etc.
Settings Changed	This signal will generate an internal event to the internal event list if any settings are changed.
Setting Groups Changed	This signal will generate an internal event to the Internal Event List if any setting groups are changed.
Change Lock	This signal will generate an internal Event to the Internal Event List if the Change Lock status is changed
File System Error	This signal will be active if both the working file and the backup file are corrupted and cannot be recovered.
DNP3 Error	This signal will be active when DNP3 detects any configuration error during startup.

13.1.4.2 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 200.

en05000296-2-en.vsd
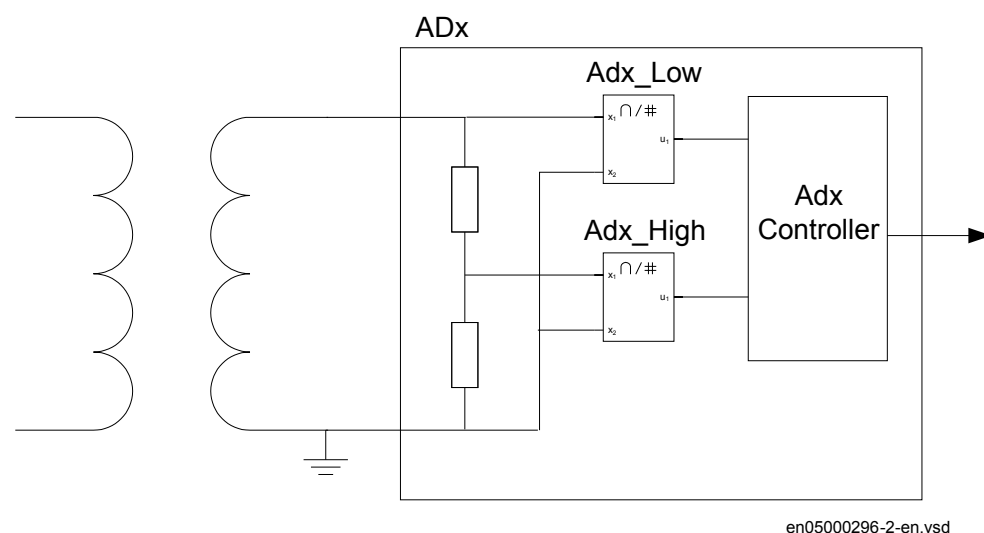
Figure 200: *Simplified drawing of A/D converter for the IED.*

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.

13.1.5   Technical data

Table 408:   Self supervision with internal event list

Data	Value
Recording manner	Continuous, event controlled
List size	40 events, first in - first out

13.2   Time synchronization

13.2.1   Functionality

Use the time synchronization source selector to select a common source of absolute time for the IED when it is a part of a control and a protection system. This makes comparison of events 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.

13.2.2 Time synchronization TIMESYNCHGEN

13.2.2.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Time synchronization	TIMESYNCHGEN	-	-

13.2.2.2 Settings

Table 409: *TIMESYNCHGEN Non group settings (basic)*

Name	Values (Range)	Unit	Step	Default	Description
CoarseSyncSrc	Off SNTP DNP	-	-	Off	Coarse time synchronization source
FineSyncSource	Off SNTP IRIG-B	-	-	Off	Fine time synchronization source
SyncMaster	Off SNTP-Server	-	-	Off	Activate IED as synchronization master

13.2.3 Time synchronization via SNTP

13.2.3.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Time synchronization via SNTP	SNTP	-	-

13.2.3.2 Settings

Table 410: *SNTP Non group settings (basic)*

Name	Values (Range)	Unit	Step	Default	Description
ServerIP-Add	0 - 255	IP Address	1	0.0.0.0	Server IP-address
RedServIP-Add	0 - 255	IP Address	1	0.0.0.0	Redundant server IP-address

13.2.4 Time system, summer time begin DTSBEGIN

13.2.4.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Time system, summer time begins	DTSBEGIN	-	-

13.2.4.2 Settings

Table 411: *DTSBEGIN 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 - 86400	s	1	3600	UTC Time of day in seconds when daylight time starts

13.2.5 Time system, summer time ends DTSEND

13.2.5.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Time system, summer time ends	DTSEND	-	-

13.2.5.2 Settings

Table 412:   DTSEND 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 - 86400	s	1	3600	UTC Time of day in seconds when daylight time ends

13.2.6 Time zone from UTC TIMEZONE

13.2.6.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Time zone from UTC	TIMEZONE	-	-

13.2.6.2 Settings

Table 413:   TIMEZONE Non group settings (basic)

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

13.2.7 Time synchronization via IRIG-B

13.2.7.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Time synchronization via IRIG-B	IRIG-B	-	-

13.2.7.2 Settings

Table 414:   IRIG-B Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
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

13.2.8 Operation principle

13.2.8.1 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)
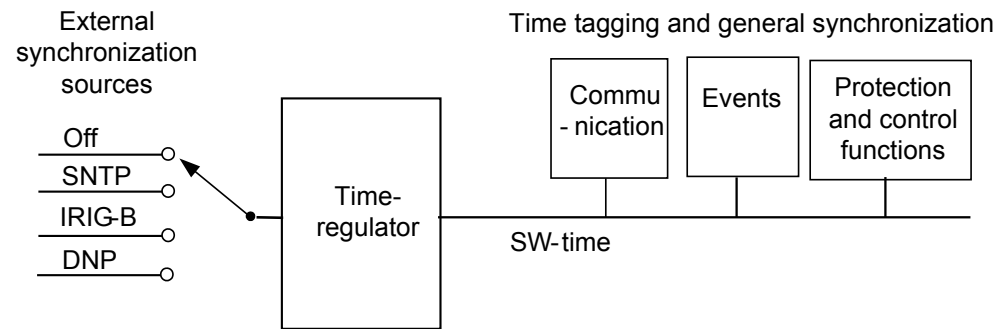
Figure 201:   Design of time system (clock synchronization)

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.
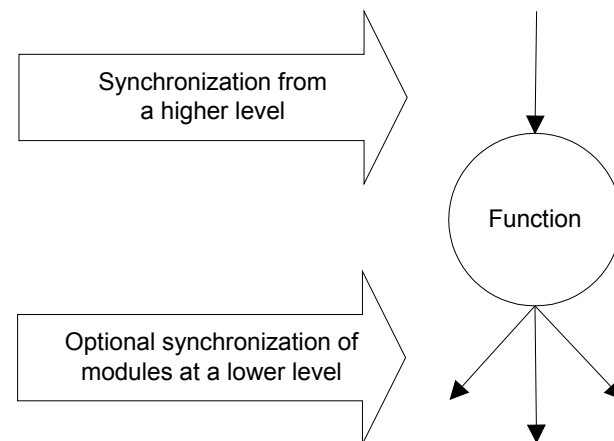
Figure 202:   Synchronization principle

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.

13.2.8.2   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

At IED startup, the internal time is free running. If the RTC is still alive since the last up time, the time in the IED will be accurate (may drift 35 ppm), but if the RTC power has been lost during power off (will happen after 5 days), the IED time will start at 1970-01-01. For more information, please refer to section "Time synchronization startup procedure" and section "".

Time synchronization startup procedure

The first message that contains the full time (as for instance SNTP and IRIG-B) gives an accurate time to the IED. The IED is brought into a safe state and the time is set to the correct value. 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, from its origin 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 500 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 10 000 ppm until the offset is removed. With an adjustment of 10 000 ppm, it takes 50 seconds to remove an offset of 500 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.

13.2.8.3 Synchronization alternatives

Two main alternatives of external time synchronization are available. The synchronization message is applied either via any of the communication ports of the IED as a telegram message including date and time or via IRIG-B.

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.

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 IRIG-B

The DNP 3.0 communication can be the source for the course time synchronization, while the fine time synchronization needs a source with higher accuracy. See Communication manual for a detailed description of the DNP 3.0 protocol.

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 one dedicated connector for the IRIG-B port. IRIG-B 00x messages can be supplied via the galvanic interface, where x (in 00x) means a number in the range of 1-7.

If the x in 00x 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 the tool or local HMI.

The IRIG-B input 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 module. In this case, send also the local time in the messages.

13.2.9 Technical data

Table 415: *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

13.3 Parameter setting group handling

13.3.1 Functionality

Use the four 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.

13.3.2 Setting group handling SETGRPS

13.3.2.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Setting group handling	SETGRPS	-	-

13.3.2.2 Settings

Table 416: *SETGRPS Non group settings (basic)*

Name	Values (Range)	Unit	Step	Default	Description
ActiveSetGrp	SettingGroup1 SettingGroup2 SettingGroup3 SettingGroup4	-	-	SettingGroup1	ActiveSettingGroup
MaxNoSetGrp	1 - 4	-	1	1	Max number of setting groups 1-4

13.3.3   Parameter setting groups ACTVGRP

13.3.3.1   Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Parameter setting groups	ACTVGRP	-	-

13.3.3.2   Function block

```
         ACTVGRP
──  ACTGRP1        GRP1  ──
──  ACTGRP2        GRP2  ──
──  ACTGRP3        GRP3  ──
──  ACTGRP4        GRP4  ──
                 SETCHGD ──
```

IEC09000064_en_1.vsd
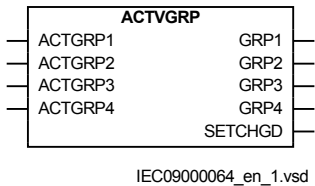
13.3.3.3   Signals

Table 417:   ACTVGRP 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

Table 418:   ACTVGRP 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
SETCHGD	BOOLEAN	Pulse when setting changed

13.3.3.4   Settings

The function does not have any settings available in Local HMI or Protection and Control IED Manager (PCM600).

13.3.4　Operation principle

Parameter setting groups (ACTVGRP) function has four 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. Five functional output signals are available for configuration purposes.

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 ACTVGRP 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 the PCM600 configuration tool 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 *MaxNoSetGrp* defines the maximum number of setting groups in use to switch between.
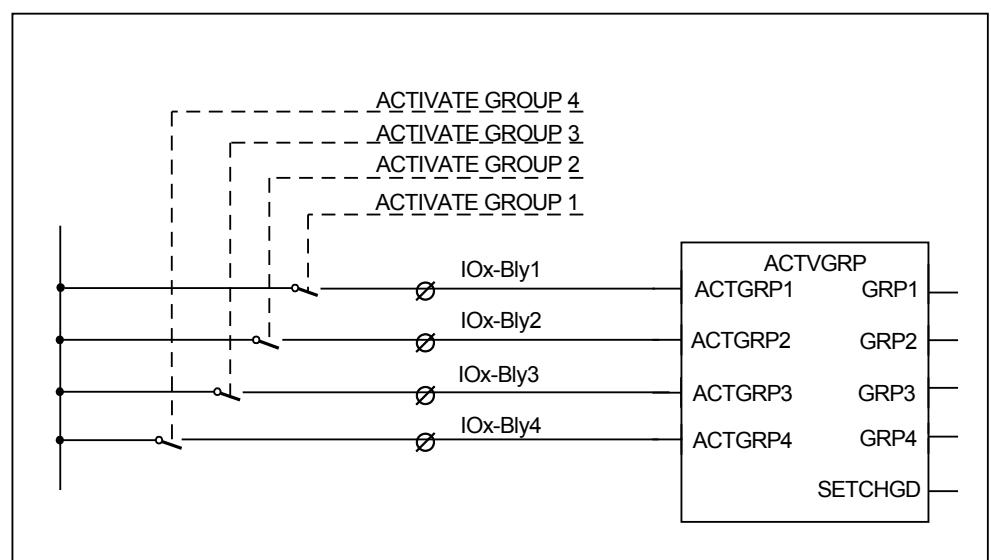
IEC09000063_en_1.vsd

Figure 203:　Connection of the function to external circuits

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

13.4 Test mode functionality TESTMODE

13.4.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Test mode functionality	TESTMODE	-	-

13.4.2 Functionality

When the 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 PST to perform required tests.

> ℹ️ 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.

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.

Forcing of binary output signals is only possible when the IED is in test mode.

13.4.3 Function block


```
          TESTMODE
 ─── INPUT           ACTIVE ───
                     OUTPUT ───
                     SETTING ───
                     NOEVENT ───
```
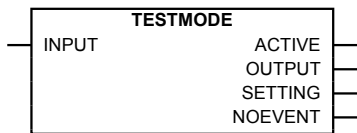
IEC09000219-1.vsd

Figure 204:   TESTMODE function block

13.4.4   Signals

Table 419:   TESTMODE Input signals

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

Table 420:   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

13.4.5   Settings

Table 421:   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

13.4.6   Operation principle

To be able to test the functions in the IED, the IED shall be put in test mode. There are two ways of setting the IED in test mode:

- By configuration, activating the input signal of the function block TESTMODE.
- By setting *TestMode* to *On* in the local HMI, under the menu: **Tests/IED test mode/1:TESTMODE**.

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.

Forcing of binary output signals is only possible when the IED is in test mode.

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). 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 TESTMODE function block.

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.

13.5 Change lock function CHNGLCK

13.5.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Change lock function	CHNGLCK	-	-

13.5.2 Functionality

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.

When CHNGLCK has a logical one on its input, then all attempts to modify the IED configuration will be denied and the message "Error: Changes blocked" will be displayed on the LHMI; in PCM600 the message will be "Operation denied by active ChangeLock". The CHNGLCK function should be configured so that it is controlled by a signal from a binary input card. This guarantees that by setting that signal to a logical zero, CHNGLCK is deactivated. If any logic is included in the signal path to the CHNGLCK input, that logic must be designed so that it cannot permanently issue a logical one on the CHNGLCK input. If such a situation would occur in spite of these precautions, then please contact the local ABB representative for remedial action.

13.5.3 Function block
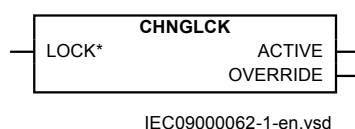
Figure 205:   CHNGLCK function block

13.5.4 Signals

Table 422:   CHNGLCK Input signals

Name	Type	Default	Description
LOCK	BOOLEAN	0	Activate change lock

Table 423:   CHNGLCK Output signals

Name	Type	Description
ACTIVE	BOOLEAN	Change lock active
OVERRIDE	BOOLEAN	Change lock override

13.5.5 Settings

The function does not have any parameters available in Local HMI or Protection and Control IED Manager (PCM600)

13.5.6 Operation principle

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

13.6 IED identifiers TERMINALID

13.6.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
IED identifiers	TERMINALID	-	-

13.6.2 Functionality

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.

13.6.3   Settings

Table 424:   *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
TechnicalKey	0 - 18	-	1	AA0J0Q0A0	Technical key

13.7   Product information

13.7.1   Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Product information	PRODINF	-	-

13.7.2   Functionality

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:

Diagnostics/IED status/Product identifiers

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

13.7.3   Settings

The function does not have any parameters available in Local HMIor Protection and Control IED Manager (PCM600).

13.8 Primary system values PRIMVAL

13.8.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Primary system values	PRIMVAL	-	-

13.8.2 Functionality

The rated system frequency and phasor rotation are set under **Main menu/ Configuration/ Power system/ Primary values/PRIMVAL** in PCM600 parameter setting tree.

13.8.3 Settings

Table 425:   PRIMVAL Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Frequency	50.0 - 60.0	Hz	10.0	50.0	Rated system frequency
PhaseRotation	Normal=L1L2L3 Inverse=L3L2L1	-	-	Normal=L1L2L3	System phase rotation

13.9 Signal matrix for analog inputs SMAI

13.9.1 Functionality

Signal matrix for analog inputs (SMAI) function (or the pre-processing function) is used within PCM600 in direct relation with SMT or ACT (see the overview of the engineering process in the *Engineering manual*). SMT represents the way analog inputs are brought in for one IED configuration.

13.9.2 Signal matrix for analog inputs SMAI_20_1

13.9.2.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Signal matrix for analog inputs	SMAI_20_1	-	-

13.9.2.2　Function block
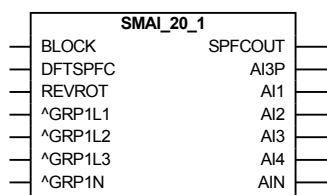
IEC09000137-1-en.vsd

Figure 206:　SMAI_20_1 function block

13.9.2.3　Signals

Table 426:　SMAI_20_1 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
REVROT	BOOLEAN	0	Reverse rotation group 1
GRP1L1	STRING	-	First analog input used for phase L1 or L1-L2 quantity
GRP1L2	STRING	-	Second analog input used for phase L2 or L2-L3 quantity
GRP1L3	STRING	-	Third analog input used for phase L3 or L3-L1 quantity
GRP1N	STRING	-	Fourth analog input used for residual or neutral quantity

Table 427:　SMAI_20_1 Output signals

Name	Type	Description
SPFCOUT	REAL	Number of samples per fundamental cycle from internal DFT reference function
AI3P	GROUP SIGNAL	Grouped three phase signal containing data from inputs 1-4
AI1	GROUP SIGNAL	Quantity connected to the first analog input
AI2	GROUP SIGNAL	Quantity connected to the second analog input
AI3	GROUP SIGNAL	Quantity connected to the third analog input
AI4	GROUP SIGNAL	Quantity connected to the fourth analog input
AIN	GROUP SIGNAL	Calculated residual quantity if inputs 1-3 are connected

13.9.2.4 Settings

Table 428:   SMAI_20_1 Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
GlobalBaseSel	1 - 6	-	1	1	Selection of one of the Global Base Value groups
DFTRefExtOut	InternalDFTRef DFTRefGrp1 DFTRefGrp2 DFTRefGrp3 DFTRefGrp4 DFTRefGrp5 DFTRefGrp6 DFTRefGrp7 DFTRefGrp8 DFTRefGrp9 DFTRefGrp10 DFTRefGrp11 DFTRefGrp12 External DFT ref	-	-	InternalDFTRef	DFT reference for external output
DFTReference	InternalDFTRef DFTRefGrp1 DFTRefGrp2 DFTRefGrp3 DFTRefGrp4 DFTRefGrp5 DFTRefGrp6 DFTRefGrp7 DFTRefGrp8 DFTRefGrp9 DFTRefGrp10 DFTRefGrp11 DFTRefGrp12 External DFT ref	-	-	InternalDFTRef	DFT reference
ConnectionType	Ph-N Ph-Ph	-	-	Ph-N	Input connection type
AnalogInputType	Voltage Current	-	-	Voltage	Analog input signal type

Table 429:   SMAI_20_1 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

13.9.3 Signal matrix for analog inputs SMAI_20_2

13.9.3.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Signal matrix for analog inputs	SMAI_20_2	-	-

13.9.3.2 Function block

```
          SMAI_20_2
   — BLOCK          AI3P —
   — REVROT          AI1 —
   — ^GRP2L1         AI2 —
   — ^GRP2L2         AI3 —
   — ^GRP2L3         AI4 —
   — ^GRP2N          AIN —

        IEC09000138-2-en.vsd
```
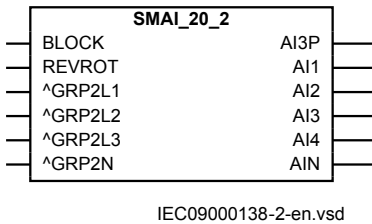
Figure 207:   *SMAI_20_2 to SMAI_20_12 function block*

Note that input and output signals on SMAI_20_2 to SMAI_20_12 are the same except for input signals GRPxL1 to GRPxN where x is equal to instance number (2 to 12).

13.9.3.3 Signals

Table 430:   *SMAI_20_2 Input signals*

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block group 2
REVROT	BOOLEAN	0	Reverse rotation group 2
GRP2L1	STRING	-	First analog input used for phase L1 or L1-L2 quantity
GRP2L2	STRING	-	Second analog input used for phase L2 or L2-L3 quantity
GRP2L3	STRING	-	Third analog input used for phase L3 or L3-L1 quantity
GRP2N	STRING	-	Fourth analog input used for residual or neutral quantity

Table 431:   *SMAI_20_2 Output signals*

Name	Type	Description
AI3P	GROUP SIGNAL	Grouped three phase signal containing data from inputs 1-4
AI1	GROUP SIGNAL	Quantity connected to the first analog input
AI2	GROUP SIGNAL	Quantity connected to the second analog input
AI3	GROUP SIGNAL	Quantity connected to the third analog input
AI4	GROUP SIGNAL	Quantity connected to the fourth analog input
AIN	GROUP SIGNAL	Calculated residual quantity if inputs 1-3 are connected

13.9.3.4   Settings

Table 432:   *SMAI_20_2 Non group settings (basic)*

Name	Values (Range)	Unit	Step	Default	Description
GlobalBaseSel	1 - 6	-	1	1	Selection of one of the Global Base Value groups
DFTReference	InternalDFTRef DFTRefGrp1 DFTRefGrp2 DFTRefGrp3 DFTRefGrp4 DFTRefGrp5 DFTRefGrp6 DFTRefGrp7 DFTRefGrp8 DFTRefGrp9 DFTRefGrp10 DFTRefGrp11 DFTRefGrp12 External DFT ref	-	-	InternalDFTRef	DFT reference
ConnectionType	Ph-N Ph-Ph	-	-	Ph-N	Input connection type
AnalogInputType	Voltage Current	-	-	Voltage	Analog input signal type

Table 433:   *SMAI_20_2 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

13.9.4 Operation principle

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 206 and figure 207. 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 signals AI1 to AI4 in SMAI_20_x function block are direct outputs of the, in SMT or ACT, connected input group signals to GRPxL1, GRPxL2, GRPxL3 and GRPxN, x=1-12. GRPxN is always the neutral current. If GRPxN is not connected, the AI4 output is all zero. The AIN output is the calculated residual sum of inputs GRPxL1, GRPxL2 and GRPxL3 and is equal to output AI4 if all inputs, including GRPxN, are connected. Note that function block will always calculate the residual sum of current/voltage if the input is not connected in SMT or ACT. Applications with a few exceptions shall always be connected to AI3P.

The input signal REVROT is used to reverse the phase order.

13.10 Summation block 3 phase 3PHSUM

13.10.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Summation block 3 phase	3PHSUM	-	-

13.10.2 Functionality

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

13.10.3 Function block
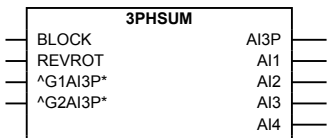
IEC09000201_1_en.vsd

Figure 208:   3PHSUM function block

13.10.4 Signals

Table 434:   3PHSUM Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block
REVROT	BOOLEAN	0	Reverse rotation
G1AI3P	GROUP SIGNAL	-	Group 1 three phase analog input from first SMAI
G2AI3P	GROUP SIGNAL	-	Group 2 three phase analog input from second SMAI

Table 435:   3PHSUM Output signals

Name	Type	Description
AI3P	GROUP SIGNAL	Linear combination of two connected three phase inputs
AI1	GROUP SIGNAL	Linear combination of input 1 signals from both SMAI blocks
AI2	GROUP SIGNAL	Linear combination of input 2 signals from both SMAI blocks
AI3	GROUP SIGNAL	Linear combination of input 3 signals from both SMAI blocks
AI4	GROUP SIGNAL	Linear combination of input 4 signals from both SMAI blocks

13.10.5 Settings

Table 436:   3PHSUM Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
GlobalBaseSel	1 - 6	-	1	1	Selection of one of the Global Base Value groups
SummationType	Group1+Group2 Group1-Group2 Group2-Group1 -(Group1+Group2)	-	-	Group1+Group2	Summation type
DFTReference	InternalDFTRef DFTRefGrp1 External DFT ref	-	-	InternalDFTRef	DFT reference

Table 437:   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

13.10.6 Operation principle

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

13.11 Global base values GBASVAL

13.11.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Global base values	GBASVAL	-	-

13.11.2 Functionality

Global base values function (GBASVAL) is used to provide global values, common for all applicable functions within the IED. One set of global values consists of values for current, voltage and apparent power and it is possible to have six different sets.

This is an advantage since all applicable functions in the IED use a single source of base values. This facilitates consistency throughout the IED and also facilitates a single point for updating values when necessary.

Each applicable function in the IED has a parameter, *GlobalBaseSel*, defining one out of the six sets of Global base value functions.

13.11.3 Settings

Table 438:   GBASVAL Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
UBase	0.05 - 2000.00	kV	0.05	132.00	Global base voltage
IBase	1 - 99999	A	1	1000	Global base current
SBase	1 - 50000	MVA	1	229	Global base apparent power

13.12 Authority check ATHCHCK

13.12.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Authority check	ATHCHCK	-	-

13.12.2 Functionality

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

13.12.3 Settings

The function does not have any parameters available in Local HMI or Protection and Control IED Manager (PCM 600).

13.12.4 Operation principle

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 defined as follows:

User type	Access rights
SystemOperator	Control from local HMI, no bypass
ProtectionEngineer	All settings
DesignEngineer	Application configuration (including SMT, GDE and CMT)
UserAdministrator	User and password administration for the IED

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.

13.12.4.1 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 (UMT).

Once a user is created and downloaded into the IED, that user can perform a Log on, using the password assigned in the tool. Then the default user will be Guest.

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/Configuration/HMI/Screen/1:SCREEN**) elapses, the IED will return to a Guest state, when only reading is possible. By factory default, the display timeout is set to 60 minutes.

If one or more users are created with the UMT and downloaded into the IED, then, when a user attempts a Log on by pressing the [key] key 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 [key] key, one 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 [key] key again. When it comes to password, upon pressing the [key] key, the following characters 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 [key] key again.

At successful Log on the local HMI shows the new username in the statusbar at the bottom of the LCD. 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 LogOn has failed, an "Error Access Denied" message will pop-up. If a user enters an incorrect password three times, that user will be blocked for ten minutes before a new attempt to log in can be performed. The user will be blocked from logging in, both from the local HMI as well as, from PCM600 tool. However, other users will be able to log in during this period.

13.13 Authority status ATHSTAT

13.13.1 Identification

| Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Authority status	ATHSTAT	-	-

13.13.2 Functionality

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

13.13.3 Function block

```
        ATHSTAT
         USRBLKED ──
         LOGGEDON ──

    IEC09000235_en_1.vsd
```
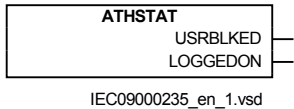
Figure 209:   ATHSTAT function block

13.13.4 Signals

Table 439:   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

13.13.5 Settings

The function does not have any parameters available in Local HMI or Protection and Control IED Manager (PCM600)

13.13.6 Operation principle

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.

13.14 Denial of service

13.14.1 Functionality

The Denial of service functions (DOSLAN1 and DOSFRNT) 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.

13.14.2 Denial of service, frame rate control for front port DOSFRNT

13.14.2.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Denial of service, frame rate control for front port	DOSFRNT	-	-

13.14.2.2 Function block
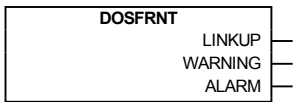
IEC09000133-1-en.vsd

Figure 210:   DOSFRNT function block

13.14.2.3 Signals

Table 440:   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

13.14.2.4   **Settings**

The function does not have any parameters available in Local HMI or Protection and Control IED Manager (PCM600)

13.14.2.5   **Monitored data**

Table 441:   DOSFRNT Monitored data

Name	Type	Values (Range)	Unit	Description
State	INTEGER	0=Off 1=Normal 2=Throttle 3=DiscardLow 4=DiscardAll 5=StopPoll	-	Frame rate control state
Quota	INTEGER	-	%	Quota level in percent 0-100
IPPackRecNorm	INTEGER	-	-	Number of IP packets received in normal mode
IPPackRecPoll	INTEGER	-	-	Number of IP packets received in polled mode
IPPackDisc	INTEGER	-	-	Number of IP packets discarded
NonIPPackRecNorm	INTEGER	-	-	Number of non IP packets received in normal mode
NonIPPackRecPoll	INTEGER	-	-	Number of non IP packets received in polled mode
NonIPPackDisc	INTEGER	-	-	Number of non IP packets discarded

13.14.3   **Denial of service, frame rate control for LAN1 port DOSLAN1**

13.14.3.1   **Identification**

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Denial of service, frame rate control for LAN1 port	DOSLAN1	-	-

13.14.3.2 Function block
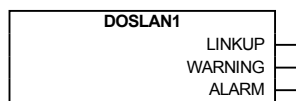
IEC09000134-1-en.vsd

Figure 211:   DOSLAN1 function block

13.14.3.3 Signals

Table 442:   DOSLAN1 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

13.14.3.4 Settings

The function does not have any parameters available in Local HMI or Protection and Control IED Manager (PCM600)

13.14.3.5 Monitored data

Table 443:   DOSLAN1 Monitored data

Name	Type	Values (Range)	Unit	Description
State	INTEGER	0=Off 1=Normal 2=Throttle 3=DiscardLow 4=DiscardAll 5=StopPoll	-	Frame rate control state
Quota	INTEGER	-	%	Quota level in percent 0-100
IPPackRecNorm	INTEGER	-	-	Number of IP packets received in normal mode
IPPackRecPoll	INTEGER	-	-	Number of IP packets received in polled mode
IPPackDisc	INTEGER	-	-	Number of IP packets discarded
Table continues on next page				

Name	Type	Values (Range)	Unit	Description
NonIPPackRecNorm	INTEGER	-	-	Number of non IP packets received in normal mode
NonIPPackRecPoll	INTEGER	-	-	Number of non IP packets received in polled mode
NonIPPackDisc	INTEGER	-	-	Number of non IP packets discarded

13.14.4 Operation principle

The Denial of service functions (DOSLAN1 and DOSFRNT) 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

Section 14   IED physical connections

14.1   Protective earth connections

The IED shall be earthed with a 16.0 mm^2 flat copper cable.

> The earth lead should be as short as possible, less than 1500 mm.
> Additional length is required for door mounting.
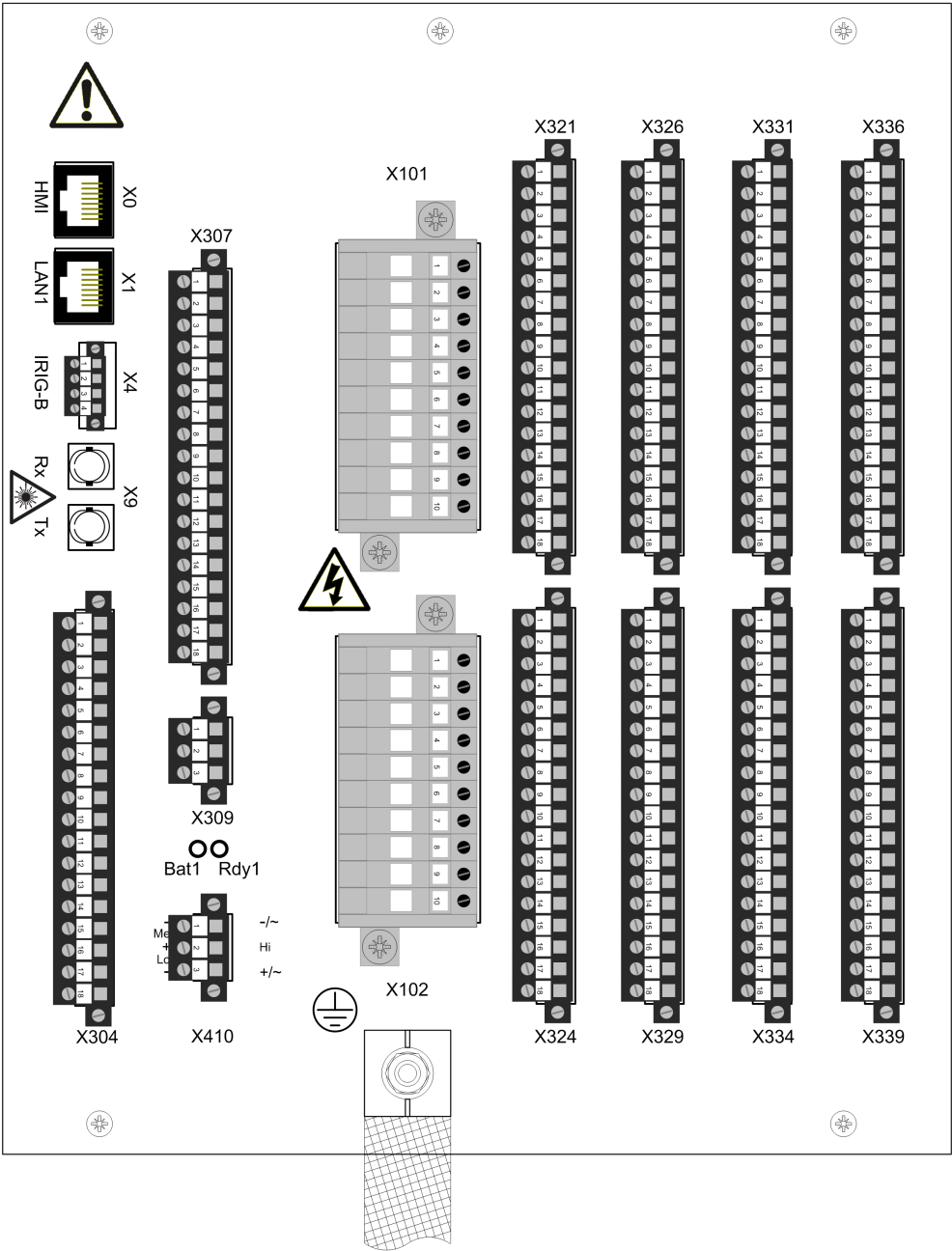
Figure 212: *Protective earth pin is located below connector X102 on the 6U half 19" case*

14.2 Inputs

14.2.1 Measuring inputs

Each terminal for CTs/VTs is dimensioned for one 0.5...6.0 mm^2 wire or for two wires of maximum 2.5 mm^2.

Table 444: Analog input modules

Terminal	TRM 6I + 4U	TRM 8I + 2U	TRM 4I + 1I + 5U	AIM 6I + 4U	AIM 4I + 1I + 5U
X101-1, 2	1/5A	1/5A	1/5A	1/5A	1/5A
X101-3, 4	1/5A	1/5A	1/5A	1/5A	1/5A
X101-5, 6	1/5A	1/5A	1/5A	1/5A	1/5A
X101-7, 8	1/5A	1/5A	1/5A	1/5A	1/5A
X101-9, 10	1/5A	1/5A	0.1/0.5A	1/5A	0.1/0.5A
X102-1, 2	1/5A	1/5A	100/220V	1/5A	100/220V
X102-3, 4	100/220V	1/5A	100/220V	100/220V	100/220V
X102-5, 6	100/220V	1/5A	100/220V	100/220V	100/220V
X102-7, 8	100/220V	100/220V	100/220V	100/220V	100/220V
X102-9, 10	100/220V	100/220V	100/220V	100/220V	100/220V

See the connection diagrams for information on the analog input module variant included in a particular configured IED.

14.2.2 Auxiliary supply voltage input

The auxiliary voltage of the IED is connected to terminals X410-1 and X410-2/3. The terminals used depend on the power supply.

The permitted auxiliary voltage range of the IED is marked on top of the IED's LHMI.

Table 445: Auxiliary voltage supply of 110...250 V DC or 100...240 V AC

Case	Terminal	Description
6U half 19"	X410-1	- Input
	X410–3	+ Input

Table 446: Auxiliary voltage supply of 48-125 V DC

Case	Terminal	Description
6U half 19"	X410-1	- Input
	X410–2	+ Input

14.2.3 Binary inputs

The binary inputs can be used, for example, to generate a blocking signal, to unlatch output contacts, to trigger the disturbance recorder or for remote control of IED settings.

Each signal connector terminal is connected with one 0.5...2.5 mm^2 wire or with two 0.5...1.0 mm^2 wires.

Table 447: *Binary inputs X304, 6U half 19"*

Terminal	Description	PCM600 info	
		Hardware module instance	Hardware channel
X304-1	Common - for inputs 1-4		
X304-2	Binary input 1 +	COM_101	BI1
X304-3	Binary input 2 +	COM_101	BI2
X304-4	Binary input 3 +	COM_101	BI3
X304-5	Binary input 4 +	COM_101	BI4
X304-6	Common - for inputs 5-8		
X304-7	Binary input 5 +	COM_101	BI5
X304-8	Binary input 6 +	COM_101	BI6
X304-9	Binary input 7 +	COM_101	BI7
X304-10	Binary input 8 +	COM_101	BI8
X304-11	Common - for inputs 9-11		
X304-12	Binary input 9 +	COM_101	BI9
X304-13	Binary input 10 +	COM_101	BI10
X304-14	Binary input 11 +	COM_101	BI11
X304-15	Common - for inputs 12-14		
X304-16	Binary input 12 +	COM_101	BI12
X304-17	Binary input 13 +	COM_101	BI13
X304-18	Binary input 14 +	COM_101	BI14

Table 448: *Binary inputs X324, 6U half 19"*

Terminal	Description	PCM600 info	
		Hardware module instance	Hardware channel
X324-1	- for input 1	BIO_3	BI1
X324-2	Binary input 1 +	BIO_3	BI1
X324-3	-		
X324-4	Common - for inputs 2-3		
X324-5	Binary input 2 +	BIO_3	BI2
X324-6	Binary input 3 +	BIO_3	BI3
X324-7	-		
Table continues on next page			

Terminal	Description	PCM600 info	
		Hardware module instance	Hardware channel
X324-8	Common - for inputs 4-5		
X324-9	Binary input 4 +	BIO_3	BI4
X324-10	Binary input 5 +	BIO_3	BI5
X324-11	-		
X324-12	Common - for inputs 6-7		
X324-13	Binary input 6 +	BIO_3	BI6
X324-14	Binary input 7 +	BIO_3	BI7
X324-15	-		
X324-16	Common - for inputs 8-9		
X324-17	Binary input 8 +	BIO_3	BI8
X324-18	Binary input 9 +	BIO_3	BI9

Table 449:   Binary inputs X329, 6U half 19"

Terminal	Description	PCM600 info	
		Hardware module instance	Hardware channel
X329-1	- for input 1	BIO_4	BI1
X329-2	Binary input 1 +	BIO_4	BI1
X329-3	-		
X329-4	Common - for inputs 2-3		
X329-5	Binary input 2 +	BIO_4	BI2
X329-6	Binary input 3 +	BIO_4	BI3
X329-7	-		
X329-8	Common - for inputs 4-5		
X329-9	Binary input 4 +	BIO_4	BI4
X329-10	Binary input 5 +	BIO_4	BI5
X329-11	-		
X329-12	Common - for inputs 6-7		
X329-13	Binary input 6 +	BIO_4	BI6
X329-14	Binary input 7 +	BIO_4	BI7
X329-15	-		
X329-16	Common - for inputs 8-9		
X329-17	Binary input 8 +	BIO_4	BI8
X329-18	Binary input 9 +	BIO_4	BI9

Table 450:   *Binary inputs X334, 6U half 19"*

Terminal	Description	PCM600 info	
		Hardware module instance	Hardware channel
X334-1	- for input 1	BIO_5	BI1
X334-2	Binary input 1 +	BIO_5	BI1
X334-3	-		
X334-4	Common - for inputs 2-3		
X334-5	Binary input 2 +	BIO_5	BI2
X334-6	Binary input 3 +	BIO_5	BI3
X334-7	-		
X334-8	Common - for inputs 4-5		
X334-9	Binary input 4 +	BIO_5	BI4
X334-10	Binary input 5 +	BIO_5	BI5
X334-11	-		
X334-12	Common - for inputs 6-7		
X334-13	Binary input 6 +	BIO_5	BI6
X334-14	Binary input 7 +	BIO_5	BI7
X334-15	-		
X334-16	Common - for inputs 8-9		
X334-17	Binary input 8 +	BIO_5	BI8
X334-18	Binary input 9 +	BIO_5	BI9

Table 451:   *Binary inputs X339, 6U half 19"*

Terminal	Description	PCM600 info	
		Hardware module instance	Hardware channel
X339-1	- for input 1	BIO_6	BI1
X339-2	Binary input 1 +	BIO_6	BI1
X339-3	-		
X339-4	Common - for inputs 2-3		
X339-5	Binary input 2 +	BIO_6	BI2
X339-6	Binary input 3 +	BIO_6	BI3
X339-7	-		
X339-8	Common - for inputs 4-5		
X339-9	Binary input 4 +	BIO_6	BI4
X339-10	Binary input 5 +	BIO_6	BI5
X339-11	-		
X339-12	Common - for inputs 6-7		
X339-13	Binary input 6 +	BIO_6	BI6
X339-14	Binary input 7 +	BIO_6	BI7
Table continues on next page			

Terminal	Description	PCM600 info	
		Hardware module instance	Hardware channel
X339-15	-		
X339-16	Common - for inputs 8-9		
X339-17	Binary input 8 +	BIO_6	BI8
X339-18	Binary input 9 +	BIO_6	BI9

14.3 Outputs

14.3.1 Outputs for tripping, controlling and signalling

Output contacts PO1, PO2 and PO3 are power output contacts used, for example, for controlling circuit breakers.

Each signal connector terminal is connected with one 0.5...2.5 mm^2 wire or with two 0.5...1.0 mm^2 wires.

> The connected DC voltage to outputs with trip circuit supervision (TCS) must have correct polarity or the trip circuit supervision TCSSCBR function will not operate properly.

Table 452:   Output contacts X307, 6U half 19"

Terminal	Description	PCM600 info	
		Hardware module instance	Hardware channel
X307-1 X307-2	Power output 1, normally open (TCS) - +	PSM_102	BO1_PO_TCS
X307-3 X307-4	Power output 2, normally open (TCS) - +	PSM_102	BO2_PO_TCS
X307-5 X307-6	Power output 3, normally open (TCS) - +	PSM_102	BO3_PO_TCS
X307-7 X307-8	Power output 4, normally open	PSM_102	BO4_PO
X307-9 X307-10	Power output 5, normally open	PSM_102	BO5_PO
X307-11 X307-12	Power output 6, normally open	PSM_102	BO6_PO

Table 453:   *Output contacts X321, 6U half 19"*

Terminal	Description	PCM600 info	
		Hardware module instance	Hardware channel
X321-1 X321-2	Power output 1, normally open	BIO_3	BO1_PO
X321-3 X321-4	Power output 2, normally open	BIO_3	BO2_PO
X321-5 X321-6	Power output 3, normally open	BIO_3	BO3_PO

Table 454:   *Output contacts X326, 6U half 19"*

Terminal	Description	PCM600 info	
		Hardware module instance	Hardware channel
X326-1 X326-2	Power output 1, normally open	BIO_4	BO1_PO
X326-3 X326-4	Power output 2, normally open	BIO_4	BO2_PO
X326-5 X326-6	Power output 3, normally open	BIO_4	BO3_PO

Table 455:   *Output contacts X331, 6U half 19"*

Terminal	Description	PCM600 info	
		Hardware module instance	Hardware channel
X331-1 X331-2	Power output 1, normally open	BIO_5	BO1_PO
X331-3 X331-4	Power output 2, normally open	BIO_5	BO2_PO
X331-5 X331-6	Power output 3, normally open	BIO_5	BO3_PO

Table 456:   *Output contacts X336, 6U half 19"*

Terminal	Description	PCM600 info	
		Hardware module instance	Hardware channel
X336-1 X336-2	Power output 1, normally open	BIO_6	BO1_PO
X336-3 X336-4	Power output 2, normally open	BIO_6	BO2_PO
X336-5 X336-6	Power output 3, normally open	BIO_6	BO3_PO

14.3.2 Outputs for signalling

Signal output contacts are used for signalling on starting and tripping of the IED. On delivery from the factory, the start and alarm signals from all the protection stages are routed to signalling outputs. See connection diagrams.

Each signal connector terminal is connected with one 0.5...2.5 mm^2 wire or with two 0.5...1.0 mm^2 wires.

Table 457:   *Output contacts X307, 6U half 19"*

Terminal	Description	PCM600 info	
		Hardware module instance	Hardware channel
X307-13 X307-14	Signal output 1, normally open	PSM_102	BO7_SO
X307-15 X307-16	Signal output 2, normally open	PSM_102	BO8_SO
X307-17 X307-18	Signal output 3, normally open	PSM_102	BO9_SO

Table 458:   *Output contacts X321, 6U half 19"*

Terminal	Description	PCM600 info	
		Hardware module instance	Hardware channel
X321-7 X321-8	Signal output 1, normally open Signal output 1	BIO_3	BO4_SO
X321-9 X321-10	Signal output 2, normally open Signal output 2	BIO_3	BO5_SO
X321-11 X321-12	Signal output 3, normally open Signal output 3	BIO_3	BO6_SO
X321-13	Signal output 4, normally open	BIO_3	BO7_SO
X321-14	Signal output 5, normally open	BIO_3	BO8_SO
X321-15	Signal outputs 4 and 5, common		
X321-16	Signal output 6, normally closed	BIO_3	BO9_SO
X321-17	Signal output 6, normally open		
X321-18	Signal output 6, common		

Table 459:   *Output contacts X326, 6U half 19"*

Terminal	Description	PCM600 info	
		Hardware module instance	Hardware channel
X326-7	Signal output 1, normally open	BIO_4	BO4_SO
X326-8	Signal output 1		
X326-9	Signal output 2, normally open	BIO_4	BO5_SO
X326-10	Signal output 2		
X326-11	Signal output 3, normally open	BIO_4	BO6_SO
X326-12	Signal output 3		
X326-13	Signal output 4, normally open	BIO_4	BO7_SO
X326-14	Signal output 5, normally open	BIO_4	BO8_SO
X326-15	Signal outputs 4 and 5, common		
X326-16	Signal output 6, normally closed	BIO_4	BO9_SO
X326-17	Signal output 6, normally open		
X326-18	Signal output 6, common		

Table 460:   *Output contacts X331, 6U half 19"*

Terminal	Description	PCM600 info	
		Hardware module instance	Hardware channel
X331-7	Signal output 1, normally open	BIO_5	BO4_SO
X331-8	Signal output 1		
X331-9	Signal output 2, normally open	BIO_5	BO5_SO
X331-10	Signal output 2		
X331-11	Signal output 3, normally open	BIO_5	BO6_SO
X331-12	Signal output 3		
X331-13	Signal output 4, normally open	BIO_5	BO7_SO
X331-14	Signal output 5, normally open	BIO_5	BO8_SO
X331-15	Signal outputs 4 and 5, common		
X331-16	Signal output 6, normally closed	BIO_5	BO9_SO
X331-17	Signal output 6, normally open		
X331-18	Signal output 6, common		

Table 461:   *Output contacts X336, 6U half 19"*

Terminal	Description	PCM600 info	
		Hardware module instance	Hardware channel
X336-7	Signal output 1, normally open	BIO_6	BO4_SO
X336-8	Signal output 1		
X336-9	Signal output 2, normally open	BIO_6	BO5_SO
X336-10	Signal output 2		

Table continues on next page

Terminal	Description	PCM600 info	
		Hardware module instance	Hardware channel
X336-11	Signal output 3, normally open	BIO_6	BO6_SO
X336-12	Signal output 3		
X337-13	Signal output 4, normally open	BIO_6	BO7_SO
X336-14	Signal output 5, normally open	BIO_6	BO8_SO
X336-15	Signal outputs 4 and 5, common		
X336-16	Signal output 6, normally closed	BIO_6	BO9_SO
X336-17	Signal output 6, normally open		
X336-18	Signal output 6, common		

14.3.3 IRF

The IRF contact functions as a change-over output contact for the self-supervision system of the IED. Under normal operating conditions, the IED is energized and one of the two contacts is closed. When a fault is detected by the self-supervision system or the auxiliary voltage is disconnected, the closed contact drops off and the other contact closes.

Each signal connector terminal is connected with one 0.5...2.5 mm^2 wire or with two 0.5...1.0 mm^2 wires.

Table 462:   IRF contact X309

Case	Terminal	Description
6U half 19"	X309-1	Closed; no IRF, and U$_{aux}$ connected
	X309-2	Closed; IRF, or U$_{aux}$ disconnected
	X309-3	IRF, common

14.4 Communication connections

The IED's LHMI is provided with an RJ-45 connector. The connector is mainly for configuration and setting purposes.

Rear communication via the X1/LAN1 connector uses a communication module with the optical LC Ethernet connection.

The HMI connector X0 is used for connecting an external HMI to the IED. The X0/HMI connector must not be used for any other purpose.

14.4.1 Ethernet RJ-45 front connection

The IED's LHMI is provided with an RJ-45 connector designed for point-to-point use. The connector is mainly for configuration and setting purposes. The interface

on the PC has to be configured in a way that it obtains the IP address automatically if the DHCPServer is enabled in LHMI. There is a DHCP server inside IED for the front interface only.

The events and setting values and all input data such as memorized values and disturbance records can be read via the front communication port.

Only one of the possible clients can be used for parametrization at a time.

- PCM600
- LHMI

The default IP address of the IED through this port is 10.1.150.3.

The front port supports TCP/IP protocol. A standard Ethernet CAT 5 crossover cable is used with the front port.

14.4.2 Station communication rear connection

The default IP address of the IED through the Ethernet connection is 192.168.1.10. The physical connector is X1/LAN1. The interface speed is 100 Mbps for the 100BASE-FX LC alternative.

14.4.3 Communication interfaces and protocols

Table 463:   *Supported communication interfaces and protocols*

Protocol	Ethernet 100BASE-FX LC
IEC 61850-8-1	●
DNP3	●
● = Supported	

14.4.4 Recommended industrial Ethernet switches

ABB recommends three third-party industrial Ethernet switches.

- RuggedCom RS900
- RuggedCom RS1600
- RuggedCom RSG2100

14.5 Connection diagrams

Connection diagrams for REC650 A01

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Transformer module (TRM)	6
Binary input/output module (BIO)	7
Binary input/output module (BIO)	8
Binary input/output module (BIO)	9

Document status: Approved

Prep.	PSTP/	TPLA	Agneta Rydh	2009-06-09
Appr.	PSTP/		Nyback Patrik	2009-09-14
Resp. dept	PSTP/	TPLA		

Connection Diagram
REC650 1(CBA) A01

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Sheet 1

ABB AB

Designations for 6U, 1/2x19" casing with 1 TRM

Module	Slot	Terminal
COM	pCOM	X0, X1, X4, X9, X304
PSM	pPSM	X307, X309, X410
TRM	p2	X101, X102
BIO	p3	X321, X324
BIO	p4	X326, X329
BIO	p5	X331, X334
BIO	p6	X336, X339

6U

1/2x19"

Rear view slot
pCOM pPSM p2 p3 p4 p5 p6

p= Position

Rear view terminals

Prep.	PSTP/	TPLA	Agneta Rydh
Appr.	PSTP/		Nyback Patrik
Resp. dept	PSTP/	TPLA	

Customer drw no

Based on

Connection Diagram
REC650 (1CBA) A01

2009-06-09
2009-09-14

ABB AB

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Sheet 2

Communication module (COM)

LOCATION=pCOM

Ethernet, RJ45 connection only for LHMI and PC-tool

Ethernet, LC optical

Cable shield grounding via capacitor

IRIG-B –
IRIG-B +

Optical serial port, Snap In
Not in use

	CONFIGURATION	
X0	LHMI	
X1	LAN 1	
X4	IRIG-B	
X9	Rx/Tx	

X304		CONFIGURATION	
1	C1-4		
2	BI01	QA1_OPEN	
3	BI02	QA1_CLOSED	
4	BI03	QA1_SPRING_CH	
5	BI04	QA1_SF6_OK	
6	C5-8		
7	BI05	QB9_OPEN	
8	BI06	QB9_CLOSED	
9	BI07	QC9_OPEN	
10	BI08	QC9_CLOSED	
11	C9-11		
12	BI09	BLOCK_CMD	
13	BI10	SPARE	
14	BI11	SPARE	
15	C12-14		
16	BI12	LOCKOUT_RESET	
17	BI13	EXT_START_DR	
18	BI14	TESTMODE_ON	

RL

Prep.	PSTP/	TPLA	Agneta Rydh	2009-06-09	Connection Diagram
Appr.	PSTP/	TPLA	Nyback Patrik	2009-09-14	REC650 (ICBA) A01
Resp. dept	PSTP/	TPLA			

ABB AB

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No of sh

REC650
Technical Manual

Power supply module 110-250 VDC, 100-240 VAC (PSM)

LOCATION=pPSM
CONFIGURATION

T1	QA1_TRIP
T2	QA1_TRIP
T3	SPARE
T4	QA1_CLOSE_CMD
T5	QA1_CLOSE_CMD
T6	GENERAL_ALARM
S1	QB_CLOSE_CMD
S2	QB_CLOSE_CMD
S3	PROT_TRIP

INTERNAL FAIL

IRF

PROTECTIVE EARTH

EL

X410

X307
TCS1
TCS2
TCS3

X309
Ready
Fail

X309

Prep.	PSTP/	TPLA	Agneta Rydh	2009-06-09	Connection Diagram
Appr.	PSTP/	TPLA	Nyback Patrik	2009-09-14	REC650 (1CBA) A01
Resp. dept	PSTP/	TPLA			Document number

ABB AB

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Sheet 5

Document status: Approved

Transformer module (TRM)
LOCATION=p2
X101 CT/VT CONFIG=4I+IN+5U

	AI01 1/5A	LINE_IL1
	AI02 1/5A	LINE_IL2
	AI03 1/5A	LINE_IL3
	AI04 1/5A	LINE_IN
	AI05 0.1/0.5A	SPARE

X102

	AI06 100-220V	LINE_UL1
	AI07 100-220V	LINE_UL2
	AI08 100-220V	LINE_UL3
	AI09 100-220V	BUS_WA1_UL1L2
	AI10 100-220V	SPARE

Standard compression or ringlug terminal blocks.

● Indicates high polarity. Note that internal polarity can be adjusted by setting of analogue input CT neutral direction and or on SMAI pre-processing function blocks.

Prep.	PSTP/ PSTP/	TPLA	Agneta Rydh	2009-06-09	Connection Diagram
Appr.		PSTP/	Nyback Patrik	2009-09-14	REC650 (1CBA) A01
Resp. dept	PSTP/	TPLA			

ABB AB

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Binary input/output module (BIO)

LOCATION=p3

	CONFIGURATION
C1	QB1_OPEN_CMD
C2	QB1_OPEN_CMD
C3	QC9_OPEN_CMD
S1	QC1_OPEN_CMD
S2	QC1_OPEN_CMD
S3	QA1_BFP_BU_TR
S4	SPARE
S5	TEST_ACTIVE
S6	QA1_LOCKOUT

X321

C1	SPARE
BIO1	
C2-3	SPARE
BIO2	
BIO3	SPARE
C4-5	ULN_OK
BIO4	
BIO5	UB1_OK
C6-7	QB1_OPEN
BIO6	
BIO7	QB1_CLOSED
C8-9	QC1_OPEN
BIO8	
BIO9	QC1_CLOSED

X324

RL

⚠ Observe polarity sequence
of RL connectors

Prep.	PSTP/ TPLA	Agneta Rydh	2009-06-09	Connection Diagram
Appr.	PSTP/	Nyback Patrik	2009-09-14	REC650 (1CBA) A01
Resp. dept	PSTP/ TPLA			

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Binary input/output module (BIO)

LOCATION=p5			
CONFIGURATION			
X331			
1	C1	QB9_OPEN_CMD	
2			
3	C2	QB9_OPEN_CMD	
4			
5	C3	SPARE	
6	S1	QB9_CLOSE_CMD	
7			
8	S2	QB9_CLOSE_CMD	
9			
10	S3	QC9_CLOSE_CMD	
11			
12	S4	SPARE	
13	S5	SPARE	
14			
15	S6	QC2_CLOSE_CMD	
16			
17			
18			

X334			
1	C1	//	EXT_START_AR
2	BI01		
4	C2-3	//	AR_ON
5	BI02		
6	BI03	//	AR_OFF
8	C4-5	//	EXT_BFP_WA1
9	BI04		
10	BI05	//	EXT_BFP_WA2
12	C6-7	//	SPARE
13	BI06		
14	BI07	//	SPARE
16	C8-9	//	SPARE
17	BI08		
18	BI09	//	SPARE

RL

⚠ Observe polarity sequence of RL connectors

Document status: Approved

Prep.	PSTP/	TPLA	Agneta Rydh	2009-06-09	Connection Diagram
Appr.	PSTP/		Nyback Patrik	2009-09-14	REC650 (1CBA) A01
Resp. dept	PSTP/	TPLA			

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Document number
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Connection diagrams for REC650 A02

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Binary input/output module (BIO)	7
Binary input/output module (BIO)	8
Binary input/output module (BIO)	9
Binary input/output module (BIO)	10

Prep.	PSTP/	TPLA	Agneta Rydh	2009-06-09	Connection Diagram
Appr.	PSTP/	TPLA	Nyback Patrik	2009-09-02	REC650 1(EBAB) A02
Resp. dept	PSTP/	TPLA			

ABB AB

Document number: **1MRK006501-CA**

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Designations for 6U, 1/2x19" casing with 1 TRM

Module	Slot	Terminal
COM	pCOM	X0, X1, X4, X9, X304
PSM	pPSM	X307, X309, X410
TRM	p2	X101, X102
BIO	p3	X321, X324
BIO	p4	X326, X329
BIO	p5	X331, X334
BIO	p6	X336, X339

Rear view slot

1/2x19"

6U

p= Position

Rear view terminals

Prep.	PSTP/	TPLA	Agneta Rydh	2009-06-09	Connection Diagram
Appr.	PSTP/		Nyback Patrik	2009-09-02	REC650 (1CBAB) A02
Resp. dept	PSTP/	TPLA			

ABB AB

Document number
1MRK006501-CA

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Sheet 2

Document status: Approved

Transformer module (TRM)

LOCATION=p2

X101 CT/VT CONFIG=4+1+5U

1		
2	AI01	1/5A
3		
4	AI02	1/5A
5		
6	AI03	1/5A
7		
8	AI04	1/5A
9		
10	AI05	0.1/0.5A

X102

1		
2	AI06	100-220V
3		
4	AI07	100-220V
5		
6	AI08	100-220V
7		
8	AI09	100-220V
9		
10	AI10	100-220V

LINE_IL1
LINE_IL2
LINE_IL3
LINE_IN
SPARE
LINE_UL1
LINE_UL2
LINE_UL3
BUS_WA1_UL1L2
BUS_WA2_UL1L2

Standard compression or ringlug terminal blocks.

● Indicates high polarity. Note that internal polarity can be be adjusted by setting of analogue input CT neutral direction and or on SMAI pre-processing function blocks.

Prep.	PSTP/	TPLA	Agneta Rydh	2009-06-09	Connection Diagram
Appr.	PSTP/		Nyback Patrik	2009-09-02	REC650 (1CBAB) A02
Resp. dept	PSTP/	TPLA			

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Customer drw no

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Binary input/output module (BIO)

LOCATION=p3

CONFIGURATION	
C1	QB1_OPEN_CMD
C2	QB1_OPEN_CMD
C3	QC9_OPEN_CMD
S1	QC1_OPEN_CMD
S2	QC1_OPEN_CMD
S3	QA1_BFP_BU_TR
S4	SPARE
S5	SPARE
S6	QA1_LOCKOUT
C1	SPARE
C2-3	SPARE
C4-5	SPARE
	ULN_OK
	UB1_OK
	QB1_OPEN
	QB1_CLOSED
	QC1_OPEN
	QC1-CLOSED

X321
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

X324
BIO1 BIO2 BIO3 BIO4 BIO5 BIO6 BIO7 BIO8 BIO9
C6-7 C8-9
RL

Observe polarity sequence
of RL connectors

Prep.	PSTP/	TPLA	Agneta Rydh	2009-06-09	Connection Diagram
Appr.	PSTP/		Nyback Patrik	2009-09-02	REC650 (1CBAB) A02
Resp. dept	PSTP/	TPLA			

ABB AB

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Lang. en Rev. B

Document status: Approved

Binary input/output module (BIO)

LOCATION=p4		
CONFIGURATION		

X326
C1	QC2_OPEN_CMD	1
C2	QC2_OPEN_CMD	2
C3	QC9_OPEN_CMD	3
S1	QC1_CLOSE_CMD	5
S2	QC1_CLOSE_CMD	6
S3	QC9_CLOSE_CMD	7
S4	SPARE	8
S5	SPARE	9
S6	QC2_CLOSE_CMD	10

X329
C1	SPARE	1
BIO1		2
C2-3	QC2_OPEN	4
BIO2		5
BIO3	QC2_CLOSED	6
C4-5	SPARE	8
BIO4		9
BIO5	UB2_OK	10
C6-7	QB2_OPEN	12
BIO6		13
BIO7	QB2_CLOSED	14
C8-9	SPARE	16
BIO8		17
BIO9	SPARE	18

RL

Observe polarity sequence
of RL connectors

Prep.	PSTP/ TPLA	Agneta Rydh	2009-06-09	Connection Diagram
Appr.	PSTP/	Nyback Patrik	2009-09-02	REC650 (1CBAB) A02
Resp. dept PSTP/	TPLA			

ABB AB

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Document status: Approved

Binary input/output module (BIO)

LOCATION=p5
CONFIGURATION

C1	QB9_OPEN_CMD	
C2	QB9_OPEN_CMD	
C3	SPARE	
S1	QB9_CLOSE_CMD	
S2	QB9_CLOSE_CMD	
S3	QC9_CLOSE_CMD	
S4	SPARE	
S5	SPARE	
S6	QC2_CLOSE_CMD	

X331
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18

C1	BI1	
BI01		
C2-3	AR_ON	
BI02		
BI03	AR_OFF	
C4-5	EXT_BFP_WA1	
BI04		
BI05	EXT_BFP_WA2	
C6-7	SPARE	
BI06		
BI07	SPARE	
C8-9	SPARE	
BI08		
BI09	SPARE	

X334
1
2
4
5
6
8
9
10
12
13
14
16
17
18

RL

⚠ Observe polarity sequence
of RL connectors

Customer drw no

Based on		

	Prep.	PSTP/	TPLA	Agneta Rydh	2009-06-09	Connection Diagram
	Appr.	PSTP/		Nyback Patrik	2009-09-02	REC650 (1CBAB) A02
	Resp. dept	PSTP/	TPLA			

ABB AB

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Document status: Approved

Binary input/output module (BIO)

LOCATION=p6

	CONFIGURATION
C1	QB2_OPEN_CMD
C2	QB2_OPEN_CMD
C3	SPARE
S1	QB2_CLOSE_CMD
S2	QB2_CLOSE_CMD
S3	SPARE
S4	SPARE
S5	SPARE
S6	TEST_ACTIVE
C1	SPARE
BI01	SPARE
C2-3	SPARE
BI02	SPARE
BI03	SPARE
C4-5	SPARE
BI04	SPARE
BI05	SPARE
C6-7	SPARE
BI06	SPARE
BI07	SPARE
C8-9	SPARE
BI08	SPARE
BI09	SPARE

Observe polarity sequence
of RL connectors

Prep.	PSTP/	TPLA	Agneta Rydh	2009-06-09	Connection Diagram
Appr.	PSTP/	PSTP/	Nyback Patrik	2009-09-02	REC650 (1CBAB) A02
Resp. dept	PSTP/	TPLA			

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Document status: Approved

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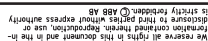
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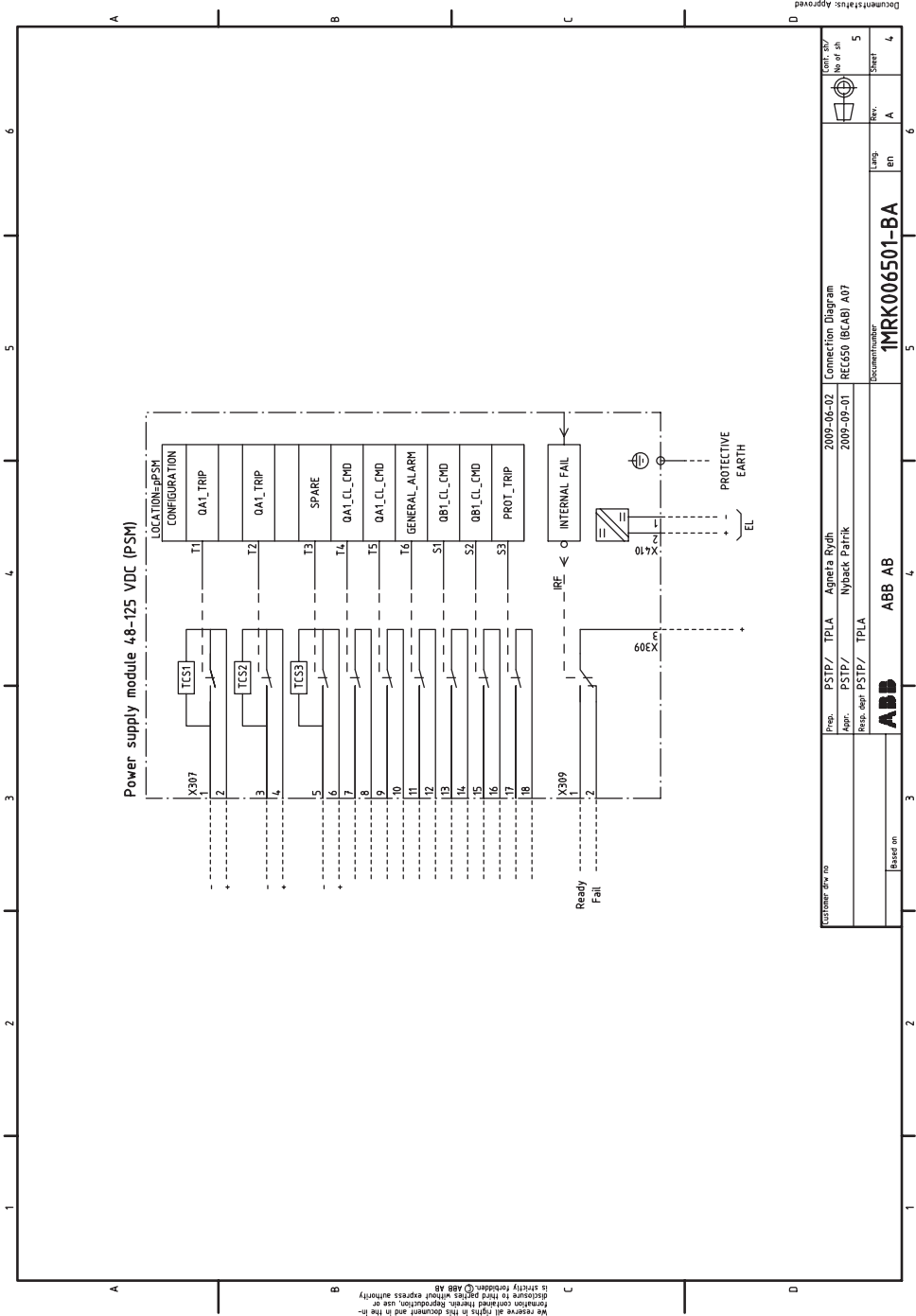| Part of product	Sheets
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Prep.	PSTP/ TPLA	Agneta Rydh
Appr.	PSTP/	Nyback Patrik
Resp. dept	PSTP/ TPLA	

2009-06-02 Connection Diagram
2009-09-01 REC650 (BCAB) A07

ABB AB

ABB

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Sheet 1

Designations for 6U, 1/2x19" casing with 1 TRM

Module	Slot	Terminal
COM	pCOM	X0, X1, X4, X9, X304
PSM	pPSM	X307, X309, X410
TRM	p2	X101, X102
BIO	p3	X321, X324
BIO	p4	X326, X329
BIO	p5	X331, X334
BIO	p6	X336, X339

6U

1/2x19"

Rear view slot

pCOM pPSM   p2   p3   p4   p5   p6

p= Position

Rear view terminals

X336   X339
X331   X334
X326   X329
X321   X324
X101   X102
X307   X309   X410
X0 X1 X4 X9   X304
Rx Tx

Connection Diagram
REC650 (BCAB) A07

1MRK006501-BA

Communication module (COM)
LOCATION=pCOM

X0	LHMI	Ethernet, RJ45 connection only for LHMI and PC-tool
X1	LAN 1	Ethernet, LC optical
X4		Cable shield grounding via capacitor
3	IRIG-B	IRIG-B -
4		IRIG-B +
X9	Rx/Tx	Optical serial port, Snap In Not in use

X304

		CONFIGURATION
1	C1-4	
2	BI01	QA1_OPEN
3	BI02	QA1_CLOSED
4	BI03	QA1_SPRING_CH
5	BI04	QA1_SF6_OK
6	C5-8	
7	BI05	QC11_OPEN
8	BI06	QC11_CLOSED
9	BI07	QC21_OPEN
10	BI08	QC21_CLOSED
11	C9-11	
12	BI09	BLOCK_CMD
13	BI10	SPARE
14	BI11	SPARE
15	C12-14	
16	BI12	SPARE
17	BI13	EXT_START_DR
18	BI14	TESTMODE_ON

RL

Prep.	PSTP/	TPLA	Agneta Rydh	2009-06-02
Appr.	PSTP/		Nyback Patrik	2009-09-01
Resp. dept	PSTP/	TPLA		

ABB AB

Document number

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Document status: Approved

Transformer module (TRM)

LOCATION=p2

X101 CT/VT CONFIG=6I+4U

1	AI01 1/5A
2	
3	AI02 1/5A
4	
5	AI03 1/5A
6	
7	AI04 1/5A
8	
9	AI05 1/5A
10	

X102

1	AI06 1/5A
2	
3	AI07 100-220V
4	
5	AI08 100-220V
6	
7	AI09 100-220V
8	
9	AI10 100-220V
10	

BUS_1_CT_IL1
BUS_1_CT_IL2
BUS_1_CT_IL3
BUS_2_CT_IL1
BUS_2_CT_IL2
BUS_2_CT_IL3
SPARE
SPARE
BUS_WA1_UL1L2
BUS_WA2_UL1L2

Standard compression or ringlug terminal blocks.

• Indicates high polarity. Note that internal polarity can be adjusted by setting of analogue input CT neutral direction and or on SMAI pre-processing function blocks.

Customer dr'w no								
	Prep.	PSTP/	TPLA	Agneta Rydh	2009-06-02	Connection Diagram		Cont. sh/ No of sh
	Appr.	PSTP/		Nyback Patrik	2009-09-01	REC650 (BCAB) A07		7
	Resp. dept	PSTP/	TPLA			Document number	Lang	
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Document status: Approved

Binary input/output module (BIO)

LOCATION=p4

	CONFIGURATION	
C1	QC2_OP_CMD	
C2	QC2_OP_CMD	
C3	QC21_OP_CMD	
S1	QC1_CL_CMD	
S2	QC1_CL_CMD	
S3	QC21_CL_CMD	
S4	SPARE	
S5	SPARE	
S6	SPARE	

C1	SPARE	
BI01		
C2-3	QC2_OPEN	
BI02		
BI03	QC2_CLOSED	
C4-5	SPARE	
BI04		
BI05	UB2_OK	
C6-7	QB2_OPEN	
BI06		
BI07	QB2_CLOSED	
C8-9	SPARE	
BI08		
BI09	SPARE	

X326

X329

RL

⚠ Observe polarity sequence
of RL connectors

Prep.	PSTP/	TPLA	Agneta Rydh	2009-06-02	Connection Diagram
Appr.	PSTP/	PSTP/	Nyback Patrik	2009-09-01	REC650 (BCAB) A07
Resp. dept	PSTP/	TPLA			

ABB AB

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Lang. en   Rev. A   Sheet

Connection Diagram
REC650 (BCAB) A07

1MRK006501-BA

Section 15   Technical data

15.1   Dimensions

Table 464:   Dimensions of the IED

Description	Type	Value
Width	half 19"	220 mm
Height	half 19"	265.9 mm (6U)
Depth	half 19"	249.5 mm
Weight	half 19" box	<10 kg (6U)
	half 19" LHMI	1.3 kg (6U)

15.2   Power supply

Table 465:   Power supply

Description	Type 1	Type 2
U_{aux}nominal	100, 110, 120, 220, 240 V AC, 50 and 60 Hz	48, 60, 110, 125 V DC
	110, 125, 220, 250 V DC	
U_{aux}variation	85...110% of U_n (85...264 V AC)	80...120% of U_n (38.4...150 V DC)
	80...120% of U_n (88...300 V DC)	
Maximum load of auxiliary voltage supply	35 W	
Ripple in the DC auxiliary voltage	Max 15% of the DC value (at frequency of 100 Hz)	
Maximum interruption time in the auxiliary DC voltage without resetting the IED	50 ms at U_{aux}	

15.3 Energizing inputs

Table 466:   Energizing inputs

Description		Value	
Rated frequency		50/60 Hz	
Operating range		Rated frequency ± 5 Hz	
Current inputs	Rated current, I_n	0.1/0.5 A[1]	1/5 A[2]
	Thermal withstand capability:		
	• Continuously	4 A	20 A
	• For 1 s	100 A	500 A
	• For 10 s	25 A	100 A
	Dynamic current withstand:		
	• Half-wave value	250 A	1250 A
	Input impedance	<100 mΩ	<10 mΩ
Voltage inputs	Rated voltage	100 V/ 110 V/ 115 V/ 120 V (Parametrization)	
	Voltage withstand:		
	• Continuous	2 x U_n (240 V)	
	• For 10 s	3 x U_n (360 V)	
	Burden at rated voltage	<0.05 VA	

1) Residual current
2) Phase currents or residual current

15.4 Binary inputs

Table 467:   Binary inputs

Description	Value
Operating range	Maximum input voltage 300 V DC
Rated voltage	24...250 V DC
Current drain	1.6...1.8 mA
Power consumption/input	<0.3 W
Threshold voltage	15...221 V DC (parametrizable in the range in steps of 1% of the rated voltage)

15.5   Signal outputs

Table 468:   Signal output and IRF output

Description	Value
Rated voltage	250 V AC/DC
Continuous contact carry	5 A
Make and carry for 3.0 s	10 A
Make and carry 0.5 s	30 A
Breaking capacity when the control-circuit time constant L/R<40 ms, at U< 48/110/220 V DC	≤0.5 A/≤0.1 A/≤0.04 A
Minimum contact load	100 mA at 24 V AC/DC

15.6   Power outputs

Table 469:   Power output relays, with or without TCS function

Description	Value
Rated voltage	250 V AC/DC
Continuous contact carry	8 A
Make and carry for 3.0 s	15 A
Make and carry for 0.5 s	30 A
Breaking capacity when the control-circuit time constant L/R<40 ms, at U< 48/110/220 V DC	≤1 A/≤0.3 A/≤0.1 A
Minimum contact load	100 mA at 24 V AC/DC

Table 470:   Power output relays with TCS function

Description	Value
Control voltage range	20...250 V DC
Current drain through the supervision circuit	~1.0 mA
Minimum voltage over the TCS contact	20 V DC

15.7   Data communication interfaces

Table 471:   Ethernet interfaces

Ethernet interface	Protocol	Cable	Data transfer rate
LAN/HMI port (X0)[1]	-	CAT 6 S/FTP or better	100 MBits/s
LAN1 (X1)	TCP/IP protocol	Fibre-optic cable with LC connector	100 MBits/s

1)   Only available for the external HMI option.

Table 472:   *Fibre-optic communication link*

Wave length	Fibre type	Connector	Permitted path attenuation[1]	Distance
1300 nm	MM 62.5/125 µm glass fibre core	LC	<8 dB	2 km

1) Maximum allowed attenuation caused by connectors and cable together

Table 473:   *X4/IRIG-B interface*

Type	Protocol	Cable
Screw terminal, pin row header	IRIG-B	Shielded twisted pair cable Recommended: CAT 5, Belden RS-485 (9841-9844) or Alpha Wire (Alpha 6222-6230)

Table 474:   *Serial rear interface*

Type	Counter connector
Serial port (X9)	Optical serial port, snap-in (not in use)

15.8   Enclosure class

Table 475:   *Degree of protection of flush-mounted IED*

Description	Value
Front side	IP 40
Rear side, connection terminals	IP 20

Table 476:   *Degree of protection of the LHMI*

Description	Value
Front and side	IP 42

15.9   Environmental conditions and tests

Table 477:   *Environmental conditions*

Description	Value
Operating temperature range	-25...+55ºC (continuous)
Short-time service temperature range	-40...+85ºC (<16h) Note: Degradation in MTBF and HMI performance outside the temperature range of -25...+55ºC
Relative humidity	<93%, non-condensing
Table continues on next page	

Description	Value
Atmospheric pressure	86...106 kPa
Altitude	up to 2000 m
Transport and storage temperature range	-40...+85ºC

Table 478:   Environmental tests

Description	Type test value	Reference
Dry heat test (humidity <50%)	• 96 h at +55ºC • 16 h at +85ºC	IEC 60068-2-2
Cold test	• 96 h at -25ºC • 16 h at -40ºC	IEC 60068-2-1
Damp heat test, cyclic	• 6 cycles at +25…55°C, humidity 93…95%	IEC 60068-2-30
Storage test	• 96 h at -40ºC • 96 h at +85ºC	IEC 60068-2-48

Section 16 IED and functionality tests

16.1 Electromagnetic compatibility tests

Table 479:   Electromagnetic compatibility tests

Description	Type test value	Reference
100 kHz and 1 MHz burst disturbance test		IEC 61000-4-18 IEC 60255-22-1, level 3
• Common mode	2.5 kV	
• Differential mode	1.0 kV	
Electrostatic discharge test		IEC 61000-4-2 IEC 60255-22-2, level 4
• Contact discharge	8 kV	
• Air discharge	15 kV	
Radio frequency interference tests		
• Conducted, common mode OK	10 V (emf), f=150 kHz...80 MHz	IEC 61000-4-6 IEC 60255-22-6, level 3
• Radiated, amplitude-modulated	20 V/m (rms), f=80...1000 MHz and f=1.4...2.7 GHz	IEC 61000-4-3 IEC 60255-22-3
Fast transient disturbance tests		IEC 61000-4-4 IEC 60255-22-4, class A
• Communication ports	2 kV	
• Other ports	4 kV	
Surge immunity test		IEC 61000-4-5 IEC 60255-22-5, level 4/3
• Binary inputs	2 kV line-to-earth, 1kV line-to-line	
• Communication	1 kV line-to-earth	
• Other ports	4 kV line-to-earth, 2 kV line-to-line	
Power frequency (50 Hz) magnetic field		IEC 61000-4-8, level 5
• 3 s	1000 A/m	
• Continuous	100 A/m	
Table continues on next page		

Description	Type test value	Reference
Power frequency immunity test • Common mode • Differential mode	300 V rms 150 V rms	IEC 60255-22-7, class A IEC 61000-4-16
Voltage dips and short interruptions	Dips: 40%/200 ms 70%/500 ms Interruptions: 0-50 ms: No restart 0...∞ s : Correct behaviour at power down	IEC 60255-11 IEC 61000-4-11
Electromagnetic emission tests • Conducted, RF-emission (mains terminal) OK 0.15...0.50 MHz 0.5...30 MHz • Radiated RF -emission 0...230 MHz 230...1000 MHz	 < 79 dB(µV) quasi peak < 66 dB(µV) average < 73 dB(µV) quasi peak < 60 dB(µV) average < 40 dB(µV/m) quasi peak, measured at 10 m distance < 47 dB(µV/m) quasi peak, measured at 10 m distance	EN 55011, class A IEC 60255-25

16.2   Insulation tests

Table 480:   Insulation tests

Description	Type test value	Reference
Dielectric tests: • Test voltage	 2 kV, 50 Hz, 1 min 1 kV, 50 Hz, 1min, communication	IEC 60255-5
Impulse voltage test: • Test voltage	 5 kV, unipolar impulses, waveform 1.2/50 µs, source energy 0.5 J 1 kV, unipolar impulses, waveform 1.2/50 µs, source energy 0.5 J, communication	IEC 60255-5
Insulation resistance measurements • Isolation resistance	 >100 MΩ, 500 V DC	IEC 60255-5
Protective bonding resistance • Resistance	 <0.1 Ω (60 s)	IEC 60255-27

16.3   Mechanical tests

Table 481:   Mechanical tests

Description	Reference	Requirement
Vibration response tests (sinusoidal)	IEC 60255-21-1	Class 2
Vibration endurance test	IEC60255-21-1	Class 1
Shock response test	IEC 60255-21-2	Class 1
Shock withstand test	IEC 60255-21-2	Class 1
Bump test	IEC 60255-21-2	Class 1
Seismic test	IEC 60255-21-3	Class 2

16.4   Product safety

Table 482:   Product safety

Description	Reference
LV directive	2006/95/EC
Standard	EN 60255-27 (2005)

16.5   EMC compliance

Table 483:   EMC compliance

Description	Reference
EMC directive	2004/108/EC
Standard	EN 50263 (2000) EN 60255-26 (2007)

Section 17   Time inverse characteristics

17.1   Application

In order to assure time selectivity between different overcurrent protections in different points in the network different time delays for the different relays are normally used. The simplest way to do this is to use definite time delay. In more sophisticated applications current dependent time characteristics are used. Both alternatives are shown in a simple application with three overcurrent protections connected in series.
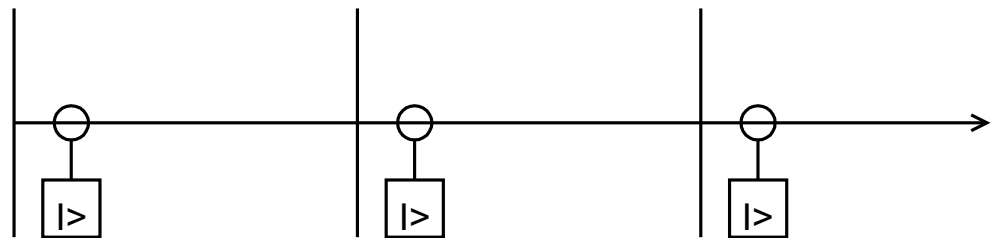
xx05000129.vsd

Figure 213:   *Three overcurrent protections connected in series*
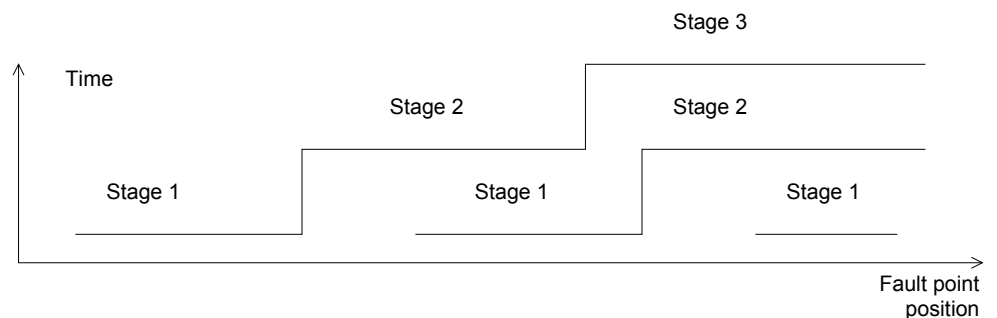
en05000130.vsd

Figure 214:   *Definite time overcurrent characteristics*
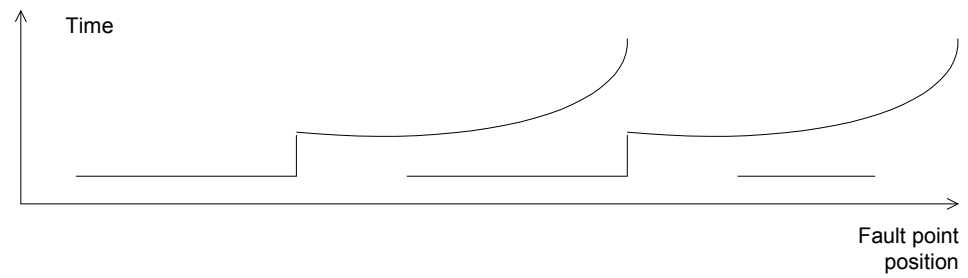
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Figure 215:   Inverse time overcurrent characteristics with inst. function

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 pick-up time of the protections to be co-ordinated
- Opening time of the breaker closest to the studied fault
- Reset time of the protection
- Margin dependent of the time-delay inaccuracy of the protections

Assume we have the following network case.
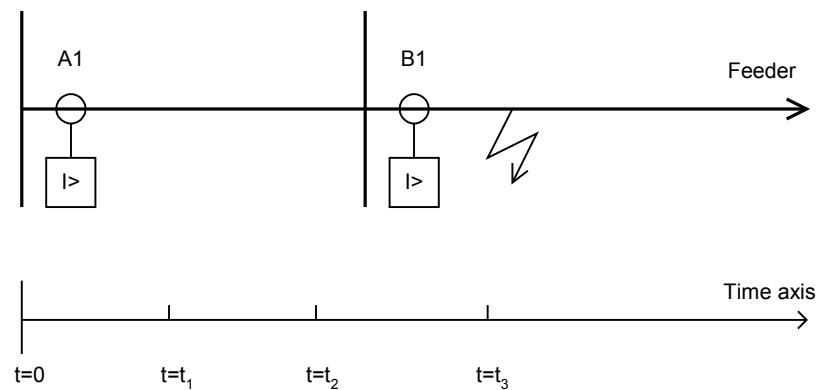
Figure 216:   Selectivity steps for a fault on feeder B1

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, i.e. the timer is stopped.

In most applications it is required that the delay 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 relay, 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.

17.2 Operation principle

17.2.1 Mode of operation

The function can operate in a definite time-lag mode or in a current dependent inverse time mode. For the inverse time characteristic both ANSI and IEC based standard curves are available.

If current in any phase exceeds the set start current value , 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.

The general expression for inverse time curves is according to equation 60.

$$t[s] = \left(\frac{A}{\left(\frac{i}{in>}\right)^p - C} + B \right) \cdot k$$

(Equation 60)

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:

$$\left(t_{op} - B \cdot k\right) \cdot \left(\left(\frac{i}{in >}\right)^{p} - C\right) = A \cdot k$$

<div align="right">(Equation 61)</div>

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 62, in addition to the constant time delay:

$$\int_{0}^{t}\left(\left(\frac{i}{in >}\right)^{p} - C\right) \cdot dt \geq A \cdot k$$

<div align="right">(Equation 62)</div>

For the numerical protection the sum below must fulfil the equation for trip.

$$\Delta t \cdot \sum_{j=1}^{n}\left(\left(\frac{i(j)}{in >}\right)^{p} - C\right) \geq A \cdot k$$

<div align="right">(Equation 63)</div>

where:

j = 1	is the first protection execution cycle when a fault has been detected, i.e. 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, i.e. 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 217.

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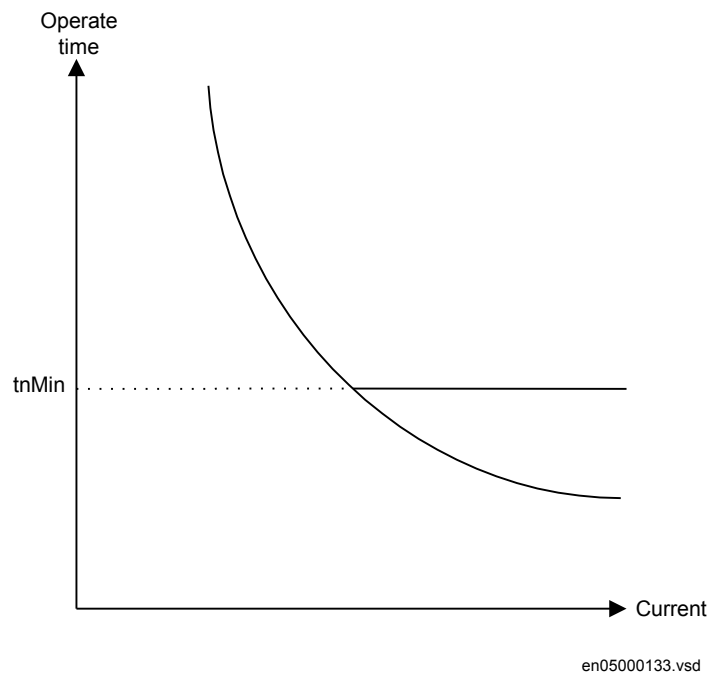
Figure 217:   Minimum time-lag operation for the IEC curves

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 65:

$$t[s] = \left(\frac{k}{0.339 - 0.235 \cdot \dfrac{in >}{i}} \right)$$

(Equation 65)

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 66:

$$t[s] = 5.8 - 1.35 \cdot \ln\left(\frac{i}{k \cdot in >}\right)$$

<div align="right">(Equation 66)</div>

where:

in>	is the set start current for step n,
k	is set time multiplier for step n and
i	is the measured current

The timer will be reset directly when the current drops below the set start current level minus the hysteresis.

17.3   Inverse time characteristics

Table 484:   ANSI Inverse time characteristics

Function	Range or value	Accuracy
Operating characteristic: $t = \left(\frac{A}{\left(I^P - 1\right)} + B\right) \cdot k$ (Equation 67) $I = I_{measured}/I_{set}$	k = 0.05-999 in steps of 0.01 unless otherwise stated	-
ANSI Extremely Inverse	A=28.2, B=0.1217, P=2.0	ANSI/IEEE C37.112, class 5 + 40 ms
ANSI Very inverse	A=19.61, B=0.491, P=2.0	
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	
ANSI Long Time Extremely Inverse	A=64.07, B=0.250, P=2.0	
ANSI Long Time Very Inverse	A=28.55, B=0.712, P=2.0	
ANSI Long Time Inverse	k=(0.01-1.20) in steps of 0.01 A=0.086, B=0.185, P=0.02	

Table 485:   *IEC Inverse time characteristics*

Function	Range or value	Accuracy
Operating characteristic: $$t = \left(\frac{A}{\left(I^P - 1 \right)} \right) \cdot k$$ (Equation 68) $I = I_{measured}/I_{set}$	k = (0.05-1.10) in steps of 0.01	-
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	

Table 486:   *RI and RD type inverse time characteristics*

Function	Range or value	Accuracy
RI type inverse characteristic $$t = \frac{1}{0.339 - \dfrac{0.236}{I}} \cdot k$$ (Equation 69) $I = I_{measured}/I_{set}$	k=(0.05-999) in steps of 0.01	IEC 60255-3, class 5 + 40 ms
RD type logarithmic inverse characteristic $$t = 5.8 - \left(1.35 \cdot In \frac{I}{k} \right)$$ (Equation 70) $I = I_{measured}/I_{set}$	k=(0.05-1.10) in steps of 0.01	IEC 60255-3, class 5 + 40 ms

Table 487:   *Inverse time characteristics for Two step undervoltage protection UV2PTUV*

Function	Range or value	Accuracy
Type A curve: $$t = \dfrac{k}{\left(\dfrac{U< -U}{U<}\right)}$$ (Equation 71) U< = U_{set} U = $UV_{measured}$	k = (0.05-1.10) in steps of 0.01	Class 5 +40 ms
Type B curve: $$t = \dfrac{k \cdot 480}{\left(32 \cdot \dfrac{U< -U}{U<} - 0.5\right)^{2.0}} + 0.055$$ (Equation 72) U< = U_{set} U = $U_{measured}$	k = (0.05-1.10) in steps of 0.01	

Table 488:   *Inverse time characteristics for Two step overvoltage protection OV2PTOV*

Function	Range or value	Accuracy
Type A curve: $$t = \dfrac{k}{\left(\dfrac{U - U>}{U>}\right)}$$ (Equation 73) U> = U_{set} U = $U_{measured}$	k = (0.05-1.10) in steps of 0.01	Class 5 +40 ms
Type B curve: $$t = \dfrac{k \cdot 480}{\left(32 \cdot \dfrac{U - U>}{U>} - 0.5\right)^{2.0} - 0.035}$$ (Equation 74)	k = (0.05-1.10) in steps of 0.01	
Type C curve: $$t = \dfrac{k \cdot 480}{\left(32 \cdot \dfrac{U - U>}{U>} - 0.5\right)^{3.0} - 0.035}$$ (Equation 75)	k = (0.05-1.10) in steps of 0.01	

Table 489: Inverse time characteristics for Two step residual overvoltage protection ROV2PTOV

Function	Range or value	Accuracy
Type A curve: $$t = \dfrac{k}{\left(\dfrac{U - U >}{U >}\right)}$$ (Equation 76) U> = U$_{set}$ U = U$_{measured}$	k = (0.05-1.10) in steps of 0.01	Class 5 +40 ms
Type B curve: $$t = \dfrac{k \cdot 480}{\left(32 \cdot \dfrac{U - U >}{U >} - 0.5\right)^{2.0} - 0.035}$$ (Equation 77)	k = (0.05-1.10) in steps of 0.01	
Type C curve: $$t = \dfrac{k \cdot 480}{\left(32 \cdot \dfrac{U - U >}{U >} - 0.5\right)^{3.0} - 0.035}$$ (Equation 78)	k = (0.05-1.10) in steps of 0.01	
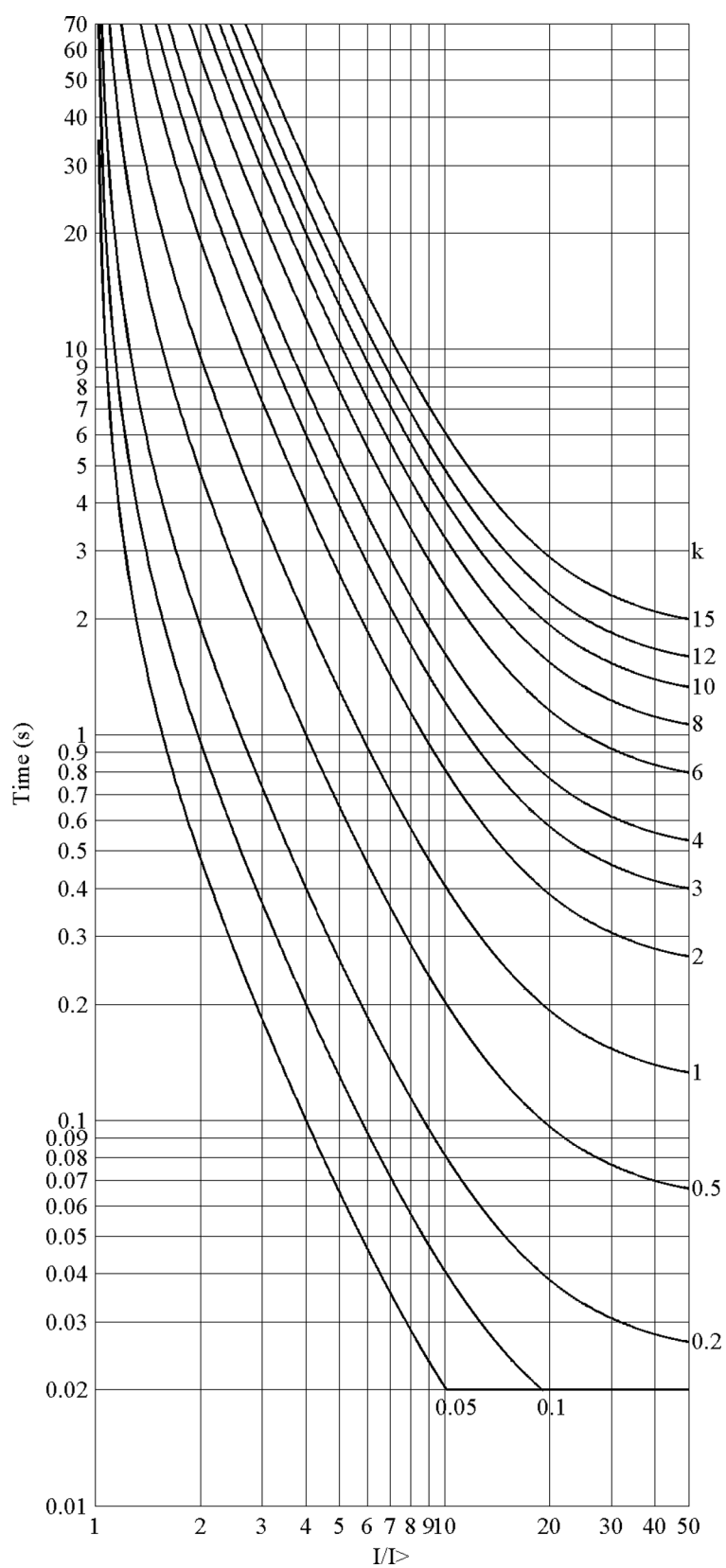
Figure 218:   ANSI Extremely inverse time characteristics
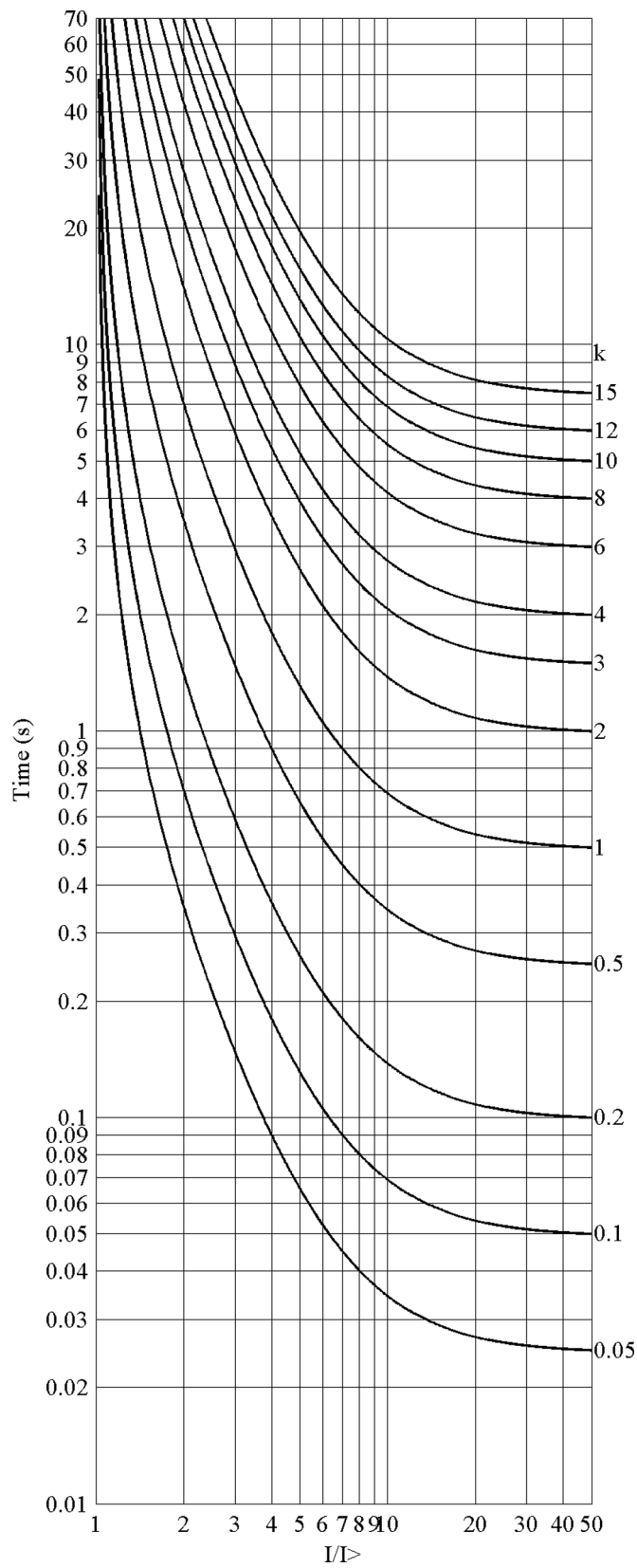
Figure 219:   ANSI Very inverse time characteristics
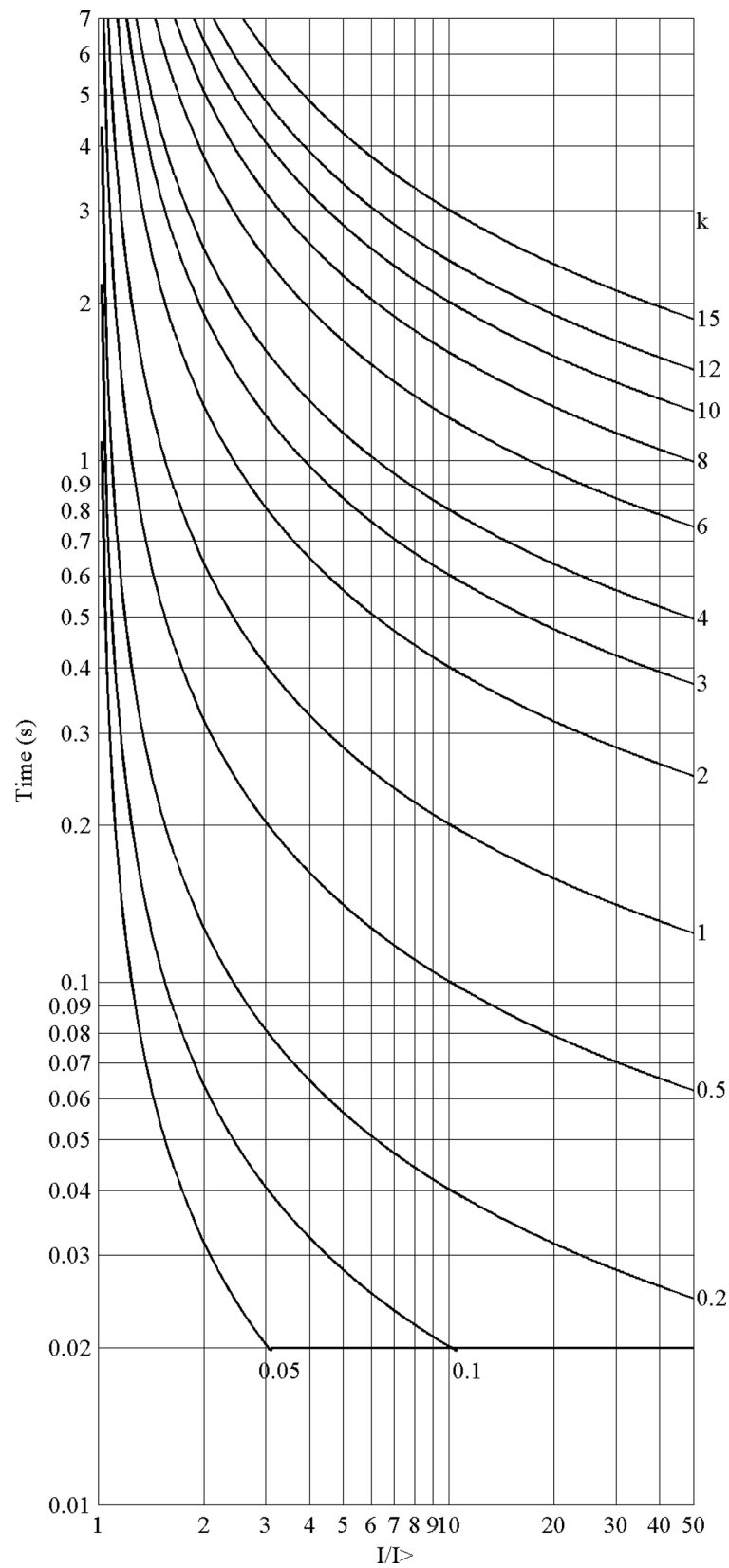
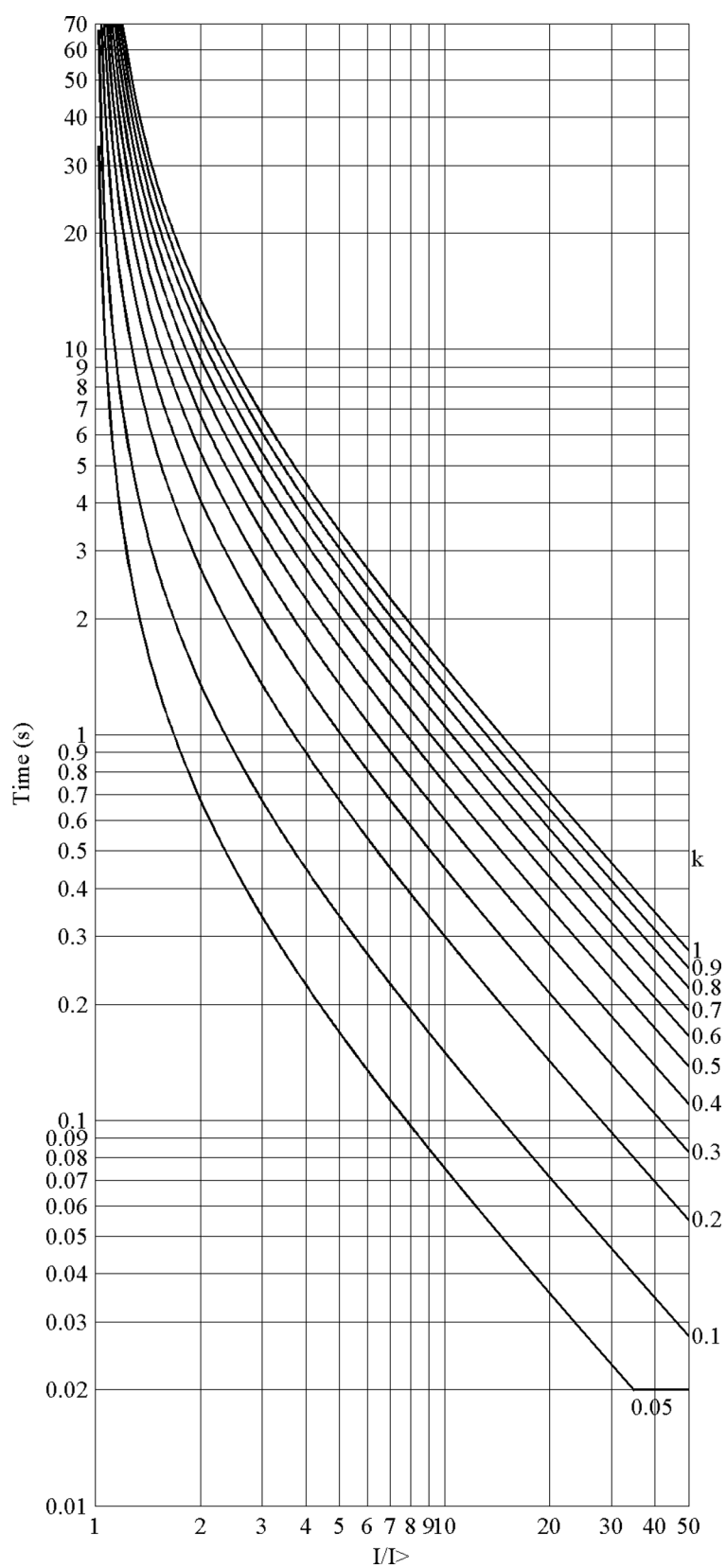*Figure 220:*   *ANSI Normal inverse time characteristics*
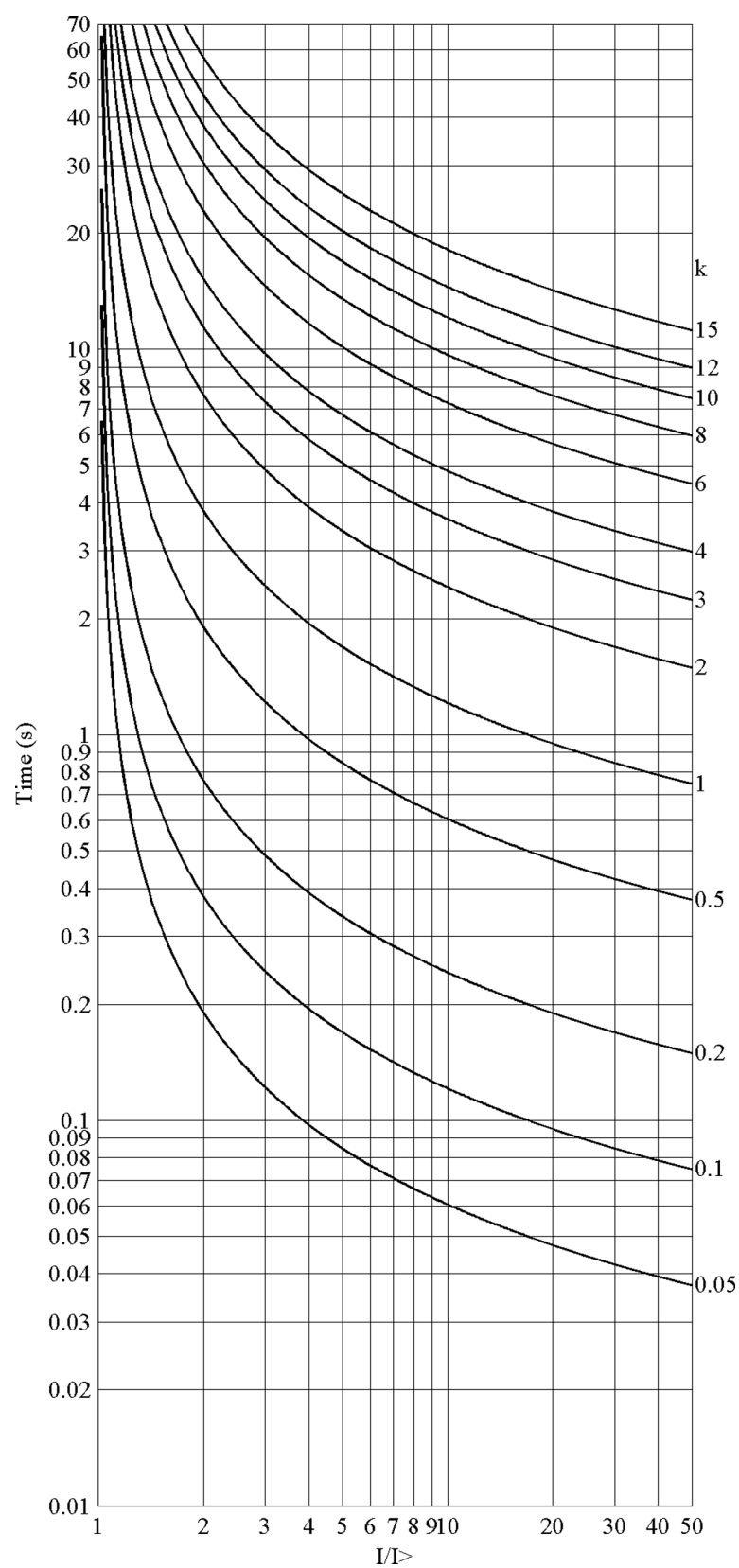
Figure 221:   ANSI Moderately inverse time characteristics

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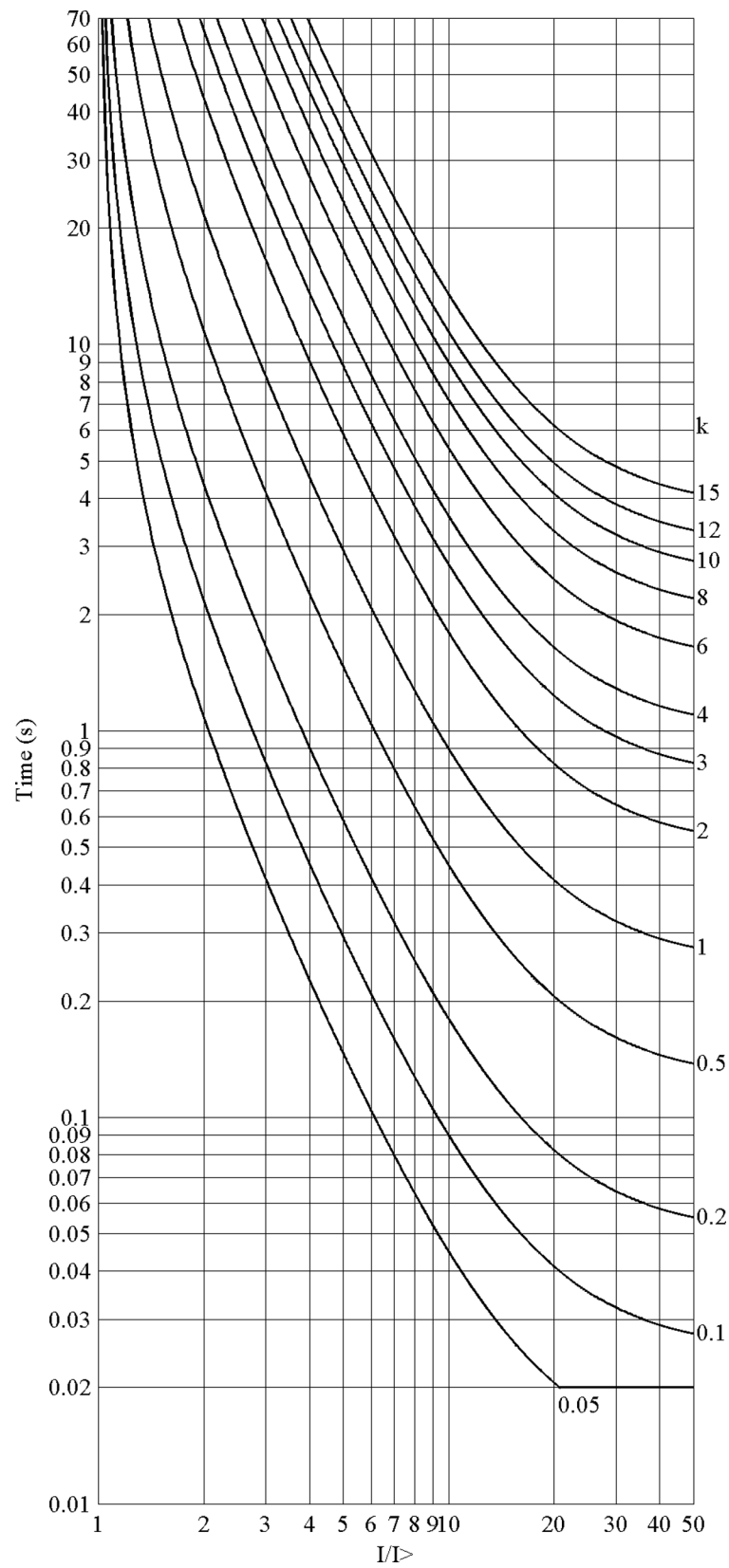
Figure 222:   *ANSI Long time extremely inverse time characteristics*
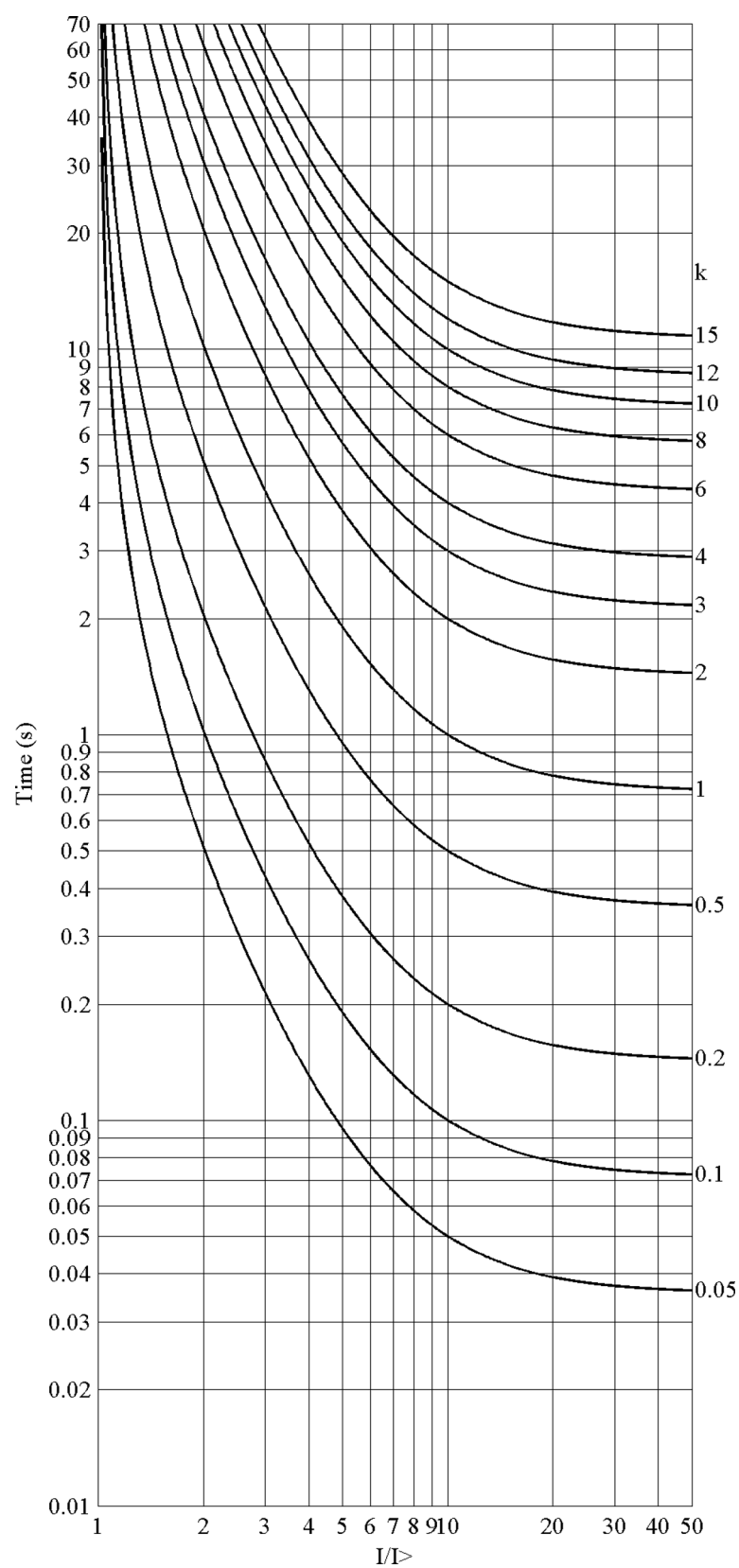
Figure 223:   ANSI Long time very inverse time characteristics
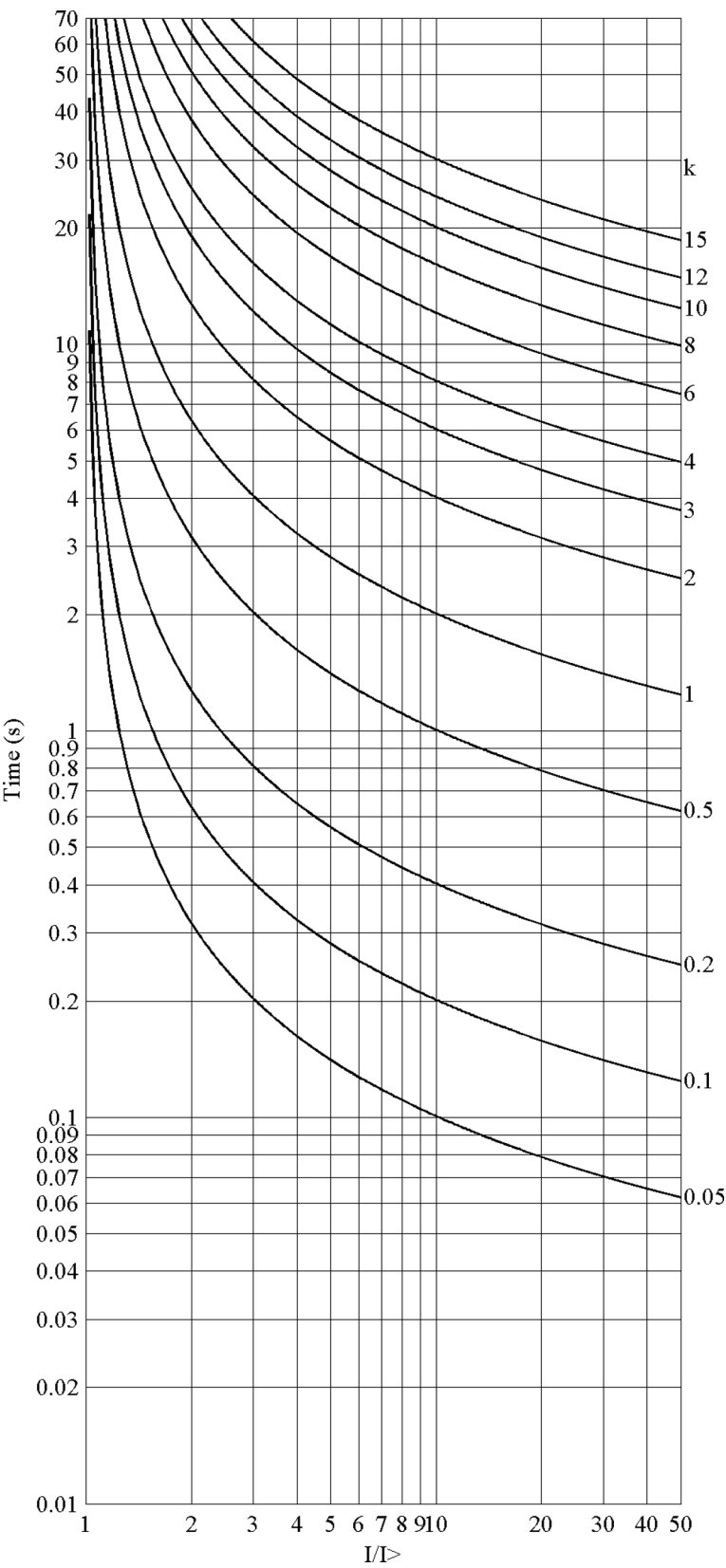
Figure 224:   *ANSI Long time inverse time characteristics*
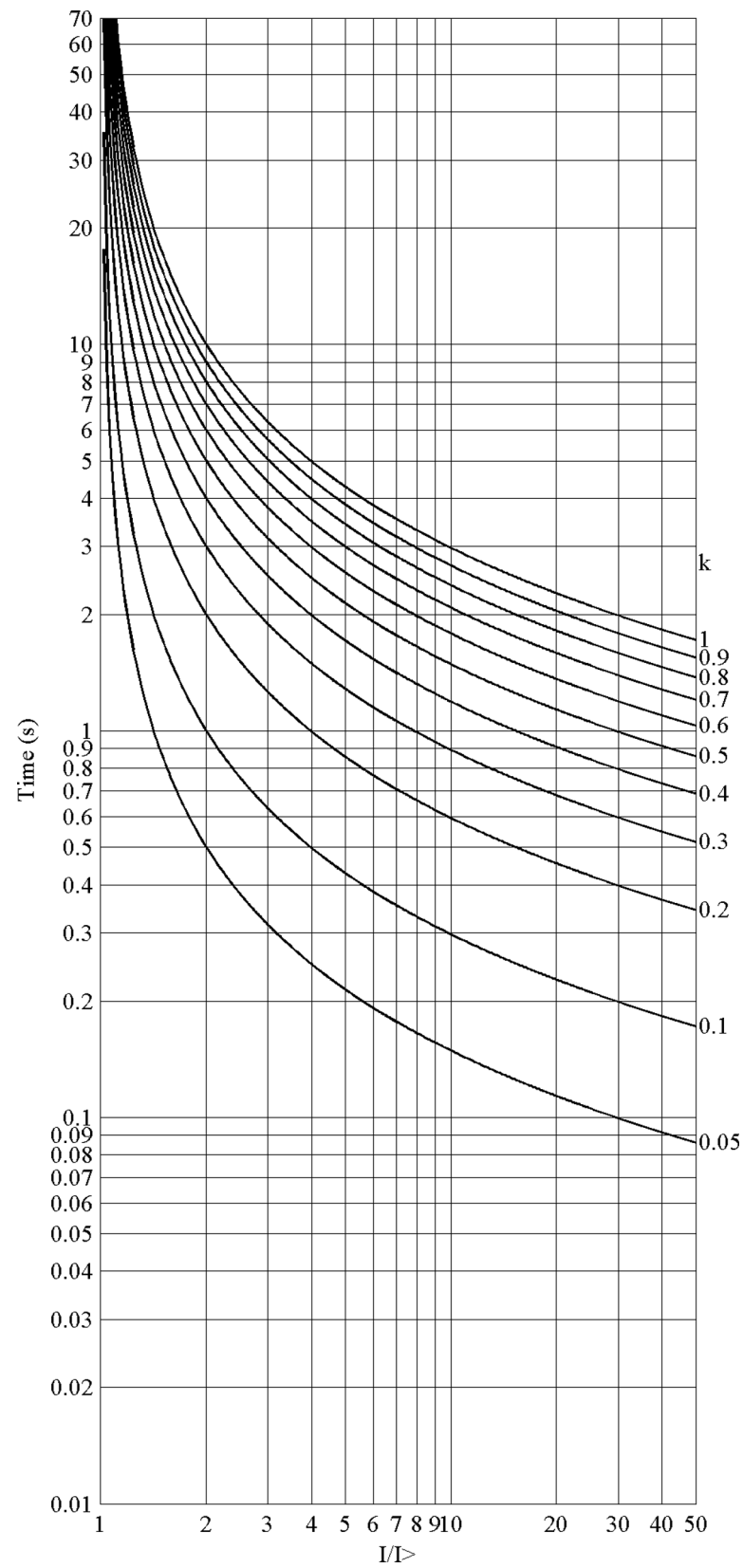
Figure 225:   IEC Normal inverse time characteristics

Figure 226:   *IEC Very inverse time characteristics*
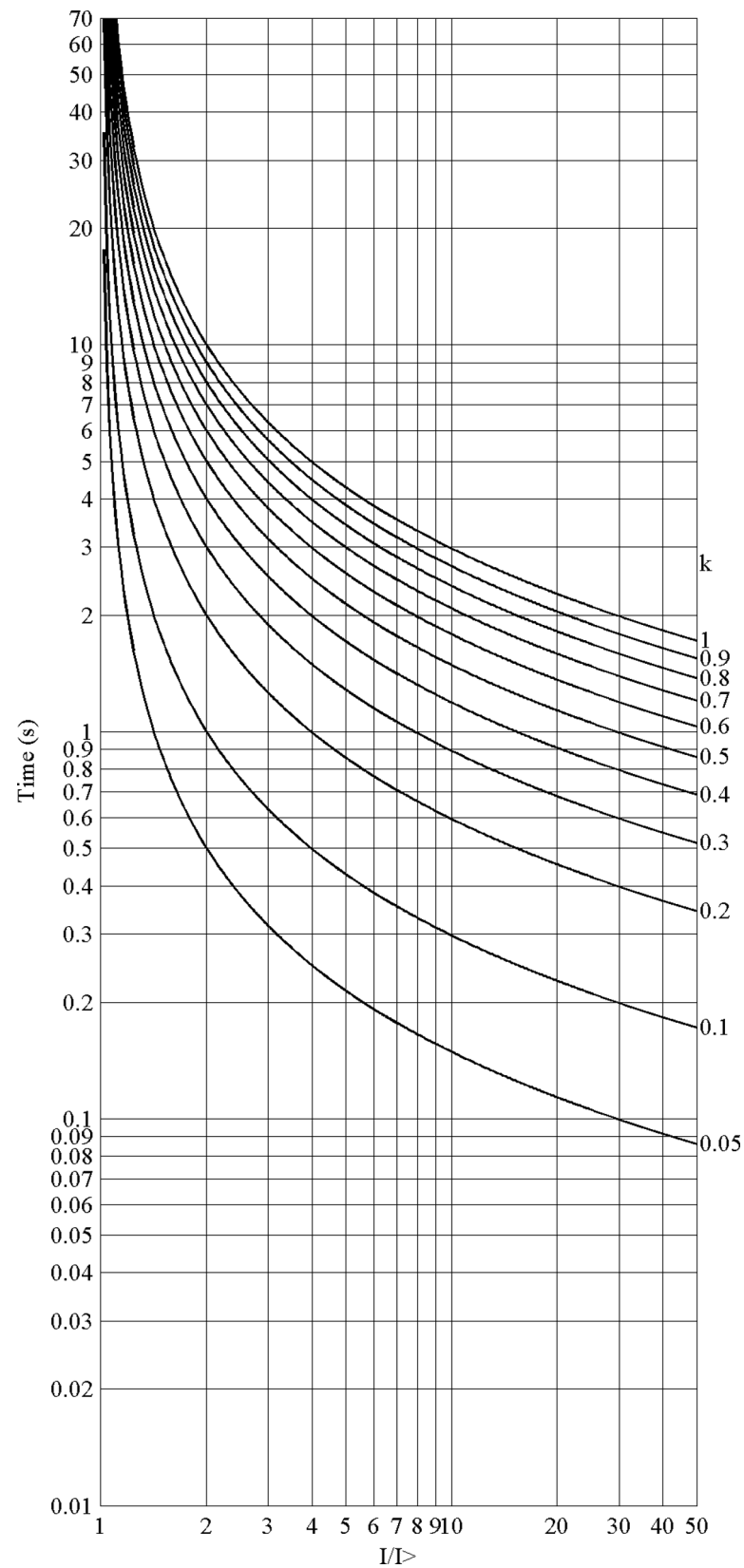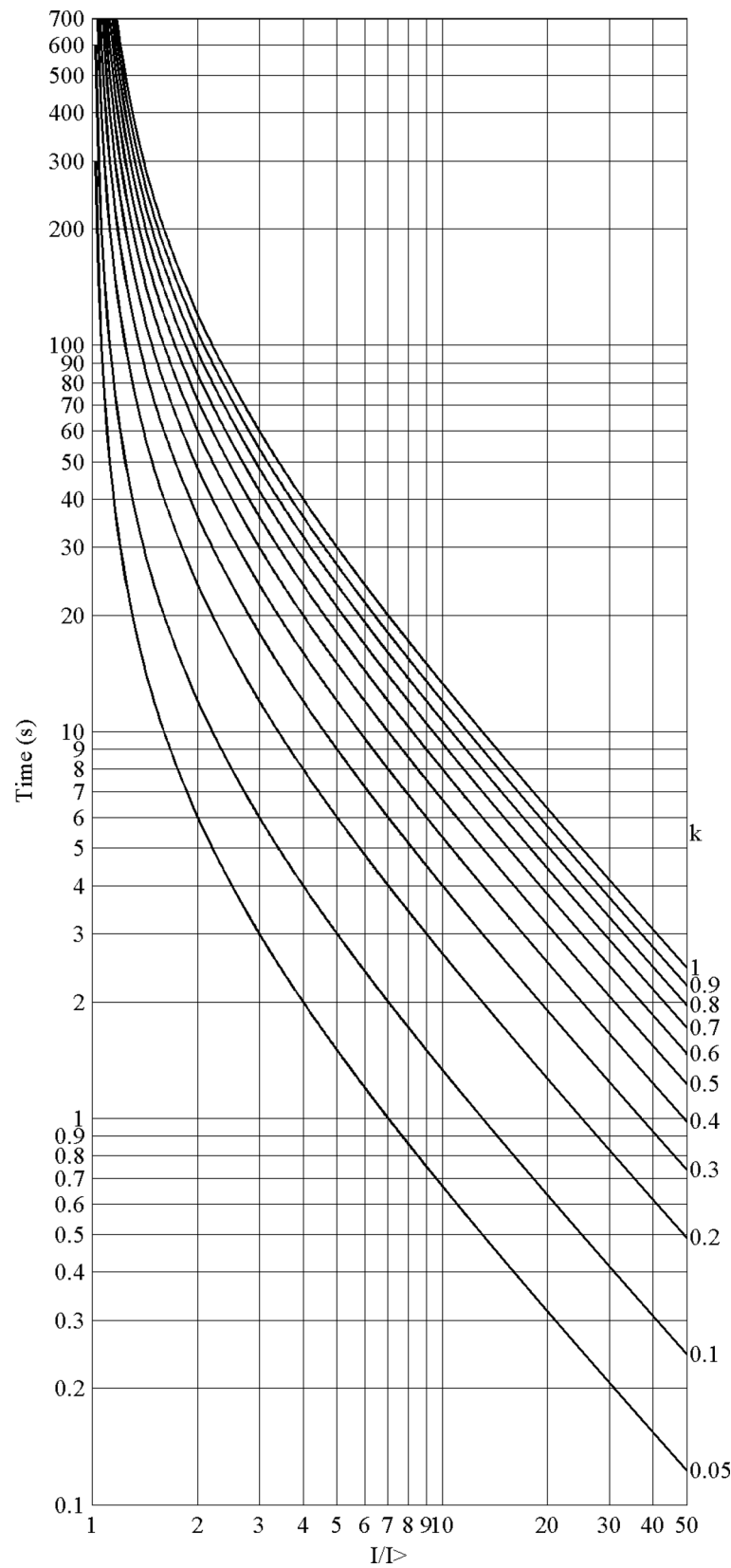
Figure 227:   IEC Inverse time characteristics

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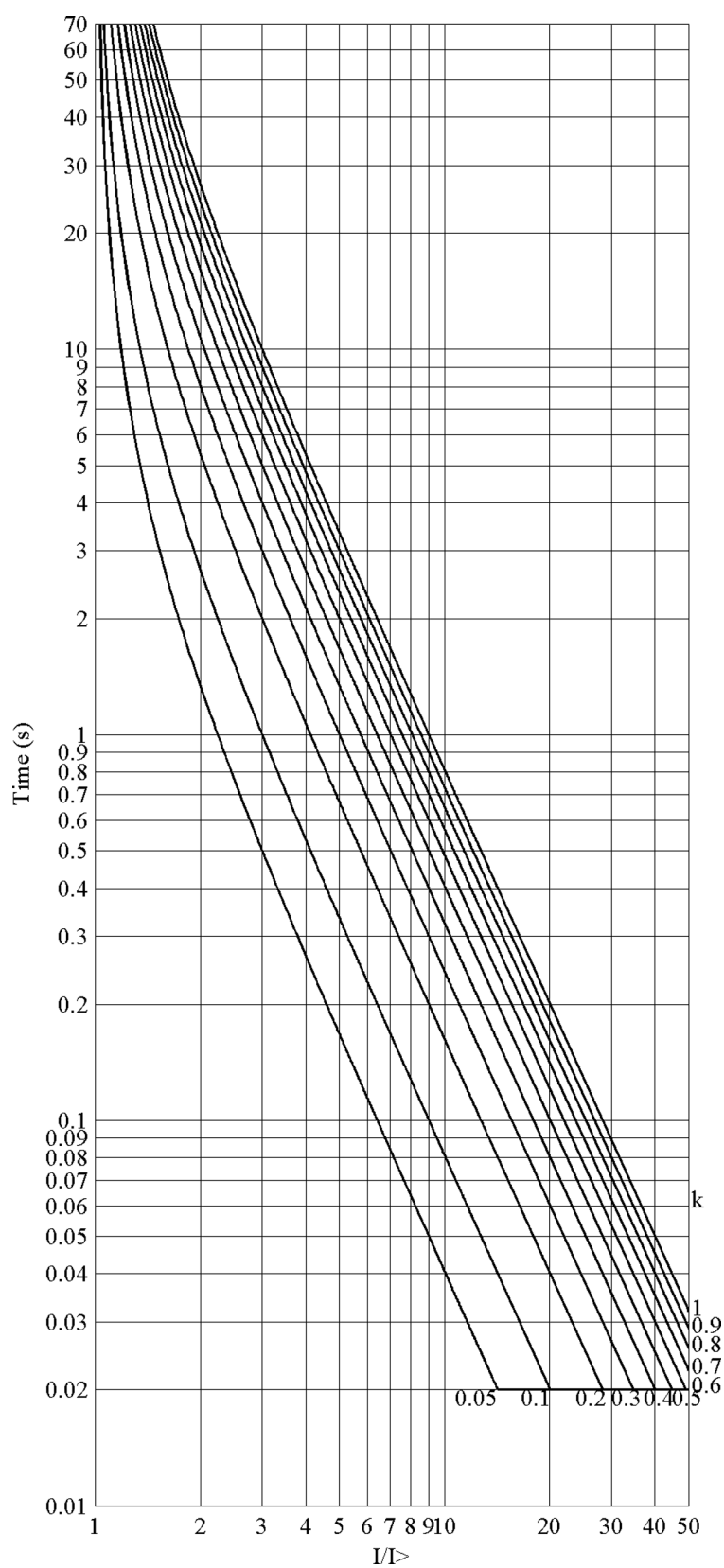
Figure 228:   *IEC Extremely inverse time characteristics*
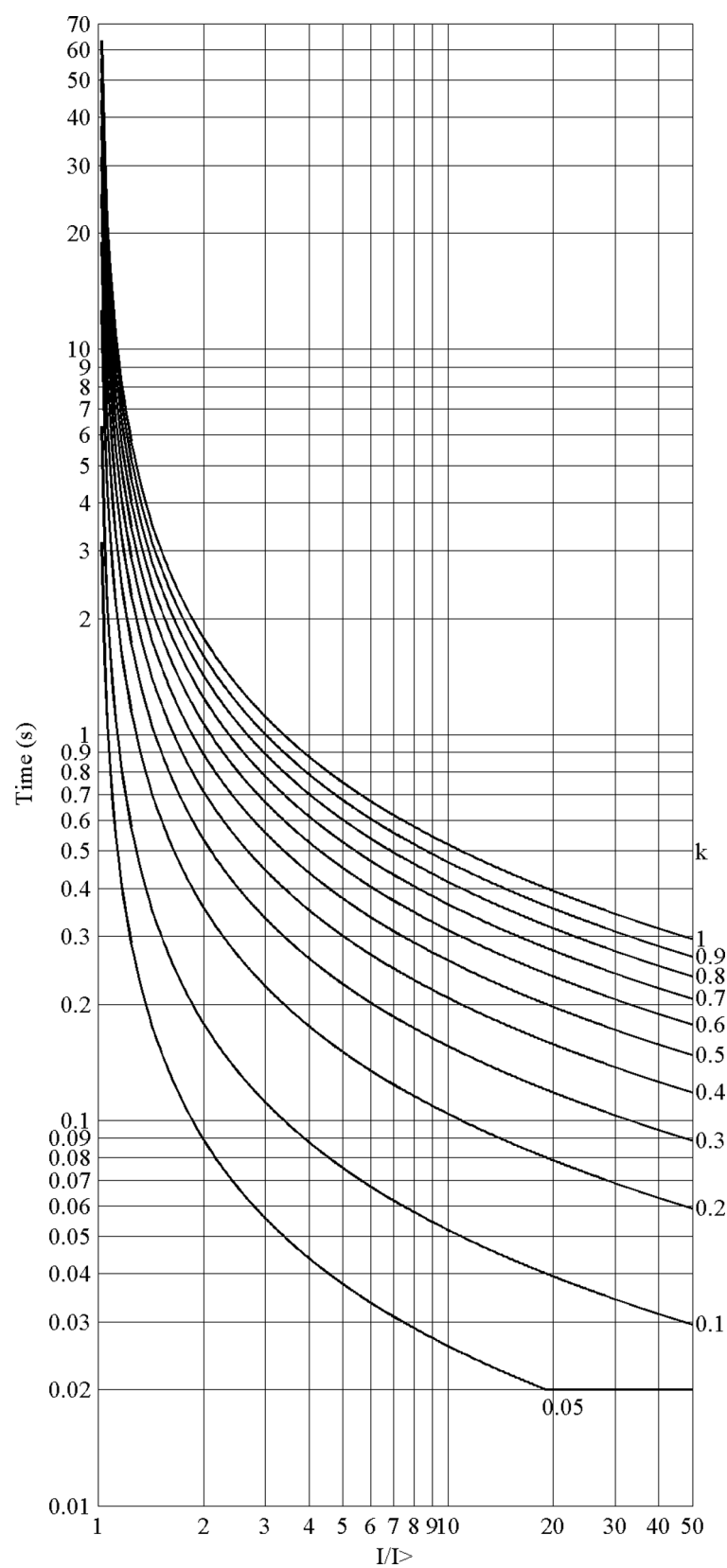
Figure 229:   IEC Short time inverse time characteristics

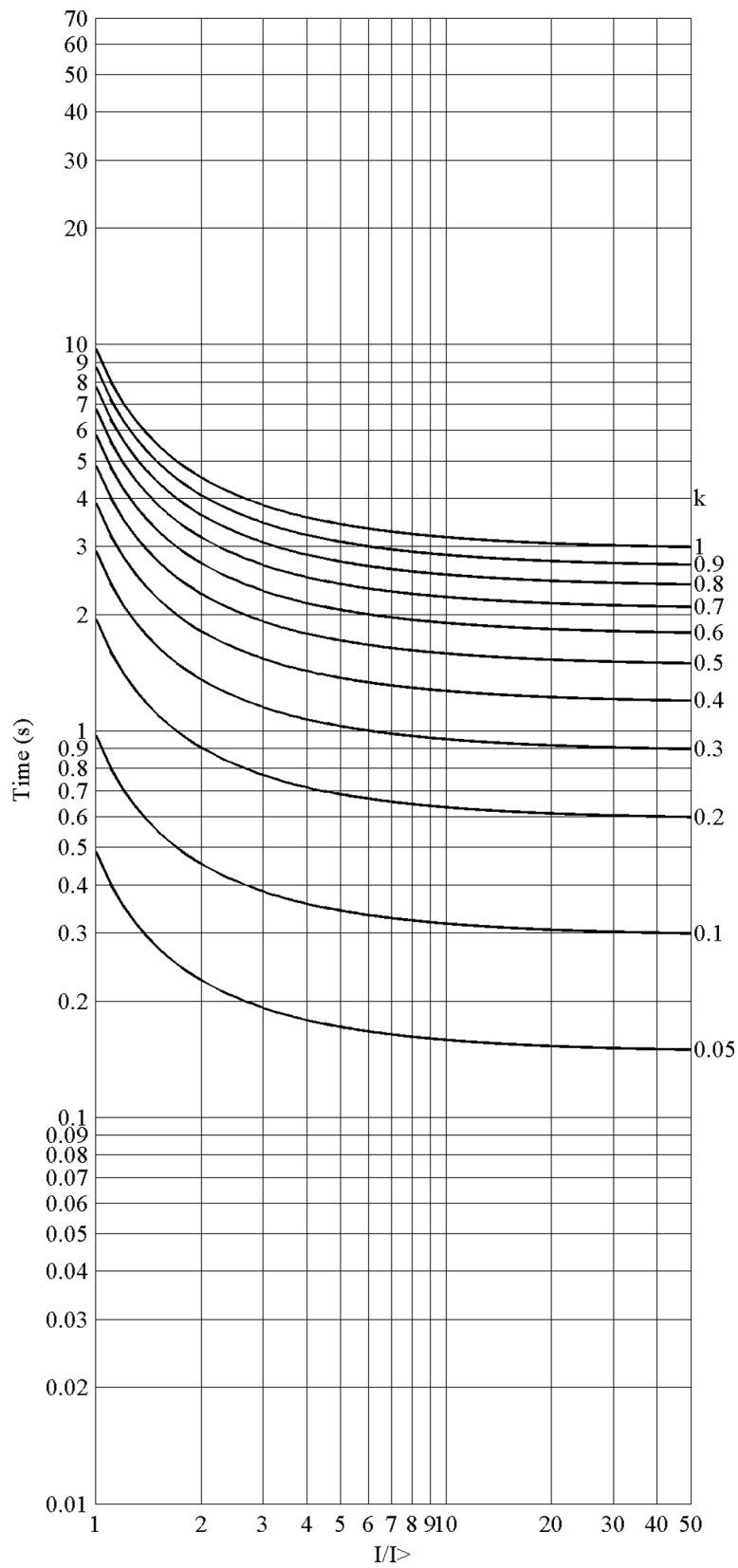*Figure 230:   IEC Long time inverse time characteristics*

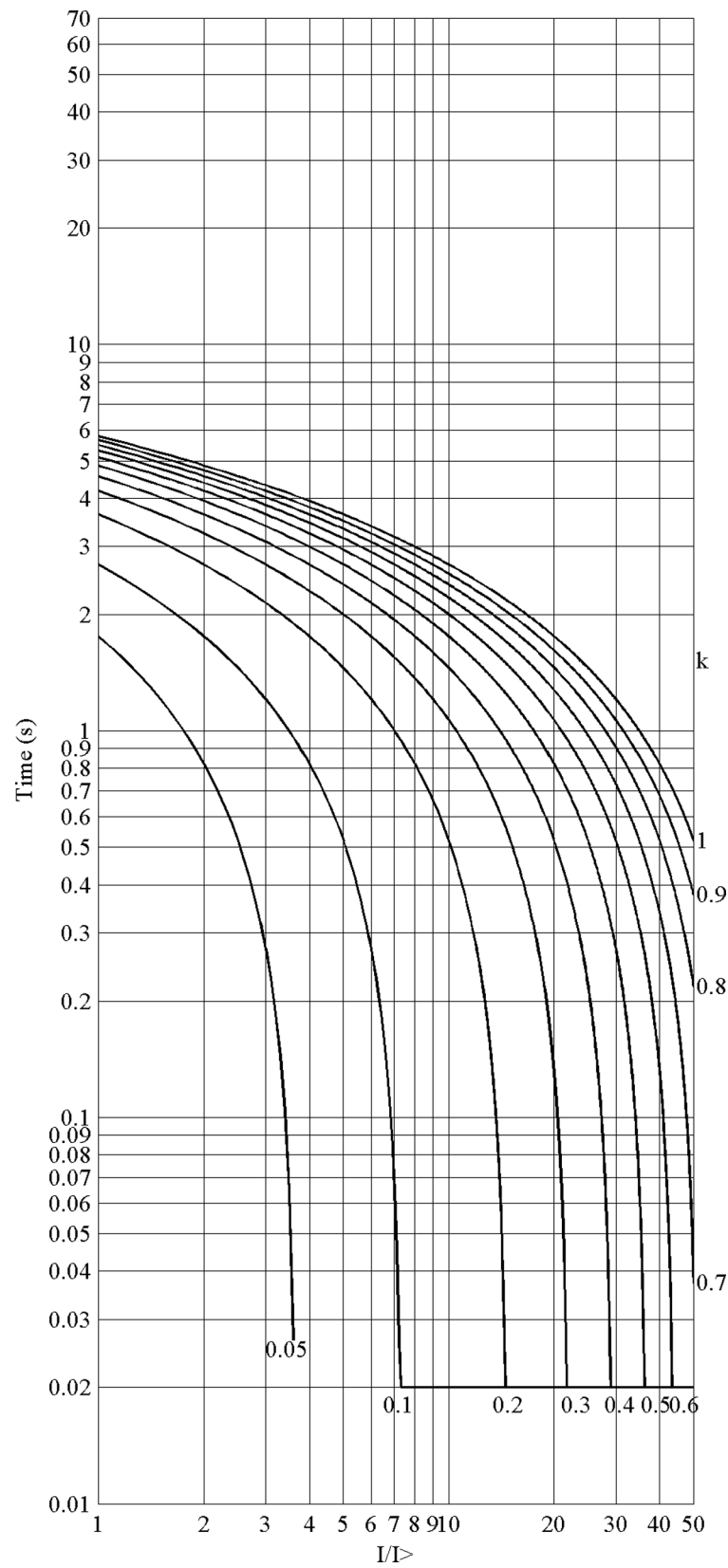*Figure 231:   RI-type inverse time characteristics*
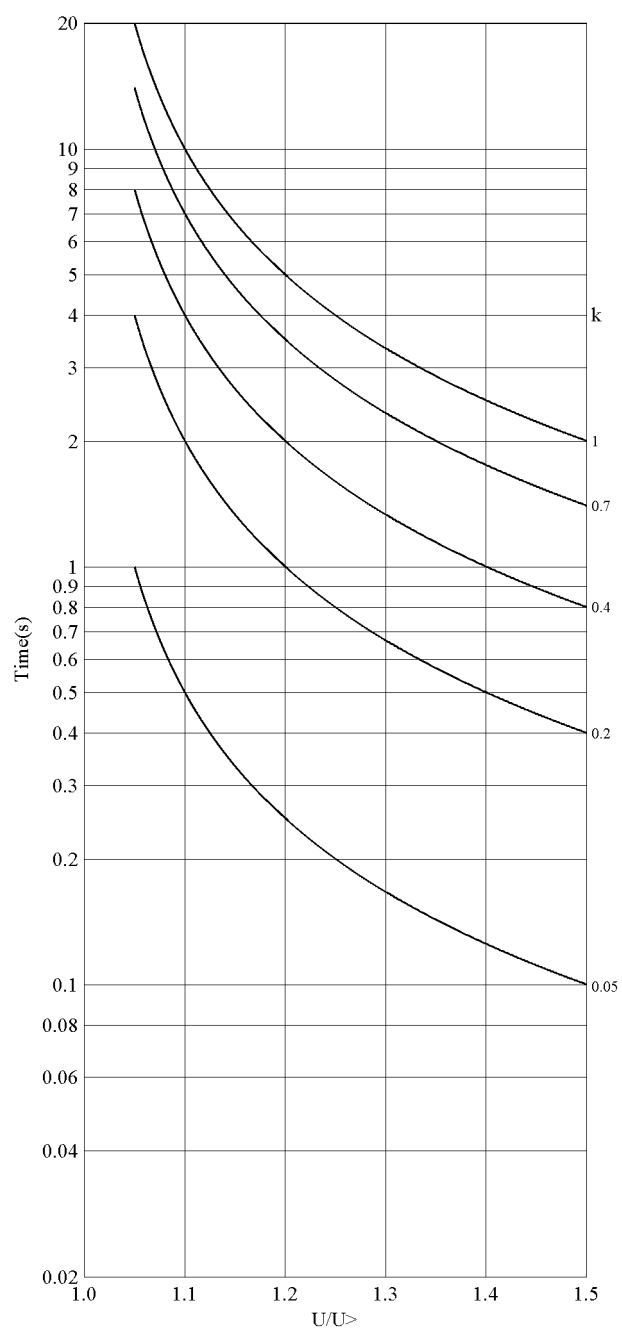
Figure 232: *RD-type inverse time characteristics*

Figure 233:   *Inverse curve A characteristic of overvoltage protection*
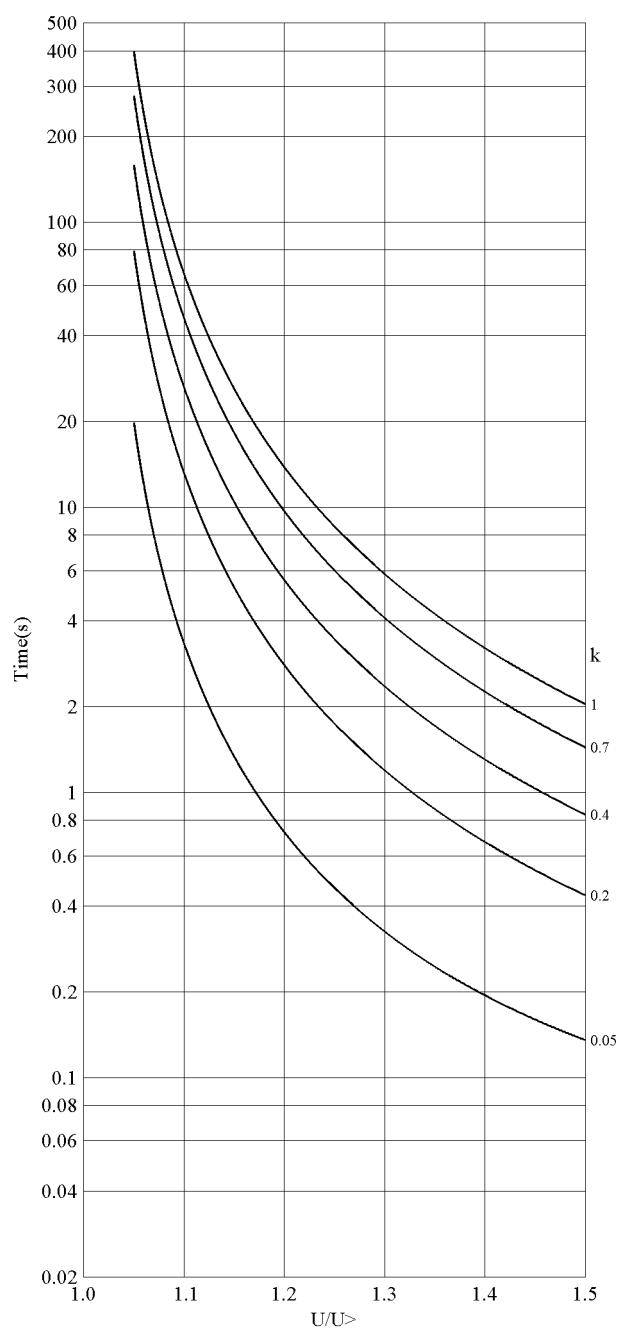
Figure 234: *Inverse curve B characteristic of overvoltage protection*
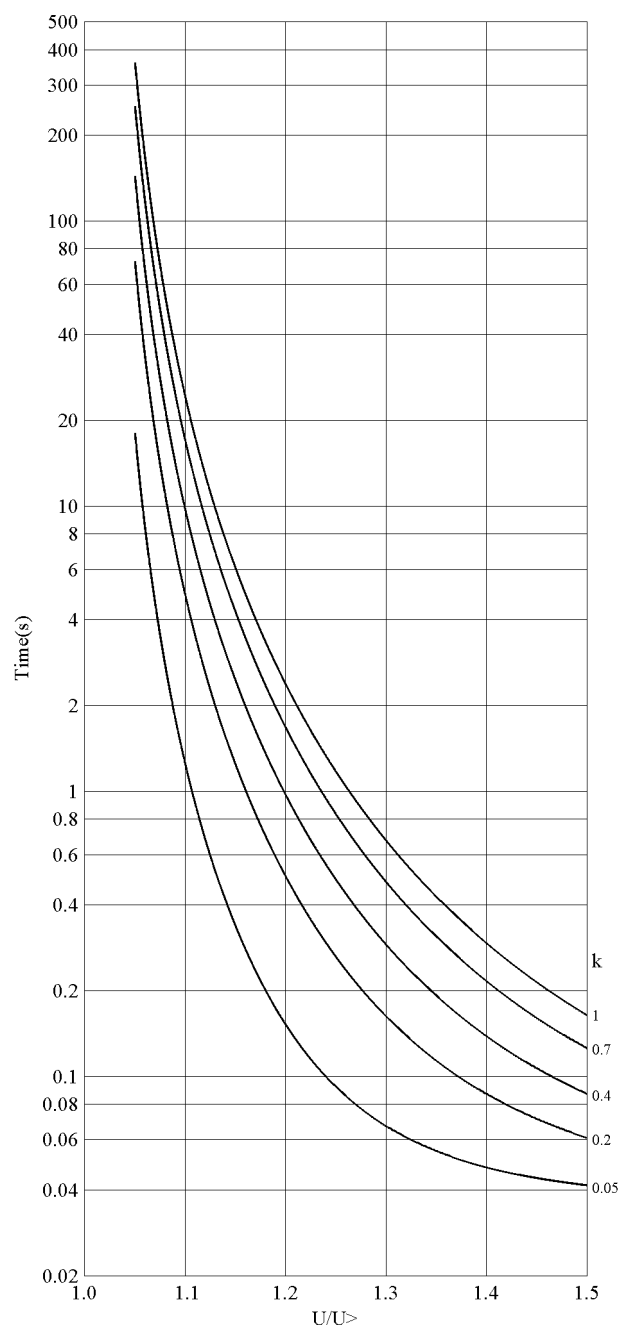
Figure 235:   *Inverse curve C characteristic of overvoltage protection*
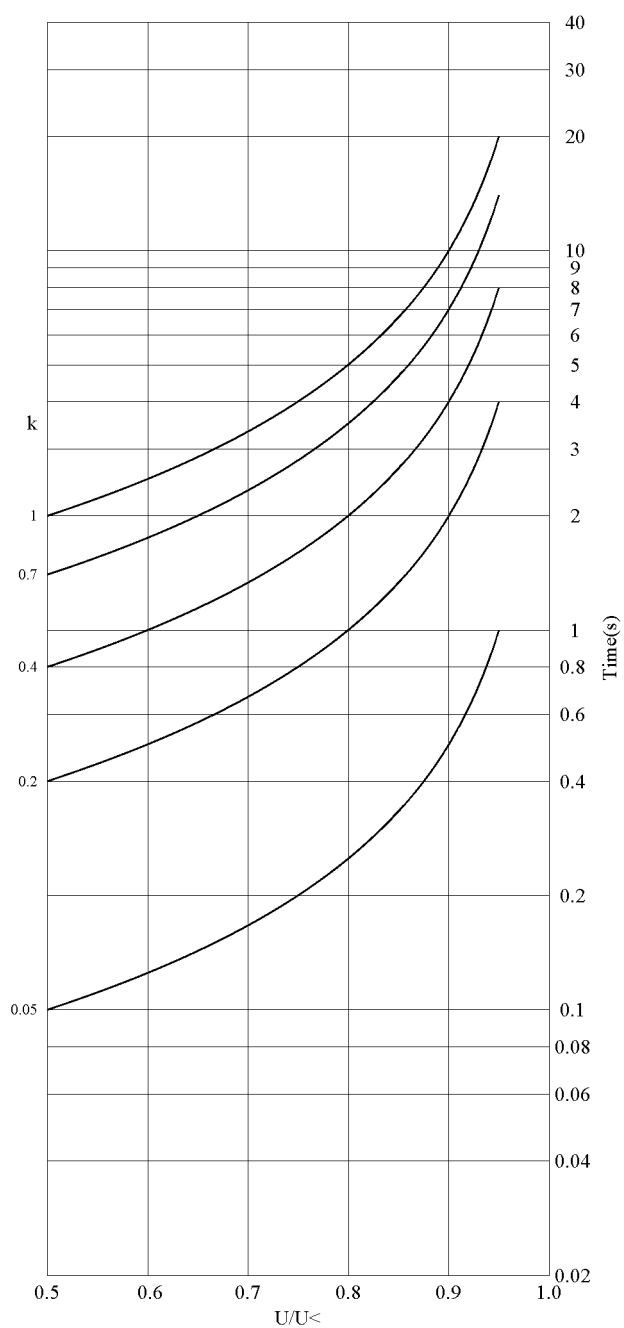
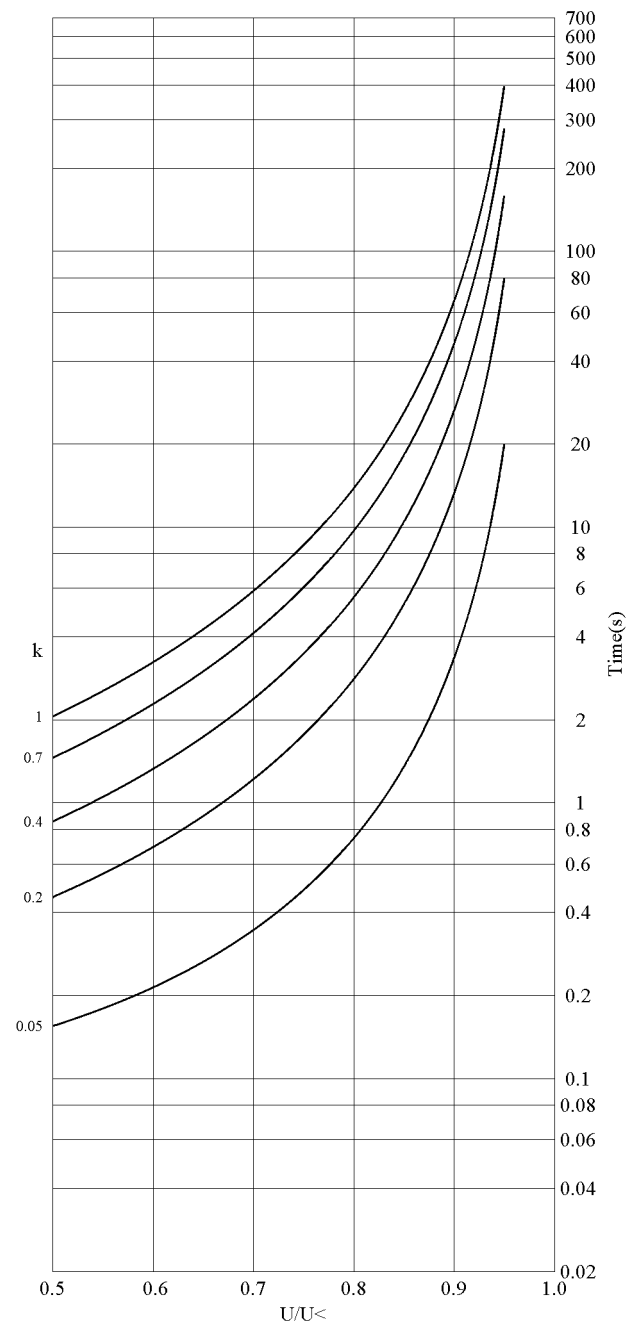Figure 236:   Inverse curve A characteristic of undervoltage protection

Figure 237:   Inverse curve B characteristic of undervoltage protection

Section 18   Glossary

AC	Alternating current
ACT	Application configuration tool within PCM600
A/D converter	Analog to digital converter
ADBS	Amplitude dead-band supervision
ANSI	American National Standards Institute
AR	Autoreclosing
ASCT	Auxiliary summation current transformer
ASD	Adaptive signal detection
AWG	American Wire Gauge standard
BR	External bi-stable relay
BS	British standard
CAN	Controller Area Network. ISO standard (ISO 11898) for serial communication
CB	Circuit breaker
CCITT	Consultative Committee for International Telegraph and Telephony. A United Nations sponsored standards body within the International Telecommunications Union.
CCVT	Capacitive Coupled Voltage Transformer
Class C	Protection Current Transformer class as per IEEE/ ANSI
CMPPS	Combined mega pulses per second
CO cycle	Close-open cycle
Co-directional	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 of with two are used for transmitting data in both directions, and two pairs for transmitting clock signals
CPU	Central processor unit
CR	Carrier receive
CRC	Cyclic redundancy check
CS	Carrier send

CT	Current transformer
CVT	Capacitive voltage transformer
DAR	Delayed auto-reclosing
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
DFT	Discrete Fourier transform
DIP-switch	Small switch mounted on a printed circuit board
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	Electro magnetic compatibility
EMF	Electro motive force
EMI	Electro magnetic interference
EnFP	End fault protection
ESD	Electrostatic discharge
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
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 auto reclosing
HV	High voltage
HVDC	High voltage direct current
IDBS	Integrating dead band supervision
IEC	International Electrical Committee
IEC 60044-6	IEC Standard, Instrument transformers – Part 6: Requirements for protective current transformers for transient performance
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 Electro Motive Force.
IED	Intelligent electronic device
I-GIS	Intelligent gas insulated switchgear
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 will have 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 re-assembly 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 fail 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
LDD	Local detection device
LED	Light emitting diode
MCB	Miniature circuit breaker
MCM	Mezzanine carrier module
MVB	Multifunction vehicle bus. Standardized serial bus originally developed for use in trains.
NCC	National Control Centre
OCO cycle	Open-close-open cycle
OCP	Overcurrent protection
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 over-reaching when the impedance presented to it is smaller than the apparent impedance to the fault applied to the balance point, i.e. 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
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
REVAL	Evaluation software
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
SC	Switch or push-button to close
SCS	Station control system
SCT	System configuration tool according to standard IEC 61850
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.
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.
TNC connector	Threaded Neill Concelman, A threaded constant impedance version of a BNC connector
TPZ, TPY, TPX, TPS	Current transformer class according to IEC
Underreach	A term used to describe how the relay behaves during a fault condition. For example a distance relay is under-reaching when the impedance presented to it is greater than the apparent impedance to the fault applied to the balance point, i.e. 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 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

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