Relion® 650 series

Transformer protection RET650 Technical Manual

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Conformity

This product complies with the directive of the Council of the European Communities on the approximation of the laws of the Member States relating to electromagnetic compatibility (EMC Directive 2004/108/EC) and concerning electrical equipment for use within specified voltage limits (Low-voltage directive 2006/95/EC).

This conformity is 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.

Table of contents

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

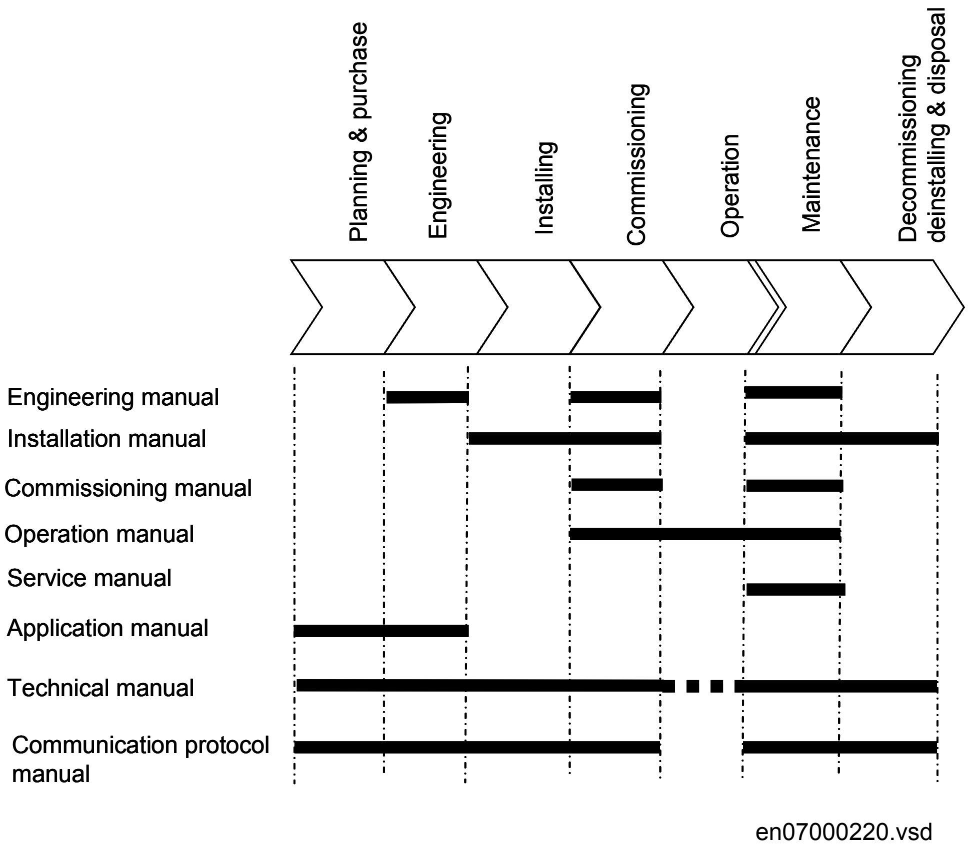


Figure 1: The intended use of manuals in different lifecycles

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 RET650	Identity number
Commissioning manual	1MRK 504 109-UEN
Technical manual	1MRK 504 106-UEN
Application manual	1MRK 504 107-UEN

Table continues on next page

Documents related to RET650	Identity number
Product Guide, configured	1MRK 504 110-BEN
Type test certificate	1MRK 504 110-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 Main protection functions

IEC 61850	ANSI	Function description	Transformer		
			RET650 (A01) 2W/1CB	RET650 (A05) 3W/1CB	RET650 (A07) OLTC
Differential protection					
T2WPDIF	87T	Transformer differential protection, two winding	1		
T3WPDIF	87T	Transformer differential protection, three winding		1	
REFPDIF	87N	Restricted earth fault protection, low impedance	2	3	

2.2 Back-up protection functions

IEC 61850	ANSI	Function description	Transformer		
			RET650 (A01) 2W/1CB	RET650 (A05) 3W/1CB	RET650 (A07) OLTC
Current protection					
PHPIOC	50	Instantaneous phase overcurrent protection	2	3	
OC4PTOC	51/67	Four step directional phase overcurrent protection	2	3	2
EFPIOC	50N	Instantaneous residual overcurrent protection	2	3	
EF4PTOC	51N/67N	Four step directional residual overcurrent protection	2	3	2
TRPTTR	49	Thermal overload protection, two time constants	2	3	2
CCRBRF	50BF	Breaker failure protection	2	3	
CCRPLD	52PD	Pole discordance protection	2	3	
GUPPDUP	37	Directional underpower protection	1	1	2
GOPPDOP	32	Directional overpower protection	1	1	2
DNSPTOC	46	Negative sequence based overcurrent function	1		
Voltage protection					
UV2PTUV	27	Two step undervoltage protection	1	1	2
OV2PTOV	59	Two step overvoltage protection	1	1	2
ROV2PTOV	59N	Two step residual overvoltage protection	1	1	2
OEXPVPH	24	Overexcitation protection		1	

Table continues on next page

IEC 61850	ANSI	Function description	Transformer		
			RET650 (A01) 2W/1CB	RET650 (A05) 3W/1CB	RET650 (A07) OLTC
Frequency protection					
SAPTUF	81	Underfrequency function	4	4	4
SAPTOF	81	Overfrequency function	4	4	4
SAPFRC	81	Rate-of-change frequency protection	2	2	4

2.3 Control and monitoring functions

IEC 61850	ANSI	Function description	Transformer		
			RET650 (A01) 2W/1CB	RET650 (A05) 3W/1CB	RET650 (A07) OLTC
Control					
QCBAY		Bay control	1	1	1
LOCREM		Handling of LR-switch positions	1	1	1
LOCREMCTRL		LHMI control of PSTO	1	1	1
TR1ATCC	90	Automatic voltage control for tapchanger, single control	1	1	
TR8ATCC	90	Automatic voltage control for tapchanger, parallell control			2
TCMYLTC	84	Tap changer control and supervision, 6 binary inputs	1	1	2
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
AUTOBITS		AutomationBits, command function for DNP3.0	3	3	3
Secondary system supervision					
TCSSCBR		Breaker close/trip circuit monitoring	3	3	3
Logic					
SMPPTRC	94	Tripping logic	2	3	2
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

Table continues on next page

IEC 61850	ANSI	Function description	Transformer		
			RET650 (A01) 2W/1CB	RET650 (A05) 3W/1CB	RET650 (A07) OLTC
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
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
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	2	2	2
SSIML	71	Insulation liquid monitoring function	2	2	2
SSCBR		Circuit breaker condition monitoring	2	3	2
Metering					
PCGGIO		Pulse counter logic	16	16	16
ETPMMTR		Function for energy calculation and demand handling	3	3	3

2.4 Designed to communicate

IEC 61850	ANSI	Function description	Transformer		
			RET650 (A01) 2W/1CB	RET650 (A05) 3W/1CB	RET650 (A07) OLTC
Station communication					
		IEC 61850 communication protocol	1	1	1
		DNP3.0 for TCP/IP communication protocol	1	1	1
GOOSEINTLKRCV		Horizontal communication via GOOSE for interlocking	59	59	59
GOOSEBINRCV		GOOSE binary receive	4	4	4

2.5 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)

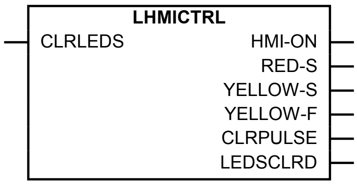
Name	Values (Range)	Unit	Step	Default	Description
DisplayTimeout	10 - 120	Min	10	60	Local HMI display timeout
ContrastLevel	-100 - 100	%	10	0	Contrast level for display
DefaultScreen	0 - 0	-	1	0	Default screen
EvListSrtOrder	Latest on top Oldest on top	-	-	Latest on top	Sort order of event list
AutoIndicationDRP	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



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

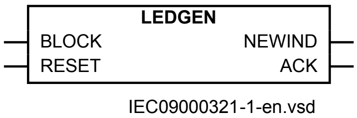


Figure 3: LEDGEN function block

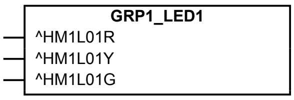


Figure 4: GRP1_LED1 function block

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

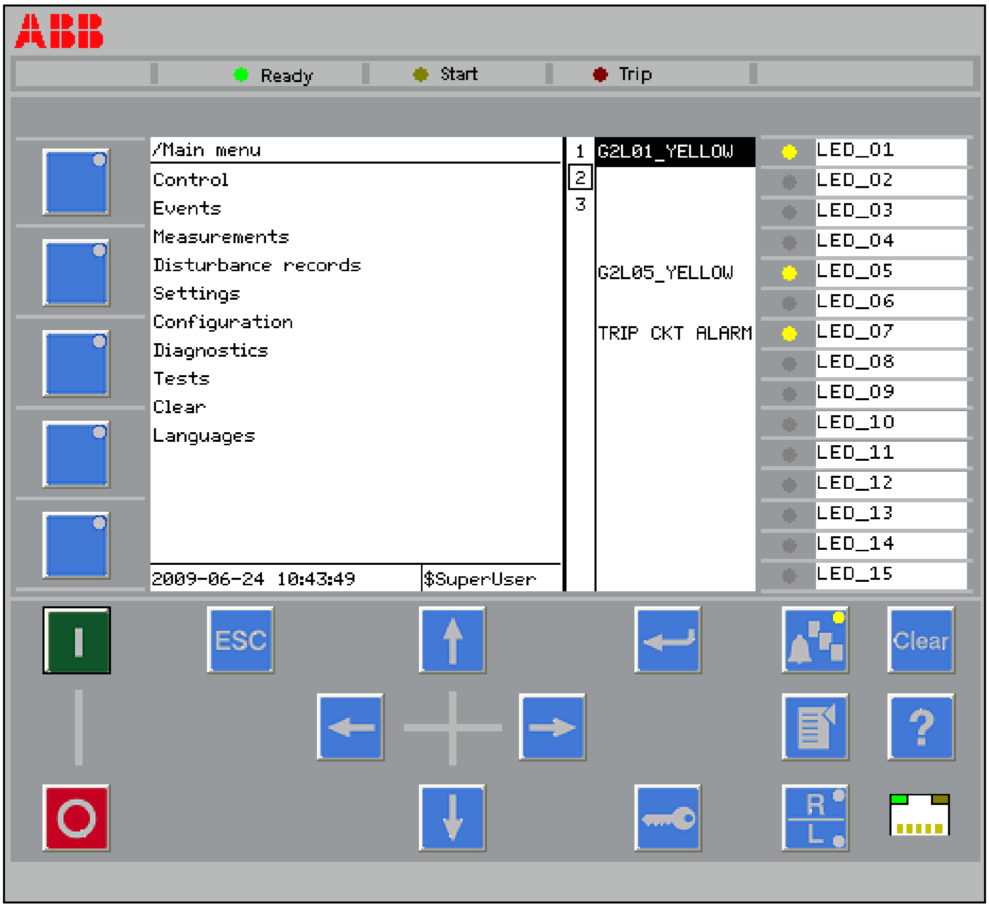


Figure 6: Local human-machine interface

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.

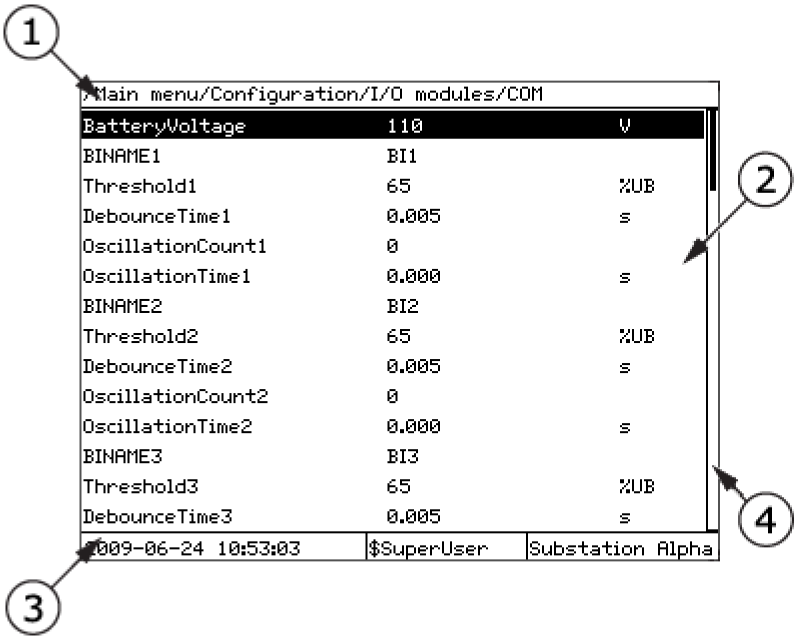


Figure 7: Display layout

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.

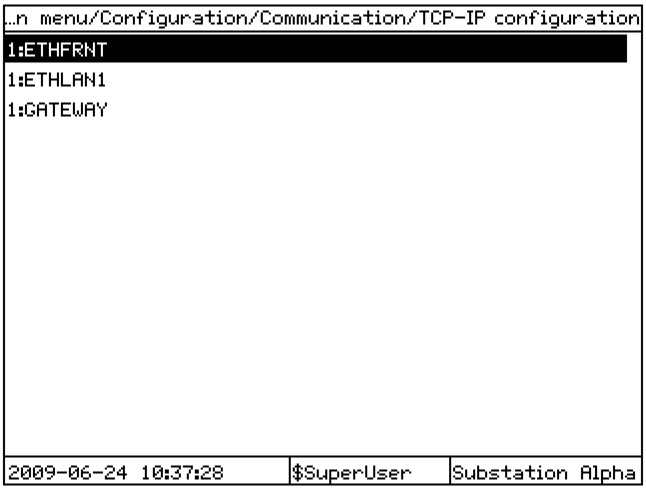


Figure 8: Truncated path

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.

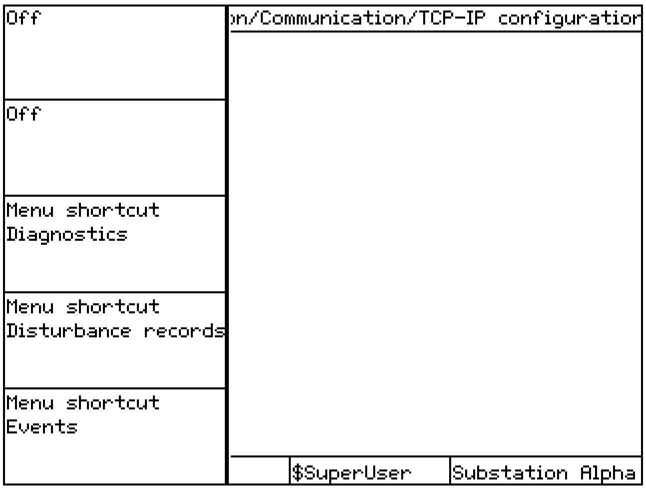


Figure 9: Function button panel

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

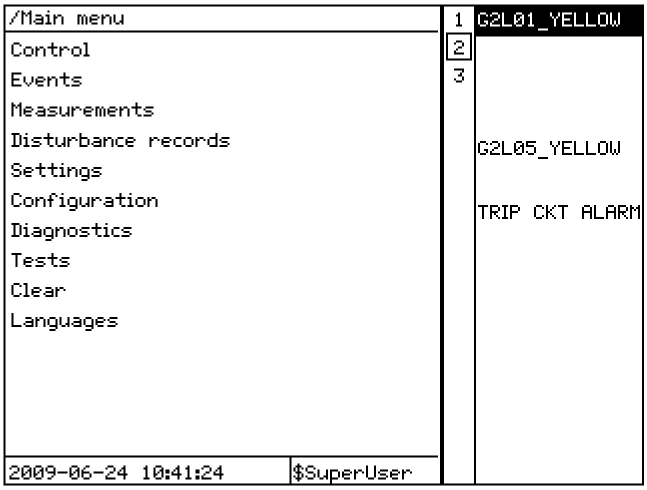


Figure 10: Alarm LED panel

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.

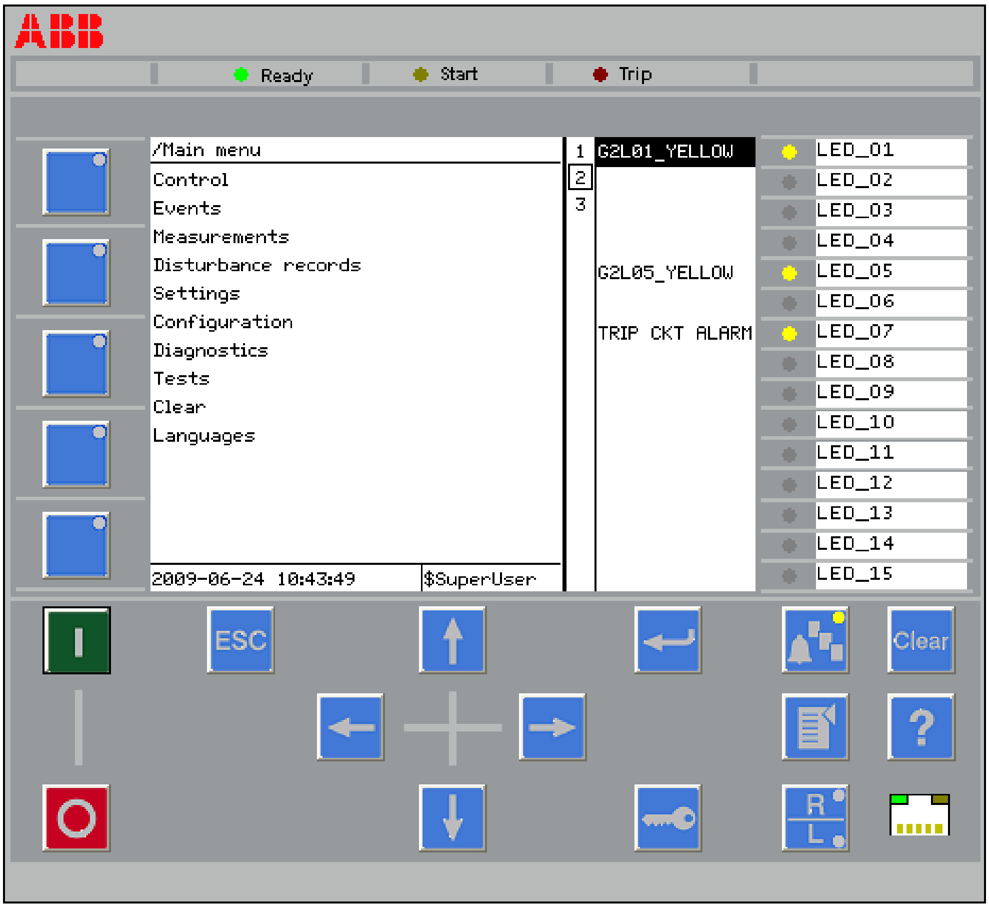


Figure 11: LHMI keypad

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  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:

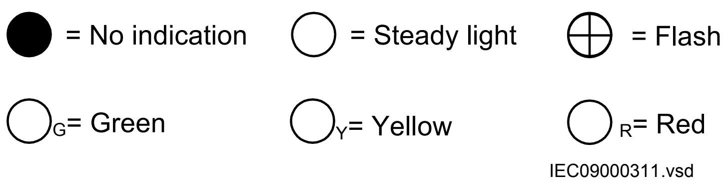


Figure 12: Symbols used in the sequence diagrams

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.

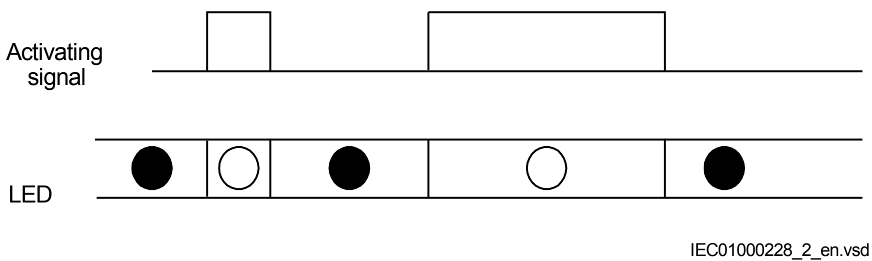


Figure 13: Operating sequence 1 (Follow-S)

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.

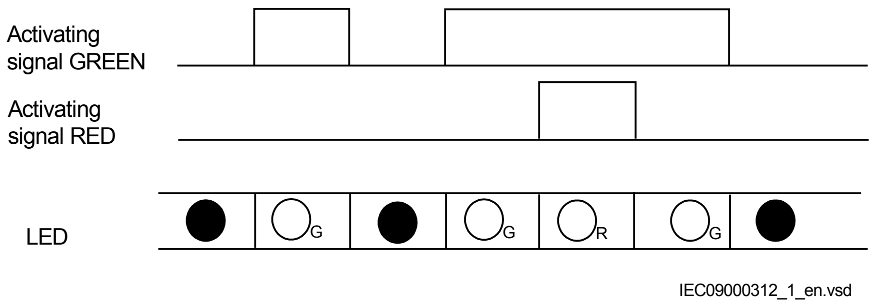


Figure 14: Operating sequence 1, two colors

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.

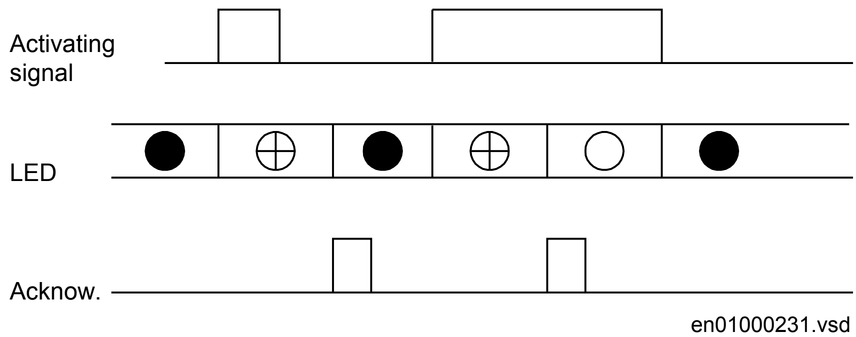


Figure 15: Operating sequence 3 (LatchedAck-F-S)

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.

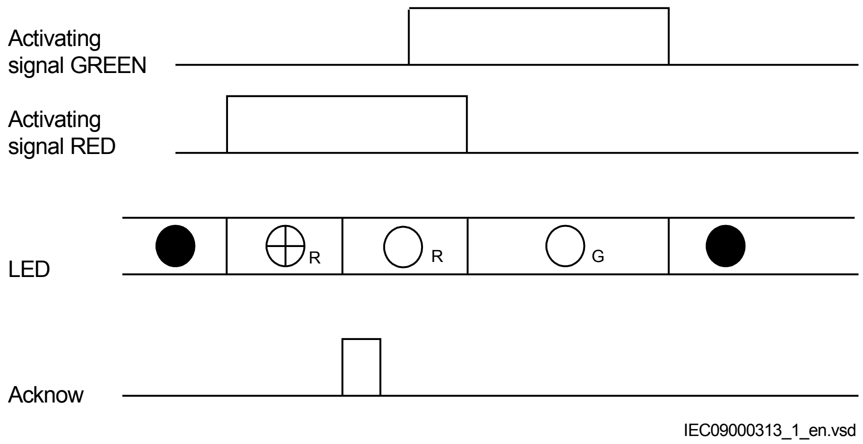


Figure 16: Operating sequence 3, 2 colors involved

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.

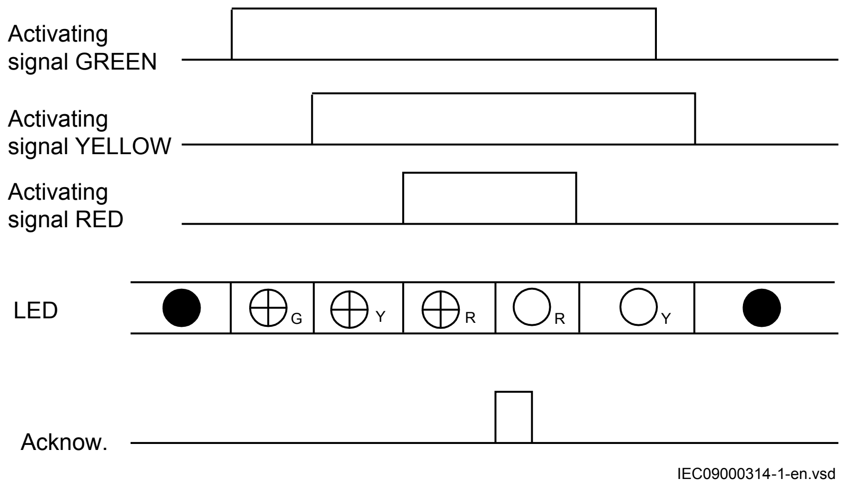


Figure 17: Operating sequence 3, three colors involved, alternative 1

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.

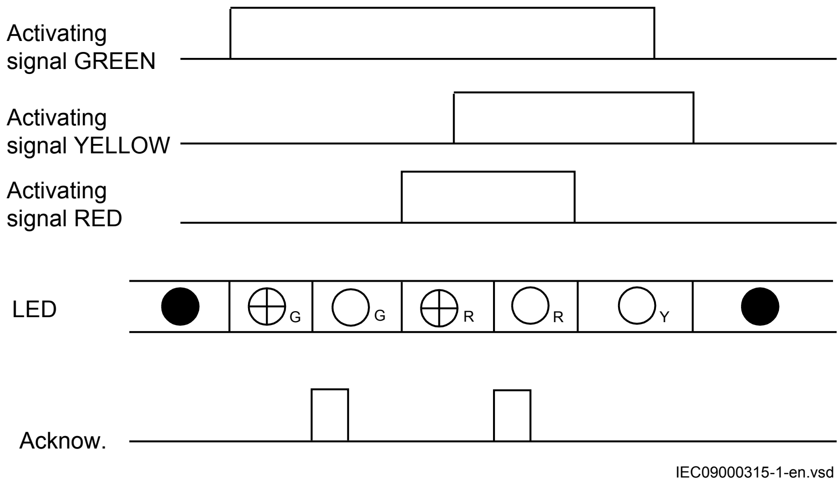


Figure 18: Operating sequence 3, three colors involved, alternative 2

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.

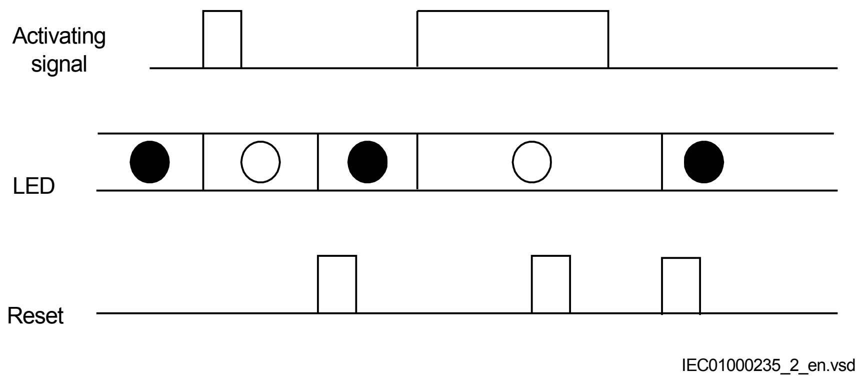


Figure 19: Operating sequence 5 (LatchedColl-S)

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.

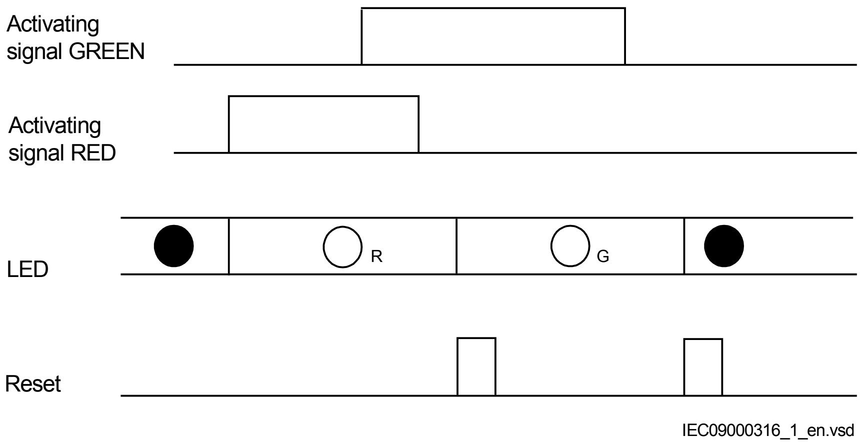


Figure 20: Operating sequence 5, two colors

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.

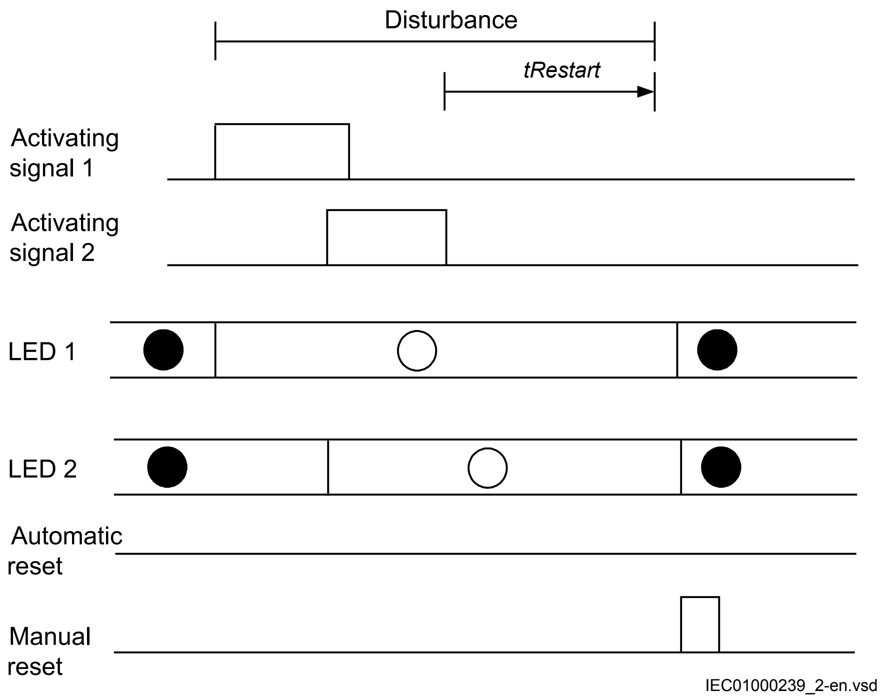


Figure 21: Operating sequence 6 (LatchedReset-S), two indications within same disturbance

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

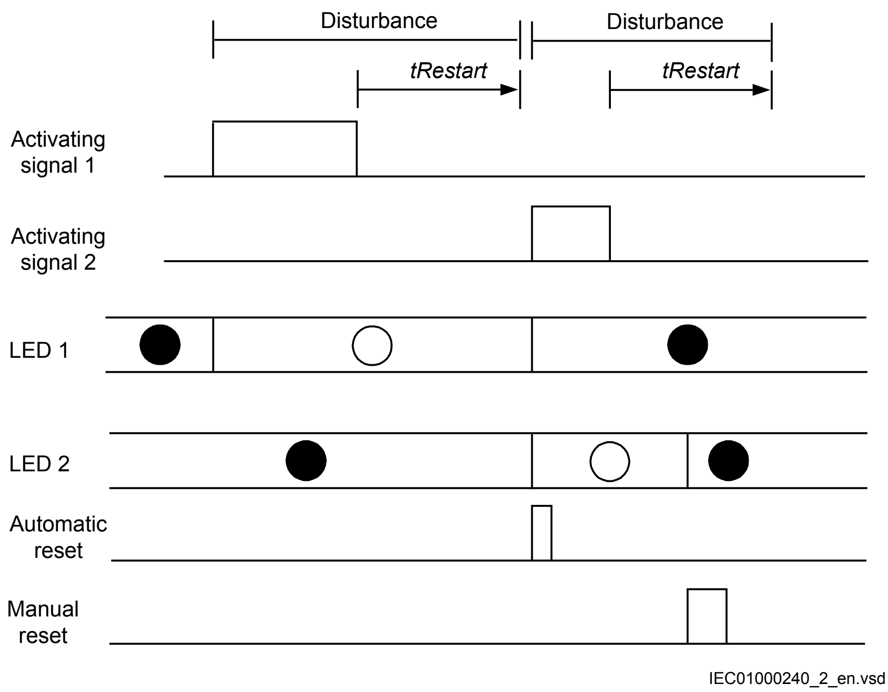


Figure 22: Operating sequence 6 (LatchedReset-S), two different disturbances

Figure 23 shows the timing diagram when a new indication appears after the first one has reset but before *tRestart* has elapsed.

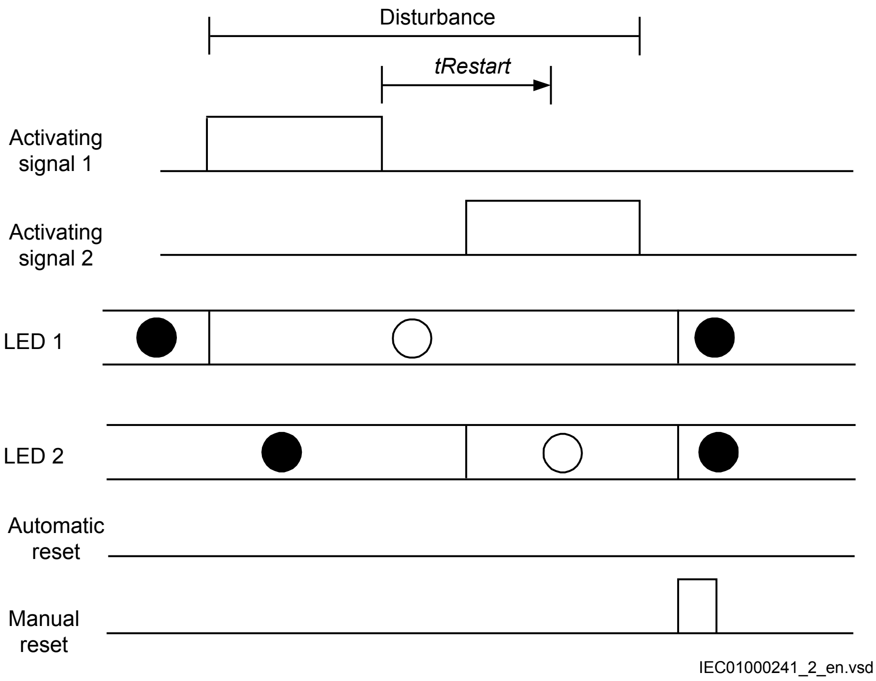


Figure 23: Operating sequence 6 (LatchedReset-S), two indications within same disturbance but with reset of activating signal between

Figure 24 shows the timing diagram for manual reset.

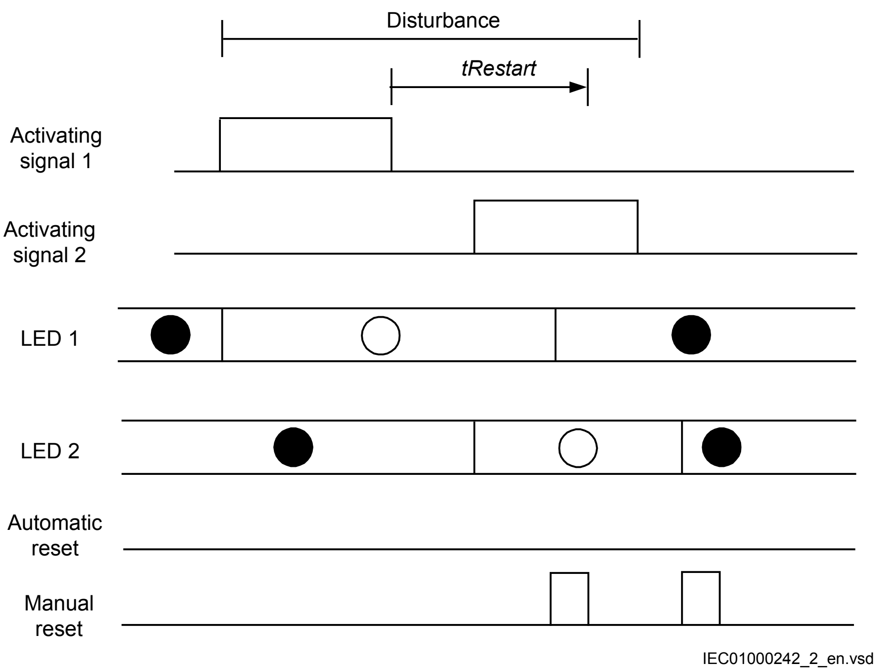


Figure 24: Operating sequence 6 (LatchedReset-S), manual reset

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.

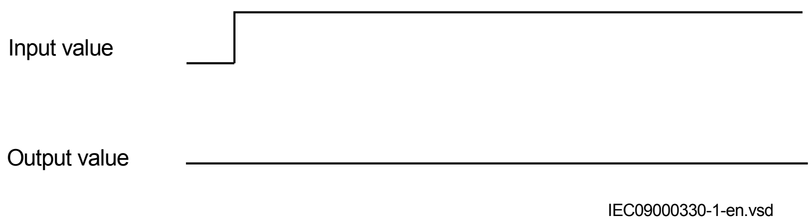


Figure 25: Sequence diagram for Mode 0

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.

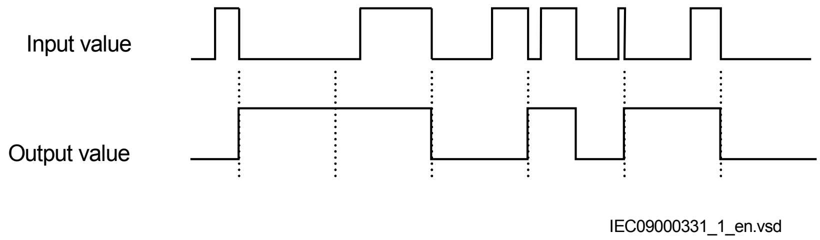


Figure 26: Sequence diagram for Mode 1

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.

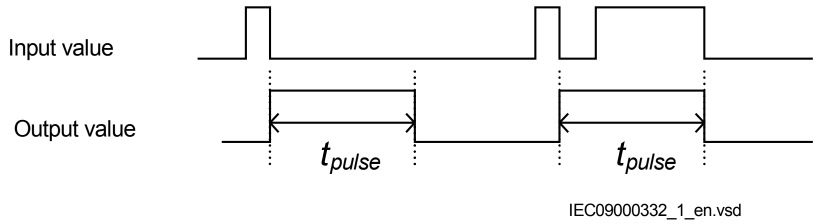


Figure 27: Sequence diagram for Mode 2

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 Differential protection

4.1 Transformer differential protection

4.1.1 Functionality

The functions Transformer differential protection, two-winding (T2WPDIF) and Transformer differential protection, three-winding (T3WPDIF) are provided with internal CT ratio matching and vector group compensation and when require zero sequence current elimination is also made internally in the software.

The function can be provided with up to three three phase sets of current inputs. All current inputs are provided with percentage bias restraint features, making the IED suitable for two or three-winding transformers arrangements.

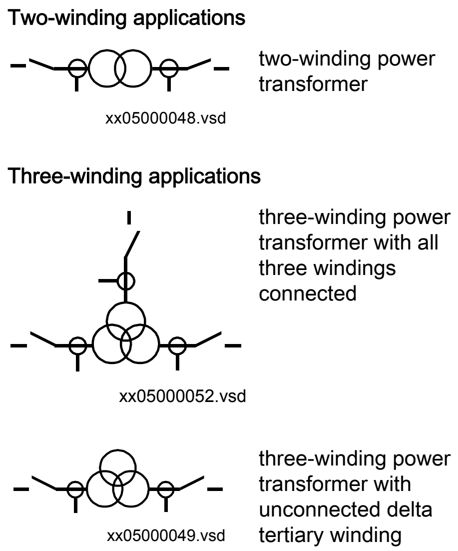


Figure 28: CT group arrangement for differential protection and other protections

The setting facilities cover for applications of the differential protection to all types of power transformers and autotransformers with or without on-load tap-changer as well as for shunt reactors or and local feeders within the station. An adaptive stabilizing feature is included for heavy through-faults.

Stabilization is included for inrush currents respectively for overexcitation condition. Adaptive stabilization is also included for system recovery inrush and CT saturation for external faults. A fast high set unrestrained differential current protection is included for very high speed tripping at high internal fault currents.

Innovative sensitive differential protection feature, based on the theory of symmetrical components, offers best possible coverage for power transformer windings turn-to-turn faults.

4.1.2 Transformer differential protection, two-winding T2WPDIF

4.1.2.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Transformer differential protection, two-winding	T2WPDIF	3Id/I	87T

4.1.2.2 Signals

Table 13: T2WPDIF Input signals

Name	Type	Default	Description
I3PW1CT1	GROUP SIGNAL	-	Three phase winding primary CT1
I3PW2CT1	GROUP SIGNAL	-	Three phase winding secondary CT1
BLOCK	BOOLEAN	0	Block of function

Table 14: T2WPDIF Output signals

Name	Type	Description
TRIP	BOOLEAN	General trip signal
TRIPRES	BOOLEAN	Trip signal from restrained differential protection
TRIPUNRE	BOOLEAN	Trip signal from unrestrained differential protection
TRNSUNR	BOOLEAN	Trip signal from unrestrained negative sequence differential protection
TRNSSENS	BOOLEAN	Trip signal from sensitive negative sequence differential protection
START	BOOLEAN	General start signal
STL1	BOOLEAN	Start signal from phase L1
STL2	BOOLEAN	Start signal from phase L2
STL3	BOOLEAN	Start signal from phase L3
BLK2H	BOOLEAN	General second harmonic block signal

Table continues on next page

Name	Type	Description
BLK5H	BOOLEAN	General fifth harmonic block signal
BLKWAV	BOOLEAN	General block signal from waveform criteria
IDALARM	BOOLEAN	General alarm for sustained differential currents
IDL1MAG	REAL	Magnitude of fundamental frequency differential current, phase L1
IDL2MAG	REAL	Magnitude of fundamental frequency differential current, phase L2
IDL3MAG	REAL	Magnitude of fundamental frequency differential current, phase L3
IBIAS	REAL	Magnitude of the bias current, which is common to all phases
IDNSMAG	REAL	Magnitude of the negative sequence differential current

4.1.2.3 Settings

Table 15: T2WPDIF Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
IdMin	0.05 - 0.60	IB	0.01	0.30	Section 1 sensitivity current, usually W1 current
EndSection1	0.20 - 1.50	IB	0.01	1.25	End of section 1, multiple of W1 rated current
EndSection2	1.00 - 10.00	IB	0.01	3.00	End of section 2, multiple of W1 rated current
SlopeSection2	10.0 - 50.0	%	0.1	40.0	Slope in section 2 of operate-restrain characteristics
SlopeSection3	30.0 - 100.0	%	0.1	80.0	Slope in section 3 of operate-restrain characteristics
IdUnre	1.00 - 50.00	IB	0.01	10.00	Unrestrained protection limit, multiple of W1 rated current
I2/I1Ratio	5.0 - 100.0	%	1.0	15.0	Maximum ratio of 2nd harmonic to fundamental harmonic differential current
I5/I1Ratio	5.0 - 100.0	%	1.0	25.0	Maximum ratio of 5th harmonic to fundamental harmonic differential current
CrossBlockEn	Off On	-	-	On	Operation Off/On for cross-block logic between phases
NegSeqDiffEn	Off On	-	-	On	Operation Off/On for negative sequence differential protections
IMinNegSeq	0.02 - 0.20	IB	0.01	0.04	Minimum negative sequence current
NegSeqROA	30.0 - 120.0	Deg	0.1	60.0	Operate angle for internal/external negative sequence fault discriminator
SOTFMode	Off On	-	-	On	Operation mode for switch onto fault
IDiffAlarm	0.05 - 1.00	IB	0.01	0.20	Differential curreent alarm, multiple of base current, usually W1 current
tAlarmDelay	0.000 - 60.000	s	0.001	10.000	Time delay for differential current alarm

Table 16: T2WPDIF Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
GlobalBaseSelW1	1 - 6	-	1	1	Global base selector for winding 1
GlobalBaseSelW2	1 - 6	-	1	1	Global base selector for winding 2
ConnectTypeW1	WYE (Y) Delta (D)	-	-	WYE (Y)	Connection type of winding 1: Y-wye or D-delta
ConnectTypeW2	WYE (Y) Delta (D)	-	-	WYE (Y)	Connection type of winding 2: Y-wye or D-delta
ClockNumberW2	0 [0 deg] 1 [30 deg lag] 2 [60 deg lag] 3 [90 deg lag] 4 [120 deg lag] 5 [150 deg lag] 6 [180 deg] 7 [150 deg lead] 8 [120 deg lead] 9 [90 deg lead] 10 [60 deg lead] 11 [30 deg lead]	-	-	0 [0 deg]	Phase displacement between W2 & W1=HV winding, hour notation
ZSCurrSubtrW1	Off On	-	-	On	Enable zero sequence subtration for W1 side, Off/On
ZSCurrSubtrW2	Off On	-	-	On	Enable zero sequence subtration for W2 side, Off/On

4.1.2.4 Monitored data

Table 17: T2WPDIF Monitored data

Name	Type	Values (Range)	Unit	Description
IDL1MAG	REAL	-	A	Magnitude of fundamental frequency differential current, phase L1
IDL2MAG	REAL	-	A	Magnitude of fundamental frequency differential current, phase L2
IDL3MAG	REAL	-	A	Magnitude of fundamental frequency differential current, phase L3
IBIAS	REAL	-	A	Magnitude of the bias current, which is common to all phases
IDNSMAG	REAL	-	A	Magnitude of the negative sequence differential current

4.1.3 Transformer differential protection, three-winding T3WPDIF

4.1.3.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Transformer differential protection, three-winding	T3WPDIF	3Id/I	87T

4.1.3.2 Signals

Table 18: T3WPDIF Input signals

Name	Type	Default	Description
I3PW1CT1	GROUP SIGNAL	-	Three phase winding primary CT1
I3PW2CT1	GROUP SIGNAL	-	Three phase winding secondary CT1
I3PW3CT1	GROUP SIGNAL	-	Three phase winding tertiary CT1
BLOCK	BOOLEAN	0	Block of function

Table 19: T3WPDIF Output signals

Name	Type	Description
TRIP	BOOLEAN	General trip signal
TRIPRES	BOOLEAN	Trip signal from restrained differential protection
TRIPUNRE	BOOLEAN	Trip signal from unrestrained differential protection
TRNSUNR	BOOLEAN	Trip signal from unrestrained negative sequence differential protection
TRNSSENS	BOOLEAN	Trip signal from sensitive negative sequence differential protection
START	BOOLEAN	General start signal
STL1	BOOLEAN	Start signal from phase L1
STL2	BOOLEAN	Start signal from phase L2
STL3	BOOLEAN	Start signal from phase L3
BLK2H	BOOLEAN	General second harmonic block signal
BLK5H	BOOLEAN	General fifth harmonic block signal
BLKWAV	BOOLEAN	General block signal from waveform criteria
IDALARM	BOOLEAN	General alarm for sustained differential currents
IDL1MAG	REAL	Magnitude of fundamental frequency differential current, phase L1

Table continues on next page

Name	Type	Description
IDL2MAG	REAL	Magnitude of fundamental frequency differential current, phase L2
IDL3MAG	REAL	Magnitude of fundamental frequency differential current, phase L3
IBIAS	REAL	Magnitude of the bias current, which is common to all phases
IDNSMAG	REAL	Magnitude of the negative sequence differential current

4.1.3.3 Settings

Table 20: T3WPDIF Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
IdMin	0.05 - 0.60	IB	0.01	0.30	Section 1 sensitivity current, usually W1 current
EndSection1	0.20 - 1.50	IB	0.01	1.25	End of section 1, multiple of W1 rated current
EndSection2	1.00 - 10.00	IB	0.01	3.00	End of section 2, multiple of W1 rated current
SlopeSection2	10.0 - 50.0	%	0.1	40.0	Slope in section 2 of operate-restrain characteristics
SlopeSection3	30.0 - 100.0	%	0.1	80.0	Slope in section 3 of operate-restrain characteristics
IdUnre	1.00 - 50.00	IB	0.01	10.00	Unrestrained protection limit, multiple of W1 rated current
I2/I1Ratio	5.0 - 100.0	%	1.0	15.0	Maximum ratio of 2nd harmonic to fundamental harmonic differential current
I5/I1Ratio	5.0 - 100.0	%	1.0	25.0	Maximum ratio of 5th harmonic to fundamental harmonic differential current
CrossBlockEn	Off On	-	-	On	Operation Off/On for cross-block logic between phases
NegSeqDiffEn	Off On	-	-	On	Operation Off/On for negative sequence differential function
IMinNegSeq	0.02 - 0.20	IB	0.01	0.04	Minimum negative sequence current
NegSeqROA	30.0 - 120.0	Deg	0.1	60.0	Operate angle for internal/external negative sequence fault discriminator
SOTFMode	Off On	-	-	On	Operation mode for switch onto fault function
IDiffAlarm	0.05 - 1.00	IB	0.01	0.20	Differential current alarm, multiple of base current, usually W1 current
tAlarmDelay	0.000 - 60.000	s	0.001	10.000	Time delay for differential current alarm

Table 21: T3WPDIF Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
GlobalBaseSelW1	1 - 6	-	1	1	Global base selector for winding 1
GlobalBaseSelW2	1 - 6	-	1	1	Global base selector for winding 2
GlobalBaseSelW3	1 - 6	-	1	1	Global base selector for winding 3
ConnectTypeW1	WYE (Y) Delta (D)	-	-	WYE (Y)	Connection type of winding 1: Y-wye or D-delta
ConnectTypeW2	WYE (Y) Delta (D)	-	-	WYE (Y)	Connection type of winding 2: Y-wye or D-delta
ConnectTypeW3	WYE (Y) Delta (D)	-	-	Delta (D)	Connection type of winding 3: Y-wye or D-delta
ClockNumberW2	0 [0 deg] 1 [30 deg lag] 2 [60 deg lag] 3 [90 deg lag] 4 [120 deg lag] 5 [150 deg lag] 6 [180 deg] 7 [150 deg lead] 8 [120 deg lead] 9 [90 deg lead] 10 [60 deg lead] 11 [30 deg lead]	-	-	0 [0 deg]	Phase displacement between W2 & W1=HV winding, hour notation
ClockNumberW3	0 [0 deg] 1 [30 deg lag] 2 [60 deg lag] 3 [90 deg lag] 4 [120 deg lag] 5 [150 deg lag] 6 [180 deg] 7 [150 deg lead] 8 [120 deg lead] 9 [90 deg lead] 10 [60 deg lead] 11 [30 deg lead]	-	-	5 [150 deg lag]	Phase displacement between W3 & W1=HV winding, hour notation
ZSCurrSubtrW1	Off On	-	-	On	Enable zero sequence subtraction for W1 side, Off/On
ZSCurrSubtrW2	Off On	-	-	On	Enable zero sequence subtraction for W2 side, Off/On
ZSCurrSubtrW3	Off On	-	-	On	Enable zero sequence subtraction for W3 side, Off/On

4.1.3.4 Monitored data

Table 22: T3WPDIF Monitored data

Name	Type	Values (Range)	Unit	Description
IDL1MAG	REAL	-	A	Magnitude of fundamental frequency differential current, phase L1
IDL2MAG	REAL	-	A	Magnitude of fundamental frequency differential current, phase L2
IDL3MAG	REAL	-	A	Magnitude of fundamental frequency differential current, phase L3
IBIAS	REAL	-	A	Magnitude of the bias current, which is common to all phases
IDNSMAG	REAL	-	A	Magnitude of the negative sequence differential current

4.1.4 Operation principle

The task of the power transformer differential protection is to determine whether a fault is within the protected zone, or outside the protected zone. The protected zone is delimited by the position of current transformers (see figure 29), and in principle can include more objects than just transformer. If the fault is found to be internal, the faulty power transformer must be quickly disconnected.

The main CTs are normally supposed to be star connected. The main CTs can be stared in any way (that is, either "ToObject" or "FromObject"). However internally the differential function will always use reference directions towards the protected transformer as shown in figure 29. Thus the IED will always internally measure the currents on all sides of the power transformer with the same reference direction towards the power transformer windings as shown in figure 29. For more information refer Application manual.

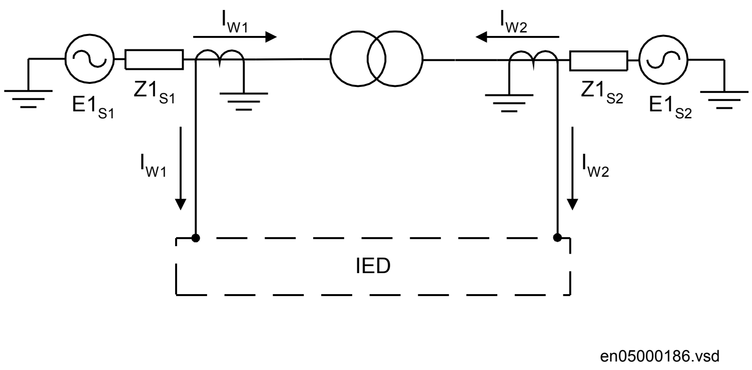


Figure 29: Typical CT location and definition of positive current direction

Even in a healthy power transformer, the currents are generally not equal when they flow through the power transformer, due to the ratio of the number of turns of the windings and the connection group of the protected transformer. Therefore the differential protection must first correlate all currents to each other before any calculation can be performed.

In numerical differential protections this correlation and comparison is performed mathematically. First, compensation for the protected transformer transformation ratio and connection group is made, and only then the currents are compared phase-wise. This makes the external auxiliary (that is, interposing) current transformers unnecessary. Conversion of all currents to the common reference side of the power transformer is performed by pre-programmed coefficient matrices, which depend on the protected power transformer transformation ratio and connection group. Once the power transformer vector group and rated currents and voltages has been entered by the user, the differential protection is capable to calculate off-line matrix coefficients required in order to perform the on-line current comparison by means of a fixed equation.

4.1.4.1 Differential current alarm

Fundamental frequency differential current level is monitored all the time within the differential function. As soon as all three fundamental frequency differential currents are above set threshold defined by setting parameter *IDiffAlarm* a delay on pickup timer is started. When the pre-set time, defined by setting parameter *tAlarmDelay*, has expired the differential current alarm is generated and output signal IDALARM is set to logical value one.

4.1.4.2 Bias current

The bias current is calculated as the highest current amongst individual winding current contributions to the total fundamental frequency differential currents. All individual winding current contributions are already referred to the power transformer winding one side (power transformer HV winding) and therefore they can be compared regarding their magnitudes. There are six (or nine in case of three-winding transformer) contributions to the total fundamental differential currents, which are the candidates for the common bias current. The highest individual current contribution is taken as a common bias (restrain) current for all three phases. This "maximum principle" makes the differential protection more secure, with less risk to operate for external faults and in the same time brings more meaning to the breakpoint settings of the operate - restrain characteristic.

The magnitudes of the common bias (restrain) current expressed in the HV side Amperes can be read as service values from the function. At the same time it is available as outputs IBIAS from the differential protection function block. Thus, it can be connected to the disturbance recorder and automatically recorded during any external or internal fault condition.

4.1.4.3 Elimination of zero sequence currents

The zero sequence currents can be explicitly eliminated from the differential currents and common bias current calculation by special, dedicated parameter settings, which are available for every individual winding.

Elimination of the zero sequence component of current is necessary whenever:

- the protected power transformer cannot transform the zero sequence currents to the other side, for any reason.

In most cases, power transformers do not properly transform the zero sequence current to the other side. A typical example is a power transformer of the star-delta type, for example YNd1. Transformers of this type do not transform the zero sequence quantities, but zero sequence currents can flow in the earthed star-connected winding. In such cases, an external earth-fault on the star-side causes the zero sequence currents to flow on the star-side of the power transformer, but not on the other side. This results in false differential currents - consisting exclusively of the zero sequence currents. If high enough, these false differential currents can cause an unwanted disconnection of the healthy power transformer. They must therefore be subtracted from the fundamental frequency differential currents if an unwanted trip is to be avoided.

For delta windings this feature shall be enabled only if an earthing transformer exist within differential zone on the delta side of the protected power transformer.

Removing the zero sequence current from the differential currents decreases to some extent sensitivity of the differential protection for internal earth-faults. In order to counteract this effect to some degree, the zero sequence currents are subtracted not only from the three fundamental frequency differential currents, but automatically from the bias current as well.

4.1.4.4 Restrained, and unrestrained limits of the differential protection

Power transformer differential protection function uses two limits, to which actual magnitudes of the three fundamental frequency differential currents are compared at each execution of the function.

The unrestrained (that is, non-stabilized, "instantaneous") part of the differential protection is used for very high differential currents, where it should be beyond any doubt, that the fault is internal. This settable limit is constant (that is, not proportional to the bias current). Neither harmonic, nor any other restrain is applied to this limit, which is therefore allowed to trip power transformer instantaneously.

The restrained (that is, stabilized) part of the differential protection compares the calculated fundamental differential (that is, operating) currents, and the bias (that is, restrain) current, by applying them to the operate - restrain characteristic. Practically, the magnitudes of the individual fundamental frequency differential currents are compared with an adaptive limit. This limit is adaptive because it is dependent on the bias (that is, restrain) current magnitude. This limit is called the operate - restrain characteristic. It is represented by a double-slope, double-breakpoint characteristic, as shown in figure 30. The restrained characteristic is determined by the following 5 settings:

1. *IdMin* (Sensitivity in section 1, multiple of trans. HV side rated current set under the parameter Ibase in GlobalbaseSelW1)
2. *EndSection1* (End of section 1, as multiple of transformer HV side rated current set under the parameter Ibase in GlobalbaseSelW1)
3. *EndSection2* (End of section 2, as multiple of transformer HV side rated current set under the parameter Ibase in GlobalbaseSelW1)
4. *SlopeSection2* (Slope in section 2, as multiple of transformer HV side rated current set under the parameter Ibase in GlobalbaseSelW1)
5. *SlopeSection3* (Slope in section 2, as multiple of transformer HV side rated current set under the parameter Ibase in GlobalbaseSelW1)

The restrained characteristic in figure 30 is defined by the settings:

1. *IdMin*
2. *EndSection1*
3. *EndSection2*
4. *SlopeSection2*
5. *SlopeSection3*

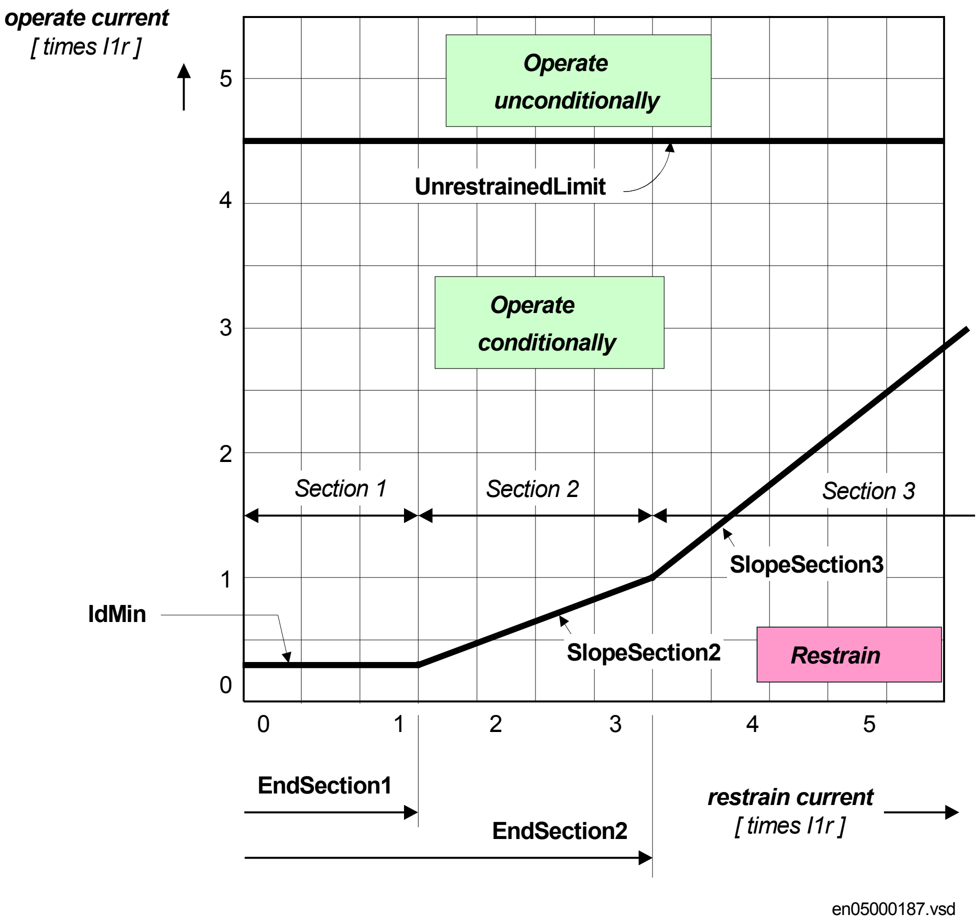


Figure 30: Description of the restrained, and the unrestrained operate characteristics

where:

$$slope = \frac{\Delta Ioperate}{\Delta Irestrain} \cdot 100\%$$

The operate - restrain characteristic is tailor-made and can be designed freely by the user after his needs. The default characteristic is recommended to be used. It gives good results in a majority of applications. The operate - restrain characteristic has in principle three sections with a section-wise proportionality of the operate value to the bias (restrain) current. The reset ratio is in all parts of the characteristic is equal to 0.95.

Section 1: This is the most sensitive part on the characteristic. In section 1, normal currents flow through the protected circuit and its current transformers, and risk for higher false differential currents is relatively low. Un-compensated on-load tap-changer is a typical reason for existence of the false differential currents in this section. Slope in section 1 is always zero percent.

Section 2: In section 2, a certain minor slope is introduced which is supposed to cope with false differential currents proportional to higher than normal currents through the current transformers.

Section 3: The more pronounced slope in section 3 is designed to result in a higher tolerance to substantial current transformer saturation at high through-fault currents, which may be expected in this section.

The operate - restrain characteristic should be designed so that it can be expected that:

- for internal faults, the operate (differential) currents are always safely, that is, with a good margin, above the operate - restrain characteristic
- for external faults, the false (spurious) operate currents are safely, that is, with a good margin, below the operate - restrain characteristic

4.1.4.5 Fundamental frequency negative sequence differential currents

Existence of relatively high negative sequence currents is in itself a proof of a disturbance on the power system, possibly a fault in the protected power transformer. The negative-sequence currents are measurable indications of abnormal conditions, similar to the zero sequence currents. One of the several advantages of the negative sequence currents compared to the zero sequence currents is however that they provide coverage for phase-to-phase and power transformer turn-to-turn faults as well, not only for earth-faults. Theoretically the negative sequence currents do not exist during symmetrical three-phase faults, however they do appear during initial stage of such faults for long enough time (in most cases) for the IED to make proper decision. Further, the negative sequence currents are not stopped at a power transformer of the Yd, or Dy connection. The negative sequence currents are always properly transformed to the other side of any power transformer for any external disturbance. Finally, the negative sequence currents are not affected by symmetrical through-load currents.

The magnitudes of the negative sequence differential current expressed in the HV side A can be read as service values from the function. In the same time it is available as outputs IDNSMAG from the differential protection function block. Thus, it can be connected to the disturbance recorder and automatically recorded during any external or internal fault condition.

4.1.4.6 Internal/external fault discriminator

The internal/external fault discriminator is a very powerful and reliable supplementary criterion to the traditional differential protection. It is recommended that this feature shall be always used (that is, enabled On) when protecting three-phase power transformers. The internal/external fault discriminator detects even minor faults, with a high sensitivity and at high speed, and at the same time discriminates with a high degree of dependability between internal and external faults.

Operation of the internal/external fault discriminator is based on the relative position of the two phasors representing winding one (W1) and winding two (W2) negative sequence current contributions, respectively. It performs a directional comparison between these two phasors. First, the LV side phasor is is referred to the HV side (W1 side). Then the relative phase displacement between the two negative sequence current phasors is calculated. In case of three-winding power transformers, a little more complex algorithm is applied, with two directional tests. The overall directional characteristic of the internal/external fault discriminator is shown in figure 31, where the directional characteristic is defined by two setting parameters:

1. *IMinNegSeq*
2. *NegSeqROA*

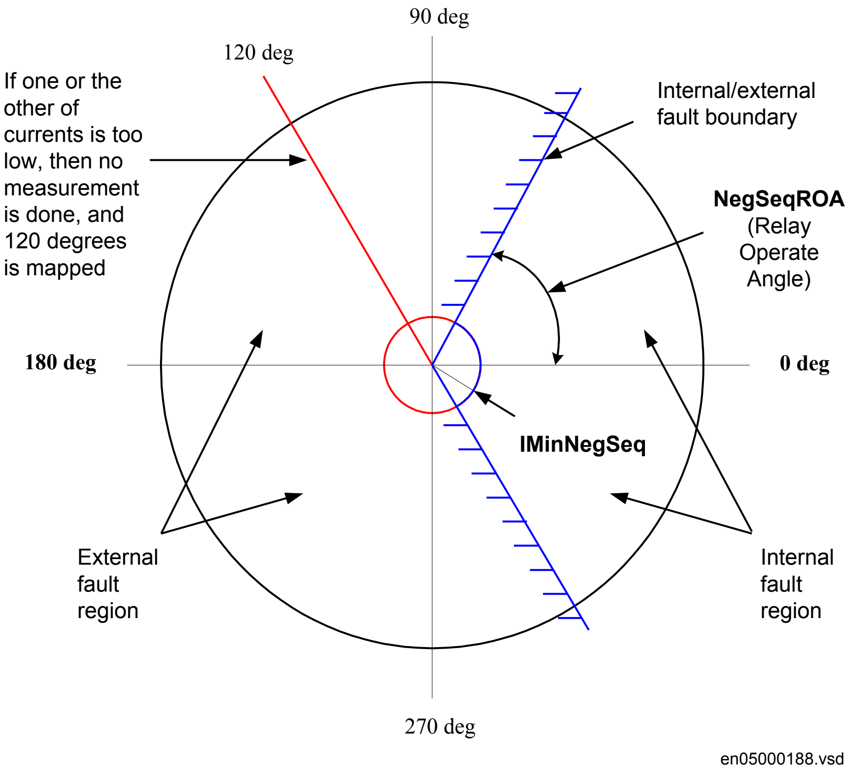


Figure 31: Operating characteristic of the internal/external fault discriminator

In order to perform directional comparison of the two phasors their magnitudes must be high enough so that one can be sure that they are due to a fault. On the other hand, in order to guarantee a good sensitivity of the internal/external fault discriminator, the value of this minimum limit must not be too high. Therefore this limit value, called *IminNegSeq*, is settable in the range of 0.02 to 0.20 times the IBase of the power transformer winding one. The default value is 0.04. Note that, in order to enhance stability at higher fault currents, the relatively very low threshold value *IminNegSeq* is dynamically increased at currents higher than normal currents: if the bias current is higher that 110 % IBase current, than 10 % od the bias current is added to the *IminNegSeq*. Only if magnitudes of both negative sequence current contributions are above the actual limit, the relative position between these two phasors is checked. If either of the negative sequence current contributions, which should be compared, is too small (less than the set value for *IminNegSeq*), no directional comparison is made in order to avoid the possibility to produce a wrong decision. The setting *NegSeqROA* represents the so-called Relay Operate Angle, which determines the boundary between the internal and external fault regions. It can be selected in the range from ±30 degrees to ±120 degrees, with a step of 0.1 degree. The default value is ±60 degrees. The default setting ±60 degree favours somewhat security in comparison to dependability.

If the above condition concerning magnitudes is fulfilled, the internal/external fault discriminator compares the relative phase angle between the negative sequence current contributions from the W1 and W2 sides of the power transformer using the following two rules:

- If the negative sequence currents contributions from W1 and W2 sides are in phase, the fault is internal (that is, both phasors are within protected zone)
- If the negative sequence currents contributions from W1 and W2 sides are 180 degrees out of phase, the fault is external (that is, W1 phasors is outside protected zone)

For example, for any unsymmetrical external fault, ideally the respective negative sequence current contributions from the W1 and W2 power transformer sides will be exactly 180 degrees apart and equal in magnitude, regardless the power transformer turns ratio and phase displacement. One such example is shown in figure 32, which shows trajectories of the two separate phasors representing the negative sequence current contributions from HV and LV sides of an Yd5 power transformer (for example, after the compensation of the transformer turns ratio and phase displacement for an unsymmetrical external fault. Observe that the relative phase angle between these two phasors is 180 electrical degrees at any point in time. No current transformer saturation was assumed for this case.

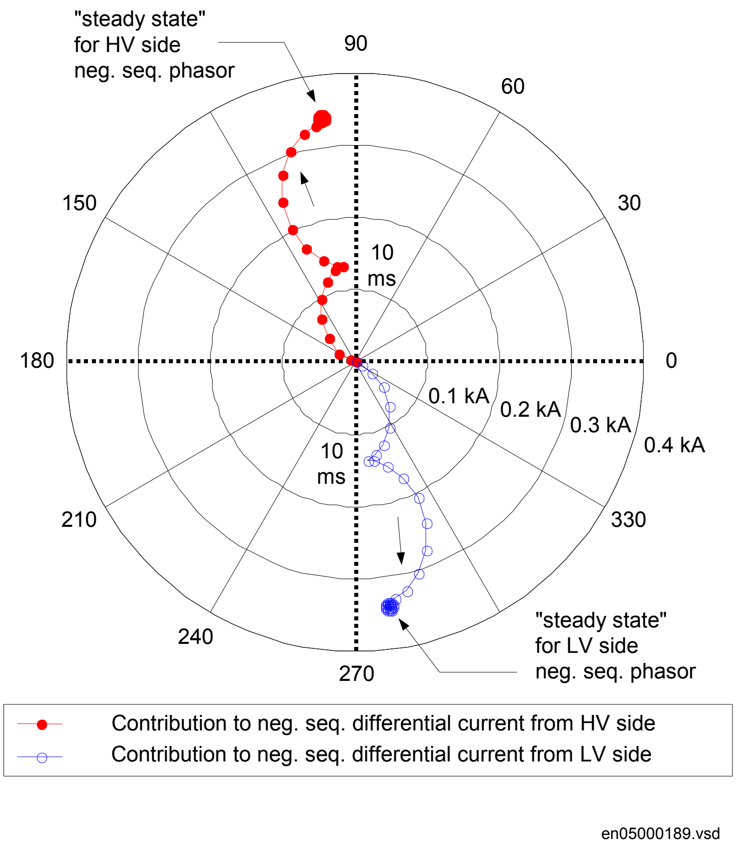


Figure 32: Trajectories of Negative Sequence Current Contributions from HV and LV sides of Yd5 power transformer during external fault

Therefore, under all external fault condition, the relative angle is theoretically equal to 180 degrees. During internal fault, the angle shall ideally be 0 degrees, but due to possible different negative sequence source impedance angles on W1 and W2 sides of the protected power transformer, it may differ somewhat from the ideal zero value. However, during heavy faults, CT saturation might cause the measured phase angle to differ from 180 degrees for external, and from about 0 degrees for internal fault. See figure 33 for an example of a heavy internal fault with transient CT saturation.

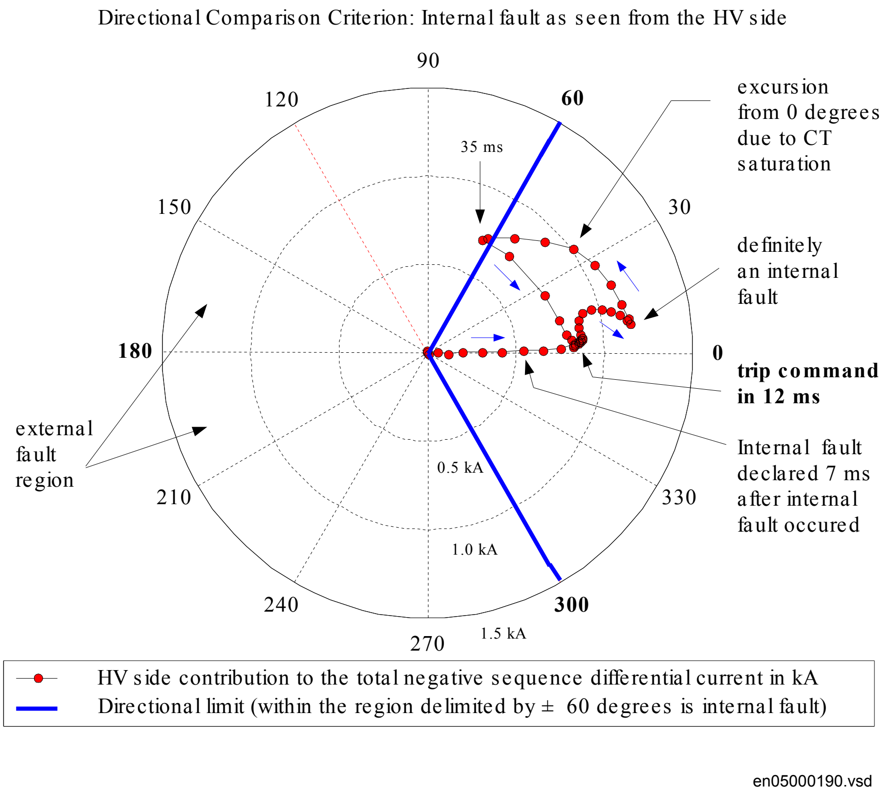


Figure 33: Operation of the internal/external fault discriminator for internal fault with CT saturation

However, it shall be noted that additional security measures are implemented in the internal/external fault discriminator algorithm in order to guaranty proper operation with heavily saturated current transformers. The trustworthy information on whether a fault is internal or external is typically obtained in about 10ms after the fault inception, depending on the setting *IminNegSeq*, and the magnitudes of the fault currents. At heavy faults, approximately 5ms time to full saturation of the main CT is sufficient in order to produce a correct discrimination between internal and external faults.

4.1.4.7 Unrestrained, and sensitive negative sequence protections

Two sub functions, which are based on the internal/external fault discriminator with the ability to trip a faulty power transformer, are parts to the traditional power transformer differential protection.

The unrestrained negative sequence differential protection

If one or more start signals have been set by the traditional differential protection algorithm, because one or more of the fundamental frequency differential currents entered the operate region on the operate - restrain characteristic then the unrestrained negative sequence protection is activated. So, this protection is not independent of the traditional restrained differential protection - it is activated after the first start signal has been placed.

If the same fault has been positively recognized as internal, then the unrestrained negative sequence differential protection places its own trip request.

If the bias current is higher than 110 % IBase of the power transformer winding W1, then any block signals by the harmonic and/or waveform criteria, which can block the traditional differential protection are overridden, and the differential protection operates quickly without any further delay. If the bias current is lower than 110 %, where harmonic block should not exist for internal faults, then this negative sequence differential protection is restrained by any harmonic block signal.

This logic guarantees a fast disconnection of a faulty power transformer for any heavier internal faults.

If the same fault has been classified as external, then generally, but not unconditionally, a trip command is prevented. If a fault is classified as external, the further analysis of the fault conditions is initiated. If all the instantaneous differential currents in phases where start signals have been issued are free of harmonic pollution, then a (minor) internal fault, simultaneous with a predominant external fault can be suspected. This conclusion can be drawn because at external faults, major false differential currents can only exist when one or more current transformers saturate. In this case, the false instantaneous differential currents are polluted by higher harmonic components, the 2nd, the 5th etc.

Sensitive negative sequence based turn-to-turn fault protection

The sensitive, negative sequence current based turn-to-turn fault protection detects the low level faults, which are not detected by the traditional differential protection until they develop into more severe faults, including power transformer iron core. The sensitive protection is independent from the traditional differential protection and is a very good complement to it. The essential part of this sensitive protection is the internal/external fault discriminator. In order to be activated, the sensitive protection requires no start signal from the traditional power transformer biased differential protection. If magnitudes of HV and LV negative sequence current contributions are above the set limit for *IminNegSeq*, then their relative positions are determined. If the disturbance is characterized as an internal fault, then a separate trip request will be placed. Any decision on the way to the final trip request must be confirmed several times in succession in order to cope with eventual CT transients. This causes a short additional operating time delay due to this security count. For very low level turn-to-turn faults the overall response time of this protection is about 30ms. The sensitive negative sequence differential protection is automatically deactivated if the bias current becomes higher than 150 % IBase. Further, this protection can always be restrained, i. e. prevented from issuing a trip request, by any harmonic block signal. This because at rather low fault currents, which are to be detected by this protection, harmonic pollution is not likely.

4.1.4.8 Harmonic and waveform block criteria

The two block criteria are the harmonic restrain and the waveform restrain. These two criteria have the power to block (that is, to prevent) a trip command by the traditional differential protection, which produces start signals by applying the differential currents, and the bias current, to the operate - restrain characteristic.

Harmonic restrain

The harmonic restrain is the classical restrain method traditionally used with power transformer differential protections. The goal is to prevent an unwanted trip command due to magnetizing inrush currents at switching operations, or due to magnetizing currents at over-voltages.

The magnetizing currents of a power transformer flow only on one side of the power transformer (one or the other) and are therefore always the cause of false differential currents. The harmonic analysis (the 2^{nd} and the 5^{th} harmonic) is applied to instantaneous differential currents. Typically instantaneous differential currents during power transformer energizing are shown in figure 34. The harmonic analysis is only applied in those phases, where start signals have been set. For example, if the content of the 2^{nd} harmonic in the instantaneous differential current of phase L1 is above the setting *I2/I1Ratio*, then a block signal is set for that phase.

Waveform restrain

The waveform restrain criterion is a good complement to the harmonic analysis. The waveform restrain is a pattern recognition algorithm, which looks for intervals within each fundamental power system cycle with low instantaneous differential current. This interval is often called current gap in protection literature. However, within differential function this criterion actually searches for long-lasting intervals with low rate-of-change in instantaneous differential current, which are typical for the power transformer inrush currents. Block signal BLKWAV is set in those phases where such behavior is detected. The algorithm do not requires any end user settings. The waveform algorithm is automatically adapted dependent only on the power transformer rated data.

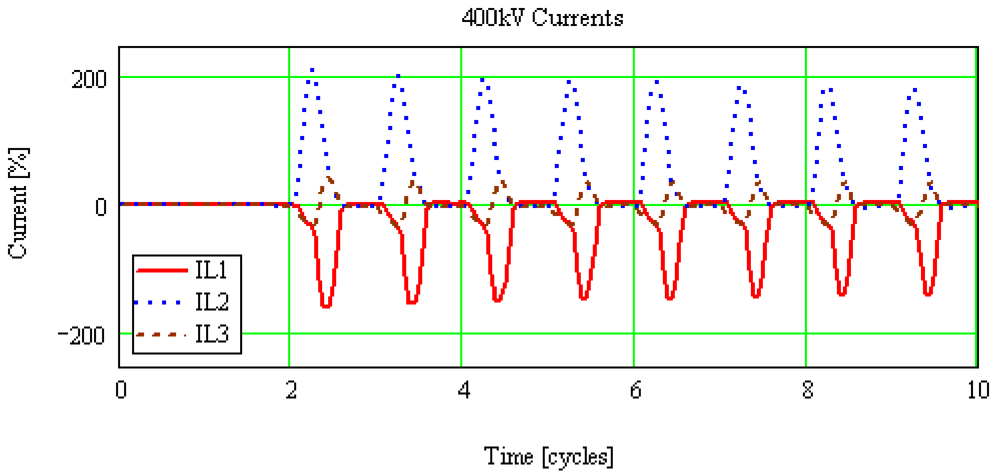


Figure 34: Inrush currents to a transformer as seen by a protective IED. Typical is a high amount of the 2^{nd} harmonic, and intervals of low current, and low rate-of-change of current within each period.

Cross-blocking between phases

Basic definition of the cross-blocking is that one of the three phases can block operation (that is,tripping) of the other two phases due to the harmonic pollution of the differential current in that phase (that is, waveform, 2^{nd} or 5^{th} harmonic content). In differential algorithm the user can control the cross-blocking between the phases via the setting parameter *CrossBlockEn=On*.

When parameter *CrossBlockEn=On* cross blocking between phases is introduced. There is no time settings involved, but the phase with the operating point above the set bias characteristic (in the operate region) will be able to cross-block other two phases if it is itself blocked by any of the previously explained restrained criteria. If the start signal in this phase is removed, i. e. reset from TRUE to FALSE, cross blocking from that phase will be inhibited. In this way cross-blocking of the temporary nature is achieved. In should be noted that this is the default (recommended) setting value for this parameter.

When parameter *CrossBlockEn=Off*, any cross blocking between phases will be disabled. It is recommended to use the value Off with caution in order to avoid the unwanted tripping during initial energizing of the power transformer.

4.1.4.9 Switch onto fault feature

Transformer differential function in the IED has a built-in, advanced switch onto fault feature. This feature can be enabled or disabled by a setting parameter *SOTFMode*. When enabled this feature ensures quick differential protection tripping in cases where a transformer is energized with a more severe (minor faults cannot be discovered) internal fault (for example, forgotten earthing on transformer LV side e.g. after a regular service). The feature is based on the waveform check. If a severe internal fault exists, then, when the power transformer is energized, the magnetic density in the iron core will be low and high sinusoidal currents will flow from the very beginning. The waveform block algorithm will in such a case remove all its three block signals in a very short interval of time. A quick reset of the waveblock criterion will temporarily disable the second harmonic blocking feature within the differential function. This consequently ensures fast operation of the transformer differential function for a switch onto a fault condition. It shall be noted that this feature is only active during initial power transformer energizing, more exactly, under the first 50 ms. When the switch onto fault feature is disabled by the setting parameter *SOTFMode*, the waveblock and second harmonic blocking features work in parallel and are completely independent from each other.

4.1.4.10 Logic diagram

The simplified internal logics, for transformer differential protection are shown in the following figures.

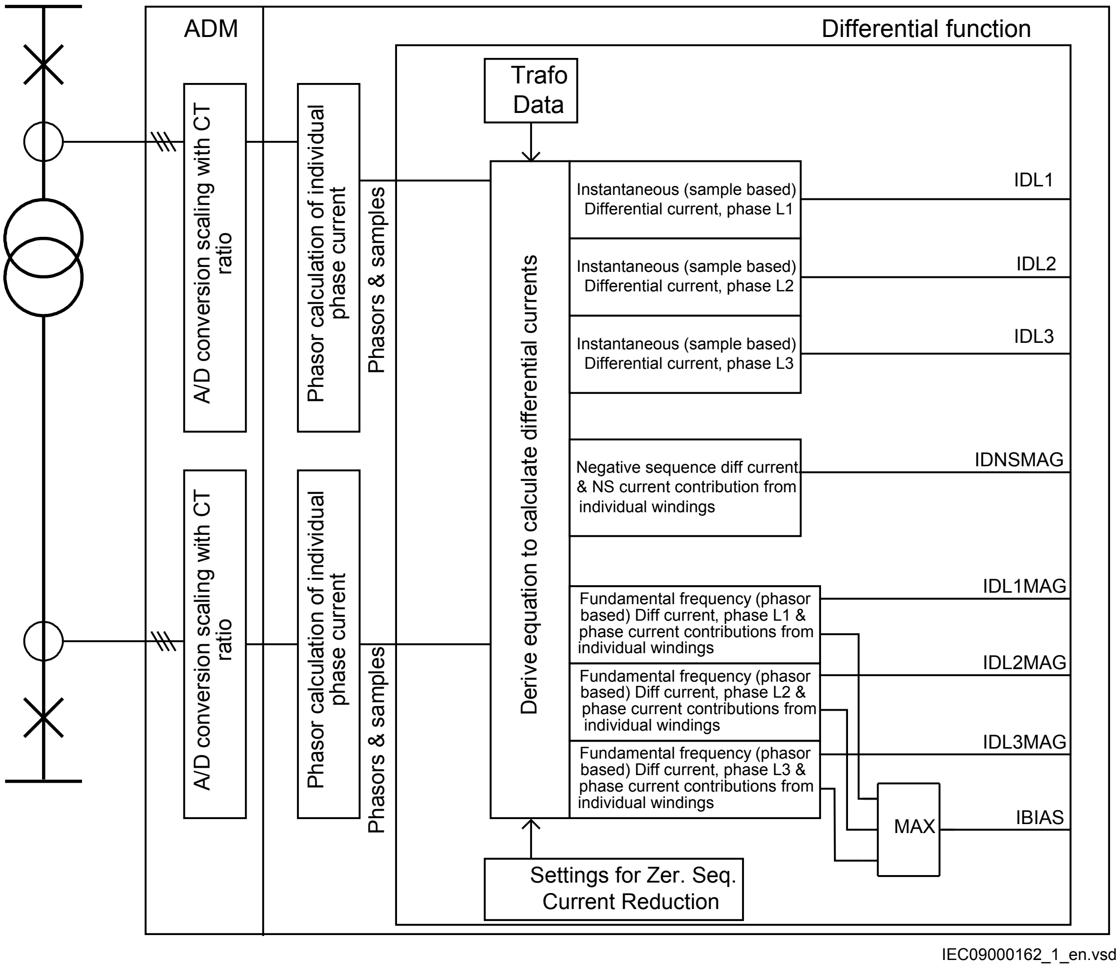


Figure 35: Treatment of measured currents within IED for transformer differential function

Figure 35 shows how internal treatment of measured currents is done in case of two-winding transformer.

The following currents are inputs to the power transformer differential protection function. They must all be expressed in true power system (primary) A, that is, as measured.

1. Instantaneous values of currents (samples) from HV, and LV sides for two-winding power transformers, and from the HV, the first LV, and the second LV sides for three-winding power transformers.
2. Currents from all power transformer sides expressed as fundamental frequency phasors, with their real, and imaginary parts. These currents are calculated within the protection function by the fundamental frequency Fourier filters.
3. Negative sequence currents from all power transformer sides expressed as phasors. These currents are calculated within the protection function by the symmetrical components module.

4.1.5 Technical data

Table 23: T2WPDIF, T3WPDIF Technical data

Function	Range or value	Accuracy
Operating characteristic	Adaptable	± 1.0% of Ir for I < Ir ± 1.0% of Ir for I > Ir
Reset ratio	> 95%	-
Unrestrained differential current limit	(1.00-50.00)x IBase on high voltage winding	± 1.0% of set value
Base sensitivity function	(0.05 - 0.60) x IBase	± 1.0% of Ir
Minimum negative sequence current	(0.02 - 0.20) x IBase	± 1,0% of I_r
Operate angle, negative sequence	(30.0 - 120.0) degrees	± 2,0 degrees
Second harmonic blocking	(5.0-100.0)% of fundamental	± 2.0% of Ir
Fifth harmonic blocking	(5.0-100.0)% of fundamental	± 5.0% of Ir
Connection type for each of the windings	Y or D	-
Phase displacement between high voltage winding, W1 and each of the windings, W2 and W3. Hour notation	0–11	-
Operate time, restrained function	25 ms typically at 0 to 5 x Id	-
Reset time, restrained function	20 ms typically at 5 to 0 x Id	-
Operate time, unrestrained function	20 ms typically at 0 to 5 x Id	-
Reset time, unrestrained function	20 ms typically at 5 to 0 x Id	-
Critical impulse time	2 ms typically at 0 to 5 x Id	-

4.2 Restricted earth-fault protection, low impedance REFPDIF

4.2.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Restricted earth fault protection, low impedance	REFPDIF	IdN/I	87N

4.2.2 Functionality

Restricted earth-fault protection, low impedance function (REFPDIF) can be used on all directly or low impedance earthed windings. REFPDIF function can provide higher sensitivity (down to 5%) and higher speed as it measures individually on each winding and thus do not need inrush stabilization.

The low impedance function is a percentage biased function with an additional zero sequence current directional comparison criteria. This gives excellent sensitivity and stability for through faults. The function allows use of different CT ratios and magnetizing characteristics on the phase and neutral CT cores and mixing with other functions and protection IEDs on the same cores.

4.2.3 Function block

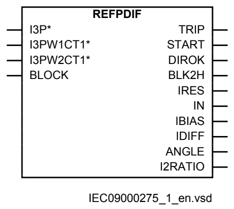


Figure 36: REFPDIF function block

4.2.4 Signals

Table 24: REFPDIF Input signals

Name	Type	Default	Description
I3P	GROUP SIGNAL	-	Group signal for neutral current input
I3PW1CT1	GROUP SIGNAL	-	Group signal for primary CT1 current input
I3PW2CT1	GROUP SIGNAL	-	Group signal for secondary CT1 current input
BLOCK	BOOLEAN	0	Block of function

Table 25: REFPDIF Output signals

Name	Type	Description
TRIP	BOOLEAN	General trip signal
START	BOOLEAN	General start signal
DIROK	BOOLEAN	Directional criteria has operated for internal fault
BLK2H	BOOLEAN	Block due to 2-nd harmonic
IRES	REAL	Magnitude of fundamental frequency residual current
Table continues on next page		

Name	Type	Description
IN	REAL	Magnitude of fundamental frequency neutral current
IBIAS	REAL	Magnitude of the bias current
IDIFF	REAL	Magnitude of fundamental frequency differential current
ANGLE	REAL	Direction angle from zero sequence feature
I2RATIO	REAL	Second harmonic ratio

4.2.5 Settings

Table 26: REFPDIF Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
IdMin	4.0 - 100.0	%IB	0.1	10.0	Maximum sensitivity in % of IBase

Table 27: REFPDIF Group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
ROA	60 - 90	Deg	1	60	Relay operate angle for zero sequence directional feature

Table 28: REFPDIF Non group settings (basic)

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

4.2.6 Monitored data

Table 29: REFPDIF Monitored data

Name	Type	Values (Range)	Unit	Description
IRES	REAL	-	A	Magnitude of fundamental frequency residual current
IN	REAL	-	A	Magnitude of fundamental frequency neutral current
IBIAS	REAL	-	A	Magnitude of the bias current
IDIFF	REAL	-	A	Magnitude of fundamental frequency differential current
ANGLE	REAL	-	deg	Direction angle from zero sequence feature
I2RATIO	REAL	-	-	Second harmonic ratio

4.2.7 Operation principle

4.2.7.1 Fundamental principles of the restricted earth-fault protection

Restricted earth-fault protection, low impedance function (REFPDIF) should detect earth-faults on earthed power transformer windings. REFPDIF is a unit protection of differential type. Since REFPDIF is based on the zero sequence currents, which theoretically only exist in case of an earth-fault, the REFPDIF can be made very sensitive; regardless of normal load currents. It is the fastest protection a power transformer winding can have. It must be borne in mind, however, that the high sensitivity, and the high speed, tend to make such a protection instable, and special measures must be taken to make it insensitive to conditions, for which it should not operate, for example heavy through faults of phase-to-phase type, or heavy external earth-faults.

REFPDIF is of “low impedance” type. All three phase currents, and the neutral point current, must be fed separately to REFPDIF. These input currents are then conditioned within REFPDIF by mathematical tools.

Fundamental frequency components of all currents are extracted from all input currents, while other eventual zero sequence components (for example, the 3rd harmonic currents) are fully suppressed. Then the residual current phasor is constructed from the three line current phasors. This zero sequence current phasor is then vectorially added to the neutral current, in order to obtain differential current.

The following facts may be observed from the figure 37 and the figure 38 (where the three-phase line CTs are lumped into a single $3I_o$ current, for the sake of simplicity).

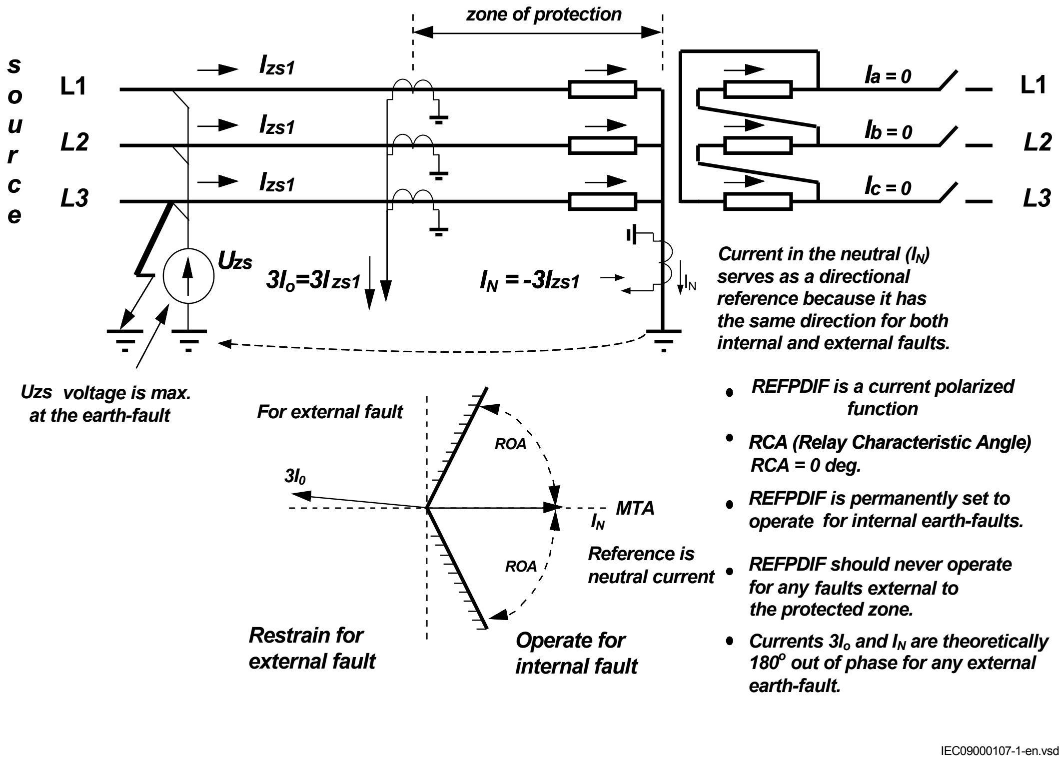


Figure 37: Currents at an external earth-fault.

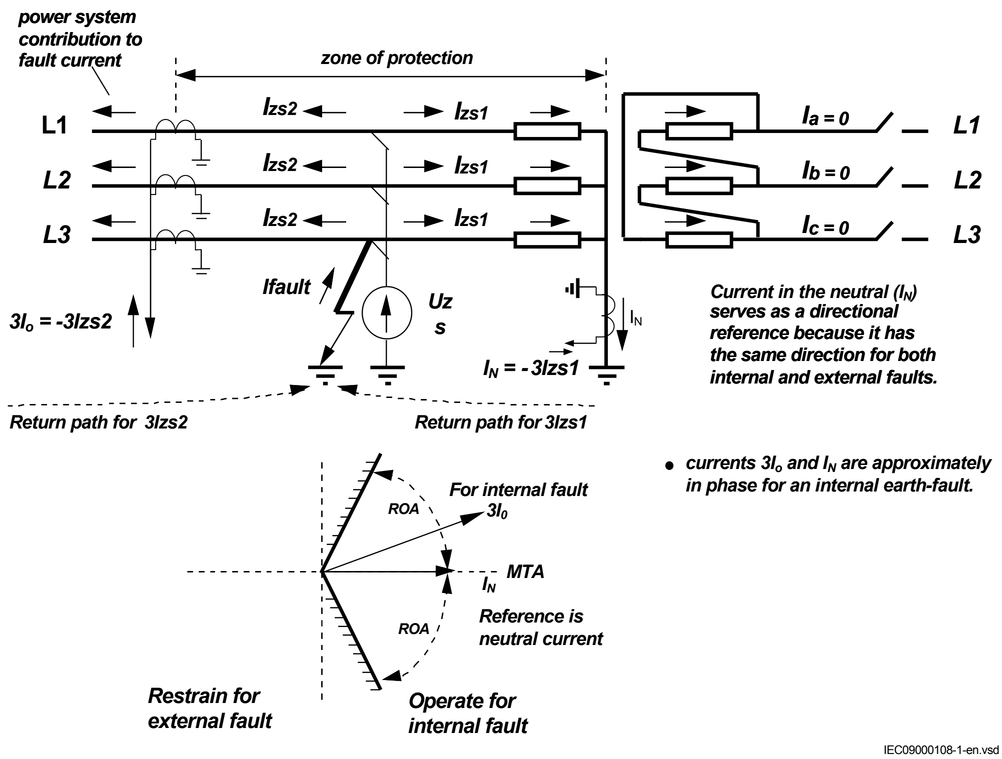


Figure 38: Currents at an internal earth-fault.

1. For an external earth-fault, (figure 37) the residual current $3I_o$ and the neutral conductor current I_N have equal magnitude, but they are 180 degree out-of-phase due to internal CT reference directions used in the IED. This is easy to understand, as both CTs ideally measure exactly the same component of the earth-fault current.
2. For an internal fault, the total earth-fault current is composed generally of two zero sequence components. One zero sequence component (that is, $3I_{ZS1}$) flows towards the power transformer neutral point and into the earth, while the other zero sequence component (that is, $3I_{ZS2}$) flows out into the connected power system. These two primary currents can be expected to be of approximately opposite directions (about the same zero sequence impedance angle is assumed on both sides of the earth-fault). However, on the secondary CT sides they will be approximately in phase due to internal CT reference directions used in the IED. The magnitudes of the two components may be different, dependent on the magnitudes of zero sequence impedances of both sides. No current can flow towards the power system, if the only point where the system is earthed, is at the protected power transformer. Likewise, no current can flow into the power system, if the winding is not connected to the power system (circuit breaker open and power transformer energized from the other side).
3. For both internal and external earth-faults, the current in the neutral connection I_N has always the same direction, that is, towards the earth.
4. The two measured zero sequence current are $3I_o$ and I_N. The vectorial sum between them is the REFPDIF differential current, which is equal to $Idiff = I_N + 3I_o$.

Since REFPDIF is a differential protection where the line zero sequence (residual) current is constructed from 3 line (terminal) currents, a bias quantity must give stability against false operations due to high through fault currents. An operate - bias characteristic (only one) has been devised to the purpose.

It is not only external earth-faults that REFPDIF should be stable against, but also heavy phase-to-phase faults, not including earth. These faults may also give rise to false zero sequence currents due to saturated line CTs. Such faults, however, produce no neutral current, and can thus be eliminated as a source of danger, at least during the fault.

As an additional measure against unwanted operation, a directional check is made in agreement with the above points 1, and 2. An operation is only allowed if currents $3I_o$ and I_N (see the figure 37 and the figure 38) are both within the operating region. By taking a smaller ROA, REFPDIF can be made more stable under heavy external fault conditions, as well as under the complex conditions, when external faults are cleared by other protections.

4.2.7.2 Restricted earth-fault protection, low impedance as a differential protection

Restricted earth-fault protection, low impedance (REFPDIF) is a protection of differential type, a unit protection, whose settings are independent of any other protection. Compared to the transformer differential protection it has some advantages. It is simpler, as no current phase correction and magnitude correction are needed, not even in the case of an eventual On-Load Tap-Changer (OLTC). REFPDIF is not sensitive to inrush and overexcitation currents. The only danger left is an eventual current transformer saturation.

REFPDIF has only one operate-bias characteristic, which is described in the table 30, and shown in the figure 39.

Table 30: Data of the operate - bias characteristic of REFPDIF.

Default sensitivity Idmin (zone 1)	Max. base sensitivity Idmin (zone 1)	Min. base sensitivity Idmin (zone 1)	End of zone 1	First slope	Second slope
% IBase	% IBase	% IBase	% IBase	%	%
30	4	100	125	70	100

As a differential protection, REFPDIF calculates a differential current and a bias current. In case of internal earth-faults, the differential current is theoretically equal to the total earth-fault current. The bias current is supposed to give stability to REFPDIF. The bias current is a measure of how high the currents are, or better, a measure of how difficult the conditions are under which the CTs operate. The higher the bias, the more difficult conditions can be suspected, and the more likely that the calculated differential current has a component of a false current, primarily due to CT saturation. This “law” is formulated by the operate-bias characteristic. This characteristic divides the Idiff - Ibias plane into two parts. The part above the operate - bias characteristic is the so called operate area, while that below is the block area, see the figure 39.

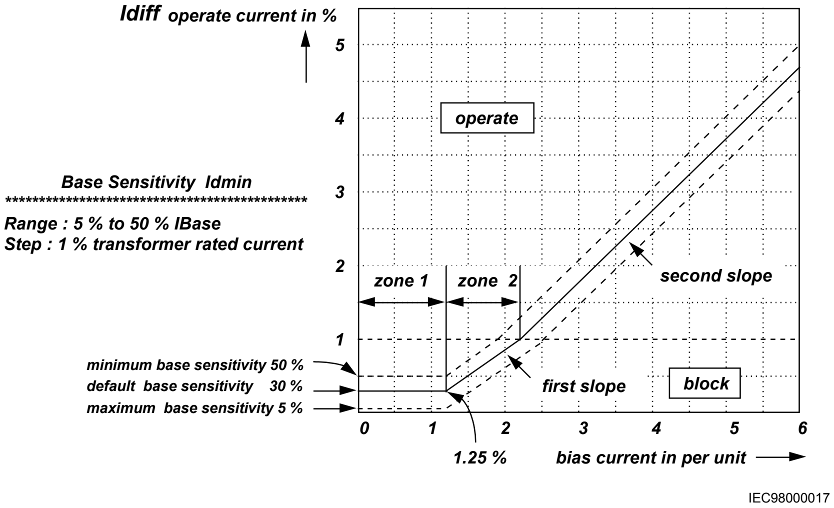


Figure 39: Operate - bias characteristic of the Restricted earth-fault protection, low impedance (REFPDIF).

4.2.7.3 Calculation of differential current and bias current

The differential current, (= operate current), as a fundamental frequency phasor, is calculated as (with designations as in the figure 37 and the figure 38)

$$Idiff = IN + 3Io$$

(Equation 2)

where:

I_N	current in the power transformer neutral as a fundamental frequency phasor,
$3I_o$	residual current of the power transformer line (terminal) currents as a phasor.

4.2.7.4 Detection of external earth-faults

External faults are more common than internal earth-faults for which the restricted earth-fault protection should operate. It is important that the restricted earth-fault protection remains stable during heavy external earth and phase-to-phase faults, and also when such a heavy external fault is cleared by some other protection such as overcurrent, or earth-fault protection, etc. The conditions during a heavy external fault, and particularly immediately after the clearing of such a fault may be complex. The circuit breaker's poles may not open exactly at the same moment, some of the CTs may still be highly saturated, etc.

The detection of external earth-faults is based on the fact that for such a fault a high neutral current appears first, while a false differential current only appears if and when one, or more, current transformers saturate.

For an internal earth-fault, a true differential current develops immediately, while for an external fault it only develops if a CT saturates. If a trip request comes first, before an external fault could be positively established, then it must be an internal fault.

If an external earth-fault has been detected, then the REFPDIF is temporarily desensitized.

Directional criterion

The directional criterion is applied in order to positively distinguish between internal- and external earth-faults. This check is an additional criterion, which should prevent malfunctions at heavy external earth-faults, and during the disconnection of such faults by other protections. Earth-faults on lines connecting the power transformer occur much more often than earth-faults on a power transformer winding. It is important therefore that the Restricted earth-fault protection, low impedance (REFPDIF) should remain secure during an external fault, and immediately after the fault has been cleared by some other protection.

For an external earth-fault with no CT saturation, the residual current in the lines ($3I_o$) and the neutral current (I_N in the figure 37) are theoretically equal in magnitude and are 180 degree out-of-phase. It is the current in the neutral (I_N) which serves as a directional reference because it flows for all earth-faults, and it has the same direction for all earth-faults, both external as well as internal. The directional criterion in REFPDIF protection makes it a current-polarized IED.

Second harmonic analysis

At energizing of a reactor a false differential current may appear in Restricted earth-fault protection, low impedance function (REFPDIF) even though it does not exist in the primary net. The phase CT's may saturate due to a high dc-component with long duration where as the current through the neutral CT does not have either the same dc-component or the same amplitude and the risk for saturation in this CT is not as high. The appearing differential current as a result of the saturation may be so high that it reaches the operate characteristic. A calculation of the content of 2^{nd} harmonic in the neutral current is made when neutral current, residual current and bias current are within some windows and some timing criteria are fulfilled. If the ratio between second and fundamental harmonic exceeds 60%, REFPDIF function will be blocked.

4.2.8 Technical data

Table 31: REFPDIF Technical data

Function	Range or value	Accuracy
Operate characteristic	Adaptable	± 1.0% of Ir_r for I < Ir ± 1.0% of I for I > Ir
Reset ratio	>95%	-
Base sensitivity function	(4.0-100.0)% of IBase	± 1.0% of I_r
Directional characteristic, for zero sequence directional function	(60 - 90) degrees	± 2.0 degree
Operate time	20 ms typically at 0 to 10 x Idiff	-
Reset time	25 ms typically at 10 to 0 x Idiff	-

Section 5 Current protection

5.1 Instantaneous phase overcurrent protection PHPIOC

5.1.1 Identification

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

5.1.2 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.

5.1.3 Function block

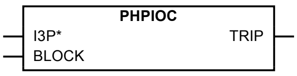


Figure 40: PHPIOC function block

5.1.4 Signals

Table 32: PHPIOC Input signals

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

Table 33: PHPIOC Output signals

Name	Type	Description
TRIP	BOOLEAN	General trip signal

5.1.5 Settings

Table 34: 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 35: PHPIOC Non group settings (basic)

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

5.1.6 Monitored data

Table 36: 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

5.1.7 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.

5.1.8 Technical data

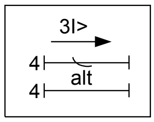
Table 37: PHPIOCTechnical data

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

5.2 Four step phase overcurrent protection OC4PTOC

5.2.1 Identification

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

5.2.2 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.

5.2.3 Function block

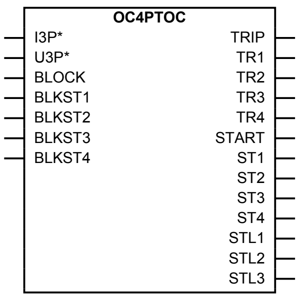


Figure 41: OC4PTOC function block

5.2.4 Signals

Table 38: 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 39: 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

5.2.5 Settings

Table 40: 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 41: 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

5.2.6 Monitored data

Table 42: 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

5.2.7 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

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:

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

(Equation 3)

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

(Equation 4)

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

(Equation 5)

Phase-earth short circuit:

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

(Equation 6)

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

(Equation 7)

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

(Equation 8)

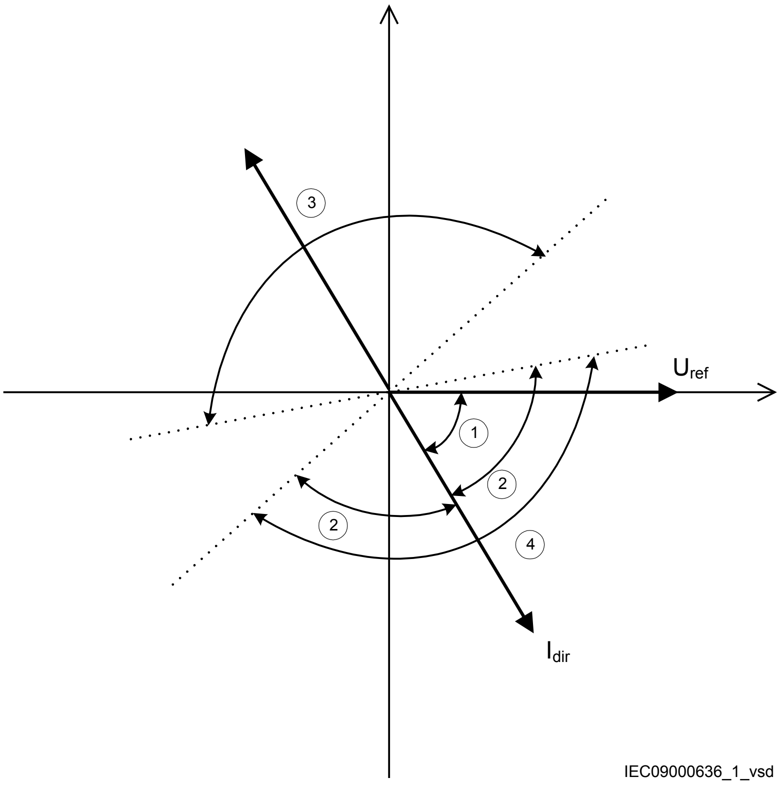


Figure 42: Directional characteristic of the phase overcurrent protection

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 18.3 "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.

5.2.8 Technical data

Table 43: OC4PTOCTechnical data

Function	Setting range	Accuracy
Operate current	(5-2500)% of IBase	± 1.0% of I_r at $I \leq I_r$ ± 1.0% of I at $I > I_r$
Reset ratio	> 95%	-
Min. operating current	(1-100)% of IBase	± 1.0% of I_r
Independent time delay	(0.000-60.000) s	± 0.5% ± 10 ms
Minimum operate time for inverse characteristics	(0.000-60.000) s	± 0.5% ± 10 ms
Inverse characteristics, see table 416, table 417 and table 418	17 curve types	See table 416, table 417 and table 418
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	-

5.3 Instantaneous residual overcurrent protection EFPIOC

5.3.1 Identification

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

5.3.2 Functionality

The single input overcurrent function has a low transient overreach and short tripping times to allow use for instantaneous earth fault protection, with the reach limited to less than typical eighty percent of the transformer impedance 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.

5.3.3 Function block

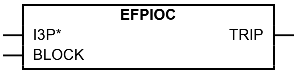


Figure 43: EFPIOC function block

5.3.4 Signals

Table 44: EFPIOC Input signals

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

Table 45: EFPIOC Output signals

Name	Type	Description
TRIP	BOOLEAN	Trip signal

5.3.5 Settings

Table 46: 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 47: EFPIOC Non group settings (basic)

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

5.3.6 Monitored data

Table 48: EFPIOC Monitored data

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

5.3.7 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.

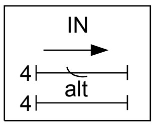
5.3.8 Technical data

Table 49: EFPIOC Technical data

Function	Range or value	Accuracy
Operate 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%	-
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	-

5.4 Four step residual overcurrent protection EF4PTOC

5.4.1 Identification

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

5.4.2 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.

5.4.3 Function block

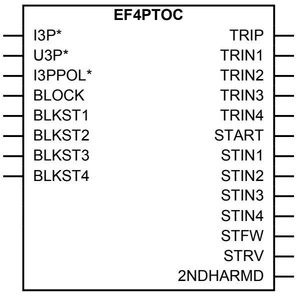


Figure 44: EF4PTOC function block

5.4.4 Signals

Table 50: 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 51: 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
Table continues on next page		

Name	Type	Description
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

5.4.5 Settings

Table 52: 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 53: EF4PTOC Non group settings (basic)

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

5.4.6 Monitored data

Table 54: 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

5.4.7 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.

5.4.7.1 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 9)

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.

5.4.7.2 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 10)

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:

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

(Equation 11)

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:

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

(Equation 12)

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:

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

(Equation 13)

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).

5.4.7.3 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.

5.4.7.4 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.

5.4.7.5 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.

5.4.7.6 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 18.3 "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 45:

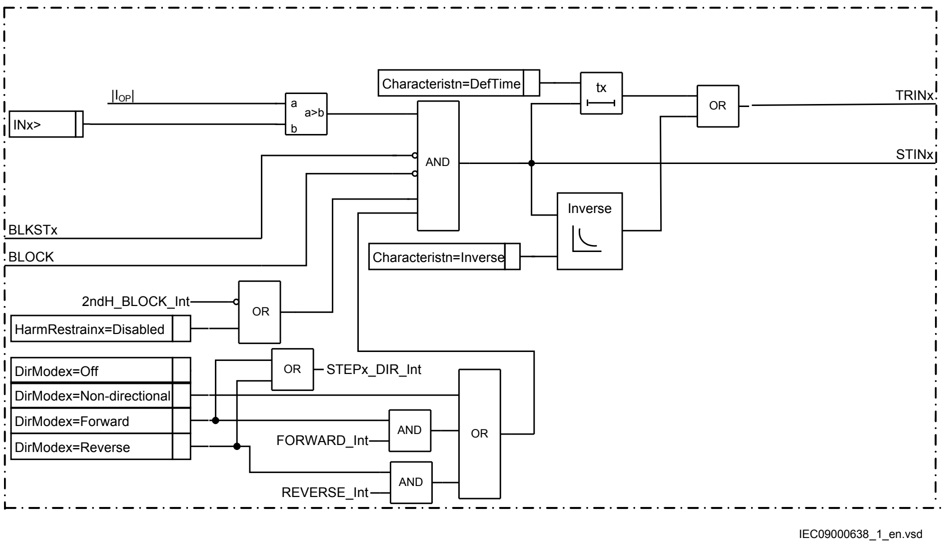


Figure 45: Simplified logic diagram for residual overcurrent, where x= step 1, 2, 3 or 4 n= step 1 and 4

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.

5.4.7.7 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 46, in order to determine the direction of the earth-fault.

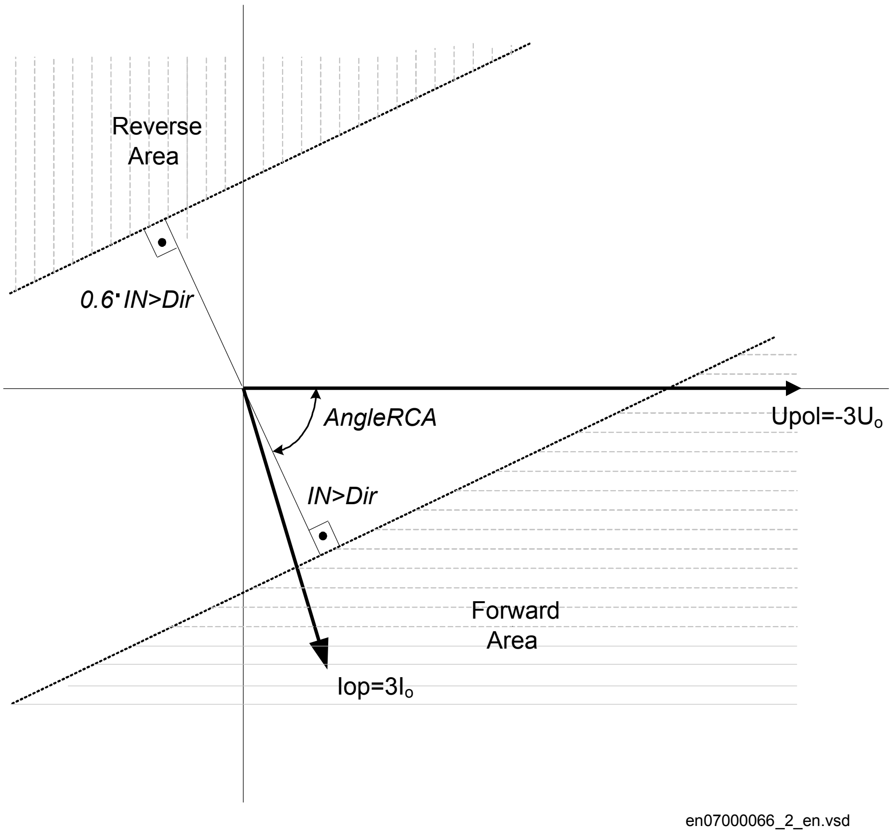


Figure 46: Operating characteristic for earth-fault directional element

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 47:

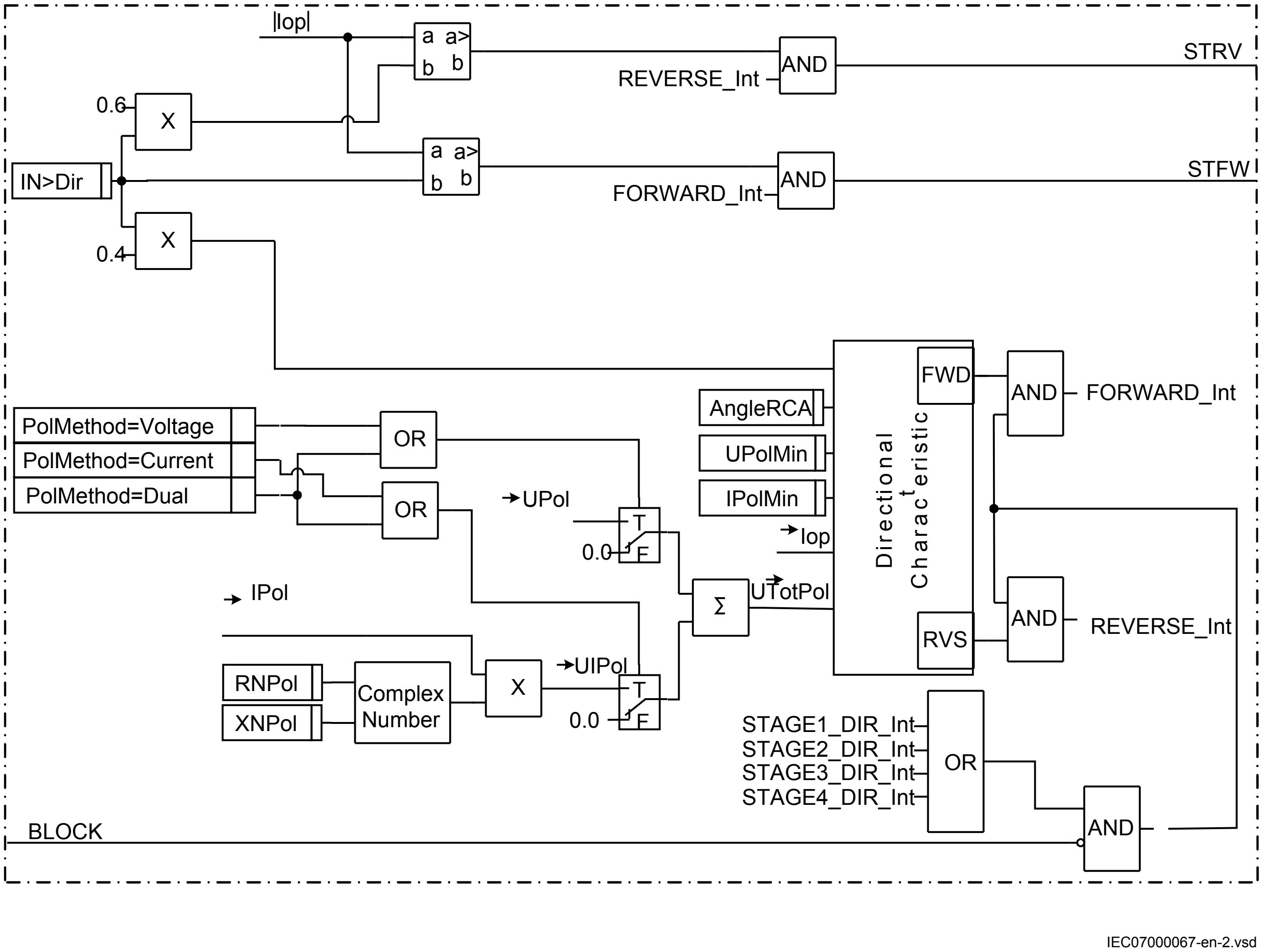


Figure 47: Simplified logic diagram for directional supervision element with integrated directional comparison step

5.4.8 Technical data

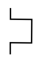
Table 55: EF4PTOC Technical data

Function	Range or value	Accuracy
Operate current	(1-2500)% of IBase	± 1.0% of I_r at $I \leq I_r$ ± 1.0% of I at $I > I_r$
Reset ratio	> 95%	-
Operate current for directional comparison	(1–100)% of IBase	± 1.0% of I_r
Timers	(0.000-60.000) s	± 0.5% ± 10 ms
Inverse characteristics, see table 416, table 417 and table 418	17 curve types	See table 416, table 417 and table 418
Table continues on next page		

Function	Range or value	Accuracy
Second harmonic restrain operation	(5–100)% of fundamental	± 2.0% of I_r
Relay characteristic angle	(-180 to 180) degrees	± 2.0 degrees
Minimum polarizing voltage	(1–100)% of UBase	± 0.5% of U_r
Minimum polarizing current	(2-100)% of IBase	±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	-

5.5 Thermal overload protection, two time constants TRPTTR

5.5.1 Identification

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

5.5.2 Functionality

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

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

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

5.5.3 Function block

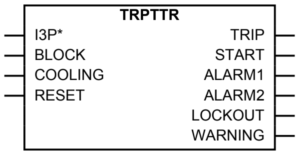


Figure 48: TRPTTR function block

5.5.4 Signals

TRPTTR is not provided with external temperature sensor in first release of 650 series. The only input that influences the temperature measurement is the binary input COOLING.

Table 56: TRPTTR Input signals

Name	Type	Default	Description
I3P	GROUP SIGNAL	-	Three phase group signal for current input
BLOCK	BOOLEAN	0	Block of function
COOLING	BOOLEAN	0	Cooling input changes IBase setting and time constant
RESET	BOOLEAN	0	Reset of function

Table 57: TRPTTR Output signals

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

5.5.5 Settings

Table 58: TRPTTR Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
IRef	10.0 - 1000.0	%IB	1.0	100.0	Reference current in % of IBase
IBase1	30.0 - 250.0	%IB	1.0	100.0	Base current IBase1 without cooling input in % of IBase
IBase2	30.0 - 250.0	%IB	1.0	100.0	Base current IBase2 with cooling input in % of IBase
Tau1	1.0 - 500.0	Min	1.0	60.0	Time constant without cooling input
Tau2	1.0 - 500.0	Min	1.0	60.0	Time constant with cooling input
IHighTau1	30.0 - 250.0	%IB1	1.0	100.0	Current setting for rescaling TC1 by TC1-IHIGH
Tau1High	5 - 2000	%tC1	1	100	Multiplier to TC1 when current is >IHIGH-TC1
ILowTau1	30.0 - 250.0	%IB1	1.0	100.0	Current setting for rescaling TC1 by TC1-ILOW
Tau1Low	5 - 2000	%tC1	1	100	Multiplier to TC1 when current is <ILOW-TC1
IHighTau2	30.0 - 250.0	%IB2	1.0	100.0	Current setting for rescaling TC2 by TC2-IHIGH
Tau2High	5 - 2000	%tC2	1	100	Multiplier to TC2 when current is >TC2-IHIGH
ILowTau2	30.0 - 250.0	%IB2	1.0	100.0	Current setting for rescaling TC2 by TC2-ILOW
Tau2Low	5 - 2000	%tC2	1	100	Multiplier to TC2 when current is <ILOW-TC2
ITrip	50.0 - 250.0	%IBx	1.0	110.0	Steady state operate current level
Alarm1	50.0 - 99.0	%Itr	1.0	80.0	First alarm level
Alarm2	50.0 - 99.0	%Itr	1.0	90.0	Second alarm level
ResLo	10.0 - 95.0	%Itr	1.0	60.0	Lockout reset level
Warning	1.0 - 500.0	Min	0.1	30.0	Time setting, below which warning would be set

Table 59: TRPTTR Non group settings (basic)

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

5.5.6 Monitored data

Table 60: TRPTTR Monitored data

Name	Type	Values (Range)	Unit	Description
TTRIP	REAL	-	-	Estimated time to trip (in min)
TTRIPCAL	INTEGER	-	-	Calculated time status to trip: not active/long time/ active
TRESCAL	INTEGER	-	-	Calculated time status to reset: not active/long time/active
TRESLO	REAL	-	-	Estimated time to reset of the function (in min)
HEATCONT	REAL	-	%	Percentage of the heat content of the transformer
I-MEASUR	REAL	-	%	Current measured by the function in % of the rated current

5.5.7 Operation principle

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

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

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

(Equation 14)

where:

I is the largest phase current

I_{ref} is a given reference current

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

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

If $\Theta_{final} > \Theta_n$

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

If $\Theta_{final} < \Theta_n$

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

where:

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

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

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

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

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

(Equation 19)

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

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

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

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

(Equation 20)

In the above equation, the final temperature is calculated according to equation 14. Since the transformer normally is disconnected, the current I is zero and thereby the Θ_{final} is also zero. The calculated component temperature can be monitored as it is exported from the function as a real figure, TRESLO.

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

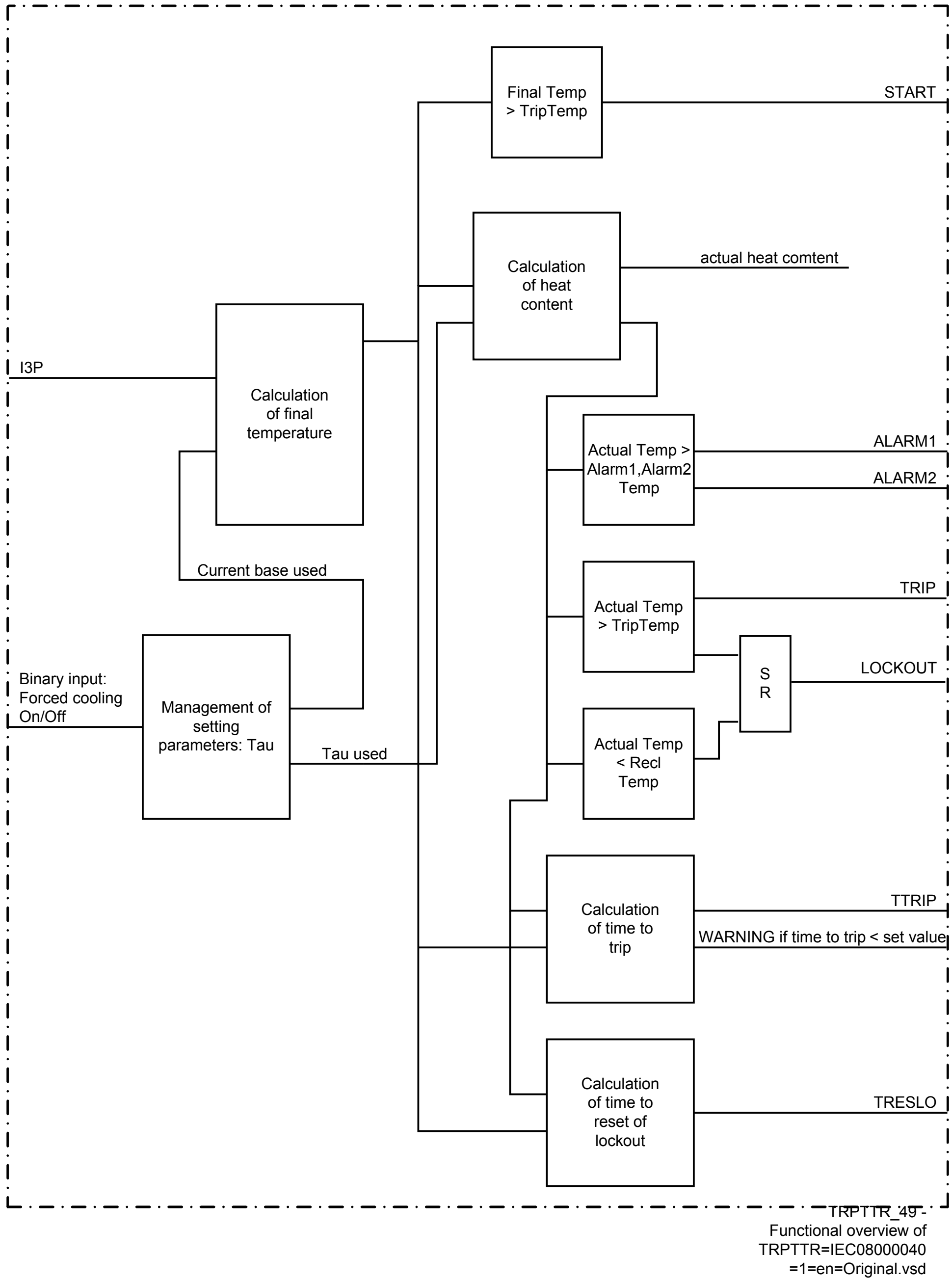


Figure 49: Functional overview of TRPTTR

5.5.8 Technical data

Table 61: TRPTTR Technical data

Function	Range or value	Accuracy
Base current 1 and 2	(30–250)% of IBase	± 1.0% of I_r
Operate time: $$t = \tau \cdot \ln \left(\frac{I^2 - I_p^{\ 2}}{I^2 - I_b^{\ 2}} \right)$$ (Equation 21) $I = I_{measured}$	I_p = load current before overload occurs Time constant τ = (1–500) minutes	IEC 60255–8, class 5 + 200 ms
Alarm level 1 and 2	(50–99)% of heat content trip value	± 2.0% of heat content trip
Operate current	(50–250)% of IBase	± 1.0% of I_r
Reset level temperature	(10–95)% of heat content trip	± 2.0% of heat content trip

5.6 Breaker failure protection CCRBRF

5.6.1 Identification

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

5.6.2 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.

5.6.3 Function block

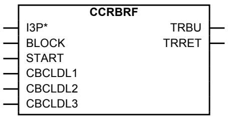


Figure 50: CCRBRF function block

5.6.4 Signals

Table 62: 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 63: CCRBRF Output signals

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

5.6.5 Settings

Table 64: 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
Table continues on next page					

Name	Values (Range)	Unit	Step	Default	Description
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 65: 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 66: 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

5.6.6 Monitored data

Table 67: 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

5.6.7 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.

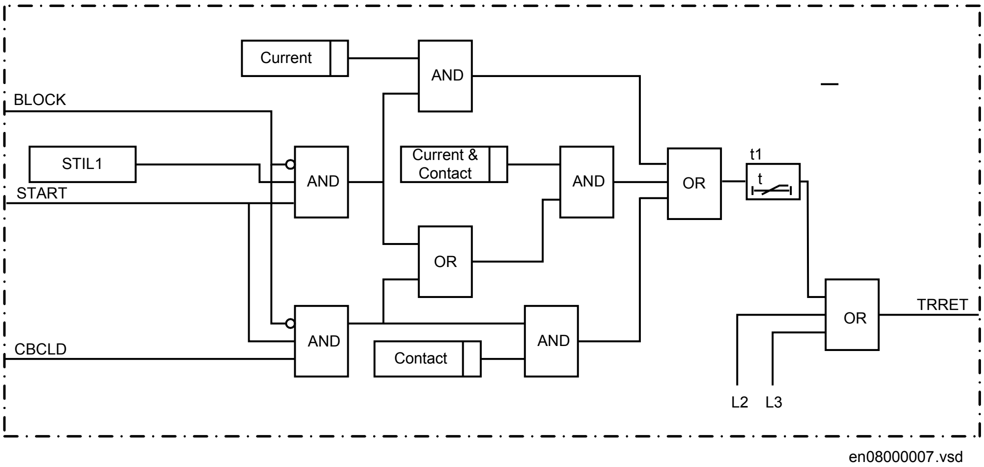


Figure 51: Simplified logic scheme of the retrip function

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>*.

5.6.8 Technical data

Table 68: CCRBRF Technical data

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

5.7 Pole discordance protection CCRPLD

5.7.1 Identification

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

5.7.2 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.

5.7.3 Function block

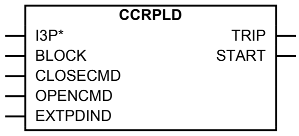


Figure 52: CCRPLD function block

5.7.4 Signals

Table 69: 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 70: CCRPLD Output signals

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

5.7.5 Settings

Table 71: 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
Table continues on next page					

Name	Values (Range)	Unit	Step	Default	Description
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

Table 72: CCRPLD Non group settings (basic)

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

5.7.6 Monitored data

Table 73: CCRPLD Monitored data

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

5.7.7 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 53

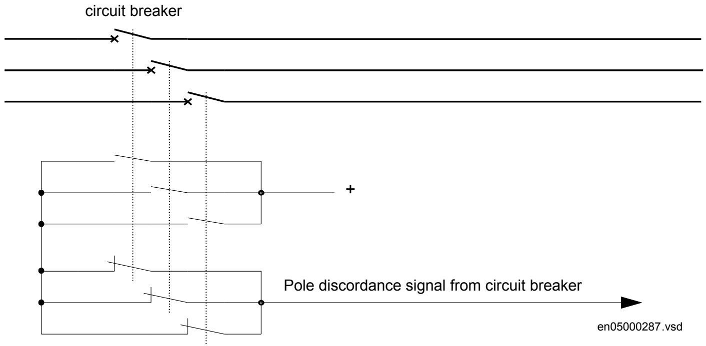


Figure 53: Pole discordance external detection logic

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.

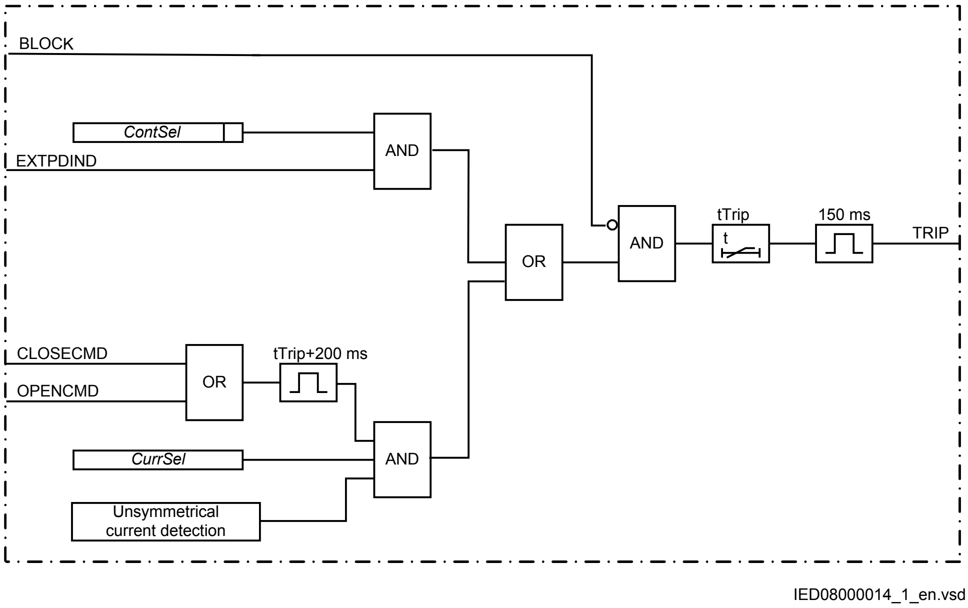


Figure 54: Simplified block diagram of pole discordance function - contact and current based

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.

5.7.7.1 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 53.After a settable time *tTrip*, a 150 ms trip pulse command TRIP is generated by the pole discordance function.

5.7.7.2 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).

5.7.8 Technical data

Table 74: 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

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

5.8.1 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.

5.8.2 Directional over-power protection GOPPDOP

5.8.2.1 Identification

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

5.8.2.2 Function block

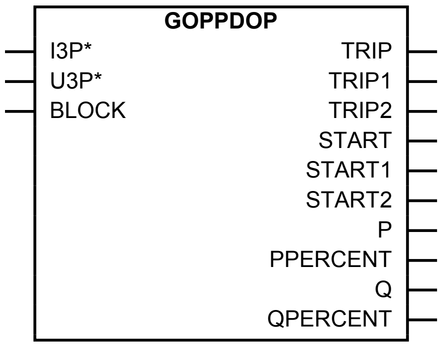


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Figure 55: GOPPDOP function block

5.8.2.3 Signals

Table 75: 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 76: 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

5.8.2.4 Settings

Table 77: 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 78: 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 79: 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

5.8.2.5 Monitored data

Table 80: 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

5.8.3 Directional under-power protection GUPPDUP

5.8.3.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Directional under-power protection	GUPPDUP	$\boxed{P < \atop \rightarrow}$	37

5.8.3.2 Function block

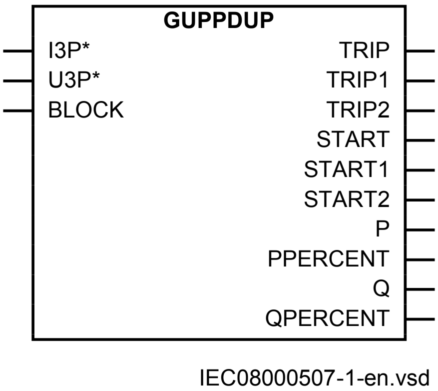

Figure 56: GUPPDUP function block

5.8.3.3 Signals

Table 81: 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 82: 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

5.8.3.4 Settings

Table 83: 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 84: 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 85: 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

5.8.3.5 Monitored data

Table 86: 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

5.8.4 Operation principle

A simplified scheme showing the principle of the power protection function is shown in figure 57. The function has two stages with individual settings.

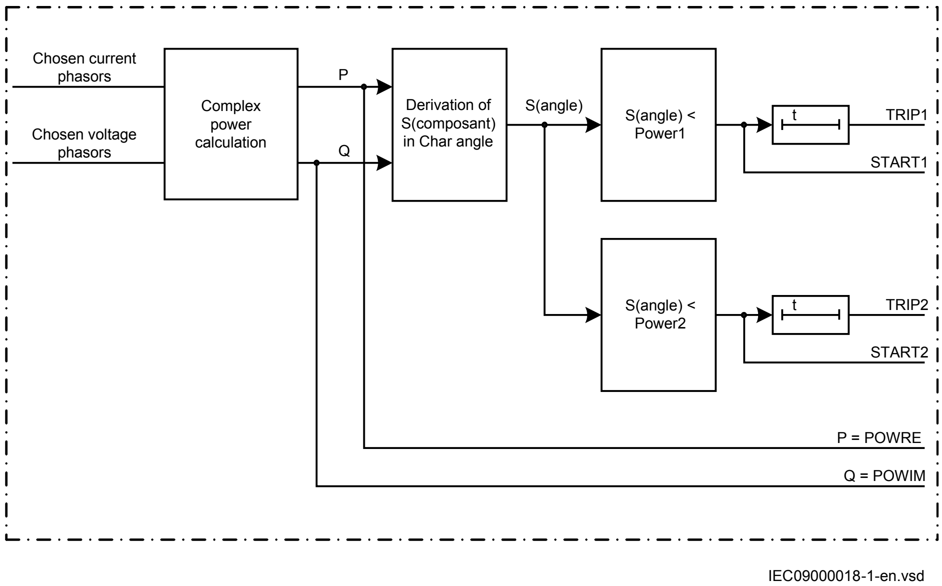

Figure 57: Simplified logic diagram of the power protection function

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 87.

Table 87: 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 22)
Arone	$\bar{S} = \bar{U}_{L1L2} \cdot \bar{I}_{L1}^{*} - \bar{U}_{L2L3} \cdot \bar{I}_{L3}^{*}$ (Equation 23)
PosSeq	$\bar{S} = 3 \cdot \bar{U}_{PosSeq} \cdot \bar{I}_{PosSeq}^{*}$ (Equation 24)
L1L2	$\bar{S} = \bar{U}_{L1L2} \cdot (\bar{I}_{L1}^{*} - \bar{I}_{L2}^{*})$ (Equation 25)
L2L3	$\bar{S} = \bar{U}_{L2L3} \cdot (\bar{I}_{L2}^{*} - \bar{I}_{L3}^{*})$ (Equation 26)
L3L1	$\bar{S} = \bar{U}_{L3L1} \cdot (\bar{I}_{L3}^{*} - \bar{I}_{L1}^{*})$ (Equation 27)
L1	$\bar{S} = 3 \cdot \bar{U}_{L1} \cdot \bar{I}_{L1}^{*}$ (Equation 28)
L2	$\bar{S} = 3 \cdot \bar{U}_{L2} \cdot \bar{I}_{L2}^{*}$ (Equation 29)
L3	$\bar{S} = 3 \cdot \bar{U}_{L3} \cdot \bar{I}_{L3}^{*}$ (Equation 30)

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.

5.8.4.1 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:

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

(Equation 31)

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.

5.8.5 Technical data

Table 88: 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

5.9 Negative sequence based overcurrent function DNSPTOC

5.9.1 Identification

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

5.9.2 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.

5.9.3 Function block

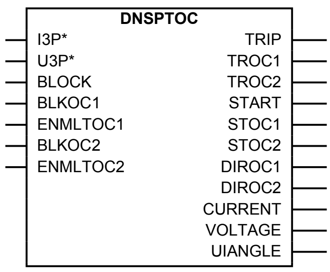

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Figure 58: DNSPTOC function block

5.9.4 Signals

Table 89: 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 90: 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

5.9.5 Settings

Table 91: 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 92: DNSPTOC Non group settings (basic)

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

5.9.6 Monitored data

Table 93: 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

5.9.7 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*.

5.9.8 Technical data

Table 94: 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 6 Voltage protection

6.1 Two step undervoltage protection UV2PTUV

6.1.1 Identification

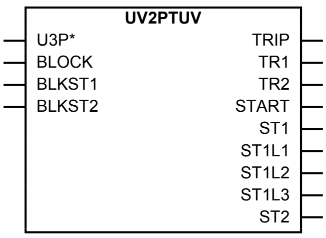
Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Two step undervoltage protection	UV2PTUV	3U<	27

6.1.2 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.

6.1.3 Function block



IEC09000285_1_en.vsd

Figure 59: UV2PTUV function block

6.1.4 Signals

Table 95: 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 96: 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

6.1.5 Settings

Table 97: 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 98: 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

6.1.6 Monitored data

Table 99: 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

6.1.7 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:

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

(Equation 32)

and operation for phase-to-phase voltage under:

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

(Equation 33)

6.1.7.1 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.

6.1.7.2 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:

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

(Equation 34)

The type B curve is described as:

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

(Equation 35)

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 18.3 "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 60 and figure 61.

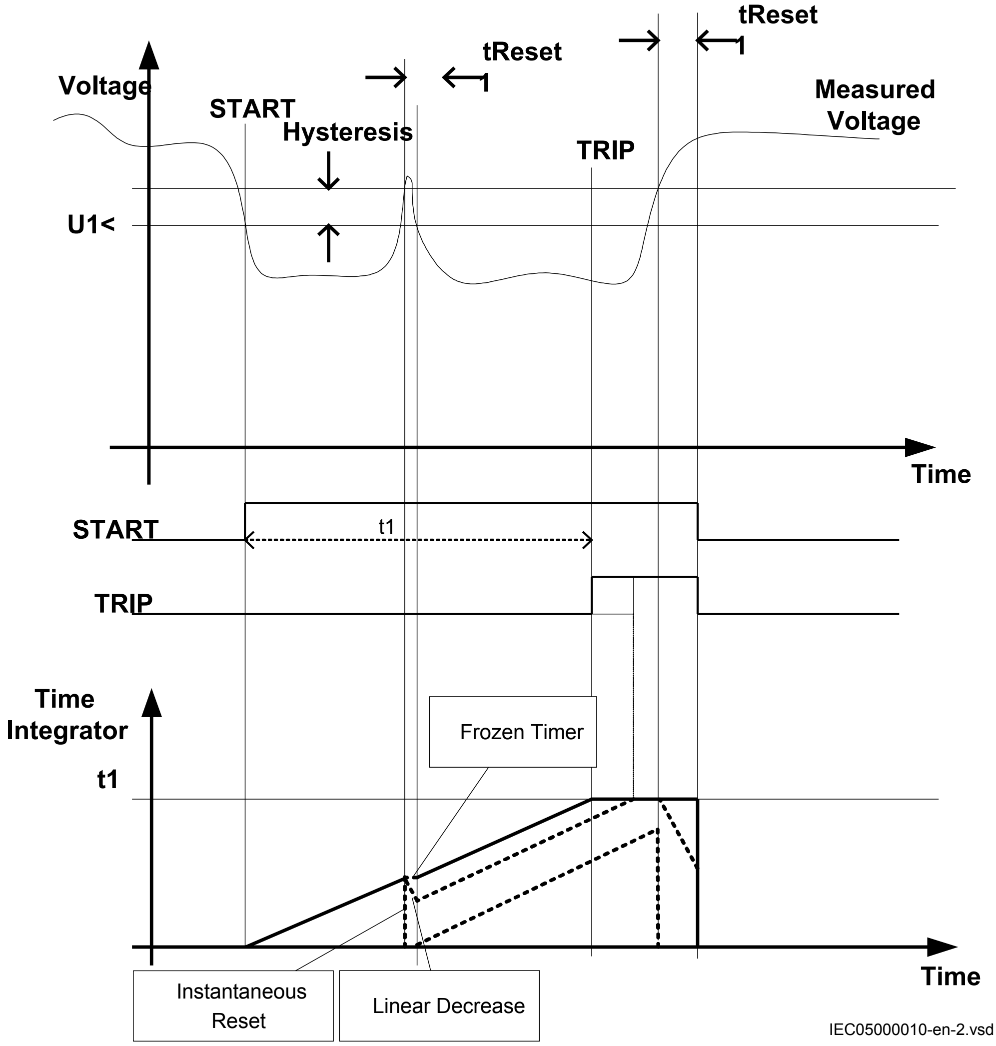


Figure 60: Voltage profile not causing a reset of the start signal for step 1, and definite time delay

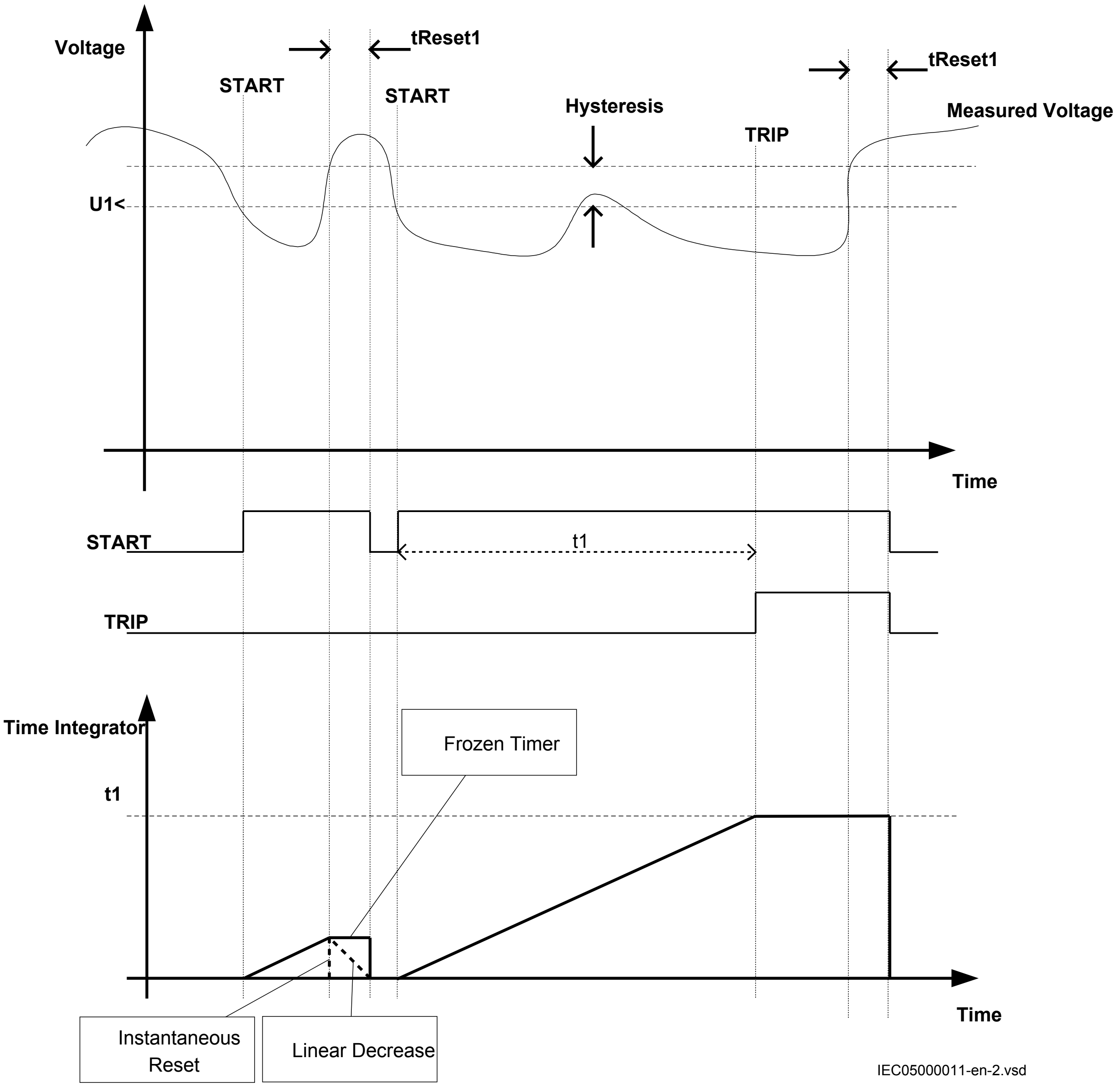


Figure 61: Voltage profile causing a reset of the start signal for step 1, and definite time delay

6.1.7.3 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

6.1.7.4 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 62.

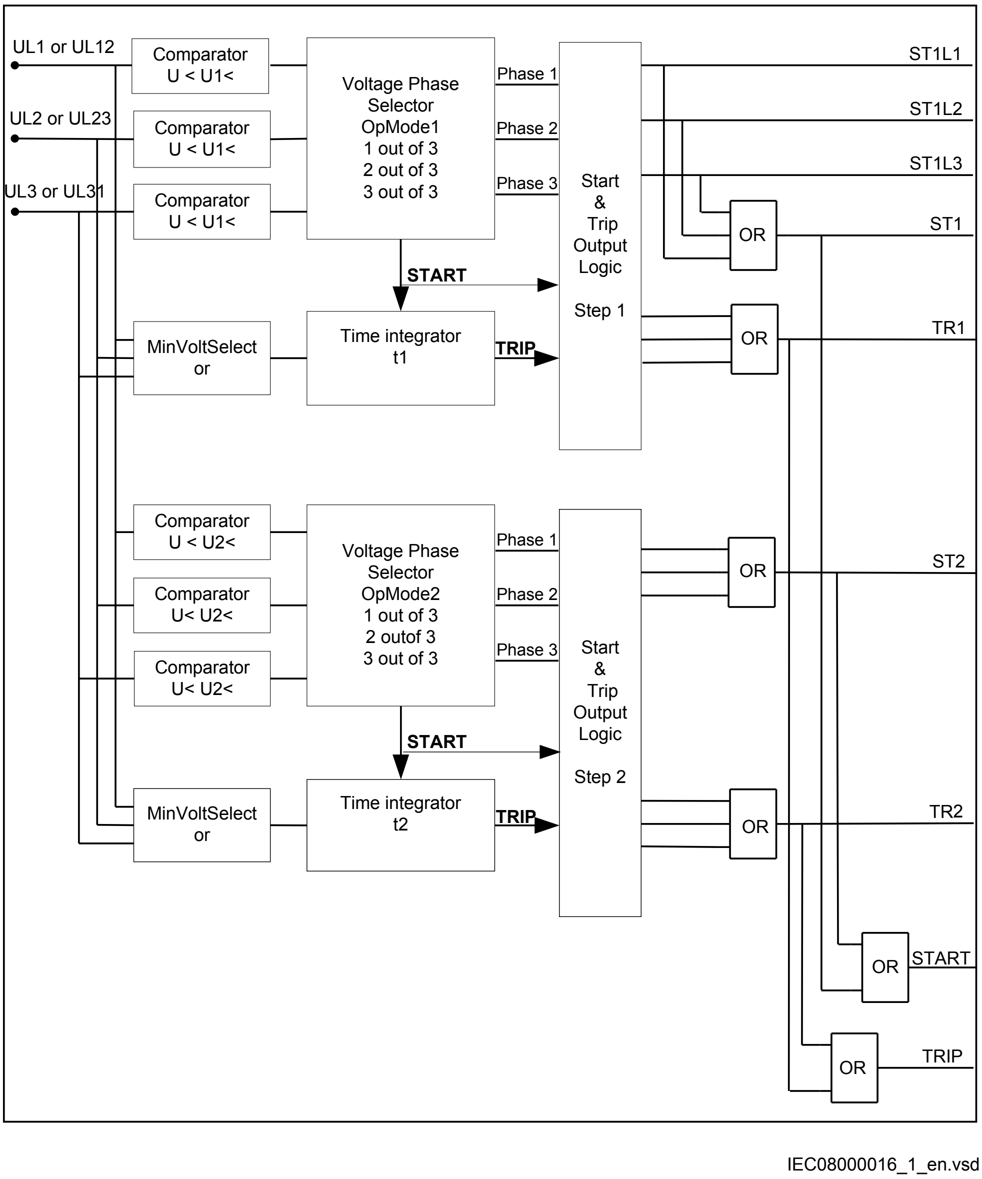


Figure 62: Schematic design of Two step undervoltage protection (UV2PTUV)

6.1.8 Technical data

Table 100: 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 419	-	See table 419
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	-

6.2 Two step overvoltage protection OV2PTOV

6.2.1 Identification

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

6.2.2 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.

6.2.3 Function block

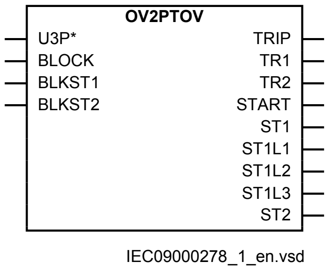


Figure 63: OV2PTOV function block

6.2.4 Signals

Table 101: 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 102: 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

6.2.5 Settings

Table 103: 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 104: 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

6.2.6 Monitored data

Table 105: 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

6.2.7 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 36)

and operation for phase for phase voltage over:

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

(Equation 37)

6.2.7.1 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.

6.2.7.2 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:

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

(Equation 38)

The type B curve is described as:

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

(Equation 39)

The type C curve is described as:

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

(Equation 40)

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 64. The details of the different inverse time characteristics are shown in section 18.3 "Inverse time characteristics"

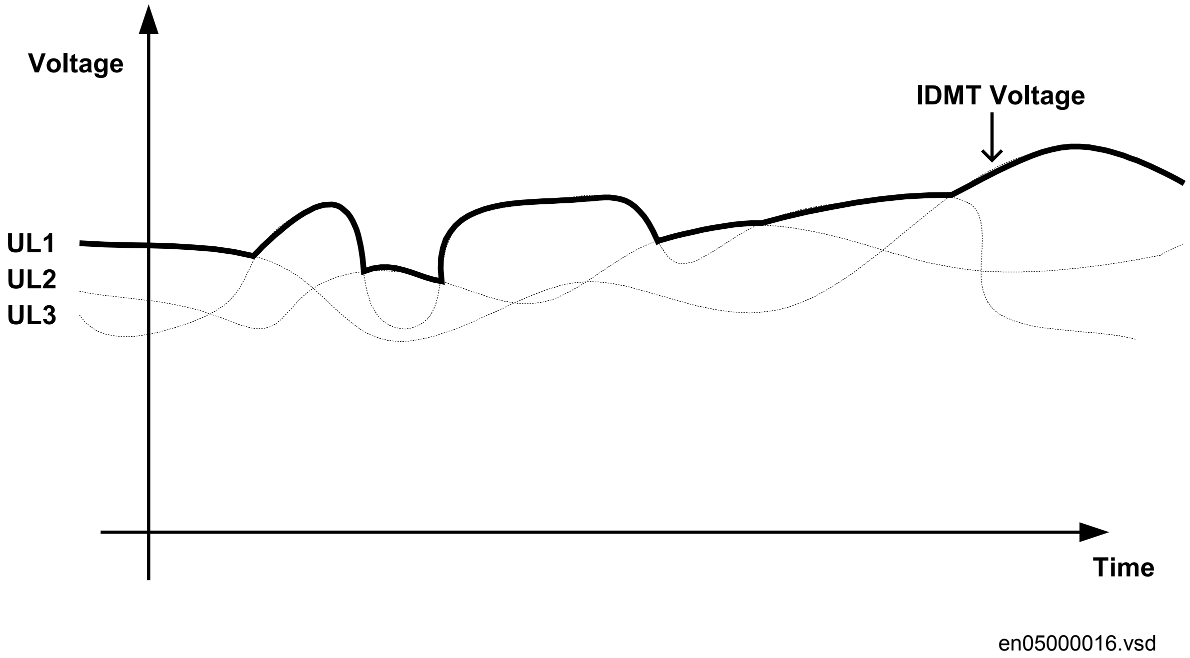


Figure 64: Voltage used for the inverse time characteristic integration

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.

6.2.7.3 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

6.2.7.4 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 65.

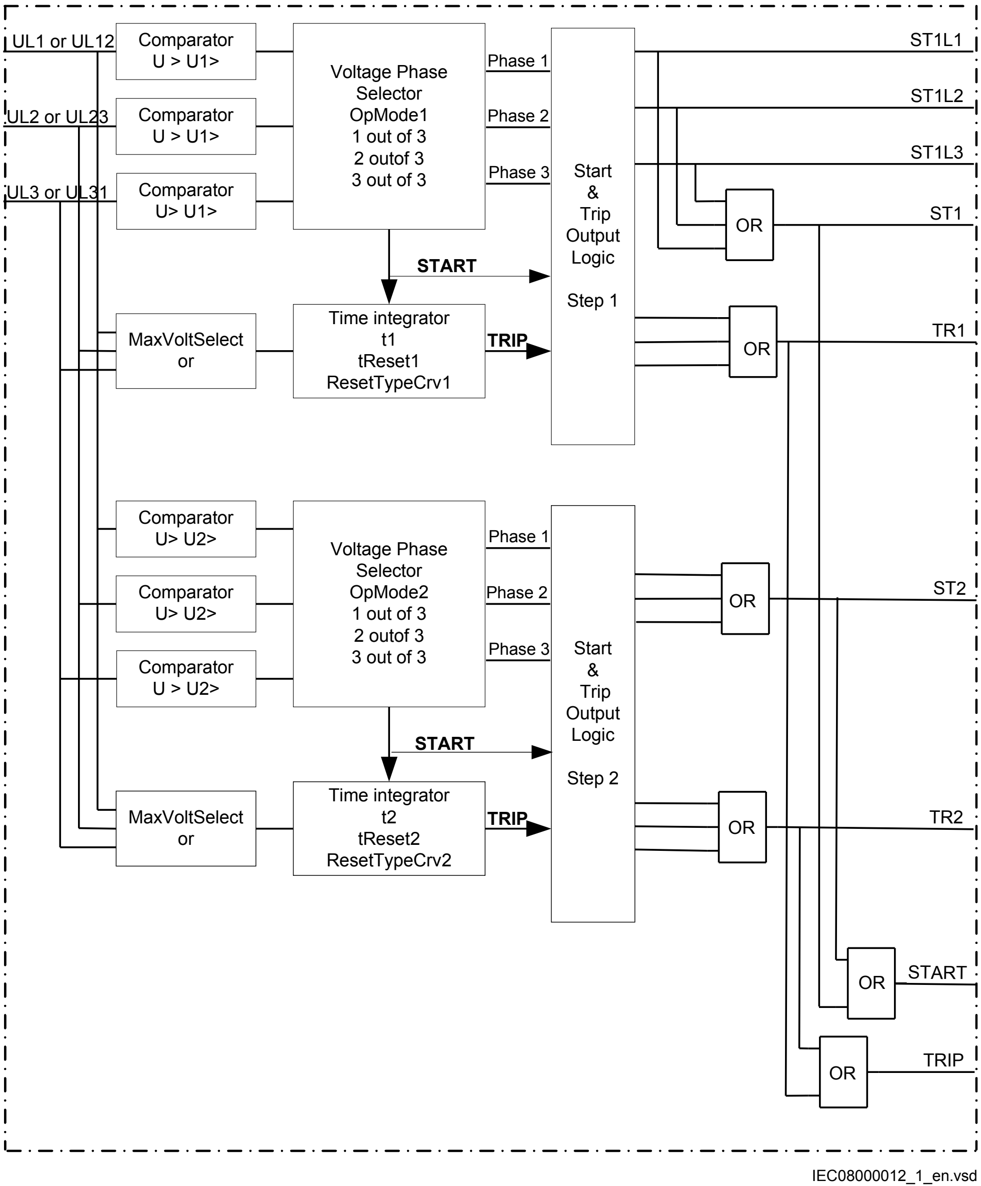


Figure 65: Schematic design of Two step overvoltage protection (OV2PTOV)

6.2.8 Technical data

Table 106: 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 420	-	See table 420
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	-

6.3 Two step residual overvoltage protection ROV2PTOV

6.3.1 Identification

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

6.3.2 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.

6.3.3 Function block

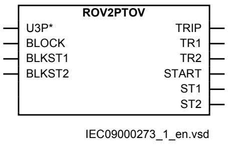


Figure 66: ROV2PTOV function block

6.3.4 Signals

Table 107: 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 108: 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

6.3.5 Settings

Table 109: 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 110: 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

6.3.6 Monitored data

Table 111: ROV2PTOV Monitored data

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

6.3.7 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.

6.3.7.1 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.

6.3.7.2 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:

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

The type B curve is described as:

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

(Equation 41)

The type C curve is described as:

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

(Equation 42)

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 18.3 "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 67 and figure 68.

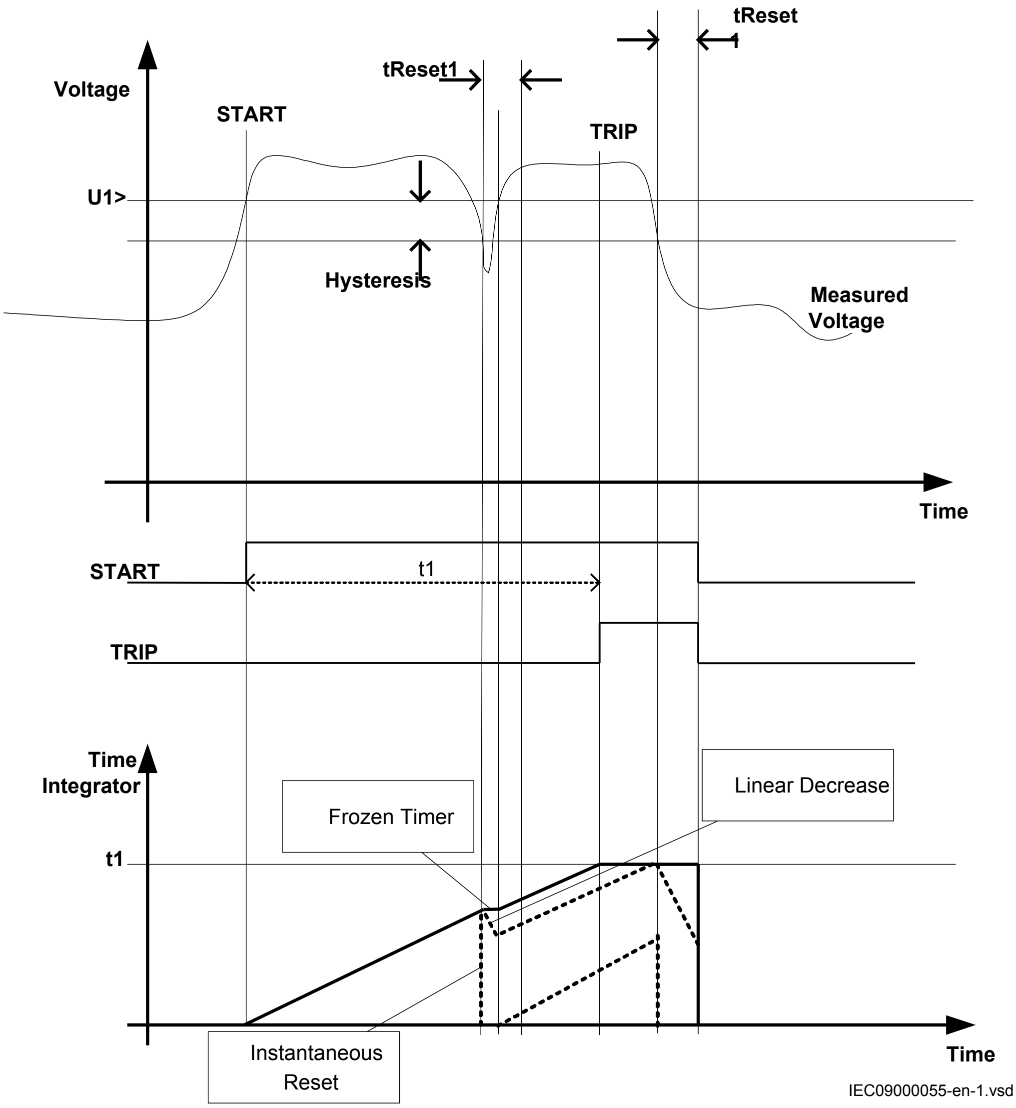


Figure 67: Voltage profile not causing a reset of the START signal for step 1, and definite time delay

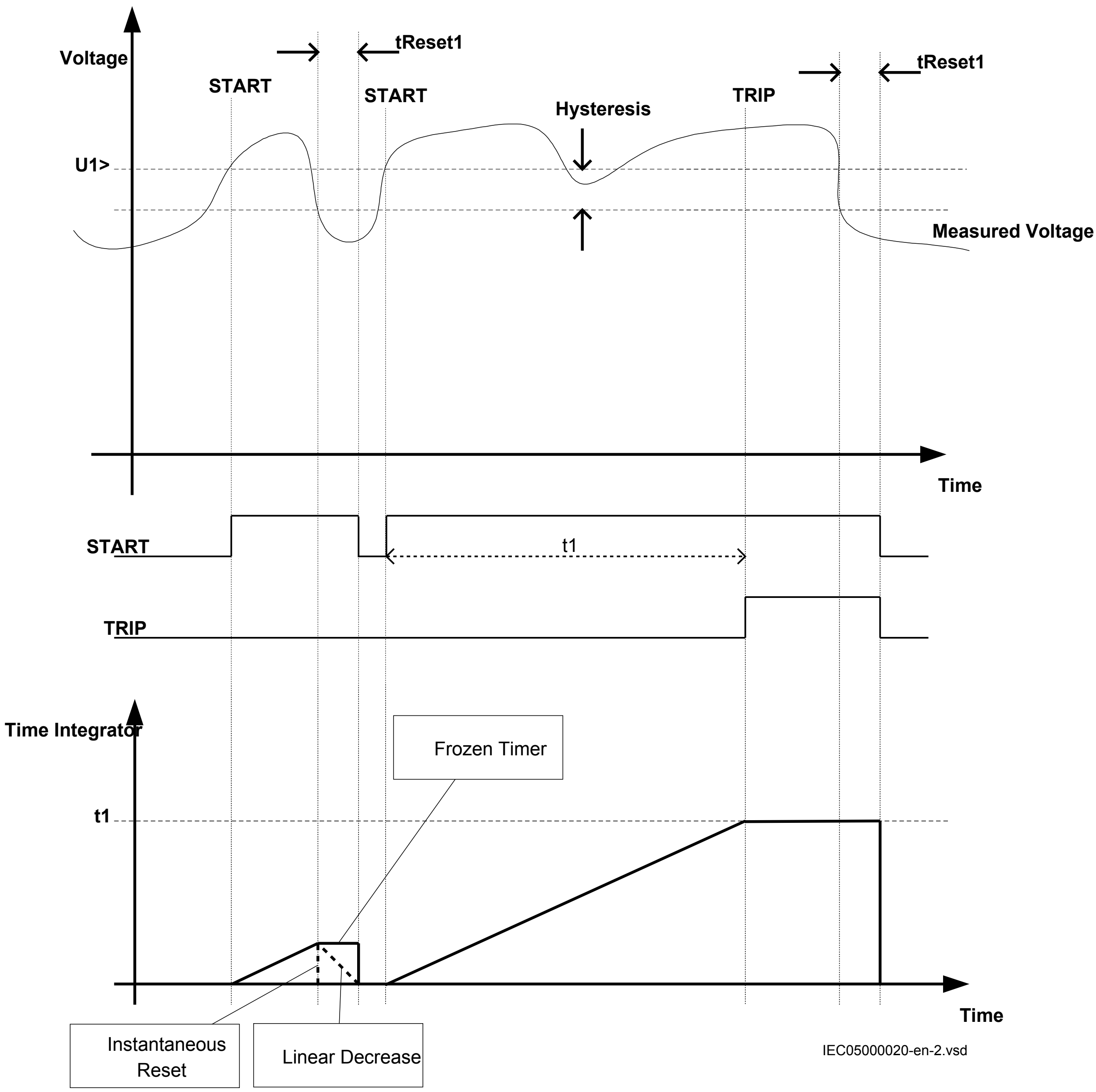


Figure 68: Voltage profile causing a reset of the START signal for step 1, and definite time delay

6.3.7.3 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

6.3.7.4 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 69.

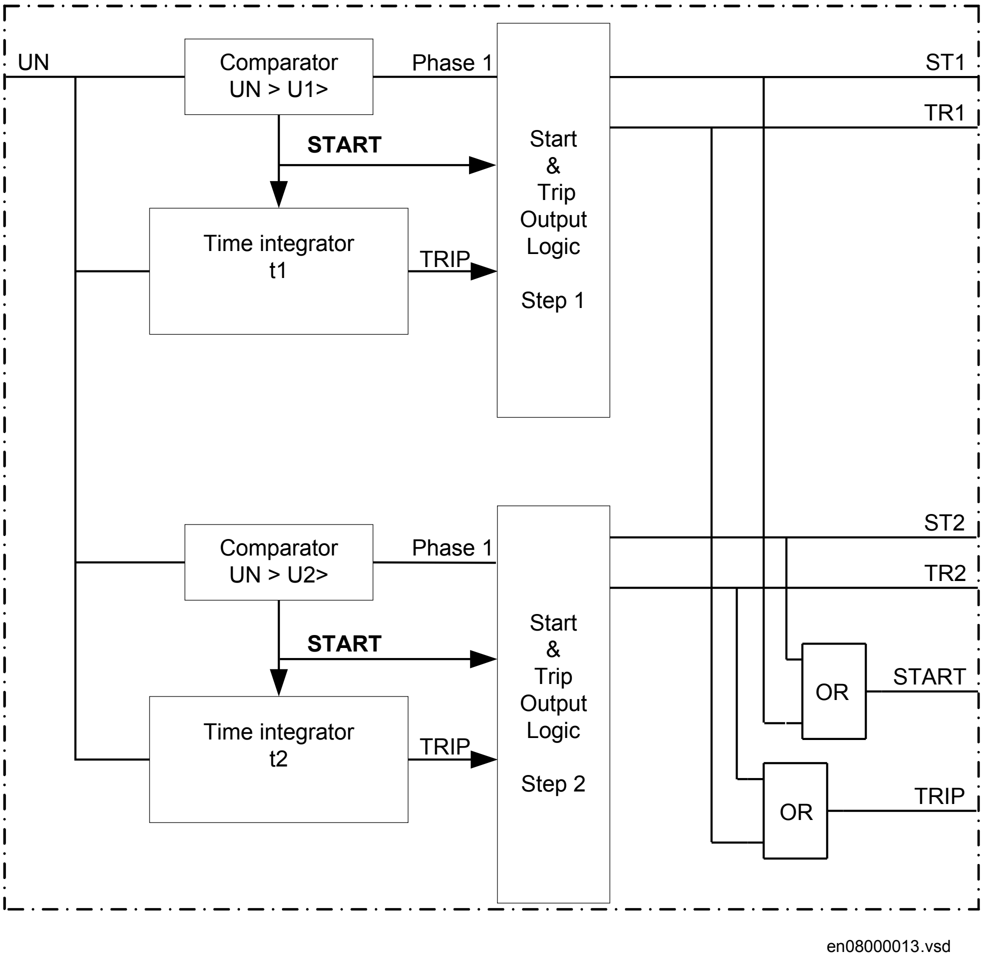


Figure 69: Schematic design of Two step residual overvoltage protection (ROV2PTOV)

6.3.8 Technical data

Table 112: 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 421	-	See table 421
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	-

6.4 Overexcitation protection OEXPVPH

6.4.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Overexcitation protection	OEXPVPH	*U/f >*	24

6.4.2 Functionality

When the laminated core of a power transformer or generator is subjected to a magnetic flux density beyond its design limits, stray flux will flow into non-laminated components not designed to carry flux and cause eddy currents to flow. The eddy currents can cause excessive heating and severe damage to insulation and adjacent parts in a relatively short time. The function has settable inverse operating curve and independent alarm stage.

6.4.3 Function block

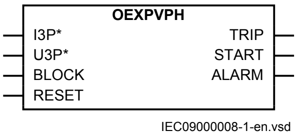


Figure 70: OEXPVPH function block

6.4.4 Signals

Table 113: OEXPVPH Input signals

Name	Type	Default	Description
I3P	GROUP SIGNAL	-	Three phase group signal for currents
U3P	GROUP SIGNAL	-	Three phase group signal for voltages
BLOCK	BOOLEAN	0	Block of function
RESET	BOOLEAN	0	Reset of function

Table 114: OEXPVPH Output signals

Name	Type	Description
TRIP	BOOLEAN	General trip signal
START	BOOLEAN	General start signal
ALARM	BOOLEAN	Overexcitation alarm signal

6.4.5 Settings

Table 115: OEXPVPH Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
V/Hz>	100.0 - 180.0	%UB/f	0.1	110.0	Operate level of V/Hz at no load and rated freq in % of (Ubase/frated)
V/Hz>>	100.0 - 200.0	%UB/f	0.1	140.0	High level of V/Hz above which tMin is used, in % of (Ubase/frated)
tMin	0.000 - 60.000	s	0.001	7.000	Minimum trip delay for V/Hz curve
kForIEEE	1 - 60	-	1	1	Time multiplier for IEEE inverse type curve
AlarmLevel	50.0 - 120.0	%	0.1	100.0	Alarm operate level
tAlarm	0.00 - 9000.00	s	0.01	5.00	Alarm time delay

Table 116: OEXPVPH Non group settings (basic)

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

6.4.6 Monitored data

Table 117: OEXPVPH Monitored data

Name	Type	Values (Range)	Unit	Description
TMTOTRIP	REAL	-	s	Calculated time to trip for overexcitation, in sec
VPERHZ	REAL	-	V/Hz	Voltage to frequency ratio in per-unit
THERMSTA	REAL	-	%	Overexcitation thermal status in % of trip level

6.4.7 Operation principle

The importance of Overexcitation protection function (OEXPVPH) is growing as the power transformers as well as other power system elements today operate most of the time near their designated limits.

Modern design transformers are more sensitive to overexcitation than earlier types. This is a result of the more efficient designs and designs which rely on the improvement in the uniformity of the excitation level of modern systems. Thus, if emergency that includes overexcitation does occur, transformers may be damaged unless corrective action is promptly taken. Transformer manufacturers recommend an overexcitation protection as a part of the transformer protection system.

Overexcitation results from excessive applied voltage, possibly in combination with below-normal frequency. Such condition may occur when a transformer unit is on load, but are more likely to arise when it is on open circuit, or at a loss of load occurrence. Transformers directly connected to generators are in particular danger to experience overexcitation condition. It follows from the fundamental transformer equation, see equation 43, that peak flux density Bmax is directly proportional to induced voltage E, and inversely proportional to frequency f, and turns n.

$$E = 4.44 \cdot f \cdot n \cdot Bmax \cdot A$$

(Equation 43)

The relative excitation M (relative V/Hz) is therefore according to equation 44.

$$M = \text{relative}\left(\frac{V}{Hz}\right) = \frac{E/f}{(Ur)/(fr)}$$

(Equation 44)

Disproportional variations in quantities E and f may give rise to core overfluxing. If the core flux density Bmax increases to a point above saturation level (typically 1.9 Tesla), the flux will no longer be contained within the core only but will extend into other (non-laminated) parts of the power transformer and give rise to eddy current circulations.

Overexcitation will result in:

- overheating of the non-laminated metal parts
- a large increase in magnetizing currents
- an increase in core and winding temperature
- an increase in transformer vibration and noise

Protection against overexcitation is based on calculation of the relative volt per hertz (V/Hz) ratio. The action of the protection is usually to initiate a reduction of excitation and, if this should fail, or is not possible, to trip the transformer after a delay which can be from seconds to minutes, typically 5 - 10 seconds.

Overexcitation protection may be of particular concern on directly connected generator unit transformers. Directly connected generator-transformers are subjected to a wide range of frequencies during the acceleration and deceleration of the turbine. In such cases, the overexcitation protection may trip the field breaker during a start-up of a machine, by means of the overexcitation ALARM signal. If this is not possible, the power transformer can be disconnected from the source, after a delay, by the TRIP signal.

The IEC 60076 - 1 standard requires that transformers shall be capable of operating continuously at 10% above rated voltage at no load, and rated frequency. At no load, the ratio of the actual generator terminal voltage to the actual frequency should not exceed 1.1 times the ratio of transformer rated voltage to the rated frequency on a sustained basis, see equation 45.

$$\frac{E}{f} \leq 1.1 \cdot \frac{Ur}{fr}$$

(Equation 45)

or equivalently, with 1.1 · Ur = *V/Hz>* according to equation 46.

$$\frac{E}{f} \leq \frac{V/Hz>}{fr}$$

(Equation 46)

where:

V/Hz> is the maximum continuously allowed voltage at no load, and rated frequency.

V/Hz> is a setting parameter. The setting range is 100% to 180%. If the user does not know exactly what to set, then the standard IEC 60076 - 1, section 4.4, the default value *V/Hz> = 110 %* shall be used.

In Overexcitation protection function (OEXPVPH), the relative excitation M (relative V/Hz) is expressed according to equation 47.

$$M = \text{relative}\left(\frac{V}{Hz}\right) = \frac{E/f}{Ur/fr}$$

(Equation 47)

It is clear from the above formula that, for an unloaded power transformer, M = 1 for any E and f, where the ratio E/f is equal to Ur/fr. A power transformer is not overexcited as long as the relative excitation is M ≤ *V/Hz>*, *V/Hz>* expressed in % of Ur/fr. The relative overexcitation is thus defined as shown in equation 48.

$$\text{overexcitation} = {\left(M - (V/Hz>)\right)}\Big/{(V/Hz>)}$$

(Equation 48)

It is assumed that overexcitation is a symmetrical phenomenon, caused by events such as loss-of-load, etc. It will be observed that a high phase-to-earth voltage does not mean overexcitation. For example, in an unearthed power system, a single phase-to-earth fault means high voltages of the “healthy” two phases-to-earth, but no overexcitation on any winding. The phase-to-phase voltages will remain essentially unchanged. The important voltage is the voltage between the two ends of each winding.

6.4.7.1 Measured voltage

Positive sequence voltage and the positive sequence current are used by OEXPVPH. A check is made if the positive sequence voltage is higher than 70% of rated phase-to-earth voltage, when below this value, OEXPVPH exits immediately, and no excitation is calculated.

The frequency value is received from the pre-processing block. The function is in operation for frequencies within the range of 33-60 Hz and of 42-75 Hz for 50 and 60 Hz respectively.

- OEXPVPH function can be connected to any power transformer side, independent from the power flow.
- The side with a possible On-Load Tap-Changer (OLTC) must not be used.

6.4.7.2 Operate time of the overexcitation protection.

The operate time of the overexcitation protection is a function of the relative overexcitation.

The so called IEEE law approximates a square law and has been chosen based on analysis of the various transformers’ overexcitation capability characteristics. They can match well a transformer core capability.

The square law is according to equation 49.

$$t_{op} = \frac{0.18 \cdot k}{\left(M \Big/ \left(V \big/ Hz > \right)^{-1} \right)^2} = \frac{0.18 \cdot k}{overexcitation^2}$$

(Equation 49)

where:

M	the relative excitation
V/Hz>	Operate level of over-excitation function at no load in % of (*UBase*/f_{rated})
k	is time multiplier for inverse time functions, see figure 72.

The relative excitation M is calculated using equation 50

$$M = \left(\frac{U_{measured}}{f_{measured}} \right) \Bigg/ \left(\frac{UBase}{f_{rated}} \right) = \frac{U_{measured}}{UBase} \cdot \frac{f_{rated}}{f_{measured}}$$

(Equation 50)

Inverse delays as per figure 72, can be modified (limited) by a special definite delay setting *tMin*, see figure 71.

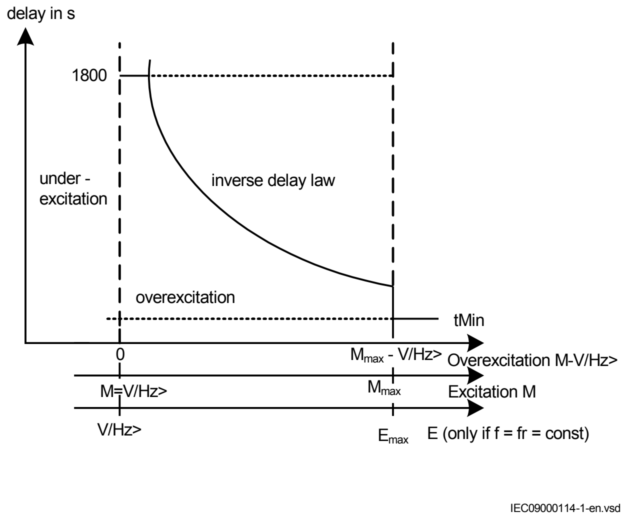


Figure 71: Restrictions imposed on inverse delays by tMin

A definite maximum time of 1800 seconds can be used to limit the operate time at low degrees of overexcitation. Inverse delays longer than 1800 seconds will not be allowed. In case the inverse delay is longer than 1800 seconds, OEXPVPH trips.

A definite minimum time, *tMin*, can be used to limit the operate time at high degrees of overexcitation. In case the inverse delay is shorter than *tMin*, OEXPVPH function trips after *tMin* seconds. Also, the inverse delay law is no more valid beyond excitation Mmax. Beyond Mmax (for excitation M > *V/Hz>*), the delay will always be *tMin*, no matter what is the overexcitation level.

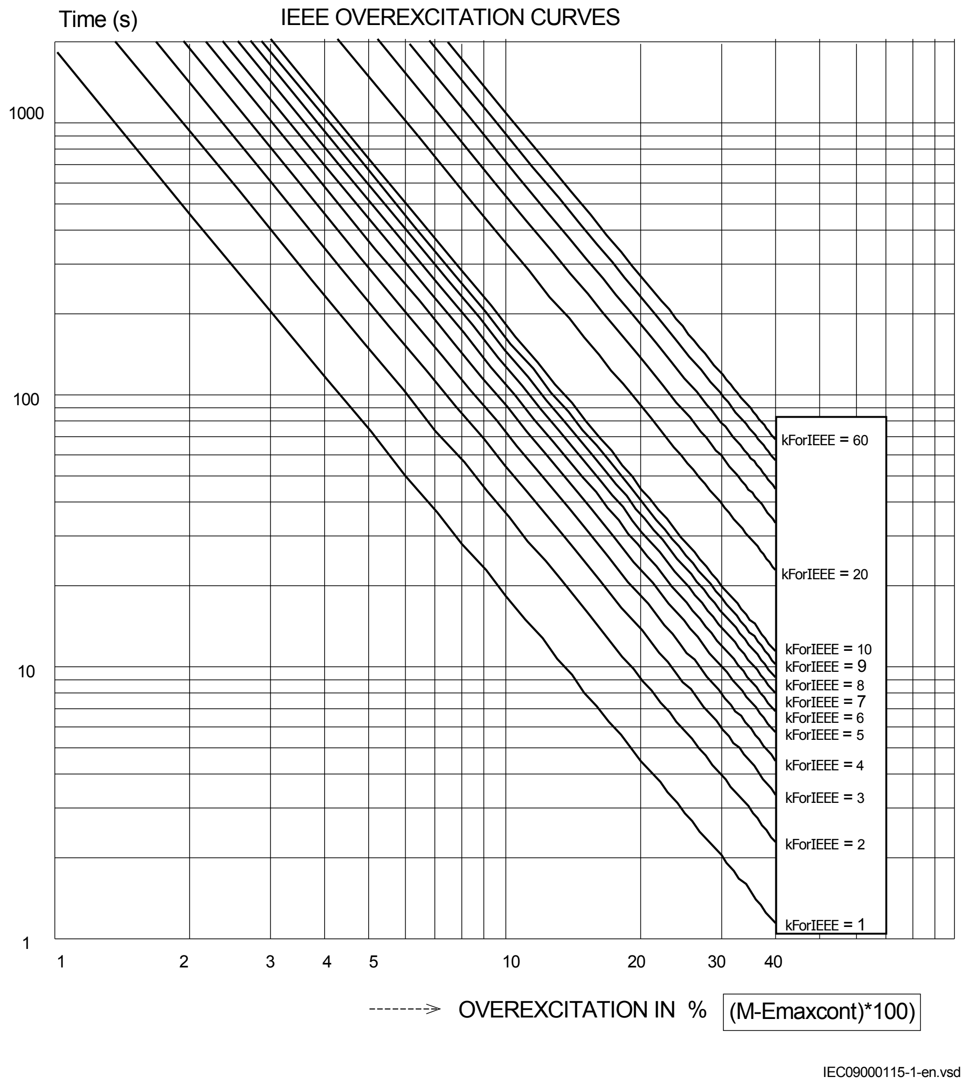


Figure 72: Delays inversely proportional to the square of the overexcitation.

The critical value of excitation M is determined indirectly via Overexcitation protection function (OEXPVPH) setting *V/Hz>>*. *V/Hz>>* can be thought of as a no-load-rated-frequency voltage, where the inverse law should be replaced by a short definite delay, *tMin*. If, for example, *V/Hz>>* = 140 %, then M is according to equation 51.

$$M = \frac{\left(V/Hz>>\right)/f}{Ur/fr} = 1.40$$

(Equation 51)

6.4.7.3 Cooling

Overexcitation protection function (OEXPVPH) is basically a thermal protection; therefore a cooling process has been introduced. Exponential cooling process is applied, with a default time constant of 20 minutes. This means that if the voltage and frequency return to normal values (no more overexcitation), the normal temperature is assumed to be reached not before approximately 5 times the default time constant of 20 minutes. If an overexcitation condition would return before that, the time to trip will be shorter than it would be otherwise.

6.4.7.4 Overexcitation protection function measurands

A monitored data value, TMTOTRIP, is available on the LHMI and in PCM600. This value is an estimation of the remaining time to trip (in seconds), if the overexcitation remained on the level it had when the estimation was done. This information can be useful with small or moderate overexcitations.

The relative excitation M, shown on LHMI and in PCM600 as a monitored data value VPERHZ, is calculated from the expression:

$$M = \text{relative}\left(\frac{V}{Hz}\right) = \frac{E/f}{Uf/fr}$$

(Equation 52)

If VPERHZ value is less than setting *V/Hz>* (in %), the power transformer is underexcited. If VPERHZ is equal to *V/Hz>* (in %), the excitation is exactly equal to the power transformer continuous capability. If VPERHZ is higher than *V/Hz>*, the protected power transformer is overexcited. For example, if VPERHZ = 1.100, while *V/Hz>* = 110 %, then the power transformer is exactly on its maximum continuous excitation limit.

Monitored data value THERMSTA shows the thermal status of the protected power transformer iron core. THERMSTA gives the thermal status in % of the trip value which corresponds to 100%. THERMSTA should reach 100% at the same time, as TMTOTRIP reaches 0 seconds. If the protected power transformer is then for some reason not switched off, THERMSTA shall go over 100%.

If the delay as per IEEE law, is limited by *tMin*, then THERMSTA will generally not reach 100% at the same time, as TMTOTRIP reaches 0 seconds. For example, if, at low degrees of overexcitation, the very long delay is limited by 30 minutes, then the TRIP output signal of OEXPVPH will be set to 1 before THERMSTA reaches 100%.

6.4.7.5 Overexcitation alarm

A separate step, *AlarmLevel*, is provided for alarming purpose. It is normally set 2% lower than (V/Hz>) and has a definite time delay, *tAlarm*. This will give the operator an early abnormal voltages warning.

6.4.7.6 Logic diagram

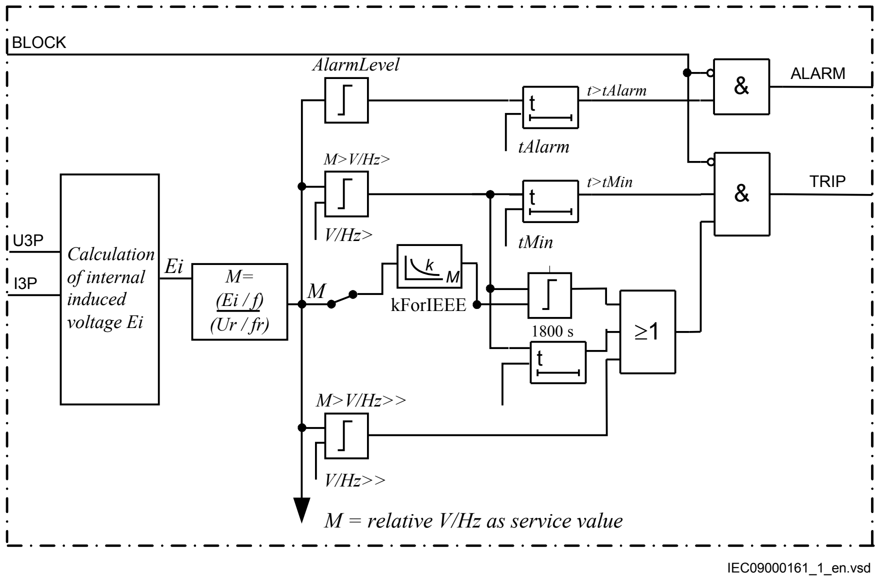


Figure 73: A simplified logic diagram of the Overexcitation protection function (OEXPVPH)

Simplification of the diagram is in the way the IEEE delays are calculated. The cooling process is not shown. It is not shown that voltage and frequency are separately checked against their respective limit values.

6.4.8 Technical data

Table 118: OEXPVPH Technical data

Function	Range or value	Accuracy
Operate value, start	(100–180)% of (Ubase/f_{rated})	± 1.0% of U
Operate value, alarm	(50–120)% of start level	± 1.0% of U_r at U ≤ U_r ± 1.0% of U at U > U_r
Operate value, high level	(100–200)% of (Ubase/f_{rated})	± 1.0% of U
Table continues on next page		

Function	Range or value	Accuracy
Curve type	IEEE $IEEE: t = \frac{(0.18 \cdot k)}{(M-1)^2}$ (Equation 53) where M = relative (V/Hz) = (E/f)/(Ur/fr)	Class 5 + 40 ms
Minimum time delay for inverse function	(0.000–60.000) s	± 0.5% ± 10 ms
Alarm time delay	(0.000–60.000) s	± 0.5% ± 10 ms

Section 7 Frequency protection

7.1 Under frequency protection SAPTUF

7.1.1 Identification

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

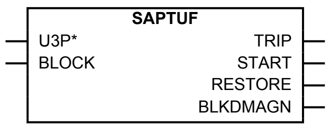
7.1.2 Functionality

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.

7.1.3 Function block



IEC09000282_1_en.vsd

Figure 74: SAPTUF function block

7.1.4 Signals

Table 119: SAPTUF Input signals

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

Table 120: 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

7.1.5 Settings

Table 121: 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

7.1.6 Monitored data

Table 122: SAPTUF Monitored data

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

7.1.7 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.

7.1.7.1 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.

7.1.7.2 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*.

7.1.7.3 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.

7.1.7.4 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 75.

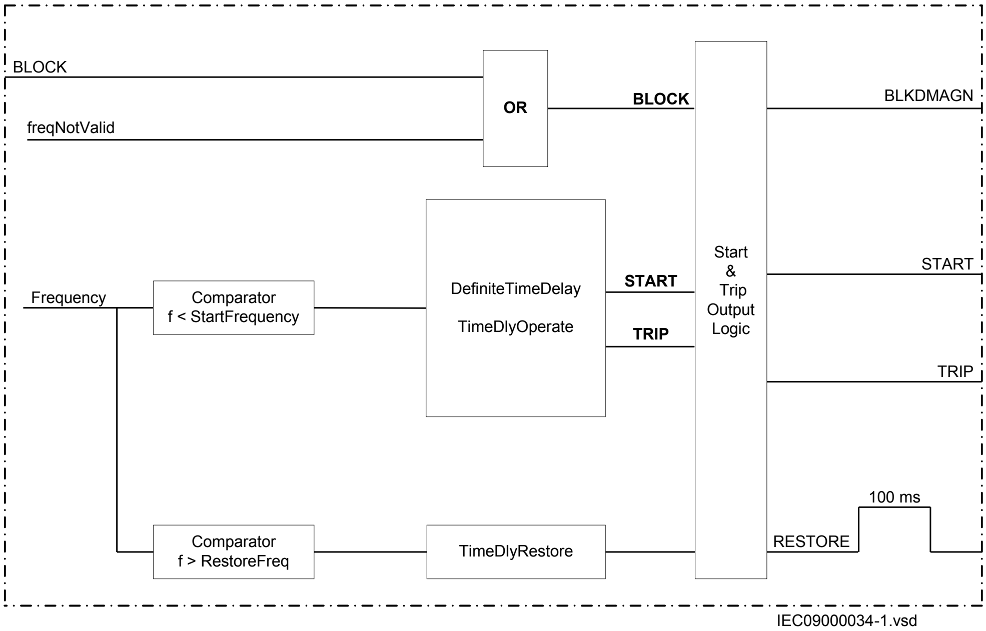


Figure 75: Schematic design of Under frequency function SAPTUF

7.1.8 Technical data

Table 123: 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

7.2 Over frequency protection SAPTOF

7.2.1 Identification

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

7.2.2 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.

7.2.3 Function block

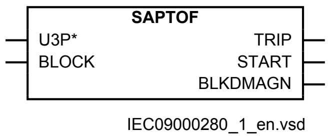


Figure 76: SAPTOF function block

7.2.4 Signals

Table 124: SAPTOF Input signals

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

Table 125: SAPTOF Output signals

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

7.2.5 Settings

Table 126: 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

7.2.6 Monitored data

Table 127: SAPTOF Monitored data

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

7.2.7 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.

7.2.7.1 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.

7.2.7.2 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.

7.2.7.3 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.

7.2.7.4 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 77.

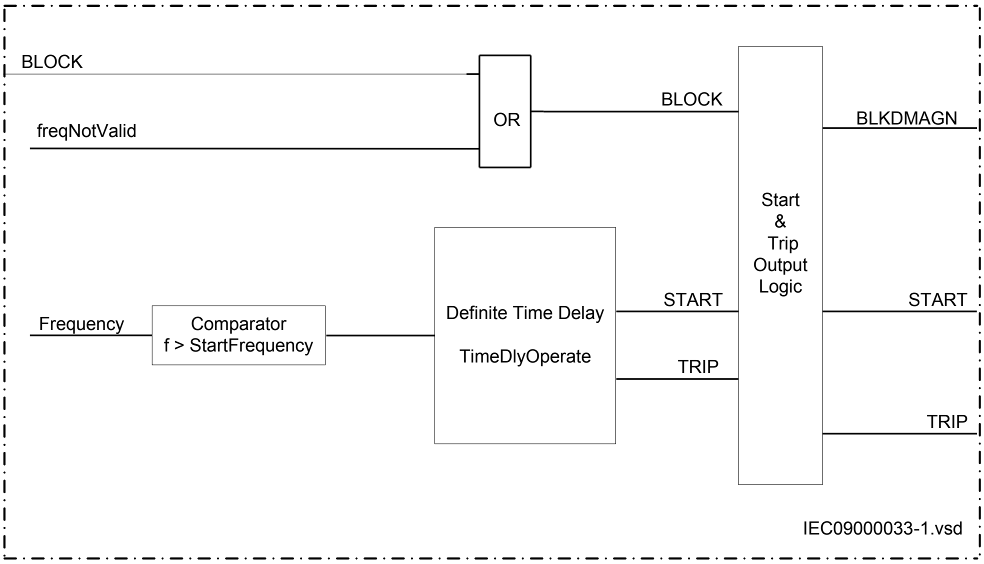


Figure 77: Schematic design of Over frequency protection (SAPTOF)

7.2.8 Technical data

Table 128: 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

7.3 Rate-of-change frequency protection SAPFRC

7.3.1 Identification

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

7.3.2 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.

7.3.3 Function block

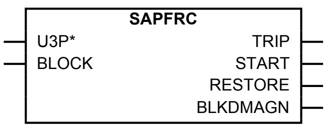


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Figure 78: SAPFRC function block

7.3.4 Signals

Table 129: SAPFRC Input signals

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

Table 130: 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

7.3.5 Settings

Table 131: 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

7.3.6 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.

7.3.6.1 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.

7.3.6.2 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*.

7.3.6.3 Design

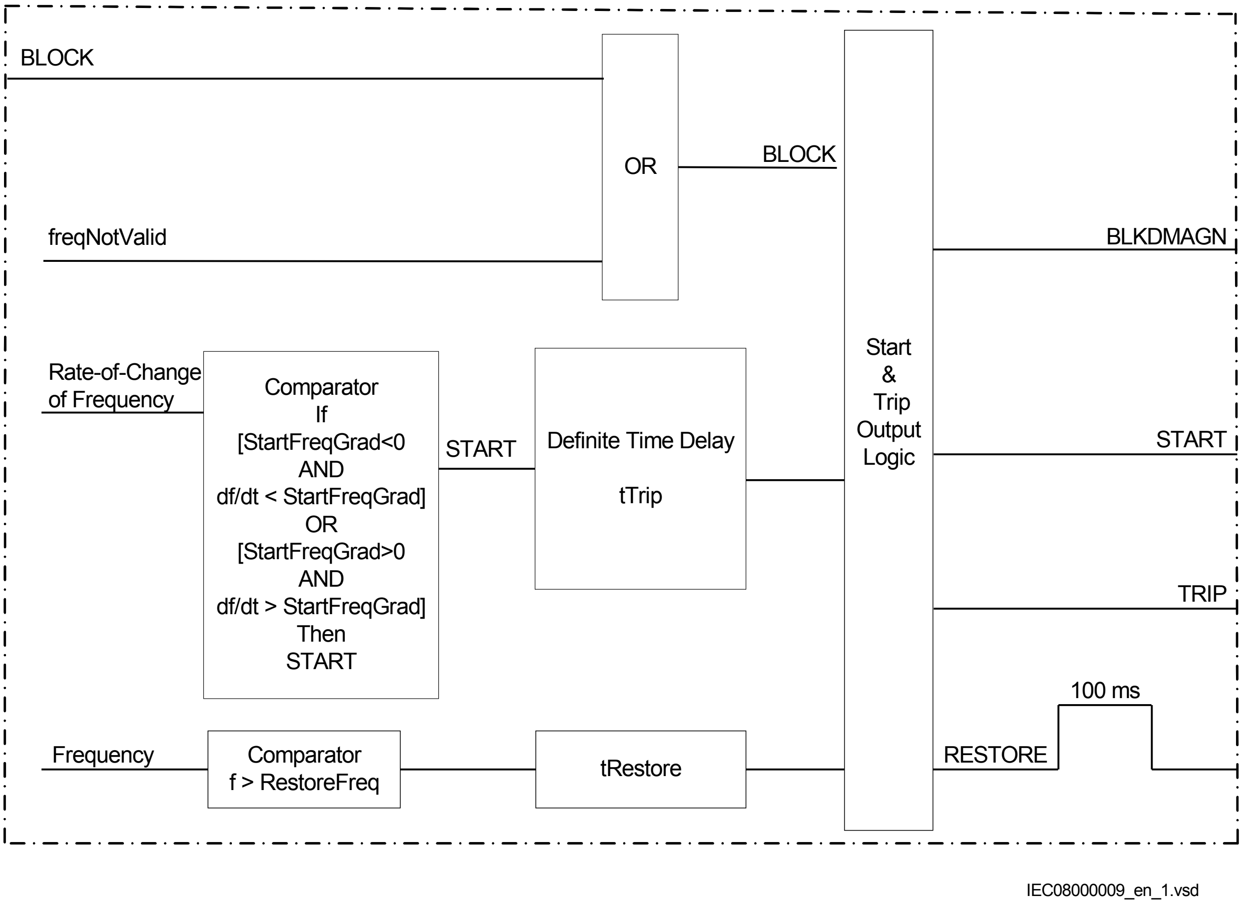

Figure 79: Schematic design of Rate-of-change frequency protection (SAPFRC)

7.3.7 Technical data

Table 132: 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 8 Secondary system supervision

8.1 Breaker close/trip circuit monitoring TCSSCBR

8.1.1 Identification

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

8.1.2 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.

8.1.3 Function block

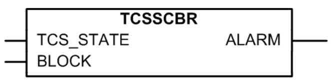

Figure 80: Function block

8.1.4 Signals

Table 133: 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 134: TCSSCBR Output signals

Name	Type	Description
ALARM	BOOLEAN	Trip circuit fault indication

8.1.5 Settings

Table 135: 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

8.1.6 Monitored data

Table 136: TCSSCBR Monitored data

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

8.1.7 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.

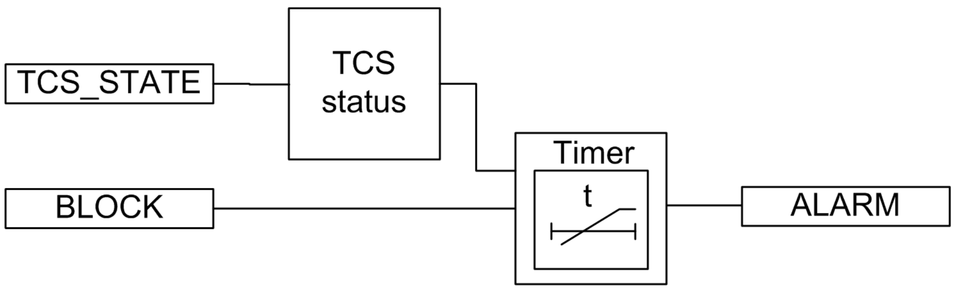

Figure 81: Functional module diagram

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.

8.1.8 Technical data

Table 137: TCSSCBR Technical data

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

Section 9 Control

9.1 Apparatus control APC

9.1.1 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.

9.1.2 Bay control QCBAY

9.1.2.1 Identification

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

9.1.2.2 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.

9.1.2.3 Function block

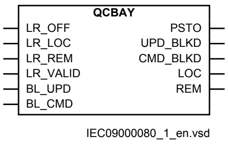

Figure 82: QCBAY function block

9.1.2.4 Signals

Table 138: 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 139: 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

9.1.2.5 Settings

Table 140: QCBAY Non group settings (basic)

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

9.1.3 Local remote LOCREM

9.1.3.1 Identification

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

9.1.3.2 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.

9.1.3.3 Function block

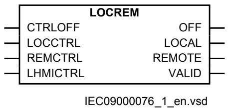

Figure 83: LOCREM function block

9.1.3.4 Signals

Table 141: 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 142: 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

9.1.3.5 Settings

Table 143: 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

9.1.4 Local remote control LOCREMCTRL

9.1.4.1 Identification

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

9.1.4.2 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.

9.1.4.3 Function block

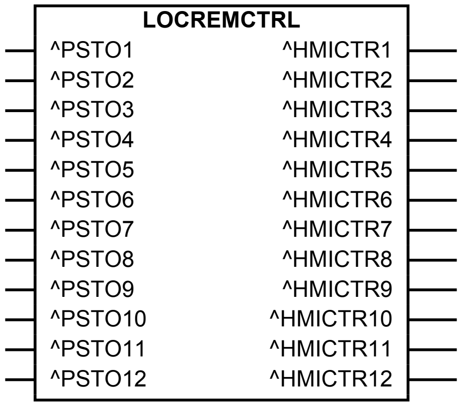

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Figure 84: LOCREMCTRL function block

9.1.4.4 Signals

Table 144: 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 145: 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

9.1.4.5 Settings

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

9.1.5 Operation principle

9.1.5.1 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 146. 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 146: 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.

9.1.5.2 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 85, where the inputs on function block LOCREM are connected to binary inputs if an external switch is used. When a local HMI is used, the inputs are not used and are set to FALSE in the configuration. The outputs from the LOCREM function block control the output PSTO (Permitted Source To Operate) on Bay control (QCBAY).

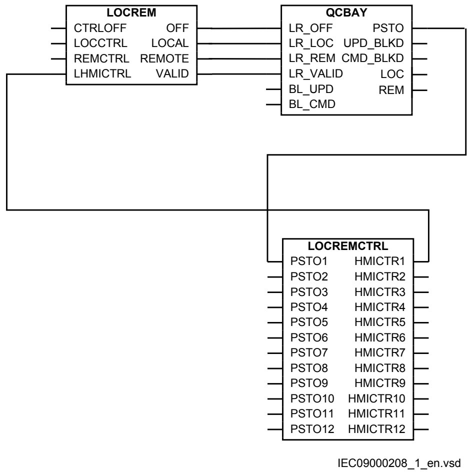

Figure 85: Configuration for the local/remote handling for a local HMI with two bays and two screen pages

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.

9.2 Voltage control

9.2.1 Functionality

The voltage control functions (Automatic voltage control for tap changer, single control (TR1ATCC), Automatic voltage control for tap changer, parallel control (TR8ATCC) and Tap changer control and supervision, 6 binary inputs (TCMYLTC) are used for control of power transformers with a motor driven on-load tap changer. The function provides automatic regulation of the voltage on the secondary side of transformers or alternatively on a load point further out in the network.

Control of a single transformer, as well as control of up to two transformers in parallel is possible. For parallel control of power transformers, three alternative methods are available, the master-follower method, the circulating current method and the reverse reactance method.

The voltage control includes many extra features such as possibility of to avoid simultaneous tapping of parallel transformers, hot stand by regulation of a transformer in a group which regulates it to a correct tap position even though the LV CB is open, compensation for a possible capacitor bank on the LV side bay of a transformer, extensive tap changer monitoring including contact wear and hunting detection, monitoring of the power flow in the transformer so that for example, the voltage control can be blocked if the power reverses etc.

In manual operating mode it is possible to give raise or lower commands to the on-load tap changer.

The Automatic voltage control for tap changer, (TR1ATCC for single control and TR8ATCC for parallel control) function controls the voltage on the LV side of a transformer either automatically or manually. The automatic control can be either for a single transformer, or for a group of parallel transformers.

The Tap changer control and supervision, 6 binary inputs (TCMYLTC) function gives the tap commands to the tap changer, and supervises that commands are carried through correctly. It has built-in extensive possibilities for tap changer position measurement, as well as supervisory and monitoring features. This is used in the voltage control and can also give information about tap position to the transformer differential protection.

9.2.2 Automatic voltage control for tap changer, single control (TR1ATCC)

9.2.2.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Automatic voltage control for tap changer, single control	TR1ATCC	-	90

9.2.2.2 Function block

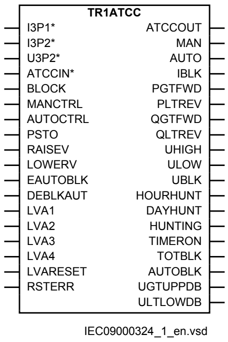

Figure 86: TR1ATCC function block

9.2.2.3 Signals

Table 147: TR1ATCC Input signals

Name	Type	Default	Description
I3P1	GROUP SIGNAL	-	Three phase group signal for current on HV side
I3P2	GROUP SIGNAL	-	Three phase group signal for current on LV side
U3P2	GROUP SIGNAL	-	Three phase group signal for voltage on LV side
ATCCIN	GROUP SIGNAL	-	Group connection from YLTCOUT
BLOCK	BOOLEAN	0	Block of function
MANCTRL	BOOLEAN	0	Binary "MAN" command
AUTOCTRL	BOOLEAN	0	Binary "AUTO" command
PSTO	INTEGER	0	Operator place selection
RAISEV	BOOLEAN	0	Binary "UP" command
LOWERV	BOOLEAN	0	Binary "DOWN" command
EAUTOBLK	BOOLEAN	0	Block the voltage control in automatic control mode
DEBLKAUT	BOOLEAN	0	Binary "Deblock Auto" command
LVA1	BOOLEAN	0	Activation of load voltage adjustment factor 1
LVA2	BOOLEAN	0	Activation of load voltage adjustment factor 2
LVA3	BOOLEAN	0	Activation of load voltage adjustment factor 3
LVA4	BOOLEAN	0	Activation of load voltage adjustment factor 4
LVARESET	BOOLEAN	0	Reset LVA
RSTERR	BOOLEAN	0	Resets automatic control commands

Table 148: TR1ATCC Output signals

Name	Type	Description
ATCCOUT	GROUP SIGNAL	Group connection to YLTCIN
MAN	BOOLEAN	Control is in manual mode
AUTO	BOOLEAN	Automatic control mode is active
IBLK	BOOLEAN	One phase current is above the set limit
PGTFWD	BOOLEAN	Active power above the set limit powerActiveForw
PLTREV	BOOLEAN	Active power below the set limit powerActiveRev
QGTFWD	BOOLEAN	Reactive power above the set limit powerReactiveForw
QLTREV	BOOLEAN	Reactive power below the set limit powerReactiveRev
UHIGH	BOOLEAN	Busbar voltage above the set limit voltBusbMaxLimit
ULOW	BOOLEAN	Busbar voltage below the set limit voltBusbMinLimit
UBLK	BOOLEAN	Busbar voltage below the set limit voltBusbBlockLimit
HOURHUNT	BOOLEAN	Number of commands within the latest hour exceeded maximum level
DAYHUNT	BOOLEAN	Number of commands within the last 24 hours exceeded maximum level
HUNTING	BOOLEAN	Number of commands in opposite direction exceeded maximum level
TIMERON	BOOLEAN	Raise or lower command to the tap activated
TOTBLK	BOOLEAN	Block of auto and manual commands
AUTOBLK	BOOLEAN	Block of auto commands
UGTUPPDB	BOOLEAN	Voltage greater than deadband-high, ULOWER command to come
ULTLOWDB	BOOLEAN	Voltage lower than deadband-low, URAISE command to come

9.2.2.4 Settings

Table 149: TR1ATCC Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
MeasMode	L1 L2 L3 L1L2 L2L3 L3L1 PosSeq	-	-	PosSeq	Selection of measured voltage and current
TotalBlock	Off On	-	-	Off	Total block of the voltage control function
Table continues on next page					

Name	Values (Range)	Unit	Step	Default	Description
AutoBlock	Off On	-	-	Off	Block of the automatic mode in voltage control function
FastStpDwnMode	Off Auto AutoMan	-	-	Off	Fast step down function activation mode
tFastStpDwn	1.0 - 100.0	s	0.1	15.0	Time delay for lower command when fast step down mode is activated
USet	85.0 - 120.0	%UB2	0.1	100.0	Voltage control set voltage, in % of rated voltage
UDeadband	0.2 - 9.0	%UB2	0.1	1.2	Outer voltage deadband, in % of rated voltage
UDeadbandInner	0.1 - 9.0	%UB2	0.1	0.9	Inner voltage deadband, in % of rated voltage
Umax	80 - 180	%UB2	1	105	Upper limit of busbar voltage, in % of rated voltage
Umin	70 - 120	%UB2	1	80	Lower limit of busbar voltage, in % of rated voltage
Ublock	50 - 120	%UB2	1	80	Undervoltage block level, in % of rated voltage
t1Use	Constant Inverse	-	-	Constant	Activation of long inverse time delay
t1	3 - 1000	s	1	60	Time delay (long) for automatic control commands
t2Use	Constant Inverse	-	-	Constant	Activation of short inverse time delay
t2	1 - 1000	s	1	15	Time delay (short) for automatic control commands
tMin	3 - 120	s	1	5	Minimum operating time in inverse mode
OperationLDC	Off On	-	-	Off	Operation line voltage drop compensation
OperCapaLDC	Off On	-	-	Off	LDC compensation for capacitive load
Rline	0.00 - 150.00	ohm	0.01	0.0	Line resistance, primary values, in ohm
Xline	-150.00 - 150.00	ohm	0.01	0.0	Line reactance, primary values, in ohm
LVAConst1	-20.0 - 20.0	%UB2	0.1	0.0	Constant 1 for LVA, % of regulated voltage
LVAConst2	-20.0 - 20.0	%UB2	0.1	0.0	Constant 2 for LVA, % of regulated voltage
LVAConst3	-20.0 - 20.0	%UB2	0.1	0.0	Constant 3 for LVA, % of regulated voltage
LVAConst4	-20.0 - 20.0	%UB2	0.1	0.0	Constant 4 for LVA, % of regulated voltage
VRAuto	-20.0 - 20.0	%UB2	0.1	0.0	Load voltage auto correction, in % of rated voltage
Iblock	0 - 250	%IB1	1	150	Overcurrent block level, in % of rated current
HourHuntDetect	0 - 30	Op/H	1	30	Level for number of counted raise/lower within one hour
Table continues on next page					

Name	Values (Range)	Unit	Step	Default	Description
DayHuntDetect	0 - 100	Op/D	1	100	Level for number of counted raise/lower within 24 hour
tWindowHunt	1 - 120	Min	1	60	Time window for hunting alarm, minutes
NoOpWindow	3 - 30	Op/W	1	30	Hunting detection alarm, maximum operations/window
P>	-9999.99 - 9999.99	MW	0.01	1000	Alarm level of active power in forward direction
P<	-9999.99 - 9999.99	MW	0.01	-1000	Alarm level of active power in reverse direction
Q>	-9999.99 - 9999.99	MVAr	0.01	1000	Alarm level of reactive power in forward direction
Q<	-9999.99 - 9999.99	MVAr	0.01	-1000	Alarm level of reactive power in reverse direction
tPower	1 - 6000	s	1	10	Time delay for alarms from power supervision

Table 150: TR1ATCC Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
GlobalBaseSel1	1 - 6	-	1	1	Global base selector for winding 1
GlobalBaseSel2	1 - 6	-	1	1	Global base selector for winding 2
Xr2	0.1 - 200.0	ohm	0.1	0.5	Transformer reactance in primary ohms on ATCC side
CmdErrBk	Alarm Auto Block Auto&Man Block	-	-	Auto Block	Alarm, auto block or auto&man block for command error
OCBk	Alarm Auto Block Auto&Man Block	-	-	Auto&Man Block	Alarm, auto block or auto&man block for overcurrent
OVPartBk	Alarm Auto Block Auto&Man Block	-	-	Auto&Man Block	Alarm, auto partial or auto&man partial block for overvoltage
RevActPartBk	Alarm Auto Block	-	-	Alarm	Alarm or auto partial block for reverse action
TapChgBk	Alarm Auto Block Auto&Man Block	-	-	Auto Block	Alarm, auto block or auto&man block for tap changer error
TapPosBk	Alarm Auto Block Auto&Man Block	-	-	Auto Block	Alarm, auto or auto&man block for position supervision
UVBk	Alarm Auto Block Auto&Man Block	-	-	Auto Block	Alarm, auto block or auto&man block for undervoltage
UVPartBk	Alarm Auto Block Auto&Man Block	-	-	Auto Block	Alarm, auto partial or auto&man partial block for undervoltage

9.2.2.5 Monitored data

Table 151: TR1ATCC Monitored data

Name	Type	Values (Range)	Unit	Description
RAISE	BOOLEAN	-	-	Raise voltage order to tapchanger
LOWER	BOOLEAN	-	-	Lower voltage order to tapchanger
BUSVOLT	REAL	-	kV	Average of the measured busbar voltage (service value)
VOLTDEV	REAL	-	%	Voltage deviation compared to dead band (%)
TRLDCURR	REAL	-	A	Amplitude of own load current
USETOUT	REAL	-	kV	Voltage setpoint used in single mode (service value)
ULOAD	REAL	-	kV	Calculated compensated voltage (service value)
P	REAL	-	MW	Calculated active power (service value)
Q	REAL	-	MVAr	Calculated reactive power (service value)
IPRIM	REAL	-	A	Maximum of 3 phase currents (service value)

9.2.3 Automatic voltage control for tap changer, parallel control (TR8ATCC)

9.2.3.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Automatic voltage control for tap changer, parallel control	TR8ATCC	-	90

9.2.3.2 Function block

IEC09000325_1_en.vsd

Figure 87: TR8ATCC function block

9.2.3.3 Signals

Table 152: TR8ATCC Input signals

Name	Type	Default	Description
I3P1	GROUP SIGNAL	-	Three phase group signal for current on HV side
I3P2	GROUP SIGNAL	-	Three phase group signal for current on LV side
U3P2	GROUP SIGNAL	-	Three phase group signal for voltage on LV side
HORIZ1	GROUP SIGNAL	-	Group connection for horizontal communication from T1
HORIZ2	GROUP SIGNAL	-	Group connection for horizontal communication from T2
HORIZ3	GROUP SIGNAL	-	Group connection for horizontal communication from T3
HORIZ4	GROUP SIGNAL	-	Group connection for horizontal communication from T4
ATCCIN	GROUP SIGNAL	-	Group connection from YLTCOUT
BLOCK	BOOLEAN	0	Block of function
MANCTRL	BOOLEAN	0	Binary "MAN" command
AUTOCTRL	BOOLEAN	0	Binary "AUTO" command
PSTO	INTEGER	0	Operator place selection
RAISEV	BOOLEAN	0	Binary "UP" command
Table continues on next page			

Name	Type	Default	Description
LOWERV	BOOLEAN	0	Binary "DOWN" command
EAUTOBLK	BOOLEAN	0	Block voltage control in automatic control mode
DEBLKAUT	BOOLEAN	0	Binary "Deblock Auto" command
LVA1	BOOLEAN	0	Activation of load voltage adjustment factor 1
LVA2	BOOLEAN	0	Activation of load voltage adjustment factor 2
LVA3	BOOLEAN	0	Activation of load voltage adjustment factor 3
LVA4	BOOLEAN	0	Activation of load voltage adjustment factor 4
LVARESET	BOOLEAN	0	Reset LVA
RSTERR	BOOLEAN	0	Resets automatic control commands
DISC	BOOLEAN	0	Disconnected transformer
SNGLMODE	BOOLEAN	0	Voltage control in single control
T1INCLD	BOOLEAN	0	Transformer1 included in parallel group
T2INCLD	BOOLEAN	0	Transformer2 included in parallel group
T3INCLD	BOOLEAN	0	Transformer3 included in parallel group
T4INCLD	BOOLEAN	0	Transformer4 included in parallel group
FORCMAST	BOOLEAN	0	Force transformer to master
RSTMAST	BOOLEAN	0	Reset forced master transformer to default

Table 153: TR8ATCC Output signals

Name	Type	Description
ATCCOUT	GROUP SIGNAL	Group connection to YLTCIN
MAN	BOOLEAN	Manual control mode is active
AUTO	BOOLEAN	Automatic control mode is active
IBLK	BOOLEAN	One phase current is above the set limit
PGTFWD	BOOLEAN	Active power above the set limit powerActiveForw
PLTREV	BOOLEAN	Active power below the set limit powerActiveRev
QGTFWD	BOOLEAN	Reactive power above the set limit powerReactiveForw
QLTREV	BOOLEAN	Reactive power below the set limit powerReactiveRev
UHIGH	BOOLEAN	Busbar voltage above the set limit voltBusbMaxLimit
ULOW	BOOLEAN	Busbar voltage below the set limit voltBusbMinLimit
UBLK	BOOLEAN	Busbar voltage below the set limit voltBusbBlockLimit
HOURHUNT	BOOLEAN	Number of commands within the latest hour exceeded maximum level
DAYHUNT	BOOLEAN	Number of commands within the last 24 hours exceeded maximum level
HUNTING	BOOLEAN	Number of commands in opposite direction exceeded maximum level

Table continues on next page

Name	Type	Description
SINGLE	BOOLEAN	Transformer operates in single mode
PARALLEL	BOOLEAN	Transformer operates in parallel mode
TIMERON	BOOLEAN	Raise or lower command to the tap activated
ADAPT	BOOLEAN	Transformer is adapting
TOTBLK	BOOLEAN	Block of auto and manual commands
AUTOBLK	BOOLEAN	Block of auto commands
MASTER	BOOLEAN	Transformer is master
FOLLOWER	BOOLEAN	This transformer is follower
MFERR	BOOLEAN	Number of masters is different from one
OUTOFPOS	BOOLEAN	Difference in tap positions exceeded the set limit
UGTUPPDB	BOOLEAN	Voltage greater than deadband-high, ULOWER command to come
ULTLOWDB	BOOLEAN	Voltage lower than deadband-low, URAISE command to come
COMMERR	BOOLEAN	Communication error
ICIRC	BOOLEAN	Block from high circulating current
TRFDISC	BOOLEAN	Transformer is disconnected
VTALARM	BOOLEAN	VT supervision alarm
T1PG	BOOLEAN	Transformer 1 included in parallel group
T2PG	BOOLEAN	Transformer 2 included in parallel group
T3PG	BOOLEAN	Transformer 3 included in parallel group
T4PG	BOOLEAN	Transformer 4 included in parallel group

9.2.3.4 Settings

Table 154: TR8ATCC Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
MeasMode	L1 L2 L3 L1L2 L2L3 L3L1 PosSeq	-	-	PosSeq	Selection of measured voltage and current
TotalBlock	Off On	-	-	Off	Total block of the voltage control function
AutoBlock	Off On	-	-	Off	Block of the automatic mode in voltage control function
FSDMode	Off Auto AutoMan	-	-	Off	Fast step down function activation mode
tFSD	1.0 - 100.0	s	0.1	15.0	Time delay for lower command when fast step down mode is activated

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
USet	85.0 - 120.0	%UB2	0.1	100.0	Voltage control set voltage, in % of rated voltage
UDeadband	0.2 - 9.0	%UB2	0.1	1.2	Outer voltage deadband, in % of rated voltage
UDeadbandInner	0.1 - 9.0	%UB2	0.1	0.9	Inner voltage deadband, in % of rated voltage
Umax	80 - 180	%UB2	1	105	Upper limit of busbar voltage, in % of rated voltage
Umin	70 - 120	%UB2	1	80	Lower limit of busbar voltage, in % of rated voltage
Ublock	50 - 120	%UB2	1	80	Undervoltage block level, % of rated voltage
t1Use	Constant Inverse	-	-	Constant	Activation of long inverse time delay
t1	3 - 1000	s	1	60	Time delay (long) for automatic control commands
t2Use	Constant Inverse	-	-	Constant	Activation of short inverse time delay
t2	1 - 1000	s	1	15	Time delay (short) for automatic control commands
tMin	3 - 120	s	1	5	Minimum operating time in inverse mode
OperationLDC	Off On	-	-	Off	Operation line voltage drop compensation
OperCapaLDC	Off On	-	-	Off	LDC compensation for capacitive load
Rline	0.00 - 150.00	ohm	0.01	0.0	Line resistance, primary values, in ohm
Xline	-150.00 - 150.00	ohm	0.01	0.0	Line reactance, primary values, in ohm
LVAConst1	-20.0 - 20.0	%UB2	0.1	0.0	Constant 1 for LVA, % of regulated voltage
LVAConst2	-20.0 - 20.0	%UB2	0.1	0.0	Constant 2 for LVA, % of regulated voltage
LVAConst3	-20.0 - 20.0	%UB2	0.1	0.0	Constant 3 for LVA, % of regulated voltage
LVAConst4	-20.0 - 20.0	%UB2	0.1	0.0	Constant 4 for LVA, % of regulated voltage
VRAuto	-20.0 - 20.0	%UB2	0.1	0.0	Load voltage auto correction, in % of rated voltage
Iblock	0 - 250	%IB1	1	150	Overcurrent block level, in % of rated current
HourHuntDetect	0 - 30	Op/H	1	30	Level for number of counted raise/lower within one hour
DayHuntDetect	0 - 100	Op/D	1	100	Level for number of counted raise/lower within 24 hour
tWindowHunt	1 - 120	Min	1	60	Time window for hunting alarm, minutes
NoOpWindow	3 - 30	Op/W	1	30	Hunting detection alarm, maximum operations/window
P>	-9999.99 - 9999.99	MW	0.01	1000	Alarm level of active power in forward direction

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
P<	-9999.99 - 9999.99	MW	0.01	-1000	Alarm level of active power in reverse direction
Q>	-9999.99 - 9999.99	MVAr	0.01	1000	Alarm level of reactive power in forward direction
Q<	-9999.99 - 9999.99	MVAr	0.01	-1000	Alarm level of reactive power in reverse direction
tPower	1 - 6000	s	1	10	Time delay for alarms from power supervision
OperationPAR	Off CC MF	-	-	Off	Parallel operation, Off/CirculatingCurrent/ MasterFollower
OperCCBlock	Off On	-	-	On	Enable block from circulating current supervision
CircCurrLimit	0.0 - 20000.0	%IB2	0.1	100.0	Block level for circulating current
tCircCurr	0 - 1000	s	1	30	Time delay for block from circulating current
Comp	0 - 2000	%	1	100	Compensation parameter in % for Circulating Current
OperSimTap	Off On	-	-	Off	Simultaneous tapping prohibited
OperUsetPar	Off On	-	-	Off	Use common voltage set point for parallel operation
VTmismatch	0.5 - 10.0	%UB2	0.1	10.0	Alarm level for VT supervision, in % of rated voltage
tVTmismatch	1 - 600	s	1	10	Time delay for VT supervision alarm
T1RXOP	Off On	-	-	Off	Receive block operation from parallel transformer 1
T2RXOP	Off On	-	-	Off	Receive block operation from parallel transformer 2
T3RXOP	Off On	-	-	Off	Receive block operation from parallel transformer 3
T4RXOP	Off On	-	-	Off	Receive block operation from parallel transformer 4
TapPosOffs	-5 - 5	-	1	0	Tap position offset in relation to the master
MFPosDiffLim	1 - 20	-	1	1	Alarm for tap position difference from master
tMFPosDiff	0 - 6000	s	1	60	Time for tap position difference from master

Table 155: TR8ATCC Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
GlobalBaseSel1	1 - 6	-	1	1	Selection of one of the Global Base Value groups, winding 1
GlobalBaseSel2	1 - 6	-	1	1	Selection of one of the Global Base Value groups, winding 2
TrfId	T1 T2 T3 T4	-	-	T1	Identity of transformer
Xr2	0.1 - 200.0	ohm	0.1	0.5	Transformer reactance in primary ohms on ATCC side
tAutoMSF	0 - 60	s	1	10	Time delay for command for auto follower
OperationAdapt	Off On	-	-	Off	Enable adapt mode
MFMode	Follow Cmd Follow Tap	-	-	Follow Cmd	Select follow tap or follow command
CircCurrBk	Alarm Auto Block Auto&Man Block	-	-	Alarm	Alarm, auto block or auto&man block for high circulating current
CmdErrBk	Alarm Auto Block Auto&Man Block	-	-	Auto Block	Alarm, auto block or auto&man block for command error
OCBk	Alarm Auto Block Auto&Man Block	-	-	Auto&Man Block	Alarm, auto block or auto&man block for overcurrent
MFPosDiffBk	Alarm Auto Block	-	-	Auto Block	Alarm or auto block for tap position difference in MF
OVPartBk	Alarm Auto Block Auto&Man Block	-	-	Auto&Man Block	Alarm, auto partial or auto&man partial block for overvoltage
RevActPartBk	Alarm Auto Block	-	-	Alarm	Alarm or auto partial block for reverse action
TapChgBk	Alarm Auto Block Auto&Man Block	-	-	Auto Block	Alarm, auto block or auto&man block for tap changer error
TapPosBk	Alarm Auto Block Auto&Man Block	-	-	Auto Block	Alarm, auto or auto&man block for position supervision
UVBk	Alarm Auto Block Auto&Man Block	-	-	Auto Block	Alarm, auto block or auto&man block for undervoltage
UVPartBk	Alarm Auto Block Auto&Man Block	-	-	Auto Block	Alarm, auto partial or auto&man partial block for undervoltage

9.2.3.5 Monitored data

Table 156: TR8ATCC Monitored data

Name	Type	Values (Range)	Unit	Description
RAISE	BOOLEAN	-	-	Raise voltage order to tapchanger
LOWER	BOOLEAN	-	-	Lower voltage order to tapchanger
BUSVOLT	REAL	-	kV	Average of measured busbar voltage (service value)
VOLTDEV	REAL	-	%	Voltage deviation compared to dead band (%)
TRLDCURR	REAL	-	A	Amplitude of own load current
USETOUT	REAL	-	kV	Voltage setpoint used in single mode (service value)
ULOAD	REAL	-	kV	Calculated compensated voltage (service value)
P	REAL	-	MW	Calculated active power (service value)
Q	REAL	-	MVAr	Calculated reactive power (service value)
IPRIM	REAL	-	A	Maximum of 3 phase currents (service value)
CCAVolt	REAL	-	kV	Circulating current adjusted voltage
USETPAR	REAL	-	kV	Average voltage setpoint used in parallel mode
ICIRCUL	REAL	-	A	Circulating current

9.2.4 Tap changer control and supervision, 6 binary inputs (TCMYLTC)

9.2.4.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Tap changer control and supervision, 6 binary inputs	TCMYLTC	-	84

9.2.4.2 Function block

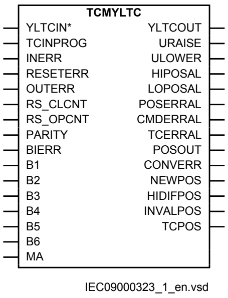

Figure 88: TCMYLTC function block

9.2.4.3 Signals

TCMYLTC has no other input for tap changer position other than, binary in first release of 650 series. Input signal MA is not supported in the IED.

Table 157: TCMYLTC Input signals

Name	Type	Default	Description
YLTCIN	GROUP SIGNAL	-	Group connection from ATCCOUT
TCINPROG	BOOLEAN	0	Indication that tap is moving
INERR	BOOLEAN	0	Supervision signal of the input board
RESETERR	BOOLEAN	0	Reset of command and tap error
OUTERR	BOOLEAN	0	Supervision of the digital output board
RS_CLCNT	BOOLEAN	0	Reset of the contact life counter
RS_OPCNT	BOOLEAN	0	Resets the operation counter
PARITY	BOOLEAN	0	Parity bit from tap changer for the tap position
BIERR	BOOLEAN	0	Error bit from tap changer for the tap position
B1	BOOLEAN	0	Bit 1 from tap changer for the tap position
B2	BOOLEAN	0	Bit 2 from tap changer for the tap position
B3	BOOLEAN	0	Bit 3 from tap changer for the tap position
B4	BOOLEAN	0	Bit 4 from tap changer for the tap position
B5	BOOLEAN	0	Bit 5 from tap changer for the tap position
B6	BOOLEAN	0	Bit 6 from tap changer for the tap position
MA	REAL	0	mA from tap changer for the tap position

Table 158: TCMYLTC Output signals

Name	Type	Description
YLTCOUT	GROUP SIGNAL	Group connection to ATCCIN
URAISE	BOOLEAN	Raise voltage command to tap changer
ULOWER	BOOLEAN	Lower voltage command to tap changer
HIPOSAL	BOOLEAN	Alarm for tap in the highest volt position
LOPOSAL	BOOLEAN	Alarm for tap in the lowest volt position
POSERRAL	BOOLEAN	Alarm that indicates a problem with the position indication
CMDERRAL	BOOLEAN	Alarm for a command without an expected position change
TCERRAL	BOOLEAN	Alarm for none or illegal tap position change
POSOUT	BOOLEAN	Tap position outside range
CONVERR	BOOLEAN	General tap position conversion error
NEWPOS	BOOLEAN	A new tap position is reported, 1 sec pulse
HIDIFPOS	BOOLEAN	Tap position has changed more than one position
INVALPOS	BOOLEAN	Last position change was an invalid change
TCPOS	INTEGER	Integer value corresponding to actual tap position

9.2.4.4 Settings

Table 159: TCMYLTC Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
tTCTimeout	1 - 120	s	1	5	Tap changer constant time-out
tPulseDur	0.5 - 10.0	s	0.1	1.5	Raise/lower command output pulse duration

Table 160: TCMYLTC Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
GlobalBaseSel	1 - 6	-	1	1	Global Base Selector
LowVoltTap	1 - 63	-	1	1	Tap position for the lowest voltage
HighVoltTap	1 - 63	-	1	33	Tap position for the highest voltage
mALow	0.000 - 25.000	mA	0.001	4.000	mA for the lowest voltage tap position
mAHigh	0.000 - 25.000	mA	0.001	20.000	mA for the highest voltage tap position
CodeType	Binary BCD Gray ContactPerTap mA	-	-	Binary	Type of code conversion
UseParity	Off On	-	-	Off	Enable parity check
Table continues on next page					

Name	Values (Range)	Unit	Step	Default	Description
tStable	1 - 60	s	1	2	Time after position change before the value is accepted
CLFactor	1.0 - 3.0	-	0.1	2.0	Adjustable factor for contact life function
InitCLCounter	0 - 9999999	s	1	250000	CL counter start value
EnabTapCmd	Off On	-	-	On	Enable commands to tap changer

9.2.4.5 Monitored data

Table 161: TCMYLTC Monitored data

Name	Type	Values (Range)	Unit	Description
CNT_VAL	INTEGER	-	-	Number of operations on tap changer
CLCNT_VAL	REAL	-	-	Remaining number of operations at rated load
TCPOS	INTEGER	-	-	Integer value corresponding to actual tap position

9.2.5 Operation principle

The voltage control function is built up by two function blocks. Both are logical nodes in IEC 61850-8-1:

- Automatic voltage control for tap changer, (TR1ATCC for single control and TR8ATCC for parallel control)
- Tap changer control and supervision, 6 binary inputs (TCMYLTC)

Automatic voltage control for tap changer, (TR1ATCC for single control and TR8ATCC for parallel control) function is designed to automatically maintain the voltage at the LV-side side of a power transformer within given limits around a set target voltage. A raise or lower command is generated whenever the measured voltage, for a given period of time, deviates from the set target value by more than the preset deadband value that is, degree of insensitivity. A time-delay (inverse or definite time) is set to avoid unnecessary operation during shorter voltage deviations from the target value, and in order to coordinate with other automatic voltage controllers in the system.

Tap changer control and supervision, 6 binary inputs (TCMYLTC) is an interface between the Automatic voltage control for tap changer, (TR1ATCC or TR8ATCC) and the transformer On-Load-Tap Changer. More specifically this means that it receives information from (TR1ATCC or TR8ATCC), and based on this it gives command-pulses to a power transformer motor driven on-load tap changer and also receives information from the On-Load-Tap Changer regarding tap position, progress of given commands etc.

9.2.5.1 Automatic voltage control for tap changer (TR1ATCC for single control and TR8ATCC parallel control)

The LV-side of the transformer is used as the voltage measuring point. If necessary, the LV side current is used as load current to calculate the line-voltage drop to the regulation point. This current is also used when parallel control with the circulating current method is used.

In addition, all three-phase currents from the HV-winding (usually the winding where the tap changer is situated) are used by the Automatic voltage control for tap changer, (TR1ATCC for single control and TR8ATCC for parallel control) function for over current blocking.

The setting *MeasMode* is a selection of single-phase, or phase-phase, or positive sequence quantity. It is to be used for voltage and current measurement on the LV-side. The involved phases are also selected. Thus, single-phases as well as phase-phase or three-phase feeding on the LV-side is possible but it is commonly selected for current and voltage.

The analog input signals are normally common for other functions in the IED for example, protection functions.

The LV-busbar voltage is designated UB, load current I_L and for load point voltage U_L will be used in the text to follow.

Automatic voltage control for tap changer, single control (TR1ATCC)

Automatic voltage control for tap changer, single control (TR1ATCC) function measures the magnitude of the busbar voltage UB. If no other additional features are enabled (line voltage drop compensation), this voltage is further used for voltage regulation.

TR1ATCC then compares this voltage with the set voltage, *USet* and decides which action should be taken. To avoid unnecessary switching around the setpoint, a deadband (degree of insensitivity) is introduced. The deadband is symmetrical around*USet* (see figure 89), and it is arranged in such a way that there is an outer and an inner deadband. Measured voltages outside the outer deadband start the timer to initiate tap commands, whilst the sequence resets when the measured voltage is once again back inside the inner deadband. One half of the outer deadband is denoted ΔU. The setting of ΔU, setting *Udeadband* should be set to a value near to the power transformer’s tap changer voltage step (typically 75–125% of the tap changer step).

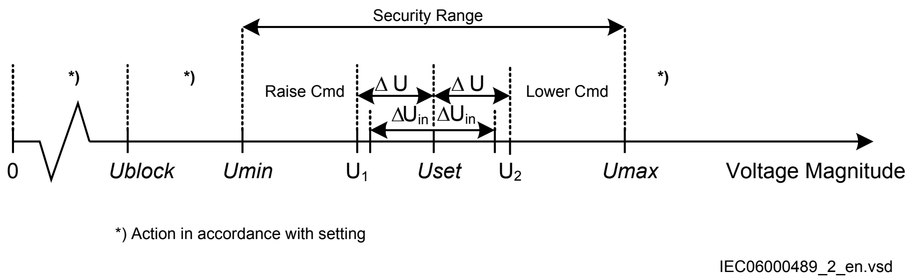

Figure 89: Control actions on a voltage scale.

During normal operating conditions the busbar voltage UB, stays within the outer deadband (interval between U1 and U2 in figure 89). In that case no actions will be taken by the TR1ATCC. However, if UB becomes smaller than U1, or greater than U2, an appropriate lower or raise timer will start. The timer will run as long as the measured voltage stays outside the inner deadband. If this condition persists longer than the preset time delay, TR1ATCC will initiate that the appropriate ULOWER or URAISE command will be sent from Tap changer control and supervision, 6 binary inputs (TCMYLTC) to the transformer On-Load-Tap-Changer. If necessary, the procedure will be repeated until the magnitude of the busbar voltage again falls within the inner deadband. One half of the inner deadband is denoted ΔU_{in}. The inner deadband ΔU_{in}, setting*UDeadbandInner* should be set to a value smaller than ΔU. It is recommended to set the inner deadband to 25-70% of the ΔU value.

This way of working is used by TR1ATCC while the busbar voltage is within the security range defined by settings*Umin and Umax*

A situation where UB falls outside this range will be regarded as an abnormal situation.

Instead of controlling the voltage at the LV busbar in the same substation as the transformer itself, it is possible to control the voltage at a load point out in the network, downstream from the transformer. The Line Voltage Drop Compensation (LDC) can be selected by a setting parameter, and it works such that the voltage drop from the transformer location to the load point is calculated based on the measured load current and the known line impedance.

In order to prevent unnecessary On-Load-Tap-Changer operations caused by temporary voltage fluctuations and to coordinate On-Load-Tap-Changer operations in radial networks, a time delay is used for the tapping command to the On-Load-Tap-Changer. The time delay can be either definite time or inverse time and two time settings are used, the first (*t1*) for the initial delay of a tap command, and the second (*t2*) for consecutive tap commands.

Automatic control for tap changer, parallel control (TR8ATCC)

Parallel control of power transformers means control of two or more power transformers connected to the same busbar on the LV side and in most cases also on the HV side. Special measures must be taken in order to avoid a runaway situation where the tap changers on the parallel transformers gradually diverge and end up in opposite end positions.

Three alternative methods can be used for parallel control with the TR8ATCC function: the master-follower method, the reverse reactance method and the circulating current method.

Parallel control with the master-follower method

In the master-follower method, one of the transformers is selected to be master, and will regulate the voltage in accordance with the principles Automatic voltage control for a tap changer, single control TR1ATCC. Selection of the master is made by activating the binary input FORCMAST in theTR8ATCC function block for one of the transformers in the group.

The followers can act in one of two alternative ways selected by a setting parameter:

1. Raise and lower commands (URAISE and ULOWER) generated by the master, initiates the corresponding command in all follower TR8ATCCs simultaneously, and consequently they will blindly follow the master commands irrespective of their individual tap positions.
2. The followers read the tap position of the master and adapt to the same tap position or to a tap position with an offset relative to the master. In this mode, the followers can also be time delayed relative to the master.

Parallel control with the reverse reactance method

In the reverse reactance method, the LDC (Line voltage drop compensation) is used. The purpose is to control the voltage at a load point further out in the network. The very same function can also be used here but with a completely different objective. Whereas the LDC, when used to control the voltage at a load point, gives a voltage drop along a line from the busbar voltage UB to a load point voltage U_L, the LDC, when used in the reverse reactance parallel control of transformers, gives a voltage increase (actually, by adjusting the ratio X_L/R_L with respect to the power factor, the length of the vector U_L will be approximately equal to the length of UB) from UB up towards the transformer itself.

When the voltage at a load point is controlled by using LDC, the line impedance from the transformer to the load point is defined by the setting *Xline*. If a negative reactance is entered instead of the normal positive line reactance, parallel transformers will act in such a way that the transformer with a higher tap position will be the first to tap down when the busbar voltage increases, and the transformer with a lower tap position will be the first to tap up when the busbar voltage decreases. The overall performance will then be that a runaway tap situation will be avoided and that the circulating current will be minimized.

Parallel control with the circulating current method

This method requires extensive exchange of data between the TR8ATCC function blocks (one TR8ATCC function for each transformer in the parallel group). The TR8ATCC function block can either be located in the same IED, where they are configured in PCM600 to co-operate, or in different IEDs.

The main objectives of the circulating current method for parallel voltage control are:

1. Regulate the busbar or load voltage to the preset target value.
2. Minimize the circulating current in order to achieve optimal sharing of the reactive load between parallel transformers.

The busbar voltage UB is measured individually for each transformer in the parallel group by its associated TR8ATCC function. These measured values will then be exchanged between the transformers, and in each TR8ATCC block, the mean value of all UB values will be calculated. The resulting value U_{Bmean} will then be used in each IED instead of UB for the voltage regulation, thus assuring that the same value is used by all TR8ATCC functions, and thereby avoiding that one erroneous measurement in one transformer could upset the voltage regulation. At the same time, supervision of the VT mismatch is also performed.

Figure 90 shows an example with two transformers connected in parallel. If transformer T1 has higher no load voltage it will drive a circulating current which adds to the load current in T1 and subtracts from the load current in T2.

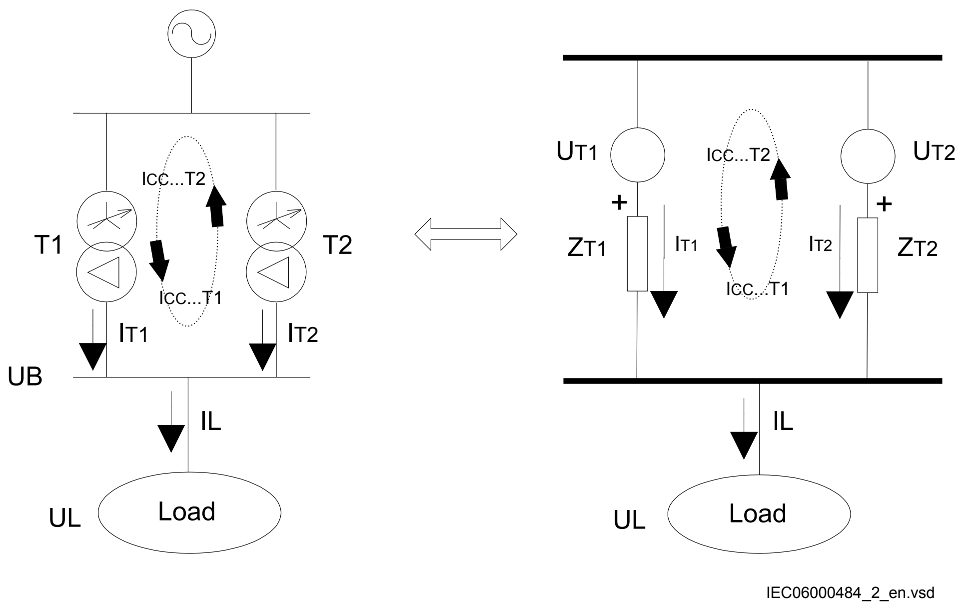

Figure 90: Circulating current in a parallel group of two transformers

It can be shown that the magnitude of the circulating current in this case can be approximately calculated with the formula:

$$\left|I_{cc\_T1}\right| = \left|I_{cc\_T2}\right| = \left|\frac{U_{T1} - U_{T2}}{Z_{T1} + Z_{T2}}\right|$$

(Equation 54)

Because the transformer impedance is dominantly inductive, it is possible to use just the transformer reactances in the above formula. At the same time this means that T1 circulating current lags the busbar voltage by almost 90°, while T2 circulating current leads the busbar voltage by almost 90°.

9.2.5.2 Tap changer control and supervision, 6 binary inputs (TCMYLTC)

Reading of tap changer position

The tap changer position can be received to the tap changer control and supervision, 6 binary inputs (TCMYLTC) function block in the following ways:

1. Via binary input signals, one per tap position (max. 6 positions).
2. Via coded binary (Binary), binary coded decimal (BCD) signals, or Gray coded binary signals.

Via binary input signals, one per tap position

In this option, each tap position has a separate contact that is hard wired to a binary input in the IED. Via the Signal Matrix tool (SMT) in PCM600, the contacts on the binary input card are then directly connected to the inputs B1 – B6 on the TCMYLTC function block.

Via coded binary (Binary), binary coded decimal (BCD) signals or Gray coded binary signals

The Tap changer control and supervision, 6 binary inputs (TCMYLTC) function decodes binary data from up to six binary inputs to an integer value. The input pattern may be decoded either as BIN, BCD or GRAY format depending on the setting of the parameter *CodeType*.

It is also possible to use even parity check of the input binary signal. Whether the parity check shall be used or not is set with the setting parameter *UseParity*.

The input BIERR on the TCMYLTC function block can be used as supervisory input for indication of any external error (Binary Input/output Module) in the system for reading of tap changer position. Likewise, the input OUTERR can be used as a supervisory of the Binary Input/output Module.

The truth table (see table 162) shows the conversion for Binary, Binary Coded Decimal, and Gray coded signals.

Table 162: Binary, BCD and Gray conversion

INPUTS							OUTPUTS					
							BIN coded		BCD coded		GRAY coded	
BIT 6 (MSB)	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1 (LSB)	PARITY PARUSE=1	VALUE	ERROR	VALUE	ERROR	VALUE	ERROR
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	1	1	1	0	1	0	1	0
0	0	0	0	1	0	1	2	0	2	0	3	0
0	0	0	0	1	1	0	3	0	3	0	2	0
0	0	0	1	0	0	1	4	0	4	0	7	0
0	0	0	1	0	1	0	5	0	5	0	6	0
0	0	0	1	1	0	0	6	0	6	0	4	0
0	0	0	1	1	1	1	7	0	7	0	5	0
0	0	1	0	0	0	1	8	0	8	0	15	0
0	0	1	0	0	1	0	9	0	9	0	14	0
0	0	1	0	1	0	0	10	0	0	1	24	0
0	0	1	0	1	1	1	11	0	0	1	13	0
0	0	1	1	0	0	0	12	0	0	1	8	0
0	0	1	1	0	1	1	13	0	0	1	9	0
0	0	1	1	1	0	1	14	0	0	1	11	0
0	0	1	1	1	1	0	15	0	0	1	10	0
0	1	0	0	0	0	1	16	0	10	0	31	0
0	1	0	0	0	1	0	17	0	11	0	30	0
0	1	0	0	1	0	0	18	0	12	0	28	0
0	1	0	0	1	1	1	19	0	13	0	29	0
0	1	0	1	0	0	0	20	0	14	0	24	0
0	1	0	1	0	1	1	21	0	15	0	25	0
0	1	0	1	1	0	1	22	0	16	0	27	0
0	1	0	1	1	1	0	23	0	17	0	26	0
0	1	1	0	0	0	0	24	0	18	0	16	0
0	1	1	0	0	1	1	25	0	19	0	17	0
0	1	1	0	1	0	1	26	0	0	1	19	0
0	1	1	0	1	1	0	27	0	0	1	18	0
0	1	1	1	0	0	1	28	0	0	1	23	0
0	1	1	1	0	1	0	29	0	0	1	22	0
0	1	1	1	1	0	0	30	0	0	1	20	0
0	1	1	1	1	1	1	31	0	0	1	21	0
1	0	0	0	0	0	1	32	0	20	0	63	0
1	0	0	0	0	1	0	33	0	21	0	62	0
1	0	0	0	1	0	0	34	0	22	0	60	0
1	0	0	0	1	1	1	35	0	23	0	61	0
1	0	0	1	0	0	0	36	0	24	0	56	0
1	0	0	1	0	1	1	37	0	25	0	57	0
1	0	0	1	1	0	1	38	0	26	0	59	0
1	0	0	1	1	1	0	39	0	27	0	58	0
1	0	1	0	0	0	0	40	0	28	1	48	0
1	0	1	0	0	1	1	41	0	29	1	49	0
1	0	1	0	1	0	1	42	0	0	1	51	0
1	0	1	0	1	1	0	43	0	0	1	50	0
1	0	1	1	0	0	1	44	0	0	1	55	0
1	0	1	1	0	1	0	45	0	0	1	54	0
1	0	1	1	1	0	0	46	0	0	1	52	0

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The Gray code conversion above is not complete and therefore the conversion from decimal numbers to Gray code is given below.

Table 163: Gray code conversion

INPUTS							OUTPUT GRAY coded
BIT 6 (MSB)	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1 (LSB)	PARITY PARUSE=1	VALUE
0	0	0	0	0	0	0	0
0	0	0	0	0	1	1	1
0	0	0	0	1	1	0	2
0	0	0	0	1	0	1	3
0	0	0	1	1	0	0	4
0	0	0	1	1	1	1	5
0	0	0	1	0	1	0	6
0	0	0	1	0	0	1	7
0	0	1	1	0	0	0	8
0	0	1	1	0	1	1	9
0	0	1	1	1	1	0	10
0	0	1	1	1	0	1	11
0	0	1	0	1	0	0	12
0	0	1	0	1	1	1	13
0	0	1	0	0	1	0	14
0	0	1	0	0	0	1	15
0	1	1	0	0	0	0	16
0	1	1	0	0	1	1	17
0	1	1	0	1	1	0	18
0	1	1	0	1	0	1	19
0	1	1	1	1	0	0	20
0	1	1	1	1	1	1	21
0	1	1	1	0	1	0	22
0	1	1	1	0	0	1	23
0	1	0	1	0	0	0	24
0	1	0	1	0	1	1	25
0	1	0	1	1	1	0	26
0	1	0	1	1	0	1	27
0	1	0	0	1	0	0	28
0	1	0	0	1	1	1	29
0	1	0	0	0	1	0	30
0	1	0	0	0	0	1	31
1	1	0	0	0	0	0	32
1	1	0	0	0	1	1	33
1	1	0	0	1	1	0	34
1	1	0	0	1	0	1	35
1	1	0	1	1	0	0	36
1	1	0	1	1	1	1	37
1	1	0	1	0	1	0	38
1	1	0	1	0	0	1	39
1	1	1	1	0	0	0	40
1	1	1	1	0	1	1	41
1	1	1	1	1	1	0	42
1	1	1	1	1	0	1	43
1	1	1	0	1	0	0	44
1	1	1	0	1	1	1	45
1	1	1	0	0	1	0	46

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9.2.5.3 Connection between TR1ATCC or TR8ATCC and TCMYLTC

The two function blocks automatic voltage control for tap changer, parallel control (TR1ATCC for single control and TR8ATCC for parallel control) and Tap changer control and supervision, 6 binary inputs (TCMYLTC) are connected to each other according to figure 91 below.

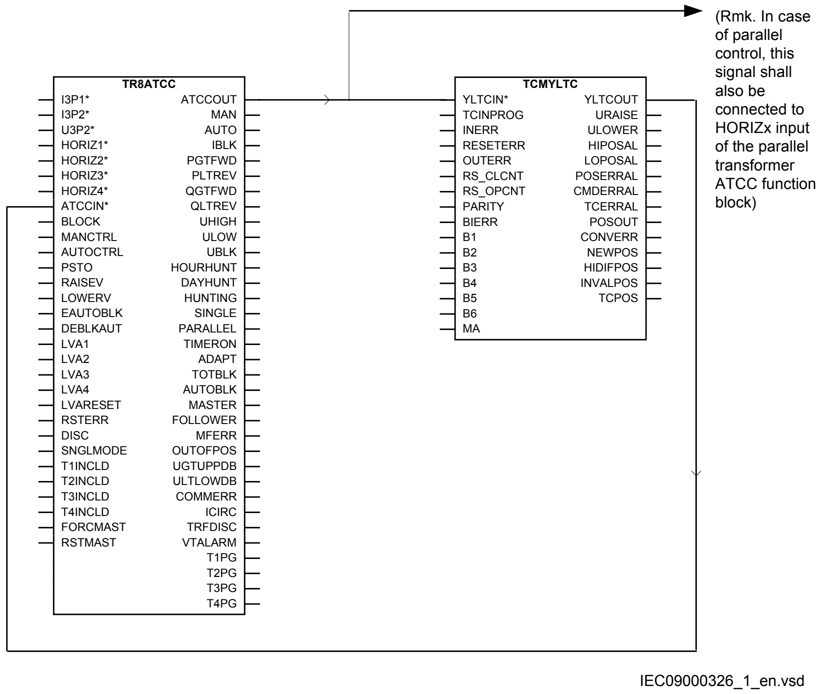


Figure 91: Connection between TR8ATCC and TCMYLTC

The TR8ATCC and TR1ATCC function blocks has an output signal ATCCOUT which is connected to input YLTCIN on TCMYLTC function. The data set sent from ATCCOUT to YLTCIN contains 5 binary signals, one “word” containing 10 binary signals and 1 analog signal. For TR8ATCC data is also sent from output ATCCOUT to other TR8ATCC function input HORIZx, when the master-follower or circulating current mode is used.

Table 164: Binary signals: ATCCOUT / YLTCIN

Signal	Description
raiseVolt	Order to TCMYLTC to make a raise command
lowerVolt	Order to TCMYLTC to make a lower command
automaticCtrl	The regulation is in automatic control
extRaiseBlock	Block raise commands
extLowerBlock	Block lower commands

Table 165: Binary signals contained in word “enableBlockSignals”: ATCCOUT / YLTCIN

Signal	Description
CircCurrBl	Alarm/Block tap changer operation because of high circulating current
CmdErrBl	Alarm/Block tap changer operation because of command error
OCBl	Alarm/Block tap changer operation because of over current
MFPosDiffBl	Alarm/Block tap changer operation because the tap difference between a follower and the master is greater than the set value
OVPartBl	Alarm/Block raise commands because the busbar voltage is above *Umax*
Table continues on next page	

Signal	Description
RevActPartBl	Alarm/Block raise commands because reverse action is activated
TapChgBl	Alarm/Block tap changer operation because of tap changer error
TapPosBl	Alarm/Block commands in one direction because the tap changer has reached an end position, or Alarm/Block tap changer operation because of tap changer error
UVBl	Alarm/Block tap changer operation because the busbar voltage is below *Ublock*
UVPartBl	Alarm/Block lower commands because the busbar voltage is between *Umin* and *Ublock*

Table 166: Analog signal: ATCCOUT / YLTCIN

Signal	Description
currAver	Value of current in the phase with the highest current value

In case of parallel control of transformers, the data set sent from output signal ATCCOUT to other TR8ATCC blocks input HORIZx contains one "word" containing 10 binary signals and 6 analog signals:

Table 167: Binary signals contained in word “status”: ATCCOUT / HORIZx

Signal	Description
TimerOn	This signal is activated by the transformer that has started its timer and is going to tap when the set time has expired.
automaticCTRL	Activated when the transformer is set in automatic control
mutualBlock	Activated when the automatic control is blocked
disc	Activated when the transformer is disconnected from the busbar
receiveStat	Signal used for the horizontal communication
TermIsForcedMaster	Activated when the transformer is selected Master in the master-follower parallel control mode
TermIsMaster	Activated for the transformer that is master in the master-follower parallel control mode
termReadyForMSF	Activated when the transformer is ready for master-follower parallel control mode
raiseVoltageOut	Order from the master to the followers to tap up
lowerVoltageOut	Order from the master to the followers to tap down

Table 168: Analog signals: ATCCOUT / HORIZx

Signal	Description
voltageBusbar	Measured busbar voltage for this transformer
ownLoad Currim	Measured load current imaginary part for this transformer
ownLoadCurrre	Measured load current real part for this transformer
reacSec	Transformer reactance in primary ohms referred to the LV side
relativePosition	The transformer's actual tap position
voltage Setpoint	The transformer's set voltage (*USet*) for automatic control

The TCMYLTC function block has an output YLTCOUT. As shown in figure 91, this output shall be connected to the input ATCCIN and it contains 10 binary signals and 4 integer signals:

Table 169: Binary signals: YLTCOUT / ATCCIN

Signal	Description
tapInOperation	Tap changer in operation, changing tap position
direction	Direction, raise or lower, for the most recent tap changer operation
tapInHighVoltPos	Tap changer in high end position
tapInLowVoltPos	Tap changer in low end position
tapPositionError	Error in reading of tap position (tap position out of range, more than one step change, BCD code error (unaccepted combination), parity fault, out of range, hardware fault for example, BIO etc.)
tapChgError	This is set high when the tap changer has not carried through a raise/lower command within the expected max. time, or if the tap changer starts tapping without a given command.
cmdError	This is set high if a given raise/lower command is not followed by a tap position change within the expected max. time
raiseVoltageFb	Feedback to TR1ATCC or TR8ATCC that a raise command shall be executed
lowerVoltageFb	Feedback to TR1ATCC or TR8ATCC that a lower command shall be executed
timeOutTC	Setting value of "*tTCTimeout*"

Table 170: Integer signals: YLTCOUT / ATCCIN

Signal	Description
tapPosition	Actual tap position as reported from the On-Load-Tap-Changer
numberOfOperations	Accumulated number of tap changer operations
tapPositionMaxVolt	Tap position for highest voltage
tapPositionMinVolt	Tap position for lowest voltage

9.2.6 Technical data

Table 171: TR1ATCC/TR8ATCC/TCMYLTC Technical data

Function	Range or value	Accuracy
Transformer reactance on ATCC side	(0.1–200.0)Ω, primary	-
Time delay for lower command when fast step down mode is activated	(1.0–100.0) s	-
Voltage control set voltage	(85.0–120.0)% of UB2	±0.25% of U_r
Outer voltage deadband	(0.2–9.0)% of UB2	± 5,0% of set value
Inner voltage deadband	(0.1–9.0)% of UB2	± 5,0% of set value
Upper limit of busbar voltage	(80–180)% of UB2	± 0.5% of U_r
Lower limit of busbar voltage	(70–120)% of UB2	± 0.5% of U_r
Table continues on next page		

Function	Range or value	Accuracy
Undervoltage block level	(0–120)% of UB2	± 0.5% of U_r
Time delay (long) for automatic control commands	(3–1000) s	± 0.5% ± 10 ms
Time delay (short) for automatic control commands	(1–1000) s	± 0.5% ± 10 ms
Minimum operating time in inverse mode	(3–120) s	± 0.5% ± 10 ms
Line resistance	(0.00–150.00)Ω, primary	-
Line resistance	(-150.00–150.00)Ω, primary	-
Load voltage adjustment constants	(-20.0–20.0)% of UB2	± 5,0% of set value
Load voltage auto correction	(-20.0–20.0)% of UB2	± 5,0% of set value
Overcurrent block level	(0–250)% of IBase (for winding 1 which is defined in a global base function, selected with setting GlobalBaseSel1 for TR1ATCC and TR8ATCC)	± 1.0% of $I_r$at $I \leq I_r$ ± 1.0% of I at $I > I_r$
Level for number of counted raise/lower within one hour	(0–30) operations/hour	-
Level for number of counted raise/lower within 24 hours	(0–100) operations/day	-
Time window for hunting alarm	(1–120) minutes	-
Hunting detection alarm, max operations/window	(3–30) operations/window	-
Alarm level of active power in forward and reverse direction	(-9999.99–9999.99) MW	± 1.0% of S_r
Alarm level of reactive power in forward and reverse direction	(-9999.99–9999.99) MVAr	± 1.0% of S_r
Time delay for alarms from power supervision	(1–6000) s	± 0.5% ± 10 ms
Tap position for lowest and highest voltage	(1–63)	-
Type of code conversion	Binary, BCD, Gray, ContactPerTap	-
Time after position change before the value is accepted	(1–60) s	± 0.5% ± 10 ms
Tap changer constant time-out	(1–120) s	± 0.5% ± 10 ms
Raise/lower command output pulse duration	(0.5–10.0) s	± 0.5% ± 10 ms

9.3 Logic rotating switch for function selection and LHMI presentation SLGGIO

9.3.1 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	-	-

9.3.2 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.

9.3.3 Function block

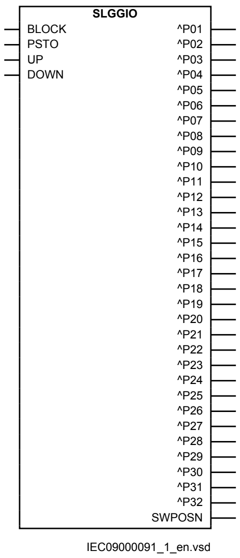


Figure 92: SLGGIO function block

9.3.4 Signals

Table 172: 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 173: 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
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

Table continues on next page

Name	Type	Description
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

9.3.5 Settings

Table 174: 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

9.3.6 Monitored data

Table 175: SLGGIO Monitored data

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

9.3.7 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.

9.4 Selector mini switch VSGGIO

9.4.1 Identification

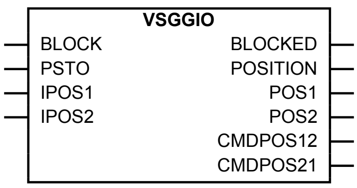
Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Selector mini switch	VSGGIO	-	-

9.4.2 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.

9.4.3 Function block



IEC09000341-1-en.vsd

9.4.4 Signals

Table 176: 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 177: 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

9.4.5 Settings

Table 178: 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

9.4.6 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

9.5 IEC 61850 generic communication I/O functions DPGGIO

9.5.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
IEC 61850 generic communication I/O functions	DPGGIO	-	-

9.5.2 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.

9.5.3 Function block

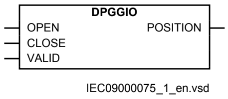


Figure 93: DPGGIO function block

9.5.4 Signals

Table 179: DPGGIO Input signals

Name	Type	Default	Description
OPEN	BOOLEAN	0	Open indication
CLOSE	BOOLEAN	0	Close indication
VALID	BOOLEAN	0	Valid indication

Table 180: DPGGIO Output signals

Name	Type	Description
POSITION	INTEGER	Double point indication

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 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.

9.6 Single point generic control 8 signals SPC8GGIO

9.6.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Single point generic control 8 signals	SPC8GGIO	-	-

9.6.2 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.

9.6.3 Function block

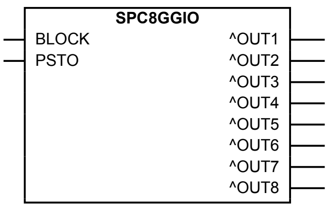


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Figure 94: SPC8GGIO function block

9.6.4 Signals

Table 181: SPC8GGIO Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of function
PSTO	INTEGER	2	Operator place selection

Table 182: 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

9.6.5 Settings

Table 183: SPC8GGIO Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off/On
Latched1	Pulsed Latched	-	-	Pulsed	Setting for pulsed/latched mode for output 1
tPulse1	0.01 - 6000.00	s	0.01	0.10	Output1 Pulse Time
Latched2	Pulsed Latched	-	-	Pulsed	Setting for pulsed/latched mode for output 2
tPulse2	0.01 - 6000.00	s	0.01	0.10	Output2 Pulse Time
Latched3	Pulsed Latched	-	-	Pulsed	Setting for pulsed/latched mode for output 3
tPulse3	0.01 - 6000.00	s	0.01	0.10	Output3 Pulse Time
Latched4	Pulsed Latched	-	-	Pulsed	Setting for pulsed/latched mode for output 4
tPulse4	0.01 - 6000.00	s	0.01	0.10	Output4 Pulse Time
Latched5	Pulsed Latched	-	-	Pulsed	Setting for pulsed/latched mode for output 5
tPulse5	0.01 - 6000.00	s	0.01	0.10	Output5 Pulse Time
Latched6	Pulsed Latched	-	-	Pulsed	Setting for pulsed/latched mode for output 6
tPulse6	0.01 - 6000.00	s	0.01	0.10	Output6 Pulse Time
Latched7	Pulsed Latched	-	-	Pulsed	Setting for pulsed/latched mode for output 7
tPulse7	0.01 - 6000.00	s	0.01	0.10	Output7 Pulse Time
Latched8	Pulsed Latched	-	-	Pulsed	Setting for pulsed/latched mode for output 8
tPulse8	0.01 - 6000.00	s	0.01	0.10	Output8 pulse time

9.6.6 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.

9.7 Automation bits AUTOBITS

9.7.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Automation bits	AUTOBITS	-	-

9.7.2 Functionality

Automation bits function (AUTOBITS) is used within PCM600 in order to get into the configuration of the commands coming through the DNP3 protocol.

9.7.3 Function block

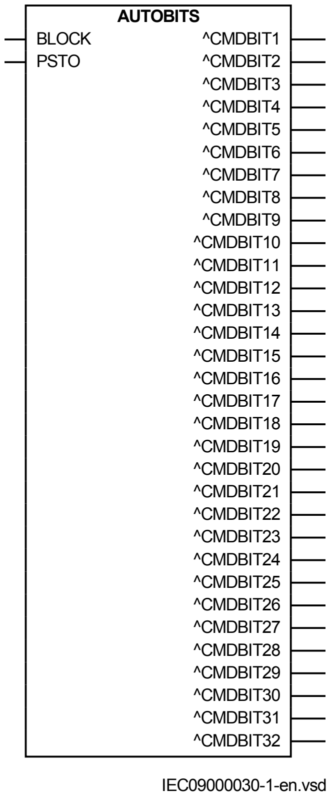

Figure 95: AUTOBITS function block

9.7.4 Signals

Table 184: AUTOBITS Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of function
PSTO	INTEGER	0	Operator place selection

Table 185: AUTOBITS Output signals

Name	Type	Description
CMDBIT1	BOOLEAN	Command out bit 1
CMDBIT2	BOOLEAN	Command out bit 2
CMDBIT3	BOOLEAN	Command out bit 3
CMDBIT4	BOOLEAN	Command out bit 4
CMDBIT5	BOOLEAN	Command out bit 5
CMDBIT6	BOOLEAN	Command out bit 6
CMDBIT7	BOOLEAN	Command out bit 7
CMDBIT8	BOOLEAN	Command out bit 8
CMDBIT9	BOOLEAN	Command out bit 9
CMDBIT10	BOOLEAN	Command out bit 10
CMDBIT11	BOOLEAN	Command out bit 11
CMDBIT12	BOOLEAN	Command out bit 12
CMDBIT13	BOOLEAN	Command out bit 13
CMDBIT14	BOOLEAN	Command out bit 14
CMDBIT15	BOOLEAN	Command out bit 15
CMDBIT16	BOOLEAN	Command out bit 16
CMDBIT17	BOOLEAN	Command out bit 17
CMDBIT18	BOOLEAN	Command out bit 18
CMDBIT19	BOOLEAN	Command out bit 19
CMDBIT20	BOOLEAN	Command out bit 20
CMDBIT21	BOOLEAN	Command out bit 21
CMDBIT22	BOOLEAN	Command out bit 22
CMDBIT23	BOOLEAN	Command out bit 23
CMDBIT24	BOOLEAN	Command out bit 24
CMDBIT25	BOOLEAN	Command out bit 25
CMDBIT26	BOOLEAN	Command out bit 26
CMDBIT27	BOOLEAN	Command out bit 27
CMDBIT28	BOOLEAN	Command out bit 28
CMDBIT29	BOOLEAN	Command out bit 29
CMDBIT30	BOOLEAN	Command out bit 30
CMDBIT31	BOOLEAN	Command out bit 31
CMDBIT32	BOOLEAN	Command out bit 32

9.7.5 Settings

Table 186: AUTOBITS Non group settings (basic)

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

9.7.6 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 10 Logic

10.1 Tripping logic SMPPTRC

10.1.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Tripping logic	SMPPRTC	I->O	94

10.1.2 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.

10.1.3 Function block

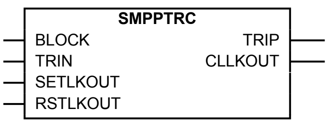

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Figure 96: SMPPTRC function block

10.1.4 Signals

Table 187: 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 188: SMPPTRC Output signals

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

10.1.5 Settings

Table 189: 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 190: 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

10.1.6 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.

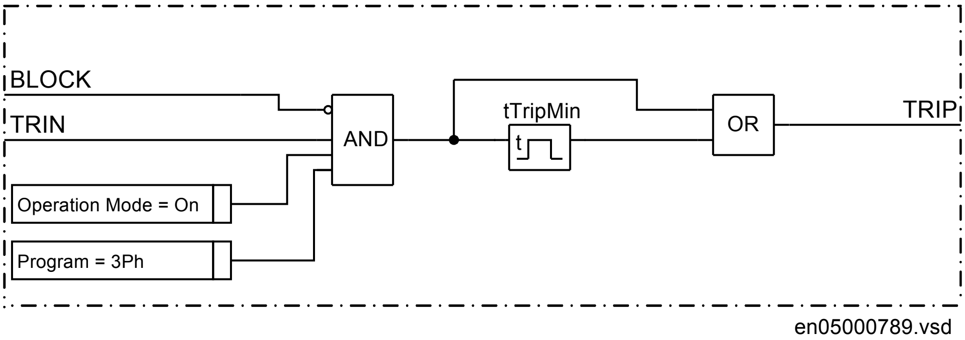


Figure 97: Simplified logic diagram for three phase trip

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.*

10.1.7 Technical data

Table 191: 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

10.2 Trip matrix logic TMAGGIO

10.2.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Trip matrix logic	TMAGGIO	-	-

10.2.2 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.

10.2.3 Function block

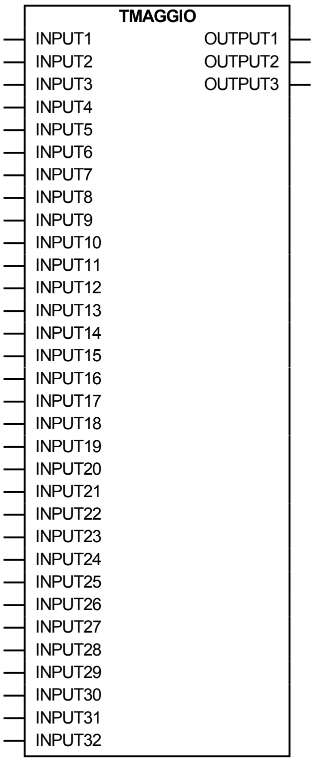


Figure 98: TMAGGIO function block

10.2.4 Signals

Table 192: 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
INPUT11	BOOLEAN	0	Binary input 11
INPUT12	BOOLEAN	0	Binary input 12
INPUT13	BOOLEAN	0	Binary input 13
Table continues on next page			

Name	Type	Default	Description
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 193: 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

10.2.5 Settings

Table 194: 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
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

10.2.6 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 99

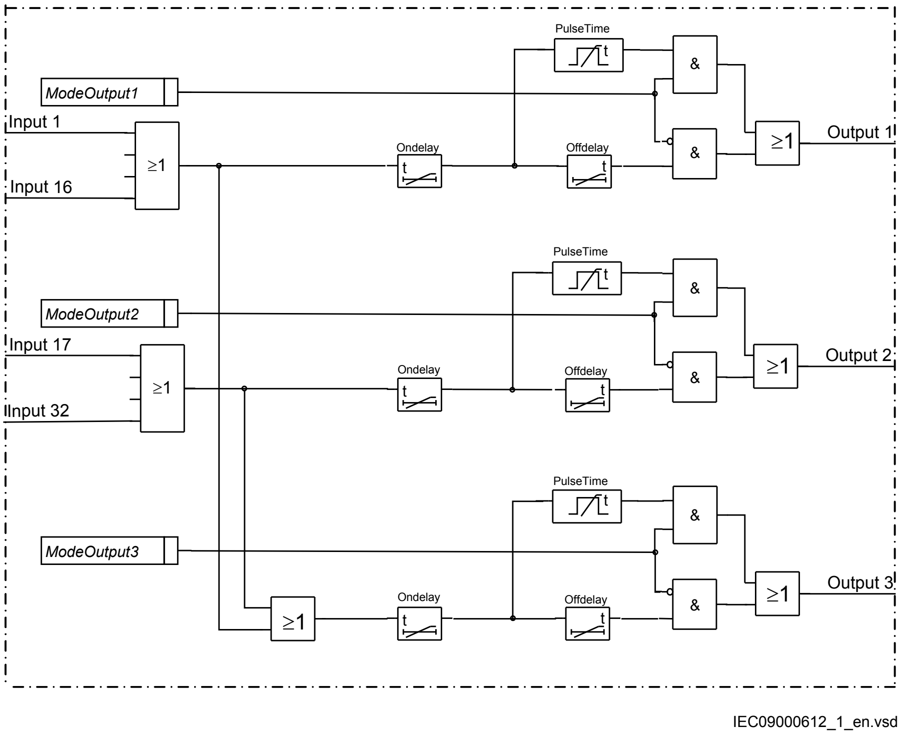


Figure 99: Trip matrix internal logic

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.

10.3 Configurable logic blocks

10.3.1 Standard configurable logic blocks

10.3.1.1 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.

10.3.1.2 OR function block

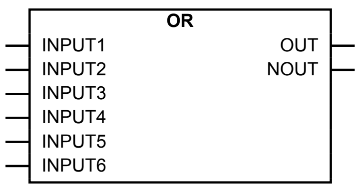
Identification

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



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Signals

Table 195: 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 196: 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).

10.3.1.3 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

IEC09000287-1-en.vsd

Signals

Table 197: INVERTER Input signals

Name	Type	Default	Description
INPUT	BOOLEAN	0	Input signal

Table 198: 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).

10.3.1.4 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

IEC09000291-1-en.vsd

Signals

Table 199: PULSETIMER Input signals

Name	Type	Default	Description
INPUT	BOOLEAN	0	Input signal

Table 200: PULSETIMER Output signals

Name	Type	Description
OUT	BOOLEAN	Output signal

Settings

Table 201: 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

10.3.1.5 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 202: GATE Input signals

Name	Type	Default	Description
INPUT	BOOLEAN	0	Input signal

Table 203: GATE Output signals

Name	Type	Description
OUT	BOOLEAN	Output signal

Settings

Table 204: GATE Group settings (basic)

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

10.3.1.6 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

IEC09000292-1-en.vsd

Signals

Table 205: XOR Input signals

Name	Type	Default	Description
INPUT1	BOOLEAN	0	Input signal 1
INPUT2	BOOLEAN	0	Input signal 2

Table 206: 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).

10.3.1.7 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 207: LOOPDELAY Input signals

Name	Type	Default	Description
INPUT	BOOLEAN	0	Input signal

Table 208: 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).

10.3.1.8 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*).

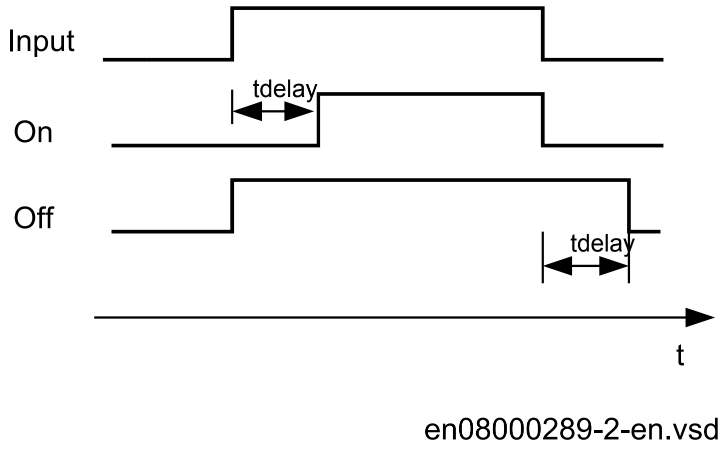


Figure 100: TIMERSET Status diagram

Function block

IEC09000290-1-en.vsd

Signals

Table 209: TIMERSET Input signals

Name	Type	Default	Description
INPUT	BOOLEAN	0	Input signal

Table 210: TIMERSET Output signals

Name	Type	Description
ON	BOOLEAN	Output signal, pick-up delayed
OFF	BOOLEAN	Output signal, drop-out delayed

Settings

Table 211: 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

10.3.1.9 AND function block

Identification

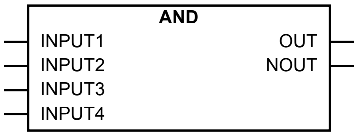
Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
AND function block	AND	-	-

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



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Signals

Table 212: 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 213: 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).

10.3.1.10 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	-	-

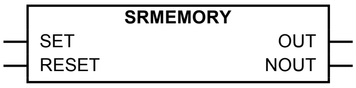
Functionality

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 214: 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



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Signals

Table 215: SRMEMORY Input signals

Name	Type	Default	Description
SET	BOOLEAN	0	Input signal to set
RESET	BOOLEAN	0	Input signal to reset

Table 216: SRMEMORY Output signals

Name	Type	Description
OUT	BOOLEAN	Output signal
NOUT	BOOLEAN	Inverted output signal

Settings

Table 217: SRMEMORY Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Memory	Off On	-	-	On	Operating mode of the memory function

10.3.1.11 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 218: 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

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Signals

Table 219: RSMEMORY Input signals

Name	Type	Default	Description
SET	BOOLEAN	0	Input signal to set
RESET	BOOLEAN	0	Input signal to reset

Table 220: RSMEMORY Output signals

Name	Type	Description
OUT	BOOLEAN	Output signal
NOUT	BOOLEAN	Inverted output signal

Settings

Table 221: RSMEMORY Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Memory	Off On	-	-	On	Operating mode of the memory function

10.3.2 Technical data

Table 222: 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	-	-
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		

10.4 Fixed signals FXDSIGN

10.4.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Fixed signals	FXDSIGN	-	-

10.4.2 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.

10.4.3 Function block

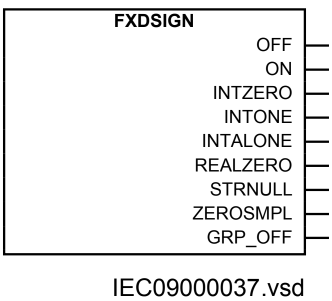


Figure 101: FXDSIGN function block

10.4.4 Signals

Table 223: 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

10.4.5 Settings

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

10.4.6 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

10.5 Boolean 16 to integer conversion B16I

10.5.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Boolean 16 to integer conversion	B16I	-	-

10.5.2 Functionality

Boolean 16 to integer conversion function (B16I) is used to transform a set of 16 binary (logical) signals into an integer.

10.5.3 Function block

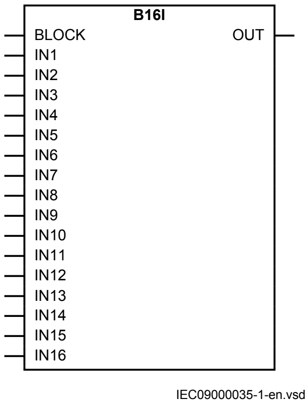


Figure 102: B16I function block

10.5.4 Signals

Table 224: B16I Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of function
IN1	BOOLEAN	0	Input 1
IN2	BOOLEAN	0	Input 2
IN3	BOOLEAN	0	Input 3
IN4	BOOLEAN	0	Input 4
IN5	BOOLEAN	0	Input 5
IN6	BOOLEAN	0	Input 6
IN7	BOOLEAN	0	Input 7
IN8	BOOLEAN	0	Input 8
IN9	BOOLEAN	0	Input 9
IN10	BOOLEAN	0	Input 10
IN11	BOOLEAN	0	Input 11
IN12	BOOLEAN	0	Input 12
IN13	BOOLEAN	0	Input 13
IN14	BOOLEAN	0	Input 14
IN15	BOOLEAN	0	Input 15
IN16	BOOLEAN	0	Input 16

Table 225: B16I Output signals

Name	Type	Description
OUT	INTEGER	Output value

10.5.5 Settings

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

10.5.6 Monitored data

Table 226: B16I Monitored data

Name	Type	Values (Range)	Unit	Description
OUT	INTEGER	-	-	Output value

10.5.7 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.

10.6 Boolean 16 to integer conversion with logic node representation B16IFCVI

10.6.1 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	-	-

10.6.2 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.

10.6.3 Function block

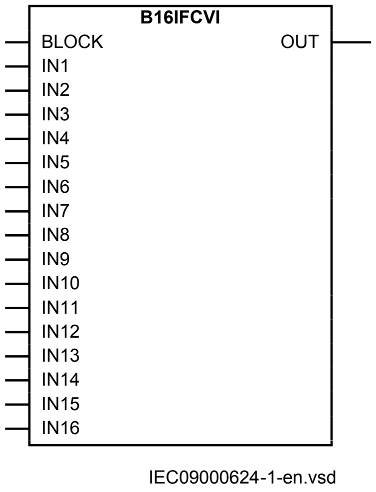


Figure 103: B16IFCVI function block

10.6.4 Signals

Table 227: B16IFCVI Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of function
IN1	BOOLEAN	0	Input 1
IN2	BOOLEAN	0	Input 2
IN3	BOOLEAN	0	Input 3
IN4	BOOLEAN	0	Input 4
IN5	BOOLEAN	0	Input 5
IN6	BOOLEAN	0	Input 6
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 228: B16IFCVI Output signals

Name	Type	Description
OUT	INTEGER	Output value

10.6.5 Settings

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

10.6.6 Monitored data

Table 229: B16IFCVI Monitored data

Name	Type	Values (Range)	Unit	Description
OUT	INTEGER	-	-	Output value

10.6.7 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.

10.7 Integer to boolean 16 conversion IB16A

10.7.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Integer to boolean 16 conversion	IB16A	-	-

10.7.2 Functionality

Integer to boolean 16 conversion function (IB16A) is used to transform an integer into a set of 16 binary (logical) signals.

10.7.3 Function block

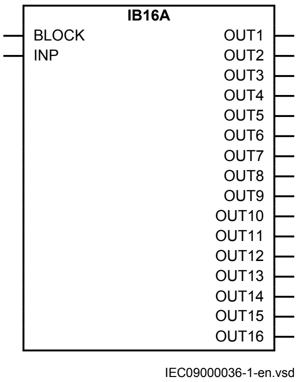


Figure 104: IB16A function block

10.7.4 Signals

Table 230: IB16A Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of function
INP	INTEGER	0	Integer Input

Table 231: IB16A Output signals

Name	Type	Description
OUT1	BOOLEAN	Output 1
OUT2	BOOLEAN	Output 2
OUT3	BOOLEAN	Output 3
OUT4	BOOLEAN	Output 4
OUT5	BOOLEAN	Output 5
OUT6	BOOLEAN	Output 6
OUT7	BOOLEAN	Output 7
OUT8	BOOLEAN	Output 8
OUT9	BOOLEAN	Output 9
OUT10	BOOLEAN	Output 10
OUT11	BOOLEAN	Output 11
OUT12	BOOLEAN	Output 12
OUT13	BOOLEAN	Output 13
OUT14	BOOLEAN	Output 14
OUT15	BOOLEAN	Output 15
OUT16	BOOLEAN	Output 16

10.7.5 Settings

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

10.7.6 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.

10.8 Integer to boolean 16 conversion with logic node representation IB16FCVB

10.8.1 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	-	-

10.8.2 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).

10.8.3 Function block

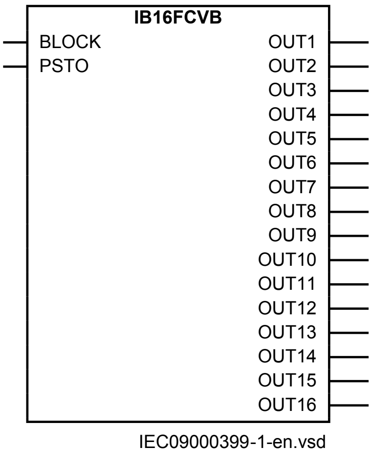


Figure 105: IB16FCVB function block

10.8.4 Signals

Table 232: IB16FCVB Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of function
PSTO	INTEGER	1	Operator place selection

Table 233: IB16FCVB Output signals

Name	Type	Description
OUT1	BOOLEAN	Output 1
OUT2	BOOLEAN	Output 2
OUT3	BOOLEAN	Output 3
OUT4	BOOLEAN	Output 4
OUT5	BOOLEAN	Output 5
OUT6	BOOLEAN	Output 6
OUT7	BOOLEAN	Output 7
OUT8	BOOLEAN	Output 8
OUT9	BOOLEAN	Output 9
OUT10	BOOLEAN	Output 10
OUT11	BOOLEAN	Output 11
OUT12	BOOLEAN	Output 12
OUT13	BOOLEAN	Output 13
OUT14	BOOLEAN	Output 14
OUT15	BOOLEAN	Output 15
OUT16	BOOLEAN	Output 16

10.8.5 Settings

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

10.8.6 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 11 Monitoring

11.1 IEC 61850 generic communication I/O functions SPGGIO

11.1.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
IEC 61850 generic communication I/O functions	SPGGIO	-	-

11.1.2 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.

11.1.3 Function block

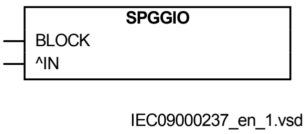


Figure 106: SPGGIO function block

11.1.4 Signals

Table 234: SPGGIO Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of function
IN	BOOLEAN	0	Input status

11.1.5 Settings

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

11.1.6 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.

11.2 IEC 61850 generic communication I/O functions 16 inputs SP16GGIO

11.2.1 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	-	-

11.2.2 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.

11.2.3 Function block

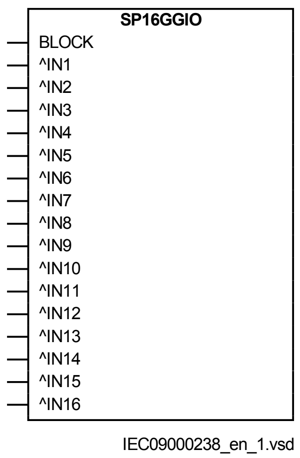


Figure 107: SP16GGIO function block

11.2.4 Signals

Table 235: 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

11.2.5 Settings

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

11.2.6 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.

11.3 IEC 61850 generic communication I/O functions MVGGIO

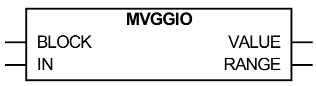
11.3.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
IEC 61850 generic communication I/O functions	MVGGIO	-	-

11.3.2 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.

11.3.3 Function block



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11.3.4 Signals

Table 236: MVGGIO Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of function
IN	REAL	0	Analog input value

Table 237: MVGGIO Output signals

Name	Type	Description
VALUE	REAL	Magnitude of deadband value
RANGE	INTEGER	Range

11.3.5 Settings

Table 238: 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)

11.3.6 Monitored data

Table 239: 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

11.3.7 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.

11.4 Measurements

11.4.1 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.

11.4.2 Measurements CVMMXN

11.4.2.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Measurements	CVMMXN	P, Q, S, I, U, f	-

11.4.2.2 Function block

The available function blocks of an IED are depending on the actual hardware (TRM) and the logic configuration made in PCM600.

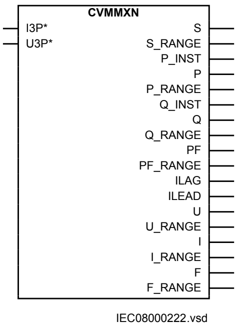


Figure 108: CVMMXN function block

11.4.2.3 Signals

Table 240: 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 241: 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

11.4.2.4 Settings

Table 242: 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 243: 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

11.4.2.5 Monitored data

Table 244: 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

11.4.3 Phase current measurement CMMXU

11.4.3.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Phase current measurement	CMMXU	$\boxed{I}$	-

11.4.3.2 Function block

The available function blocks of an IED are depending on the actual hardware (TRM) and the logic configuration made in PCM600.

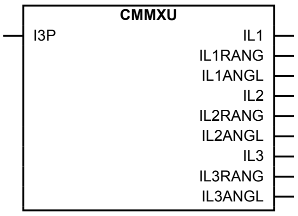


Figure 109: CMMXU function block

11.4.3.3 Signals

Table 245: CMMXU Input signals

Name	Type	Default	Description
I3P	GROUP SIGNAL	-	Three phase group signal for current inputs

Table 246: 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

11.4.3.4 Settings

Table 247: 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 248: 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

11.4.3.5 Monitored data

Table 249: 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

11.4.4 Phase-phase voltage measurement VMMXU

11.4.4.1 Identification

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

11.4.4.2 Function block

The available function blocks of an IED are depending on the actual hardware (TRM) and the logic configuration made in PCM600.

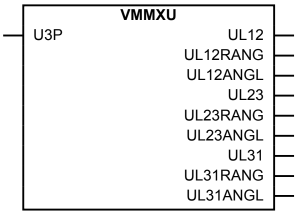


Figure 110: VMMXU function block

11.4.4.3 Signals

Table 250: VMMXU Input signals

Name	Type	Default	Description
U3P	GROUP SIGNAL	-	Three phase group signal for voltage inputs

Table 251: 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

11.4.4.4 Settings

Table 252: 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 253: 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

11.4.4.5 Monitored data

Table 254: 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

11.4.5 Current sequence component measurement CMSQI

11.4.5.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Current sequence component measurement	CMSQI	*I1, I2, I0*	-

11.4.5.2 Function block

The available function blocks of an IED are depending on the actual hardware (TRM) and the logic configuration made in PCM600.

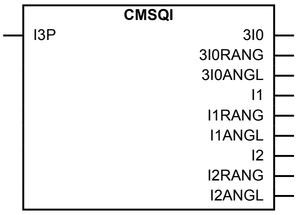


Figure 111: CMSQI function block

11.4.5.3 Signals

Table 255: CMSQI Input signals

Name	Type	Default	Description
I3P	GROUP SIGNAL	-	Three phase group signal for current inputs

Table 256: 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

11.4.5.4 Settings

Table 257: 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 258: 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)

11.4.5.5 Monitored data

Table 259: 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

11.4.6 Voltage sequence measurement VMSQI

11.4.6.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Voltage sequence measurement	VMSQI	U1, U2, U0	-

11.4.6.2 Function block

The available function blocks of an IED are depending on the actual hardware (TRM) and the logic configuration made in PCM600.

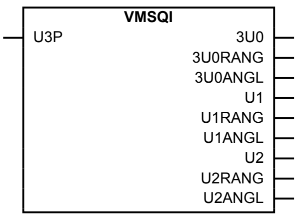


Figure 112: VMSQI function block

11.4.6.3 Signals

Table 260: VMSQI Input signals

Name	Type	Default	Description
U3P	GROUP SIGNAL	-	Three phase group signal for voltage inputs

Table 261: 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

11.4.6.4 Settings

Table 262: 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 263: 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)

11.4.6.5 Monitored data

Table 264: 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

11.4.7 Phase-neutral voltage measurement VNMMXU

11.4.7.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Phase-neutral voltage measurement	VNMMXU	U	-

11.4.7.2 Function block

The available function blocks of an IED are depending on the actual hardware (TRM) and the logic configuration made in PCM600.

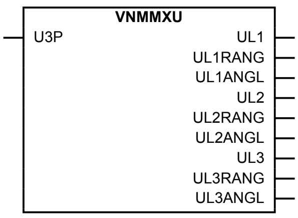


Figure 113: VNMMXU function block

11.4.7.3 Signals

Table 265: VNMMXU Input signals

Name	Type	Default	Description
U3P	GROUP SIGNAL	-	Three phase group signal for voltage inputs

Table 266: 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

11.4.7.4 Settings

Table 267: 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 268: 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

11.4.7.5 Monitored data

Table 269: 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

11.4.8 Operation principle

11.4.8.1 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 114. 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 114.

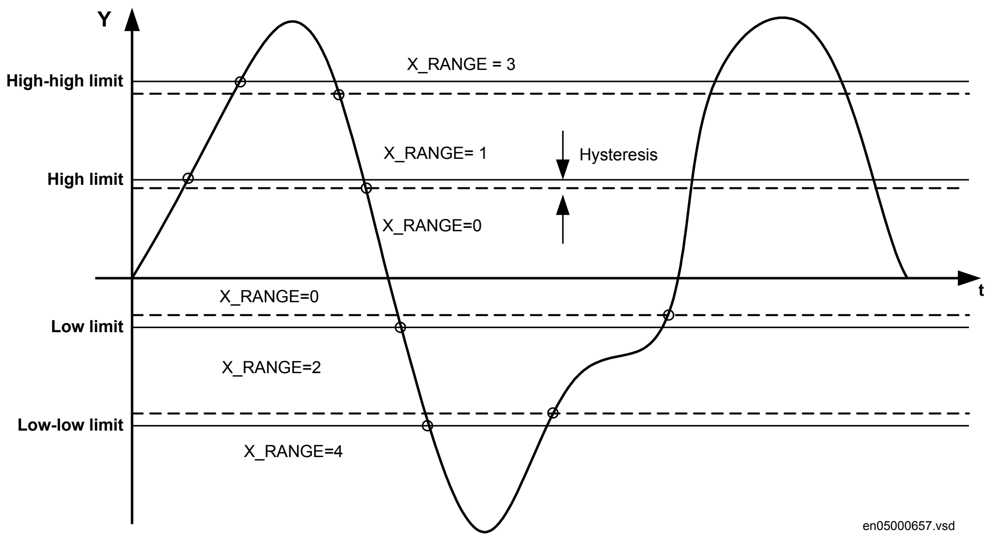


Figure 114: Presentation of operating limits

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 114.

The user can set the hysteresis (*XLimHyst*), which determines the difference between the operating and reset value at each operating point, in wide range for each measuring channel separately. The hysteresis is common for all operating values within one channel.

Actual value of the measured quantity

The actual value of the measured quantity is available locally and remotely. The measurement is continuous for each measured quantity separately, but the reporting of the value to the higher levels depends on the selected reporting mode. The following basic reporting modes are available:

- Cyclic reporting (*Cyclic*)
- Amplitude dead-band supervision (*Dead band*)
- Integral dead-band supervision (*Int deadband*)

Cyclic reporting

The cyclic reporting of measured value is performed according to chosen setting (*XRepTyp*). The measuring channel reports the value independent of amplitude or integral dead-band reporting.

In addition to the normal cyclic reporting the IED also report spontaneously when measured value passes any of the defined threshold limits.

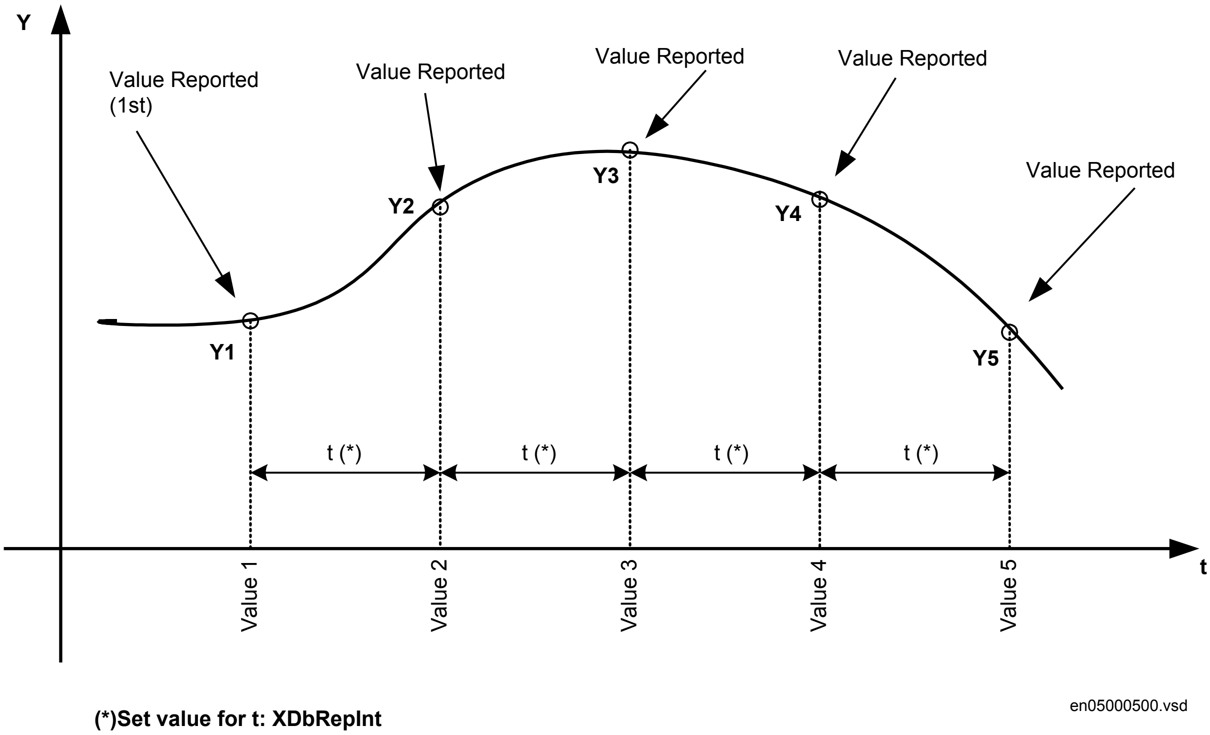


Figure 115: Periodic reporting

Amplitude dead-band supervision

If a measuring value is changed, compared to the last reported value, and the change is larger than the ±ΔY pre-defined limits that are set by user (*XZeroDb*), then the measuring channel reports the new value to a higher level, if this is detected by a new measured value. This limits the information flow to a minimum necessary. Figure 116 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.

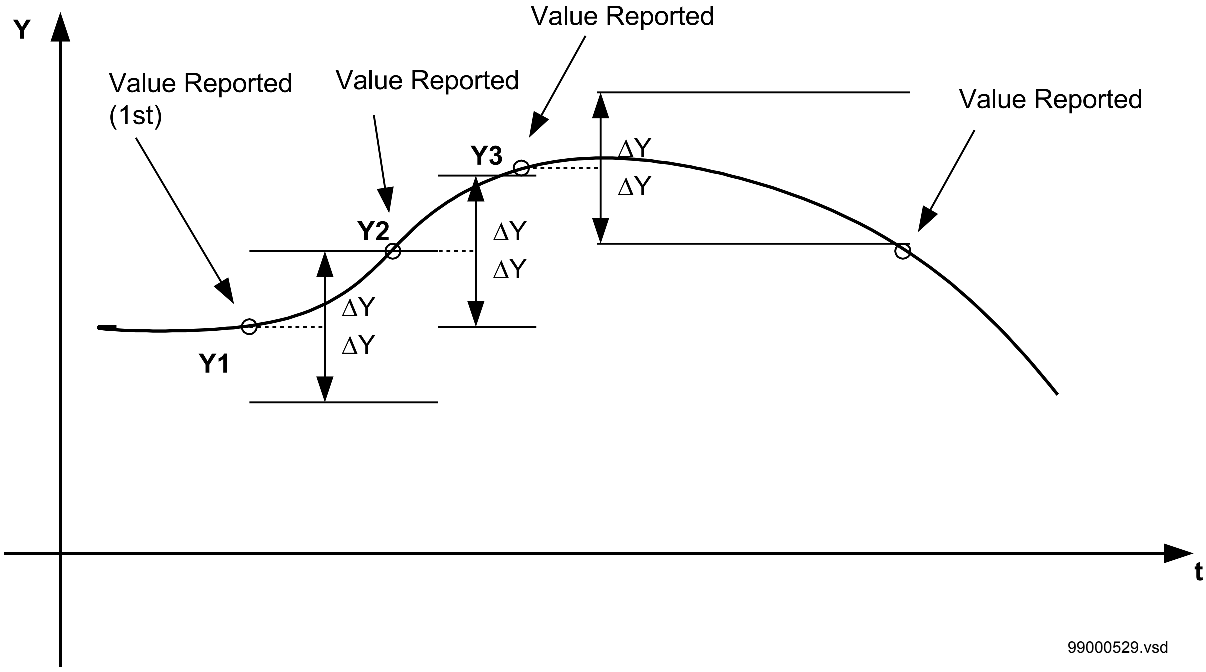


Figure 116: Amplitude dead-band supervision reporting

After the new value is reported, the ±ΔY limits for dead-band are automatically set around it. The new value is reported only if the measured quantity changes more than defined by the ±ΔY set limits. Even if amplitude dead-band reporting is selected, there will be a 30 s "back-ground" cyclic reporting as well.

Integral dead-band reporting

The measured value is reported if the time integral of all changes exceeds the pre-set limit (*XZeroDb*), figure 117, 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 117 serves as a basic value for further measurement. A difference is calculated between the last reported and the newly measured value and is multiplied by the time increment (discrete integral). The absolute values of these integral values are added until the pre-set value is exceeded. This occurs with the value Y2 that is reported and set as a new base for the following measurements (as well as for the values Y3, Y4 and Y5).

The integral dead-band supervision is particularly suitable for monitoring signals with small variations that can last for relatively long periods. Even if integral dead-band reporting is selected, there will be a 30 s "back-ground" cyclic reporting as well.

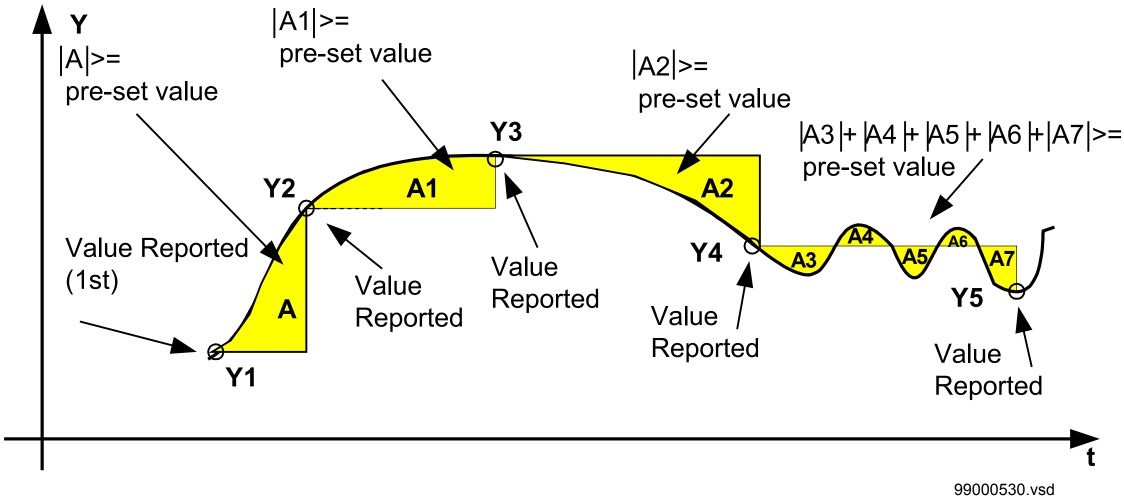


Figure 117: Reporting with integral dead-band supervision

11.4.8.2 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	$\overline{S} = \overline{U_{L1}} \cdot \overline{I_{L1}^*} + \overline{U_{L2}} \cdot \overline{I_{L2}^*} + \overline{U_{L3}} \cdot \overline{I_{L3}^*}$	$U = (\lvert\overline{U_{L1}}\rvert + \lvert\overline{U_{L2}}\rvert + \lvert\overline{U_{L3}}\rvert) / \sqrt{3}$ $I = (\lvert\overline{I_{L1}}\rvert + \lvert\overline{I_{L2}}\rvert + \lvert\overline{I_{L3}}\rvert) / 3$	Used when three phase-to-earth voltages are available
2	Arone	$\overline{S} = \overline{U_{L1L2}} \cdot \overline{I_{L1}^*} - \overline{U_{L2L3}} \cdot \overline{I_{L3}^*}$ (Equation 55)	$U = (\lvert\overline{U_{L1L2}}\rvert + \lvert\overline{U_{L2L3}}\rvert) / 2$ $I = (\lvert\overline{I_{L1}}\rvert + \lvert\overline{I_{L3}}\rvert) / 2$ (Equation 56)	Used when three two phase-to-phase voltages are available
3	PosSeq	$\overline{S} = 3 \cdot \overline{U_{PosSeq}} \cdot \overline{I_{PosSeq}^*}$ (Equation 57)	$U = \sqrt{3} \cdot \lvert\overline{U_{PosSeq}}\rvert$ $I = \lvert\overline{I_{PosSeq}}\rvert$ (Equation 58)	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 59)	$U = \left\|\overline{U_{L1L2}}\right\|$ $I = (\left\|\overline{I_{L1}}\right\| + \left\|\overline{I_{L2}}\right\|)/2$ (Equation 60)	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 61)	$U = \left\|\overline{U_{L2L3}}\right\|$ $I = (\left\|\overline{I_{L2}}\right\| + \left\|\overline{I_{L3}}\right\|)/2$ (Equation 62)	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 63)	$U = \left\|\overline{U_{L3L1}}\right\|$ $I = (\left\|\overline{I_{L3}}\right\| + \left\|\overline{I_{L1}}\right\|)/2$ (Equation 64)	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 65)	$U = \sqrt{3} \cdot \left\|\overline{U_{L1}}\right\|$ $I = \left\|\overline{I_{L1}}\right\|$ (Equation 66)	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 67)	$U = \sqrt{3} \cdot \left\|\overline{U_{L2}}\right\|$ $I = \left\|\overline{I_{L2}}\right\|$ (Equation 68)	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 69)	$U = \sqrt{3} \cdot \left\|\overline{U_{L3}}\right\|$ $I = \left\|\overline{I_{L3}}\right\|$ (Equation 70)	Used when only U_{L3} phase-to-earth voltage is available
* means complex conjugated value				

It shall be noted that only in the first two operating modes that is, 1 & 2 the measurement function calculates exact three-phase power. In other operating modes that is, from 3 to 9 it calculates the three-phase power under assumption that the power system is fully symmetrical. Once the complex apparent power is calculated then the P, Q, S, & PF are calculated in accordance with the following formulas:

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

(Equation 71)

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

(Equation 72)

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

(Equation 73)

$$PF = \cos\varphi = \frac{P}{S}$$

(Equation 74)

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 118.

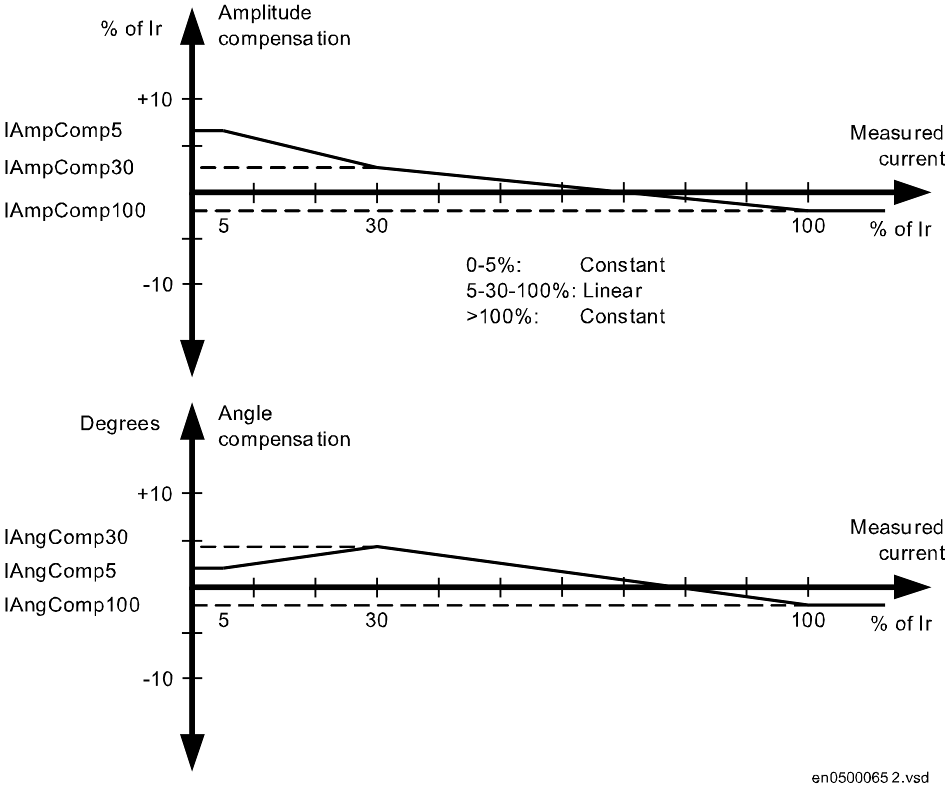


Figure 118: Calibration curves

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 75)

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.

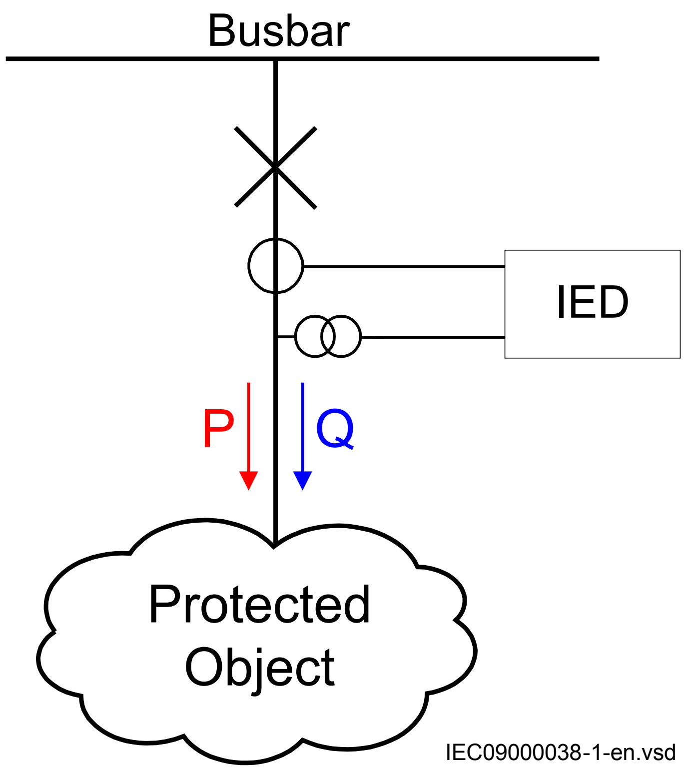


Figure 119: Internal IED directionality convention for P & Q measurements

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.

11.4.8.3 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 118 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".

11.4.8.4 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".

11.4.8.5 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".

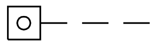
11.4.9 Technical data

Table 270: CVMMXN Tehcnical data

Function	Range or value	Accuracy
Frequency	$(0.95\text{-}1.05) \times f_r$	± 2.0 mHz
Connected current	$(0.2\text{-}4.0) \times I_r$	± 0.5% of I_r at $I \leq I_r$ ± 0.5% of I at $I > I_r$

11.5 Event Counter CNTGGIO

11.5.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Event counter	CNTGGIO		-

11.5.2 Functionality

Event counter (CNTGGIO) has six counters which are used for storing the number of times each counter input has been activated.

11.5.3 Function block

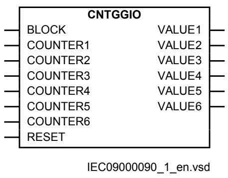


Figure 120: CNTGGIO function block

11.5.4 Signals

Table 271: 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 272: 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

11.5.5 Settings

Table 273: CNTGGIO Group settings (basic)

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

11.5.6 Monitored data

Table 274: 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

11.5.7 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.

11.5.7.1 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.

11.5.8 Technical data

Table 275: CNTGGIO Technical data

Function	Range or value	Accuracy
Counter value	0-10000	-
Max. count up speed	10 pulses/s	-

11.6 Disturbance report

11.6.1 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.

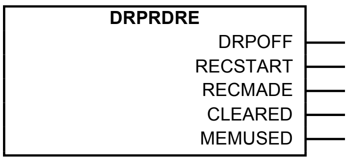
Every disturbance report recording is saved in the IED in the standard Comtrade format. The same applies to all events, which are continuously saved in a ring-buffer. The local HMI is used to get information about the recordings, but the disturbance report files may be uploaded to PCM600 (Protection and Control IED Manager) and further analysis using the disturbance handling tool.

11.6.2 Disturbance report DRPRDRE

11.6.2.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Disturbance report	DRPRDRE	-	-

11.6.2.2 Function block



IEC09000346-1-en.vsd

Figure 121: DRPRDRE function block

11.6.2.3 Signals

Table 276: 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

11.6.2.4 Settings

Table 277: 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

11.6.2.5 Monitored data

Table 278: 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

11.6.2.6 Measured values

Table 279: 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

11.6.3 Analog input signals AxRADR

11.6.3.1 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	-	-

11.6.3.2 Function block

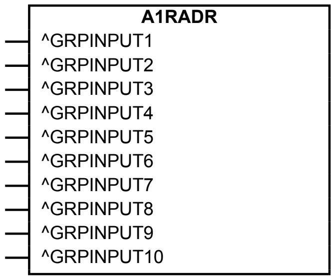


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Figure 122: A1RADR function block, analog inputs, example for A1RADR, A2RADR and A3RADR

11.6.3.3 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 280: 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

11.6.3.4 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 281: 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 282: 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

11.6.4 Analog input signals A4RADR

11.6.4.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Analog input signals	A41RADR	-	-

11.6.4.2 Function block

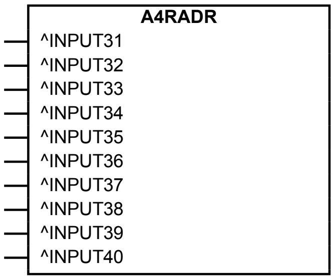

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Figure 123: A4RADR function block, derived analog inputs

11.6.4.3 Signals

Table 283: 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

11.6.4.4 Settings

Table 284: 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 285: 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

11.6.5 Binary input signals BxRBDR

11.6.5.1 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	-	-

11.6.5.2 Function block

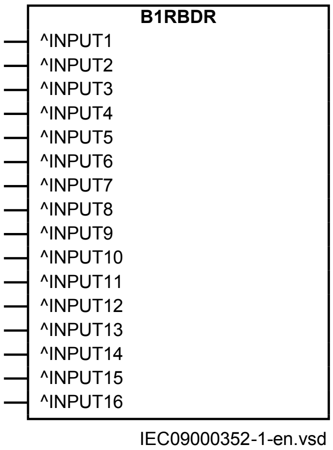


Figure 124: B1RBDR function block, binary inputs, example for B1RBDR - B6RBDR

11.6.5.3 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 286: 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

11.6.5.4 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 287: 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 288: 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

11.6.6 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 125 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.

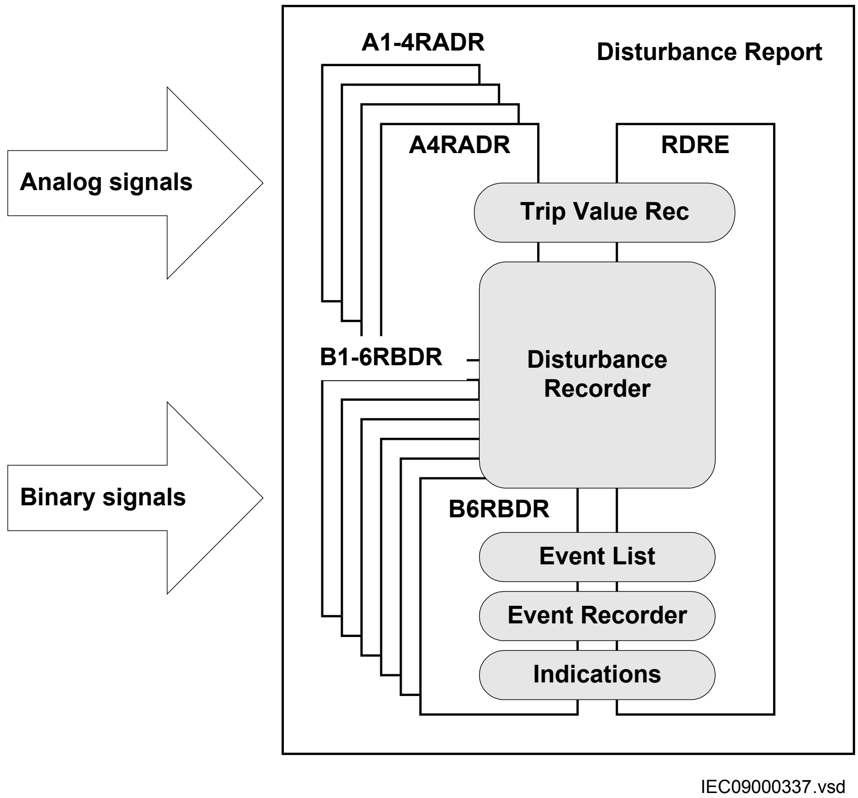


Figure 125: Disturbance report functions and related function blocks

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.

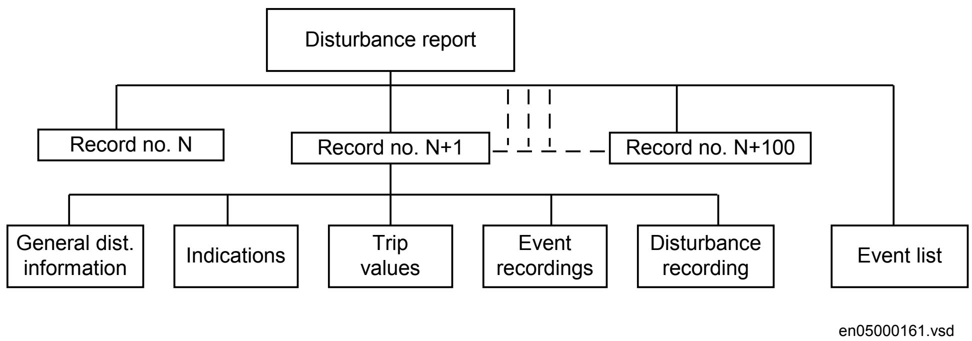


Figure 126: Disturbance report structure

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).

11.6.6.1 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).

11.6.6.2 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.

11.6.6.3 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.

11.6.6.4 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.

11.6.6.5 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.

11.6.6.6 Disturbance recorder

Disturbance recorder records analog and binary signal data before, during and after the fault. See Disturbance recorder section for detailed information.

11.6.6.7 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

11.6.6.8 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

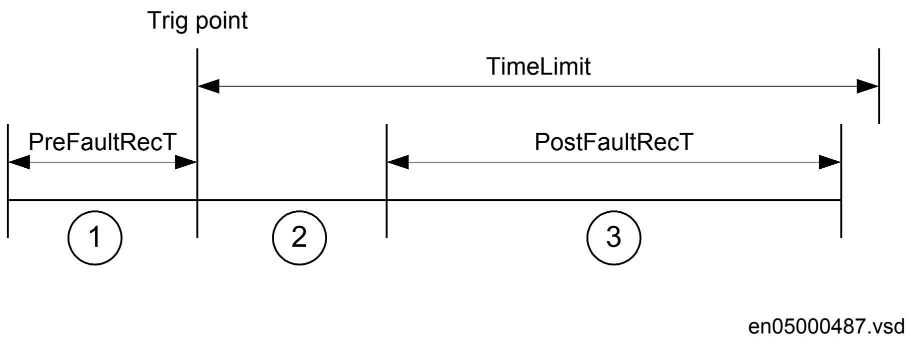


Figure 127: The recording times definition

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.

11.6.6.9 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.).

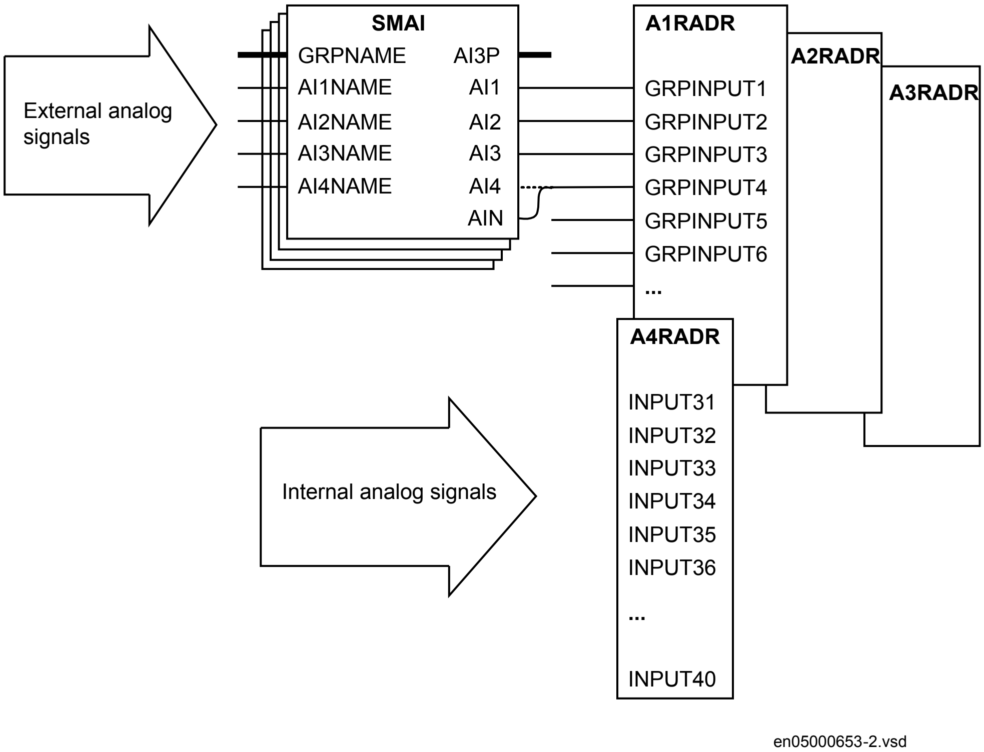


Figure 128: Analog input function blocks

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.

11.6.6.10 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*.

11.6.6.11 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 .

11.6.6.12 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.

11.6.7 Technical data

Table 289: DRPRDRE Technical data

Function	Range or value	Accuracy
Current recording	-	± 1,0% of I_r at $I \le I_r$ ± 1,0% of I at I > Ir
Voltage recording	-	± 1,0% of U_r at $U \le U_r$ ± 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	-

11.7 Indications

11.7.1 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.

11.7.2 Function block

The Indications function has no function block of it's own. .

11.7.3 Signals

11.7.3.1 Input signals

The Indications function may log the same binary input signals as the Disturbance report function.

11.7.4 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 .

11.7.5 Technical data

Table 290: DRPRDRE Technical data

Function		Value
Buffer capacity	Maximum number of indications presented for single disturbance	96
	Maximum number of recorded disturbances	100

11.8 Event recorder

11.8.1 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).

11.8.2 Function block

The Event recorder has no function block of it’s own.

11.8.3 Signals

11.8.3.1 Input signals

The Event recorder function logs the same binary input signals as the Disturbance report function.

11.8.4 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.

11.8.5 Technical data

Table 291: 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

11.9 Event list

11.9.1 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.

11.9.2 Function block

The Event list has no function block of it’s own.

11.9.3 Signals

11.9.3.1 Input signals

The Event list logs the same binary input signals as configured for the Disturbance report function.

11.9.4 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 .

11.9.5 Technical data

Table 292: DRPRDRE Technical data

Function		Value
Buffer capacity	Maximum number of events in the list	1000
Resolution		1 ms
Accuracy		Depending on time synchronizing

11.10 Trip value recorder

11.10.1 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).

11.10.2 Function block

The Trip value recorder has no function block of it's own.

11.10.3 Signals

11.10.3.1 Input signals

The trip value recorder function uses analog input signals connected to (not).

11.10.4 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.

11.10.5 Technical data

Table 293: DRPRDRE Technical data

Function		Value
Buffer capacity	Maximum number of analog inputs	30
	Maximum number of disturbance reports	100

11.11 Disturbance recorder

11.11.1 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.

11.11.2 Function block

The Disturbance recorder has no function block of it’s own.

11.11.3 Signals

11.11.3.1 Input and output signals

See Disturbance report for input and output signals.

11.11.4 Setting parameters

See Disturbance report for settings.

11.11.5 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.

11.11.5.1 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.

11.11.6 Technical data

Table 294: 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

11.12 Measured value expander block MVEXP

11.12.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Measured value expander block	MVEXP	-	-

11.12.2 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.

11.12.3 Function block

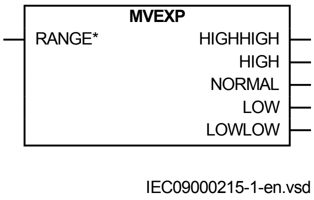


Figure 129: MVEXP function block

11.12.4 Signals

Table 295: MVEXP Input signals

Name	Type	Default	Description
RANGE	INTEGER	0	Measured value range

Table 296: 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

11.12.5 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.

11.12.6 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 297.

Table 297: Input integer value converted to binary output signals

Measured supervised value is:	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
Output:					
LOWLOW	High				
LOW		High			
NORMAL			High		
HIGH				High	
HIGHHIGH					High

11.13 Station battery supervision SPVNZBAT

11.13.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Station battery supervision function	SPVNZBAT	U<>	-

11.13.2 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.

11.13.3 Function block

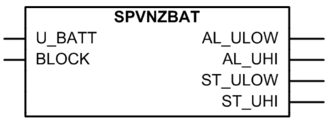


Figure 130: Function block

11.13.4 Signals

Table 298: 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 299: 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

11.13.5 Settings

Table 300: 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

11.13.6 Monitored data

Table 301: SPVNZBAT Monitored data

Name	Type	Values (Range)	Unit	Description
BATTVOLT	REAL	-	kV	Service value of the battery terminal voltage

11.13.7 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.

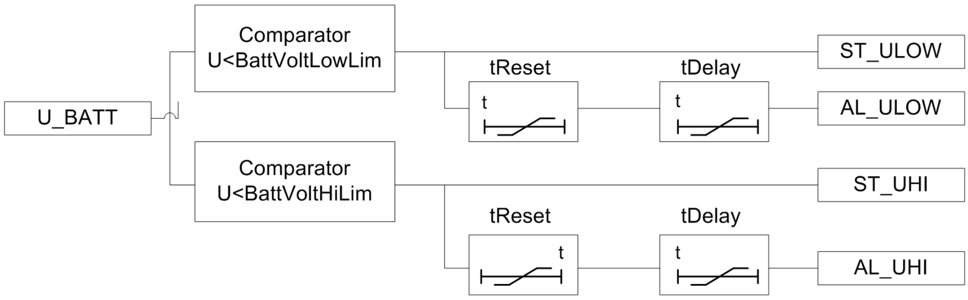


Figure 131: *Functional module diagram*

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.

Table 302: SPVNZBAT Technical data

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

11.14 Insulation gas monitoring function SSIMG

11.14.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Insulation gas monitoring function	SSIMG	-	63

11.14.2 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.

11.14.3 Function block

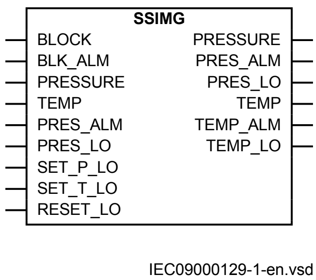


Figure 132: SSIMG function block

11.14.4 Signals

Inputs PRESSURE and TEMP together with settings *PressAlmLimit*, *PressLOLimit*, *TempAlarmLimit* and *TempLOLimit* are not supported in first release of 650 series.

Table 303: 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 304: 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

11.14.5 Settings

Table 305: 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

11.14.6 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.

11.14.7 Technical data

Table 306: 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

11.15 Insulation liquid monitoring function SSIML

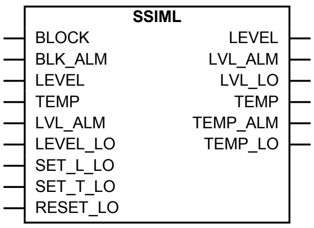
11.15.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Insulation liquid monitoring function	SSIML	-	71

11.15.2 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.

11.15.3 Function block



IEC09000128-1-en.vsd

Figure 133: SSIML function block

11.15.4 Signals

Inputs LEVEL and TEMP together with settings *LevelAlmLimit*, *LevelLOLimit*, *TempAlarmLimit* and *TempLOLimit* are not supported in first release of 650 series.

Table 307: 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 308: 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

11.15.5 Settings

Table 309: 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

11.15.6 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.

11.15.7 Technical data

Table 310: 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

11.16 Circuit breaker condition monitoring SSCBR

11.16.1 Identification

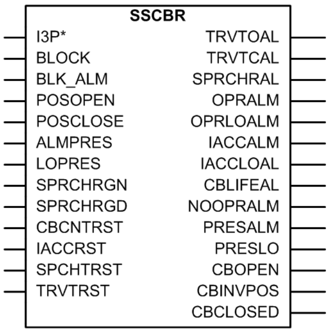
Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Circuit breaker condition monitoring	SSCBR	-	-

11.16.2 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.

11.16.3 Function block



11.16.4 Signals

Table 311: 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 312: 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

11.16.5 Settings

Table 313: 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

11.16.6 Monitored data

Table 314: 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

11.16.7 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.

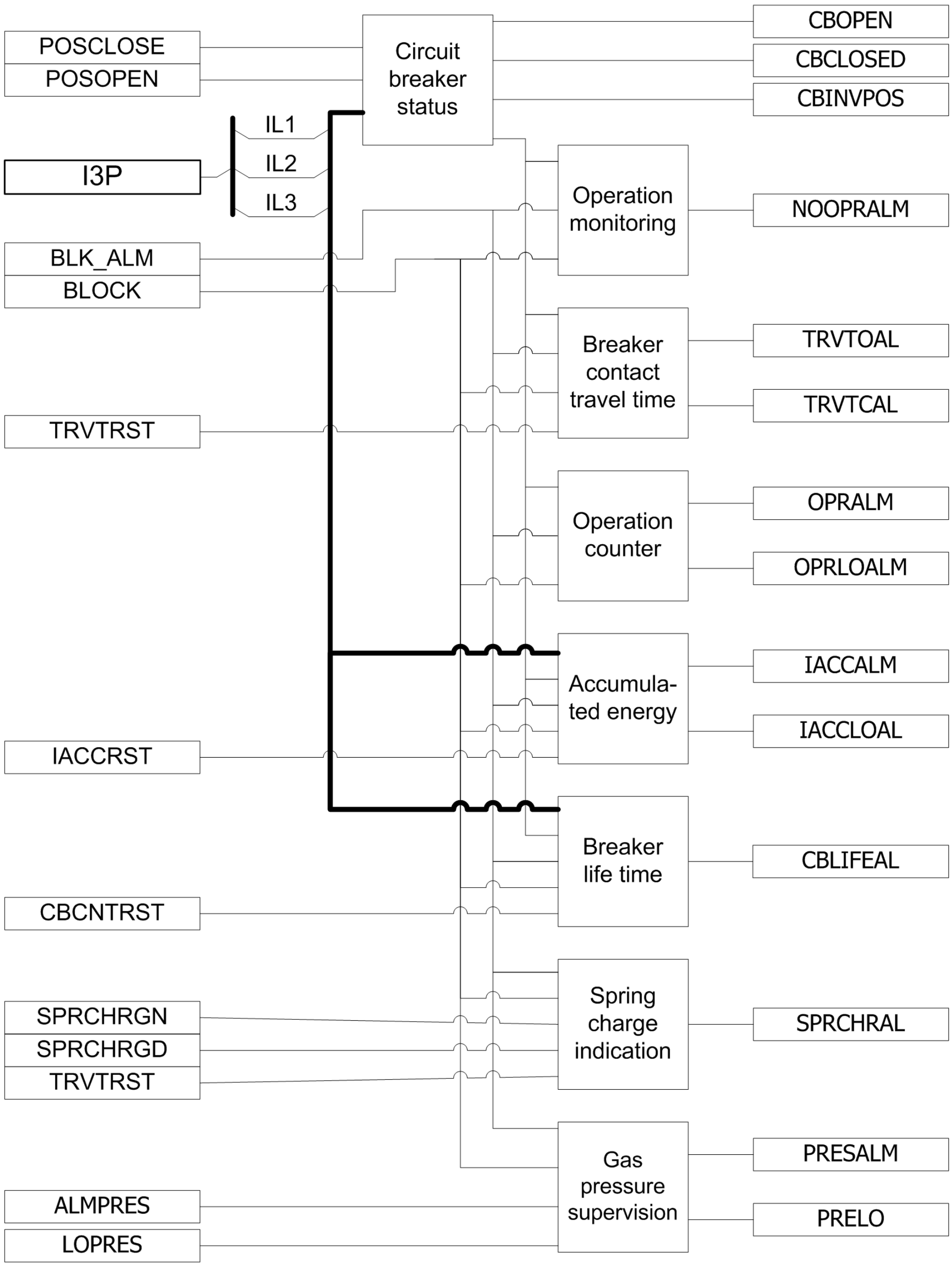


Figure 134: Functional module diagram

11.16.7.1 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.

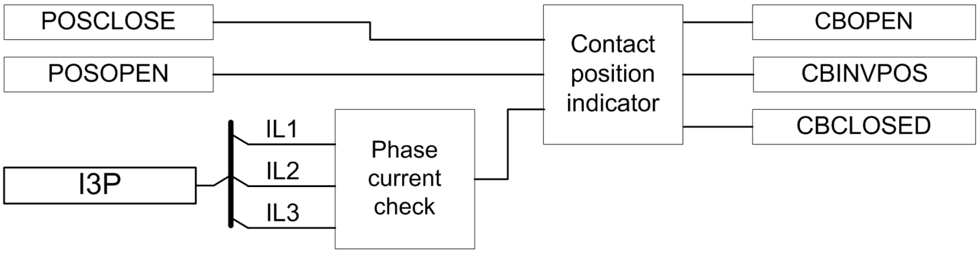


Figure 135: Functional module diagram for monitoring circuit breaker status

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.

11.16.7.2 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.

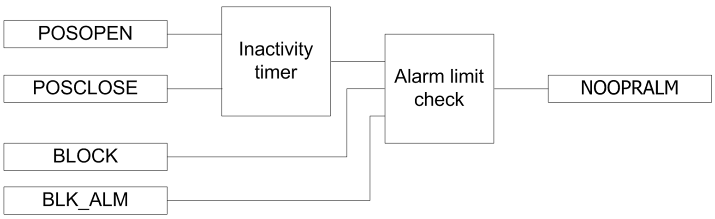


Figure 136: Functional module diagram for calculating inactive days and alarm for circuit breaker operation monitoring

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.

11.16.7.3 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.

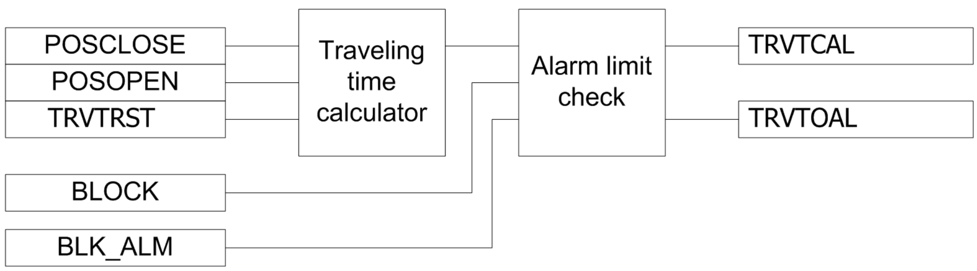
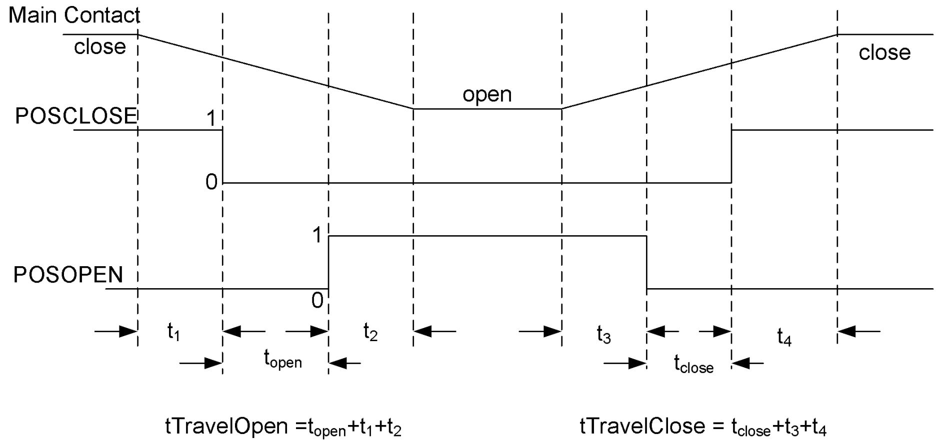


Figure 137: Functional module diagram for breaker contact travel time

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.



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.

11.16.7.4 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.

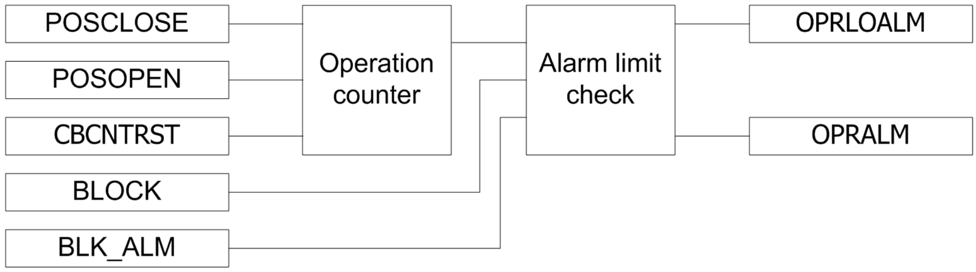


Figure 138: Functional module diagram for counting circuit breaker operations

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.

11.16.7.5 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.

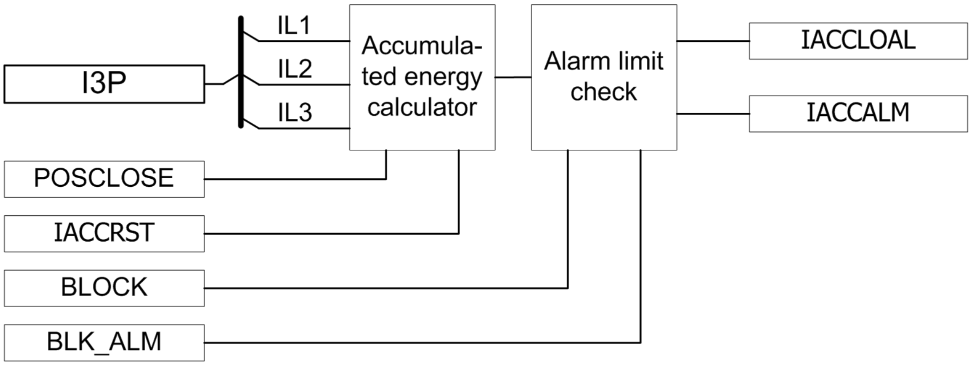


Figure 139: Functional module diagram for calculating accumulative energy and alarm

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.

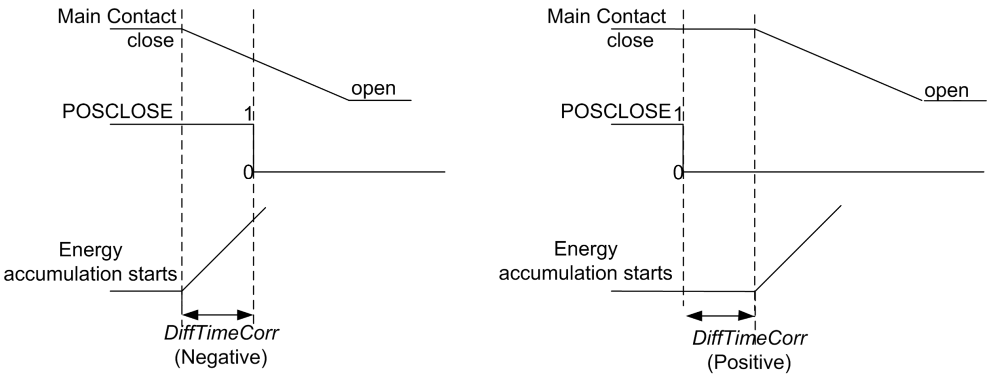


Figure 140: Significance of theDiffTimeCorr setting

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.

11.16.7.6 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.

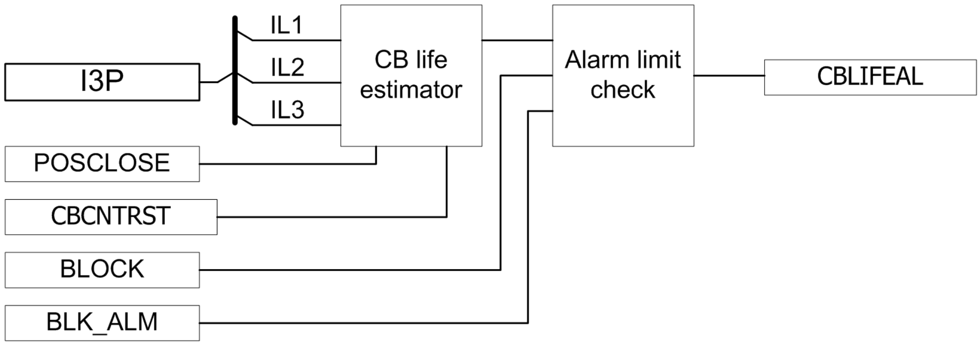


Figure 141: Functional module diagram for estimating the life of the circuit breaker

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.

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`.

11.16.7.7 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.

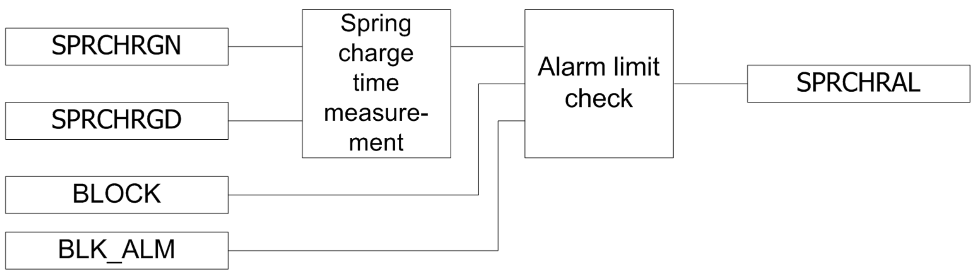


Figure 142: Functional module diagram for circuit breaker spring charged indication and alarm

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.

11.16.7.8 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.

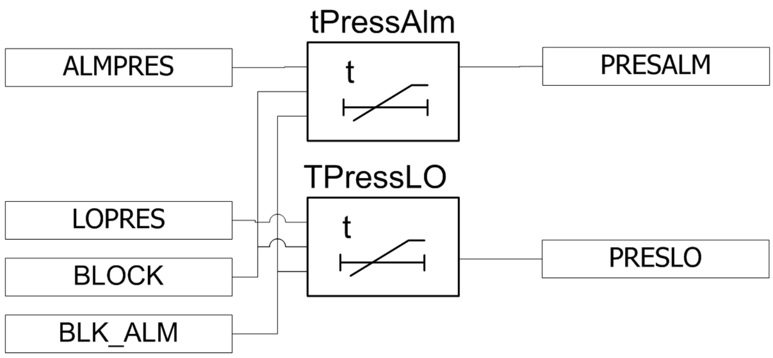


Figure 143: Functional module diagram for circuit breaker gas pressure alarm

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.

11.16.8 Technical data

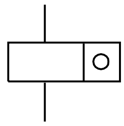
Table 315: SSCBR Technical data

Function	Range or value	Accuracy
RMS current setting below which energy accumulation stops	(5.00-500.00) A	± 1.0% of I_r at $I \leq I_r$ ± 1.0% of I at $I > I_r$
Alarm level for accumulated energy	0.00-20000.00	< ± 5.0% of set value
Lockout limit for accumulated energy	0.00-20000.00	< ± 5.0% of set value
Alarm levels for open and close travel time	(0-200) ms	± 0.5% ± 10ms
Setting of alarm for spring charging time	(0.00-60.00) s	± 0.5% ± 10ms
Time delay for gas pressure alarm	(0.00-60.00) s	± 0.5% ± 10ms
Time delay for gas pressure lockout	(0.00-60.00) s	± 0.5% ± 10ms

Section 12 Metering

12.1 Pulse counter PCGGIO

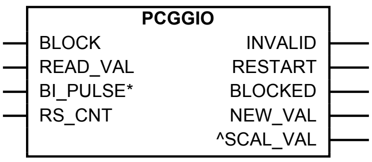
12.1.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Pulse counter	PCGGIO		-

12.1.2 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.

12.1.3 Function block



IEC09000335-1-en.vsd

Figure 144: PCGGIO function block

12.1.4 Signals

Table 316: 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 317: 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

12.1.5 Settings

Table 318: 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

12.1.6 Monitored data

Table 319: 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

12.1.7 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 accessable 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.

12.1.8 Technical data

Table 320: PCGGIO Technical data

Function	Setting range	Accuracy
Cycle time for report of counter value	(1–3600) s	-

12.2 Energy calculation and demand handling ETPMMTR

12.2.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Energy calculation and demand handling	ETPMMTR	-	-

12.2.2 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.

12.2.3 Function block

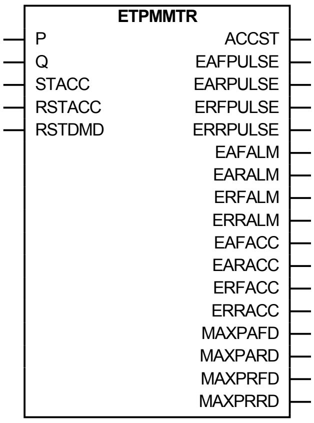


Figure 145: ETPMMTR function block

12.2.4 Signals

Table 321: 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 322: 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

12.2.5 Settings

Table 323: 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 324: 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

12.2.6 Monitored data

Table 325: 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

12.2.7 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.

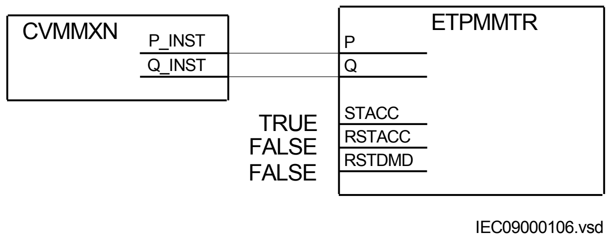


Figure 146: Connection of Energy calculation and demand handling function (ETPMMTR) to the Measurements function (CVMMXN)

12.2.8 Technical data

Table 326: 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 13 Station communication

13.1 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.

13.2 IEC 61850-8-1 communication protocol

13.2.1 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	-	-

13.2.2 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 327: Supported communication interface and protocol alternatives

Interfaces/Protocols	Ethernet 100BASE-FX LC
IEC 61850-8-1	●
DNP3	●
● = Supported	

13.2.3 Settings

Table 328: 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

13.2.4 Technical data

Table 329: IEC 61850-8-1 communication protocol

Function	Value
Protocol	IEC 61850-8-1
Communication speed for the IEDs	100BASE-FX

13.3 Horizontal communication via GOOSE for interlocking

13.3.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Horizontal communication via GOOSE for interlocking	GOOSEINTLKRCV	-	-

13.3.2 Function block

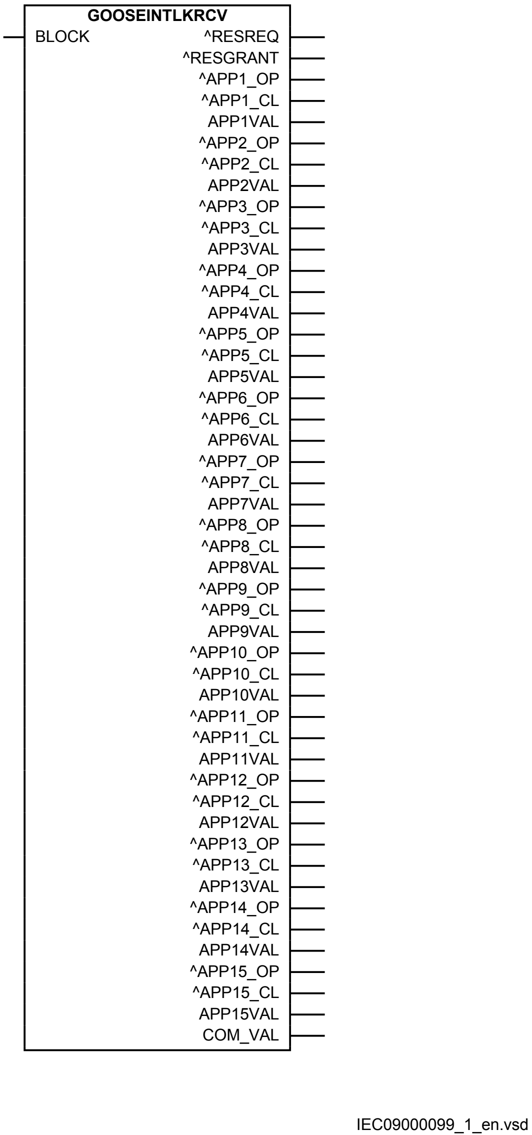


Figure 147: GOOSEINTLKRCV function block

13.3.3 Signals

Table 330: GOOSEINTLKRCV Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of output signals

Table 331: 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

13.3.4 Settings

Table 332: GOOSEINTLKRCV Non group settings (basic)

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

13.4 Goose binary receive GOOSEBINRCV

13.4.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Goose binary receive	GOOSEBINRCV	-	-

13.4.2 Function block

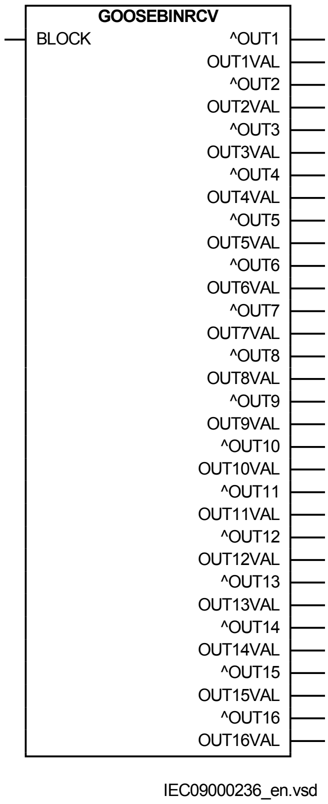


Figure 148: GOOSEBINRCV function block

13.4.3 Signals

Table 333: GOOSEBINRCV Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of output signals

Table 334: 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

13.4.4 Settings

Table 335: GOOSEBINRCV Non group settings (basic)

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

Section 14 Basic IED functions

14.1 Self supervision with internal event list

14.1.1 Functionality

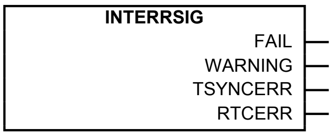
Self supervision with internal event list (INTERRSIG and SELFSUPEVLST) function listens and reacts to internal system events, generated by the different built-in self-supervision elements. The internal events are saved in an internal event list.

14.1.2 Internal error signals INTERRSIG

14.1.2.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Internal error signal	INTERRSIG	-	-

14.1.2.2 Function block



IEC09000334-1-en.vsd

Figure 149: INTERRSIG function block

14.1.2.3 Signals

Table 336: 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

14.1.2.4 Settings

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

14.1.3 Internal event list SELFSUPEVLST

14.1.3.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Internal event list	SELFSUPEVLST	-	-

14.1.3.2 Settings

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

14.1.4 Operation principle

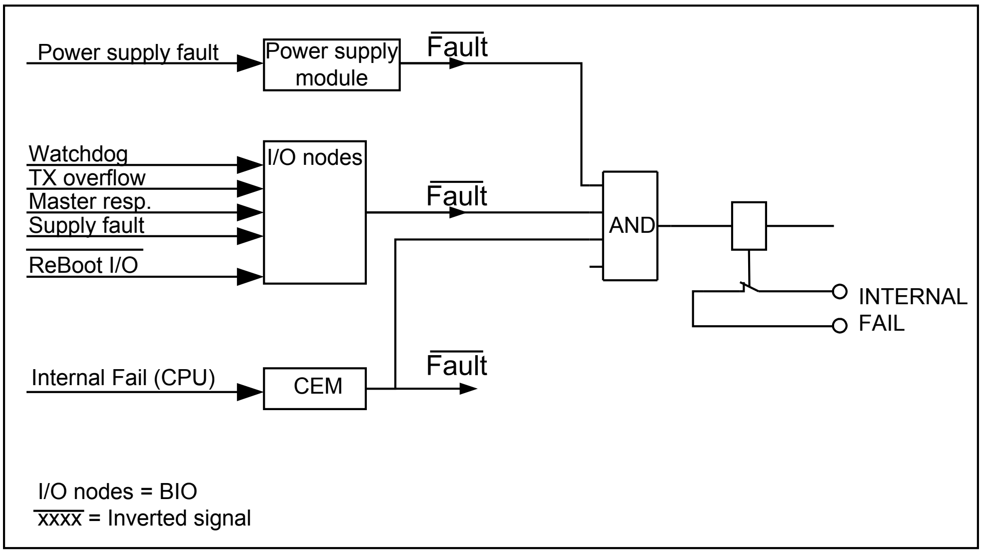
The self-supervision operates continuously and includes:

- 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 150. Also the software watchdog timeout and the undervoltage detection of the PSM will deactivate the relay.



IEC09000390-1-en.vsd

Figure 150: Hardware self-supervision, potential-free contact

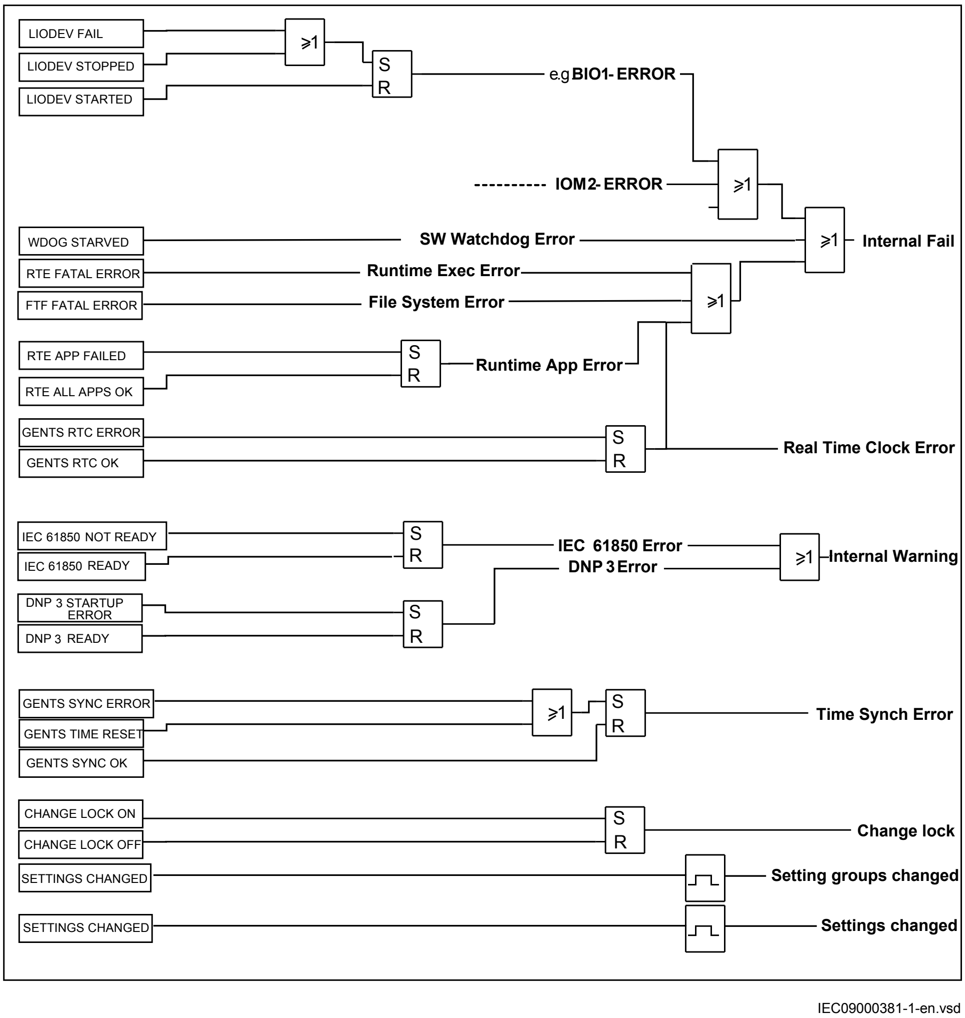


Figure 151: Self supervision, function block internal signals

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.

14.1.4.1 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 337. The hardware dependent internal signals are listed in table 338. Explanations of internal signals are listed in table 339.

Table 337: 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 338: 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 339: 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.

14.1.4.2 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 152.

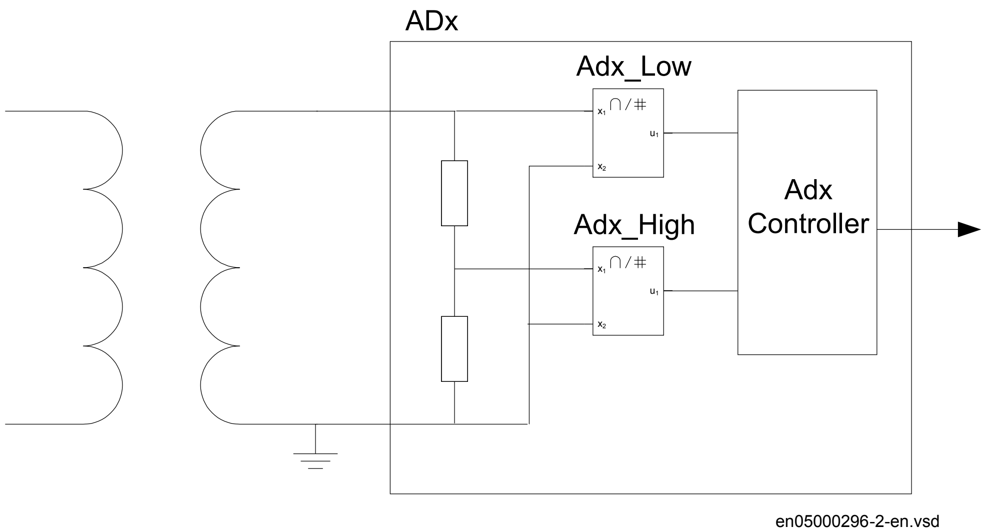


Figure 152: Simplified drawing of A/D converter for the IED.

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.

14.1.5 Technical data

Table 340: Self supervision with internal event list

Data	Value
Recording manner	Continuous, event controlled
List size	40 events, first in - first out

14.2 Time synchronization

14.2.1 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 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.

14.2.2 Time synchronization TIMESYNCHGEN

14.2.2.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Time synchronization	TIMESYNCHGEN	-	-

14.2.2.2 Settings

Table 341: 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

14.2.3 Time synchronization via SNTP

14.2.3.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Time synchronization via SNTP	SNTP	-	-

14.2.3.2 Settings

Table 342: 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

14.2.4 Time system, summer time begin DTSBEGIN

14.2.4.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Time system, summer time begins	DTSBEGIN	-	-

14.2.4.2 Settings

Table 343: 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

14.2.5 Time system, summer time ends DTSEND

14.2.5.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Time system, summer time ends	DTSEND	-	-

14.2.5.2 Settings

Table 344: 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

14.2.6 Time zone from UTC TIMEZONE

14.2.6.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Time zone from UTC	TIMEZONE	-	-

14.2.6.2 Settings

Table 345: TIMEZONE Non group settings (basic)

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

14.2.7 Time synchronization via IRIG-B

14.2.7.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Time synchronization via IRIG-B	IRIG-B	-	-

14.2.7.2 Settings

Table 346: 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

14.2.8 Operation principle

14.2.8.1 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)

The time system is based on a "software clock", which can be adjusted from external time sources and a hardware clock. The protection and control functions will be timed from a “hardware” clock, which runs independently from the “software” clock. See figure 153.

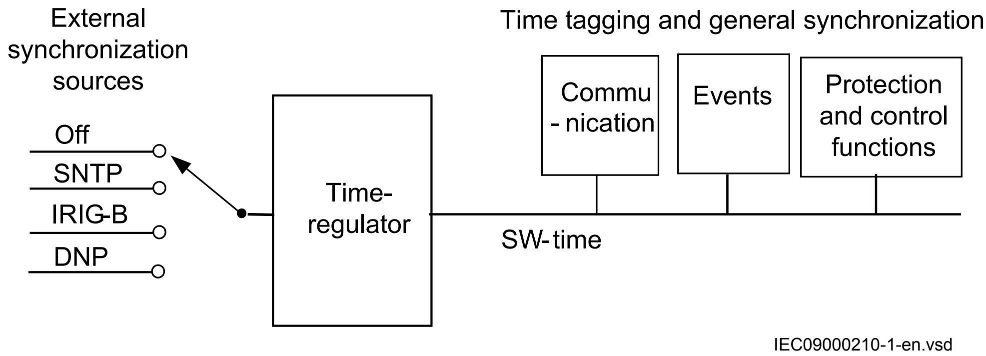


Figure 153: Design of time system (clock synchronization)

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

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.

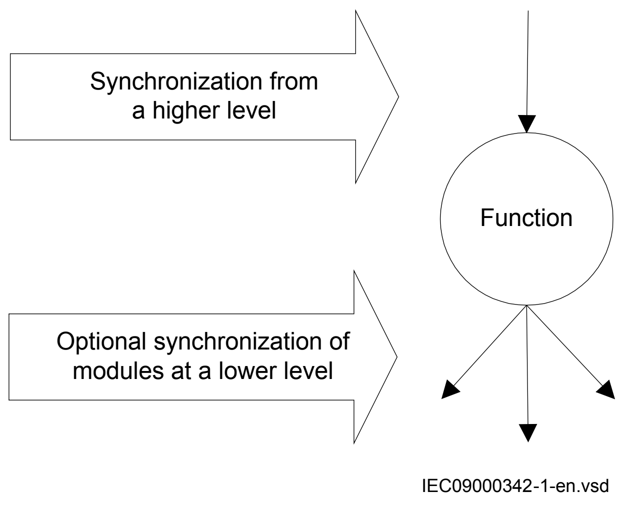


Figure 154: Synchronization principle

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.

14.2.8.2 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

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.

14.2.8.3 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.

14.2.9 Technical data

Table 347: 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

14.3 Parameter setting group handling

14.3.1 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.

14.3.2 Setting group handling SETGRPS

14.3.2.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Setting group handling	SETGRPS	-	-

14.3.2.2 Settings

Table 348: SETGRPS Non group settings (basic)

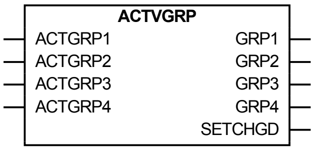
Name	Values (Range)	Unit	Step	Default	Description
ActiveSetGrp	SettingGroup1 SettingGroup2 SettingGroup3 SettingGroup4	-	-	SettingGroup1	ActiveSettingGroup
MaxNoSetGrp	1 - 4	-	1	1	Max number of setting groups 1-4

14.3.3 Parameter setting groups ACTVGRP

14.3.3.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Parameter setting groups	ACTVGRP	-	-

14.3.3.2 Function block



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14.3.3.3 Signals

Table 349: 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 350: 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

14.3.3.4 Settings

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

14.3.4 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.

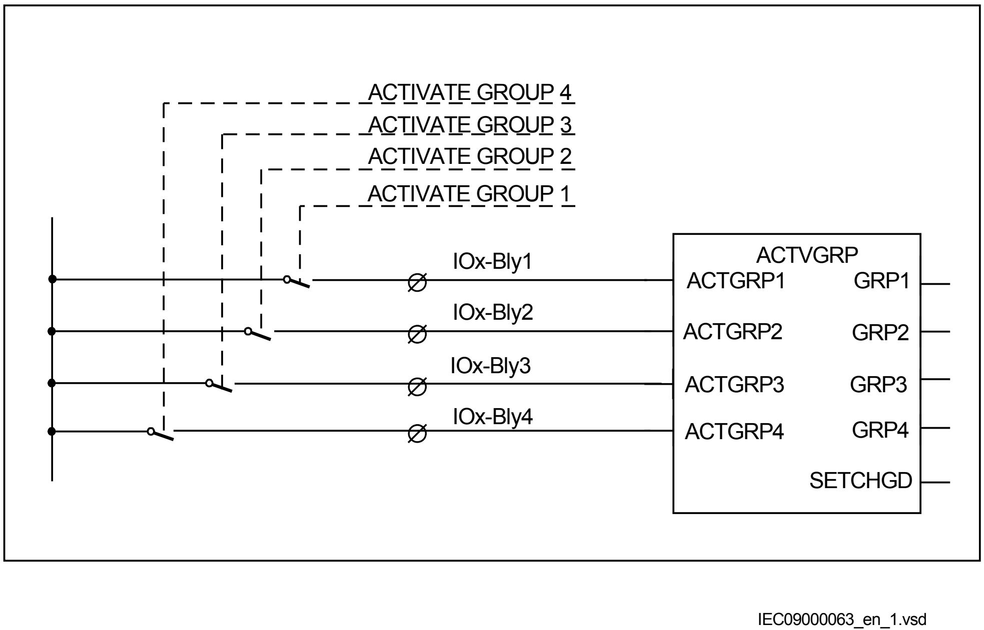

Figure 155: Connection of the function to external circuits

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

14.4 Test mode functionality TESTMODE

14.4.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Test mode functionality	TESTMODE	-	-

14.4.2 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.

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.

14.4.3 Function block

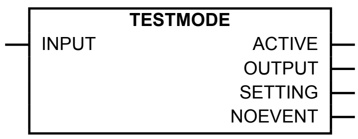

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Figure 156: TESTMODE function block

14.4.4 Signals

Table 351: TESTMODE Input signals

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

Table 352: 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

14.4.5 Settings

Table 353: 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

14.4.6 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.

14.5 Change lock function CHNGLCK

14.5.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Change lock function	CHNGLCK	-	-

14.5.2 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.

14.5.3 Function block

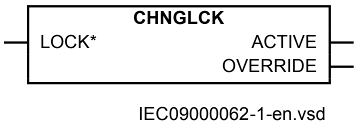

Figure 157: CHNGLCK function block

14.5.4 Signals

Table 354: CHNGLCK Input signals

Name	Type	Default	Description
LOCK	BOOLEAN	0	Activate change lock

Table 355: CHNGLCK Output signals

Name	Type	Description
ACTIVE	BOOLEAN	Change lock active
OVERRIDE	BOOLEAN	Change lock override

14.5.5 Settings

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

14.5.6 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

14.6 IED identifiers TERMINALID

14.6.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
IED identifiers	TERMINALID	-	-

14.6.2 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.

14.6.3 Settings

Table 356: 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

14.7 Product information

14.7.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Product information	PRODINF	-	-

14.7.2 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).

14.7.3 Settings

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

14.8 Primary system values PRIMVAL

14.8.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Primary system values	PRIMVAL	-	-

14.8.2 Functionality

The rated system frequency and phasor rotation are set under **Main menu/ Configuration/ Power system/ Primary values/PRIMVAL** in PCM600 parameter setting tree.

14.8.3 Settings

Table 357: 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

14.9 Signal matrix for analog inputs SMAI

14.9.1 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.

14.9.2 Signal matrix for analog inputs SMAI_20_1

14.9.2.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Signal matrix for analog inputs	SMAI_20_1	-	-

14.9.2.2 Function block

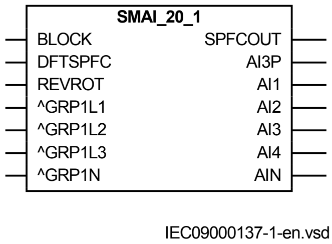

Figure 158: SMAI_20_1 function block

14.9.2.3 Signals

Table 358: 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 359: 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

14.9.2.4 Settings

Table 360: 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 361: 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

14.9.3 Signal matrix for analog inputs SMAI_20_2

14.9.3.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Signal matrix for analog inputs	SMAI_20_2	-	-

14.9.3.2 Function block

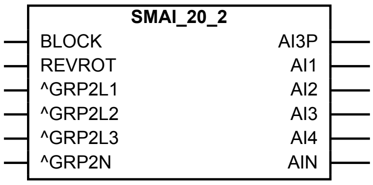

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Figure 159: SMAI_20_2 to SMAI_20_12 function block

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).

14.9.3.3 Signals

Table 362: 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 363: 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

14.9.3.4 Settings

Table 364: 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 365: 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

14.9.4 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 158 and figure 159. 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.

14.10 Summation block 3 phase 3PHSUM

14.10.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Summation block 3 phase	3PHSUM	-	-

14.10.2 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.

14.10.3 Function block

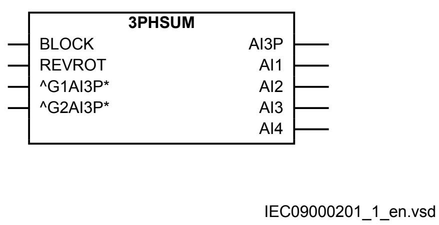


Figure 160: 3PHSUM function block

14.10.4 Signals

Table 366: 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 367: 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

14.10.5 Settings

Table 368: 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 369: 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

14.10.6 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.

14.11 Global base values GBASVAL

14.11.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Global base values	GBASVAL	-	-

14.11.2 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.

14.11.3 Settings

Table 370: 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

14.12 Authority check ATHCHCK

14.12.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Authority check	ATHCHCK	-	-

14.12.2 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

14.12.3 Settings

The function does not have any parameters available in Local HMI or Protection and Control IED Manager (PCM 600).

14.12.4 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.

14.12.4.1 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 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, 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 again. When it comes to password, upon pressing the 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 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.

14.13 Authority status ATHSTAT

14.13.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Authority status	ATHSTAT	-	-

14.13.2 Functionality

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

14.13.3 Function block

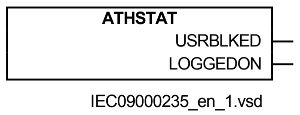


Figure 161: ATHSTAT function block

14.13.4 Signals

Table 371: 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

14.13.5 Settings

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

14.13.6 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.

14.14 Denial of service

14.14.1 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.

14.14.2 Denial of service, frame rate control for front port DOSFRNT

14.14.2.1 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	-	-

14.14.2.2 Function block

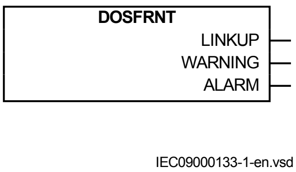


Figure 162: DOSFRNT function block

14.14.2.3 Signals

Table 372: 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

14.14.2.4 Settings

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

14.14.2.5 Monitored data

Table 373: 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

14.14.3 Denial of service, frame rate control for LAN1 port DOSLAN1

14.14.3.1 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	-	-

14.14.3.2 Function block

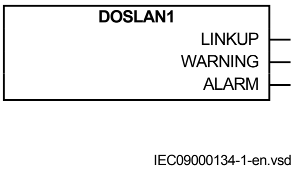


Figure 163: DOSLAN1 function block

14.14.3.3 Signals

Table 374: 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

14.14.3.4 Settings

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

14.14.3.5 Monitored data

Table 375: 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

14.14.4 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 15 IED physical connections

15.1 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.

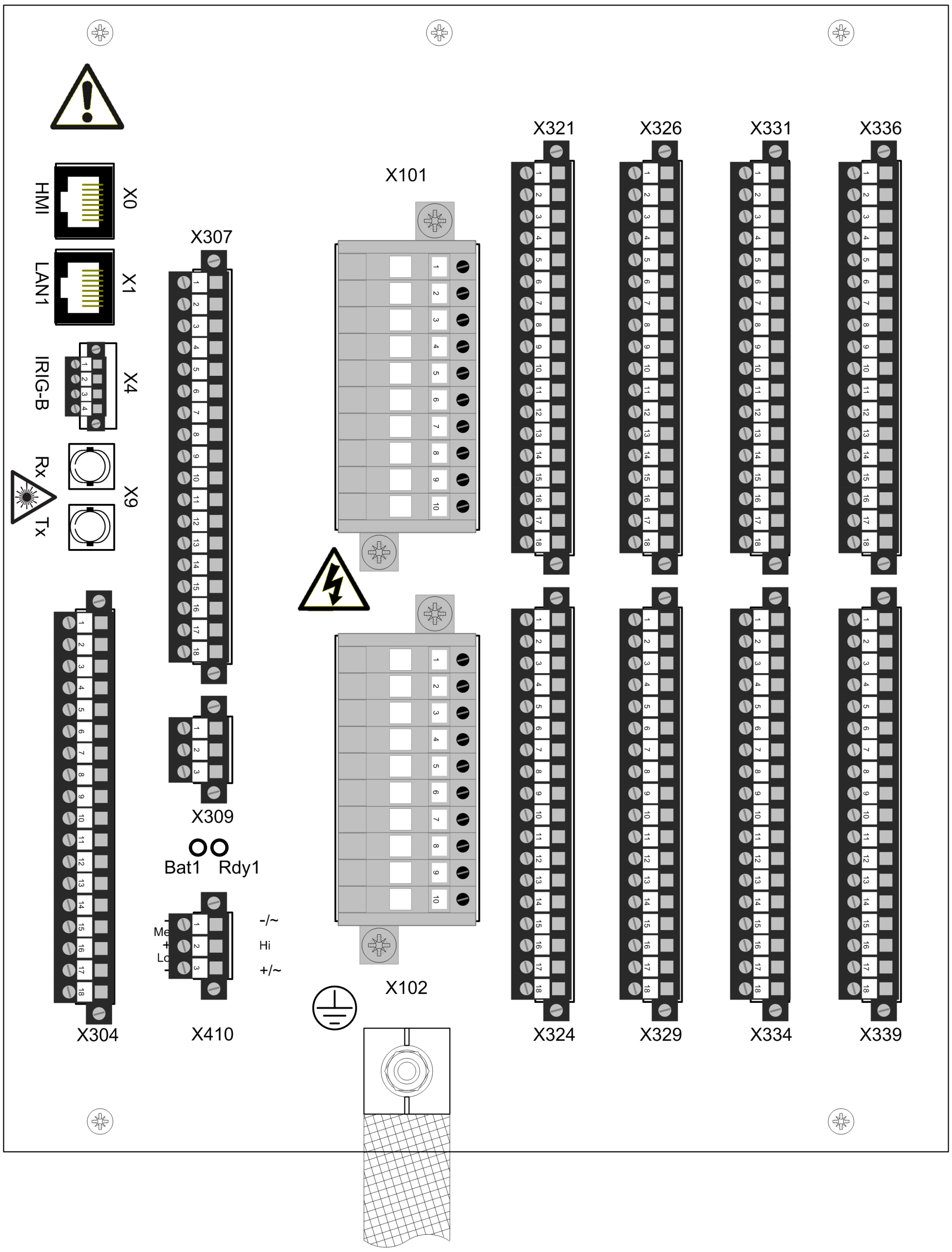


Figure 164: Protective earth pin is located below connector X102 on the 6U half 19” case

15.2 Inputs

15.2.1 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 376: 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.

15.2.2 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 377: 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 378: Auxiliary voltage supply of 48-125 V DC

Case	Terminal	Description
6U half 19”	X410-1	- Input
	X410–2	+ Input

15.2.3 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 379: 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 380: 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 381: 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 382: 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 383: 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

15.3 Outputs

15.3.1 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 384: 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 385: *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 386: *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 387: *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 388: *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

15.3.2 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 389: 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 390: 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 X321-14 X321-15	Signal output 4, normally open Signal output 5, normally open Signal outputs 4 and 5, common	BIO_3 BIO_3	BO7_SO BO8_SO
X321-16 X321-17 X321-18	Signal output 6, normally closed Signal output 6, normally open Signal output 6, common	BIO_3	BO9_SO

Table 391: 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 392: 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 393: 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 X336-12	Signal output 3, normally open Signal output 3	BIO_6	BO6_SO
X337-13 X336-14 X336-15	Signal output 4, normally open Signal output 5, normally open Signal outputs 4 and 5, common	BIO_6 BIO_6	BO7_SO BO8_SO
X336-16 X336-17 X336-18	Signal output 6, normally closed Signal output 6, normally open Signal output 6, common	BIO_6	BO9_SO

15.3.3 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 394: 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

15.4 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.

15.4.1 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.

15.4.2 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.

15.4.3 Communication interfaces and protocols

Table 395: Supported communication interfaces and protocols

Protocol	Ethernet 100BASE-FX LC
IEC 61850-8-1	●
DNP3	●
● = Supported	

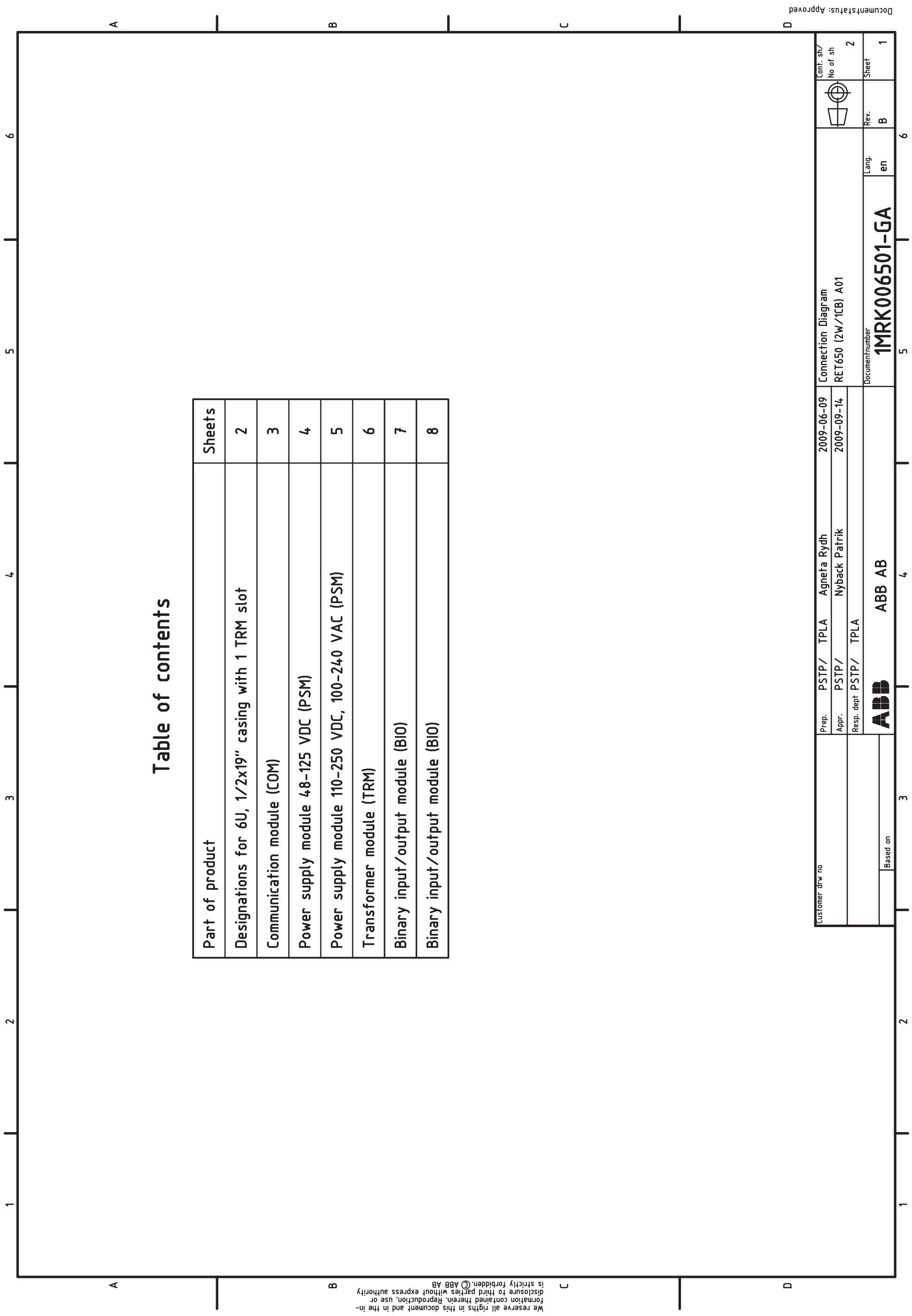
15.4.4 Recommended industrial Ethernet switches

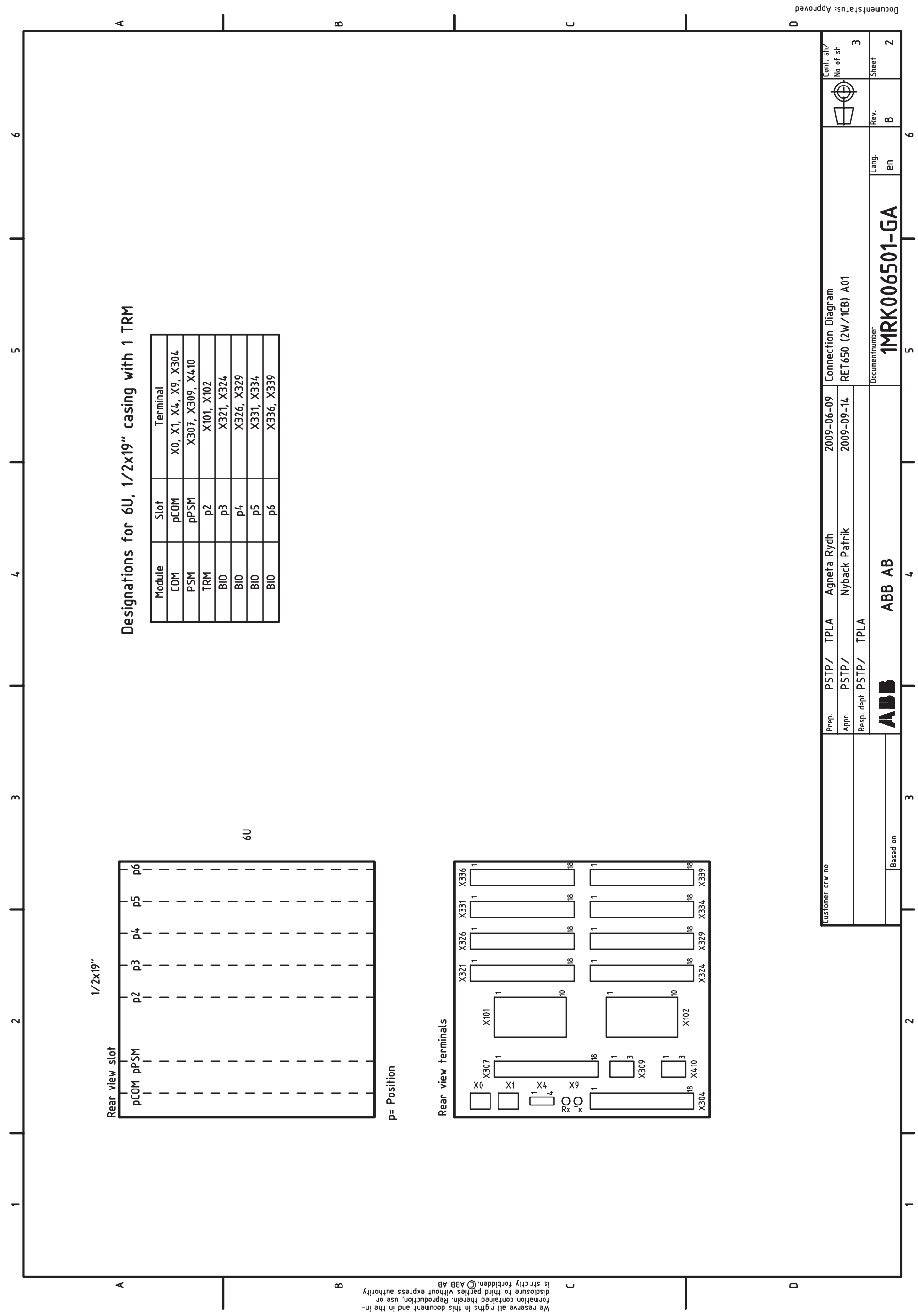
ABB recommends three third-party industrial Ethernet switches.

- RuggedCom RS900
- RuggedCom RS1600
- RuggedCom RSG2100

15.5 Connection diagrams

Connection diagrams for RET650 A01




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
pCOM pPSM p2 p3 p4 p5 p6
p= Position
Rear view terminals
X0 X1 X4 X9 Rx Tx
X304 X307 X309 X410 X101 X102
X321 X324 X326 X329 X331 X334 X336 X339
Prep. PSTP/ TPLA Agneta Rydh 2009-06-09
Appr. PSTP/ Nyback Patrik 2009-09-14
Resp. dept PSTP/ TPLA
ABB AB
Connection Diagram
RET650 (2W/1CB) A01
Documentnumber
1MRK006501-GA
Lang. en
Rev. B
Sheet 2
Cont. sh/ No of sh 3
Customer drw no
Based on
DocumentStatus: Approved
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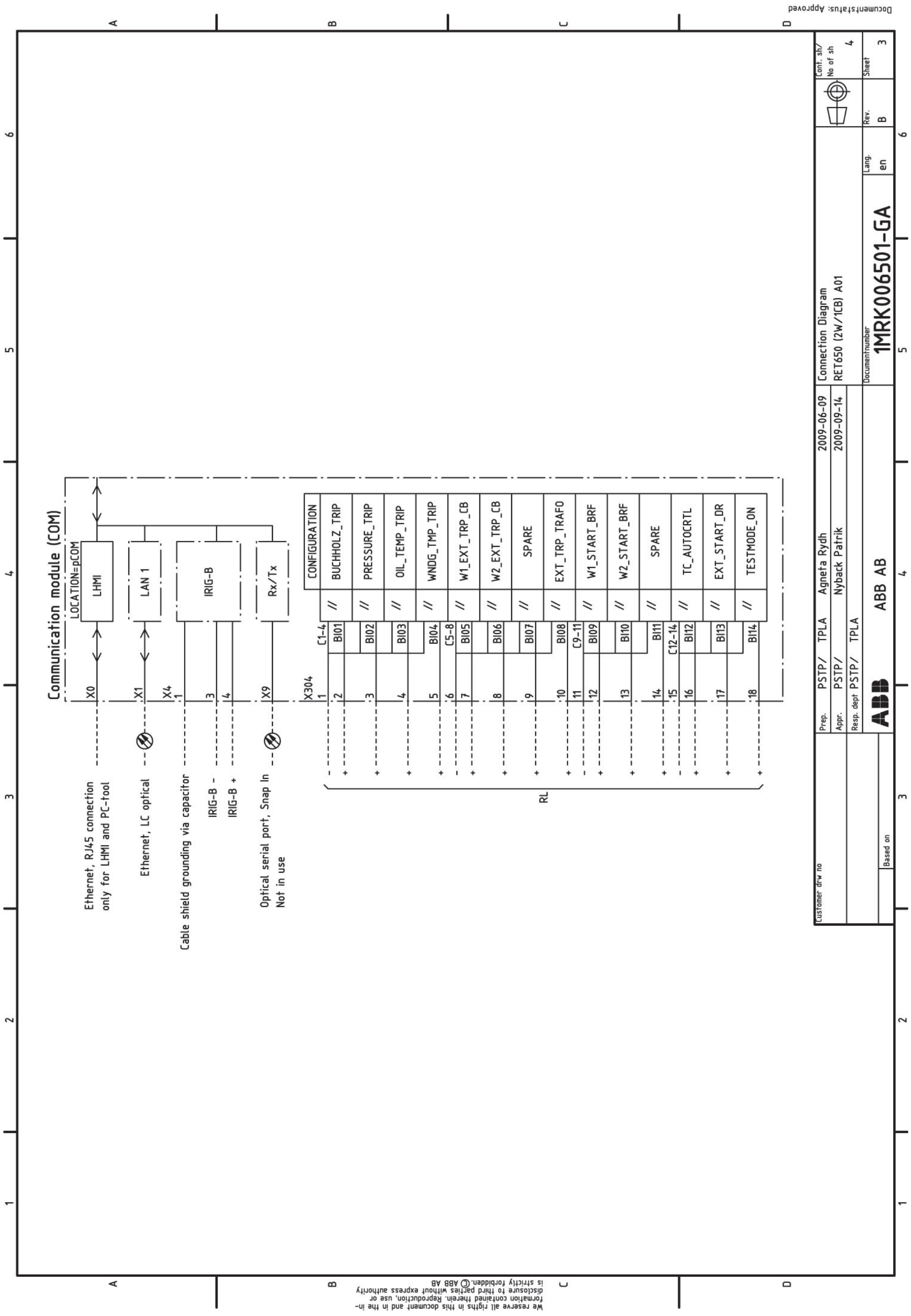
Communication module (COM)
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LHMI
LAN 1
IRIG-B
Rx/Tx
X0
X1
X4
X9
X304
Ethernet, RJ45 connection only for LHMI and PC-tool
Ethernet, LC optical
Cable shield grounding via capacitor
IRIG-B -
IRIG-B +
Optical serial port, Snap In
Not in use
CONFIGURATION
BUCHHOLZ_TRIP
PRESSURE_TRIP
OIL_TEMP_TRIP
WNDG_TMP_TRIP
W1_EXT_TRP_CB
W2_EXT_TRP_CB
SPARE
EXT_TRP_TRAFO
W1_START_BRF
W2_START_BRF
SPARE
TC_AUTOCRTL
EXT_START_DR
TESTMODE_ON
C1-4
BI01
BI02
BI03
BI04
C5-8
BI05
BI06
BI07
BI08
C9-11
BI09
BI10
BI11
C12-14
BI12
BI13
BI14
RL
Connection Diagram
RET650 (2W/1CB) A01
1MRK006501-GA
ABB AB
Prep. PSTP/ TPLA Agneta Rydh 2009-06-09
Appr. PSTP/ Nyback Patrik 2009-09-14
Resp. dept PSTP/ TPLA
Lang. en
Rev. B
Sheet 3
No of sh 4
Customer drw no
Based on
DocumentStatus: Approved
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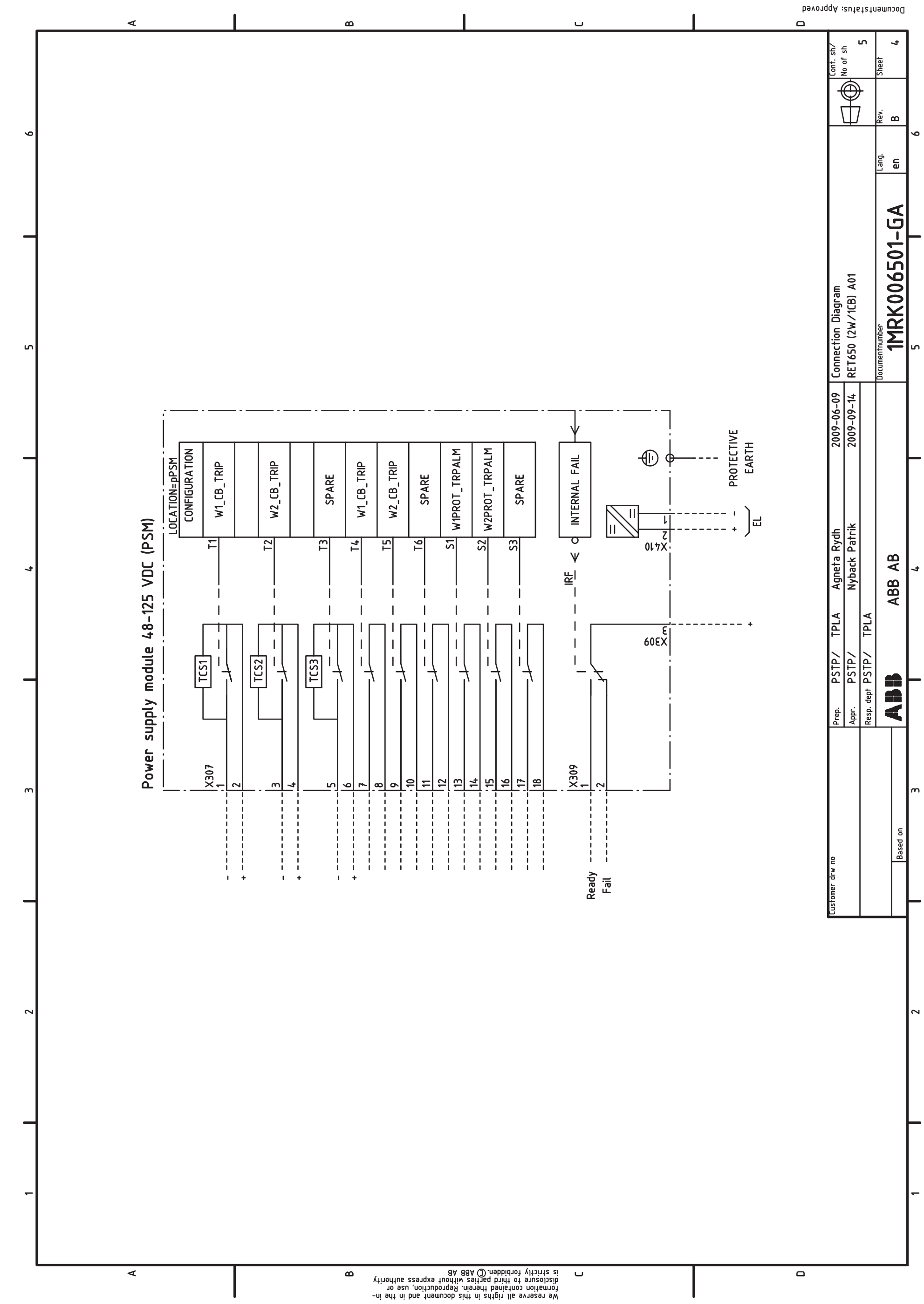
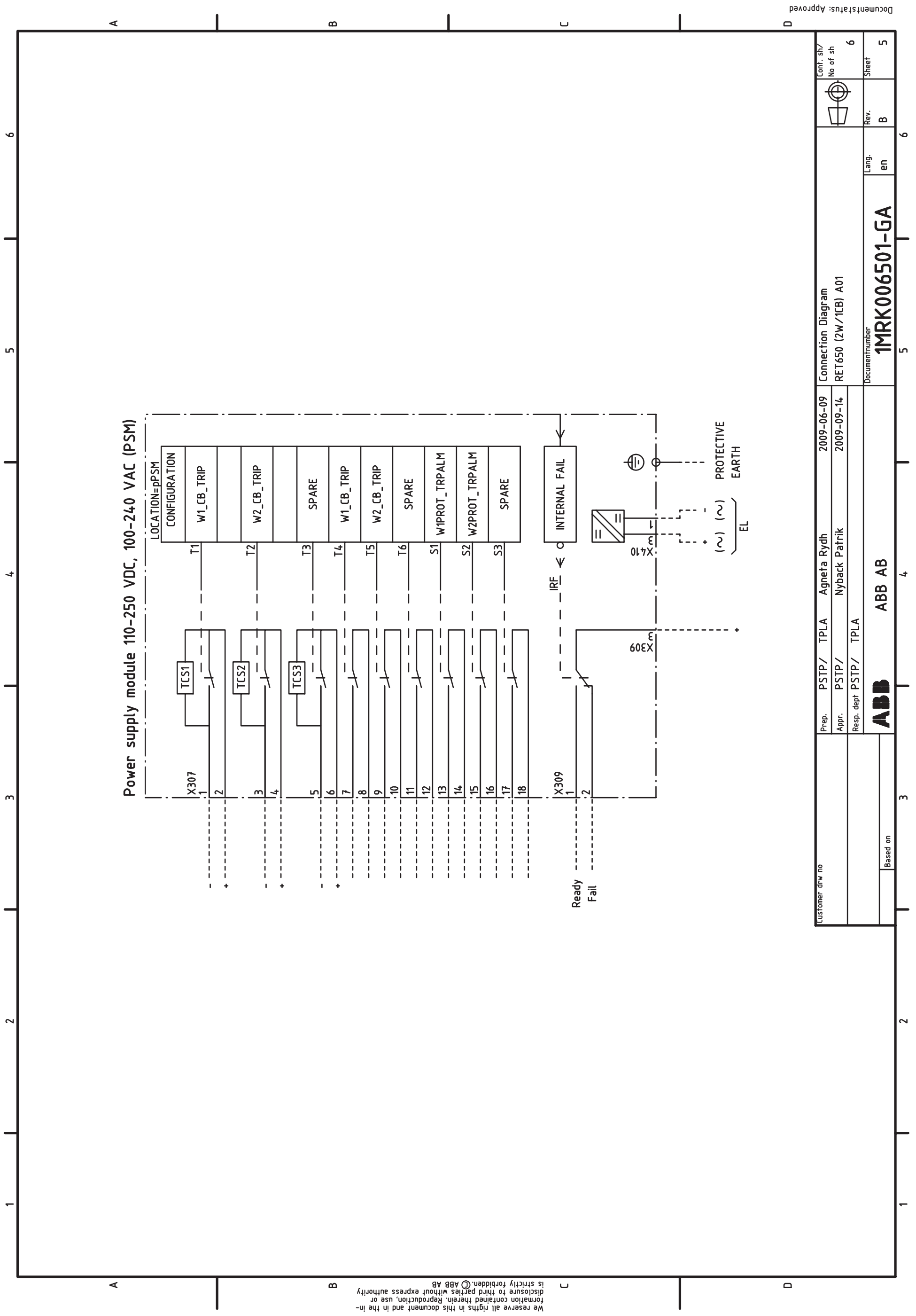
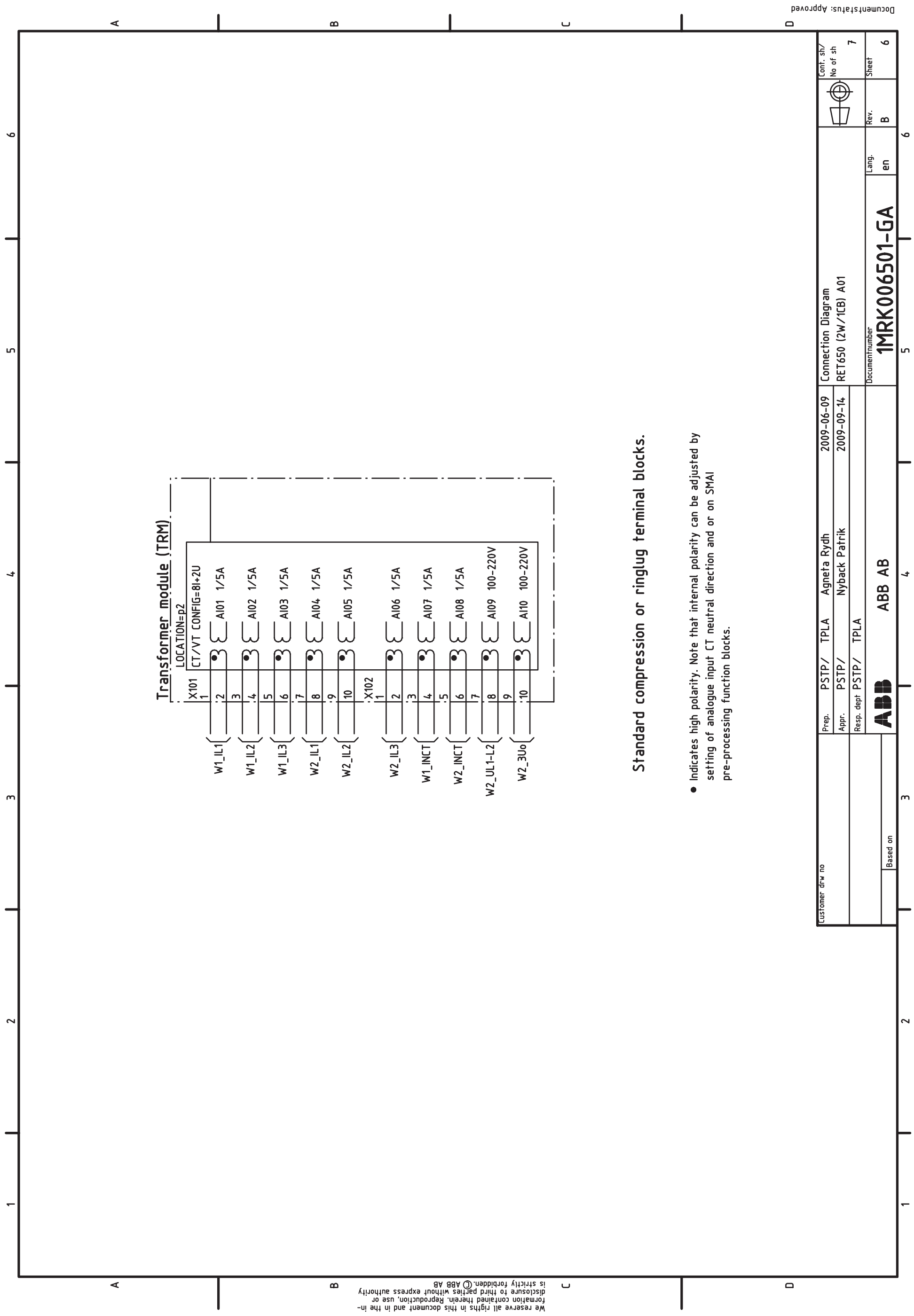

Power supply module 48-125 VDC (PSM)
LOCATION=pPSM
CONFIGURATION
W1_CB_TRIP
W2_CB_TRIP
SPARE
W1_CB_TRIP
W2_CB_TRIP
SPARE
W1PROT_TRPALM
W2PROT_TRPALM
SPARE
INTERNAL FAIL
IRF
PROTECTIVE EARTH
EL
TCS1
TCS2
TCS3
X307
X309
X410
Ready
Fail
Connection Diagram
RET650 (2W/1CB) A01
1MRK006501-GA
ABB AB
Agneta Rydh
Nyback Patrik
2009-06-09
2009-09-14
DocumentStatus: Approved


Power supply module 110-250 VDC, 100-240 VAC (PSM)
LOCATION=pPSM
CONFIGURATION
W1_CB_TRIP
W2_CB_TRIP
SPARE
W1_CB_TRIP
W2_CB_TRIP
SPARE
W1PROT_TRPALM
W2PROT_TRPALM
SPARE
INTERNAL FAIL
IRF
TCS1
TCS2
TCS3
X307
X309
X410
PROTECTIVE EARTH
EL
Ready
Fail
Connection Diagram
RET650 (2W/1CB) A01
1MRK006501-GA
ABB AB
Agneta Rydh
Nyback Patrik
2009-06-09
2009-09-14
DocumentStatus: Approved


Transformer module (TRM)
LOCATION=p2
CT/VT CONFIG=8I+2U
X101
X102
AI01 1/5A
AI02 1/5A
AI03 1/5A
AI04 1/5A
AI05 1/5A
AI06 1/5A
AI07 1/5A
AI08 1/5A
AI09 100-220V
AI10 100-220V
W1_IL1
W1_IL2
W1_IL3
W2_IL1
W2_IL2
W2_IL3
W1_INCT
W2_INCT
W2_UL1-L2
W2_3Uo
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 drw no
Prep. PSTP/ TPLA Agneta Rydh 2009-06-09
Appr. PSTP/ Nyback Patrik 2009-09-14
Resp. dept PSTP/ TPLA
Based on
ABB AB
Connection Diagram
RET650 (2W/1CB) A01
Documentnumber
1MRK006501-GA
Lang. en
Rev. B
Sheet 6
No of sh 7
Cont. sh/
DocumentStatus: Approved
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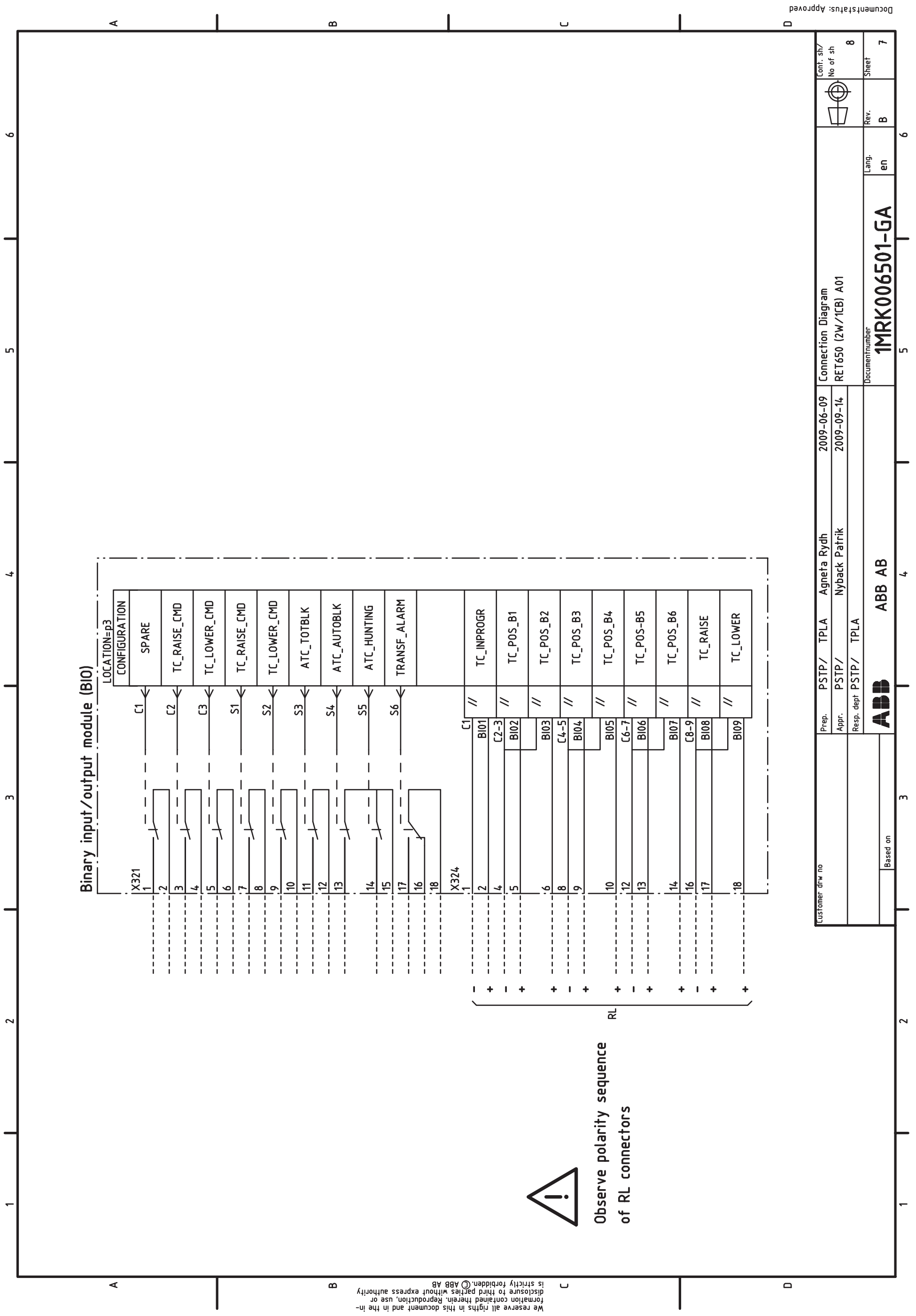
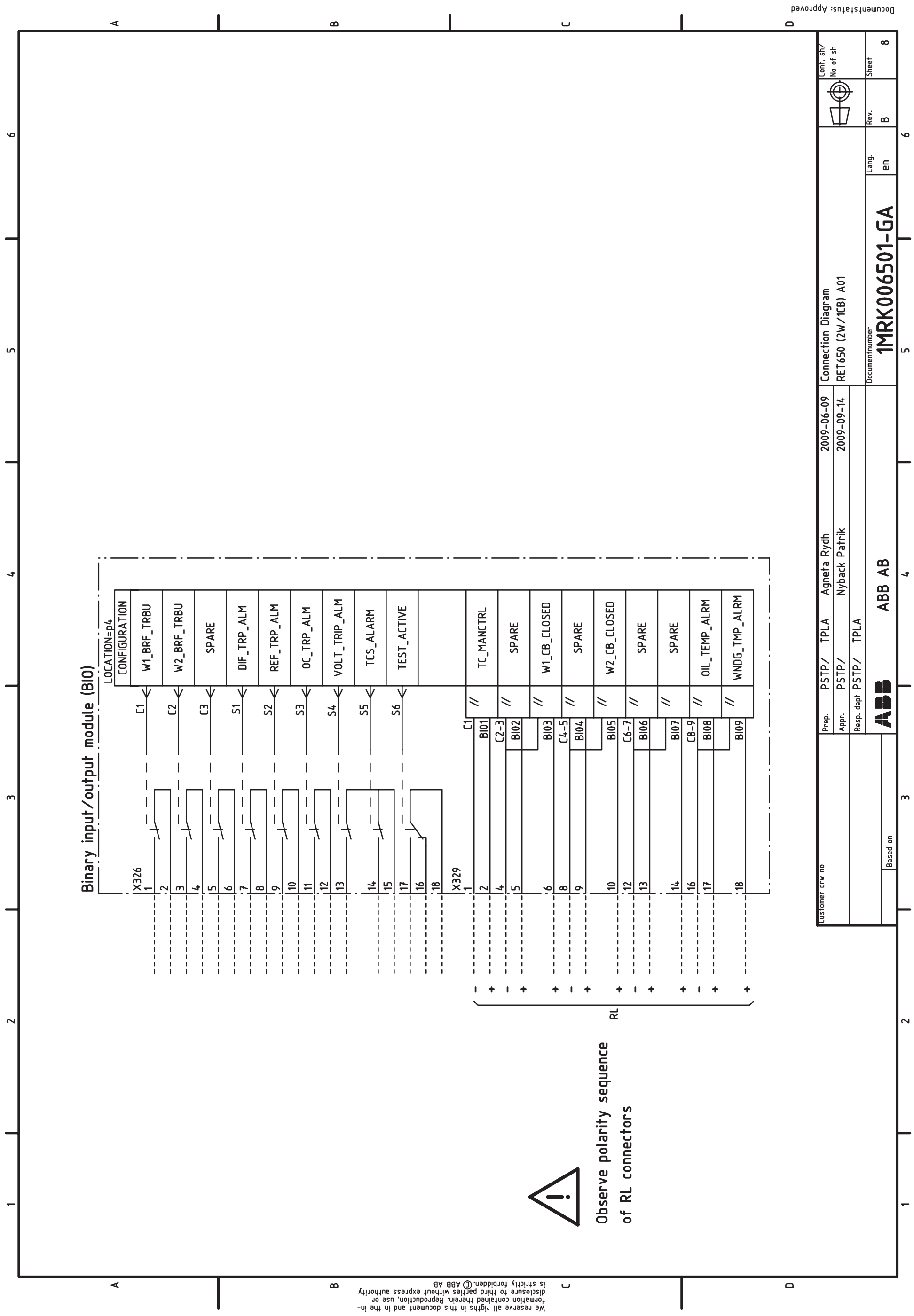

Binary input/output module (BIO)
LOCATION=p3
CONFIGURATION
SPARE
TC_RAISE_CMD
TC_LOWER_CMD
TC_RAISE_CMD
TC_LOWER_CMD
ATC_TOTBLK
ATC_AUTOBLK
ATC_HUNTING
TRANSF_ALARM
TC_INPROGR
TC_POS_B1
TC_POS_B2
TC_POS_B3
TC_POS_B4
TC_POS-B5
TC_POS_B6
TC_RAISE
TC_LOWER
X321
X324
RL
Observe polarity sequence
of RL connectors
Connection Diagram
RET650 (2W/1CB) A01
1MRK006501-GA
ABB AB
Agneta Rydh
Nyback Patrik
2009-06-09
2009-09-14
DocumentStatus: Approved


DocumentStatus: Approved
Binary input/output module (BIO)
LOCATION=p4
CONFIGURATION
W1_BRF_TRBU
W2_BRF_TRBU
SPARE
DIF_TRP_ALM
REF_TRP_ALM
OC_TRP_ALM
VOLT_TRIP_ALM
TCS_ALARM
TEST_ACTIVE
TC_MANCTRL
SPARE
W1_CB_CLOSED
SPARE
W2_CB_CLOSED
SPARE
SPARE
OIL_TEMP_ALRM
WNDG_TMP_ALRM
X326
X329
RL
Observe polarity sequence
of RL connectors
Prep. PSTP/ TPLA Agneta Rydh 2009-06-09
Appr. PSTP/ Nyback Patrik 2009-09-14
Resp. dept PSTP/ TPLA
Connection Diagram
RET650 (2W/1CB) A01
ABB AB
Documentnumber
1MRK006501-GA
Lang. en
Rev. B
Sheet 8
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Connection diagrams for RET650 A05

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Communication module (COM)	3
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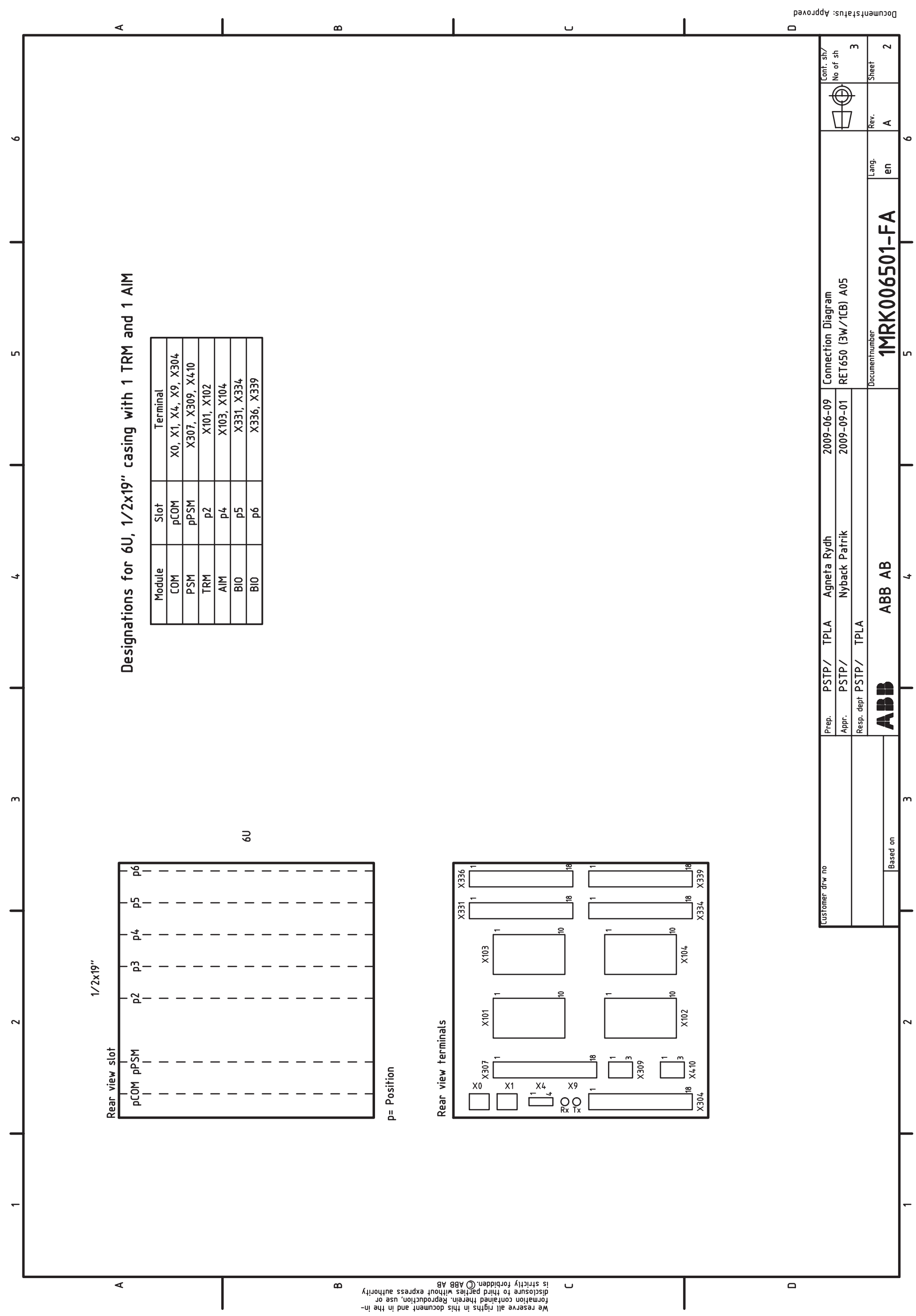
Power supply module 110-250 VDC, 100-240 VAC (PSM)	5
Transformer module (TRM)	6
Analogue input module (AIM)	7
Binary input/output module (BIO)	8
Binary input/output module (BIO)	9

DocumentStatus: Approved

Customer drw no	Prep. PSTP/ TPLA Agneta Rydh	2009-06-09	Connection Diagram RET650 (3W/1CB) A05	Conf. sh/ No of sh 2
	Appr. PSTP/ Nyback Patrik	2009-09-01		
	Resp. dept PSTP/ TPLA			
Based on	ABB AB		Document number 1MRK006501-FA	Lang. en · Rev. A · Sheet 1


Designations for 6U, 1/2x19" casing with 1 TRM and 1 AIM
Module | Slot | Terminal
COM | pCOM | X0, X1, X4, X9, X304
PSM | pPSM | X307, X309, X410
TRM | p2 | X101, X102
AIM | p4 | X103, X104
BIO | p5 | X331, X334
BIO | p6 | X336, X339
Rear view slot
1/2x19"
6U
pCOM pPSM p2 p3 p4 p5 p6
p= Position
Rear view terminals
X0 X1 X4 X9
Rx Tx
X304 X307 X309 X410
X101 X102 X103 X104
X331 X334 X336 X339
Prep. PSTP/ TPLA Agneta Rydh 2009-06-09
Appr. PSTP/ Nyback Patrik 2009-09-01
Resp. dept PSTP/ TPLA
Connection Diagram
RET650 (3W/1CB) A05
ABB AB
Documentnumber
1MRK006501-FA
Lang. en
Rev. A
Sheet 2
No of sh 3
Customer drw no
Based on
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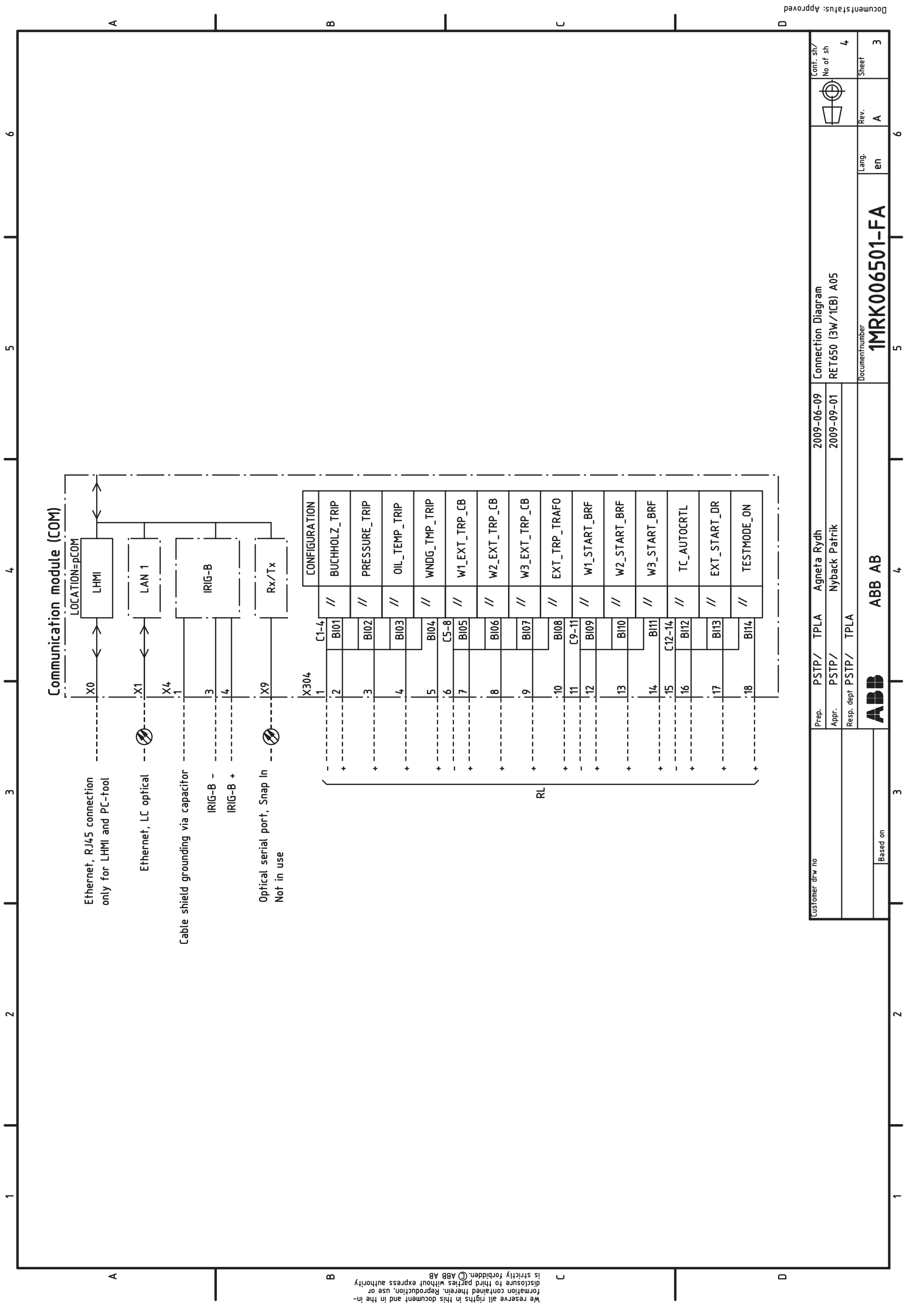
DocumentStatus: Approved
Communication module (COM)
LOCATION=pCOM
LHMI
LAN 1
IRIG-B
Rx/Tx
X0
X1
X4
X9
X304
Ethernet, RJ45 connection only for LHMI and PC-tool
Ethernet, LC optical
Cable shield grounding via capacitor
IRIG-B -
IRIG-B +
Optical serial port, Snap In Not in use
CONFIGURATION
BUCHHOLZ_TRIP
PRESSURE_TRIP
OIL_TEMP_TRIP
WNDG_TMP_TRIP
W1_EXT_TRP_CB
W2_EXT_TRP_CB
W3_EXT_TRP_CB
EXT_TRP_TRAFO
W1_START_BRF
W2_START_BRF
W3_START_BRF
TC_AUTOCRTL
EXT_START_DR
TESTMODE_ON
C1-4
BI01
BI02
BI03
BI04
C5-8
BI05
BI06
BI07
BI08
C9-11
BI09
BI10
BI11
C12-14
BI12
BI13
BI14
RL
Customer drw no
Prep. PSTP/ TPLA Agneta Rydh 2009-06-09
Appr. PSTP/ Nyback Patrik 2009-09-01
Resp. dept PSTP/ TPLA
Based on
ABB AB
Connection Diagram
RET650 (3W/1CB) A05
Documentnumber
1MRK006501-FA
Lang. en
Rev. A
Sheet 3
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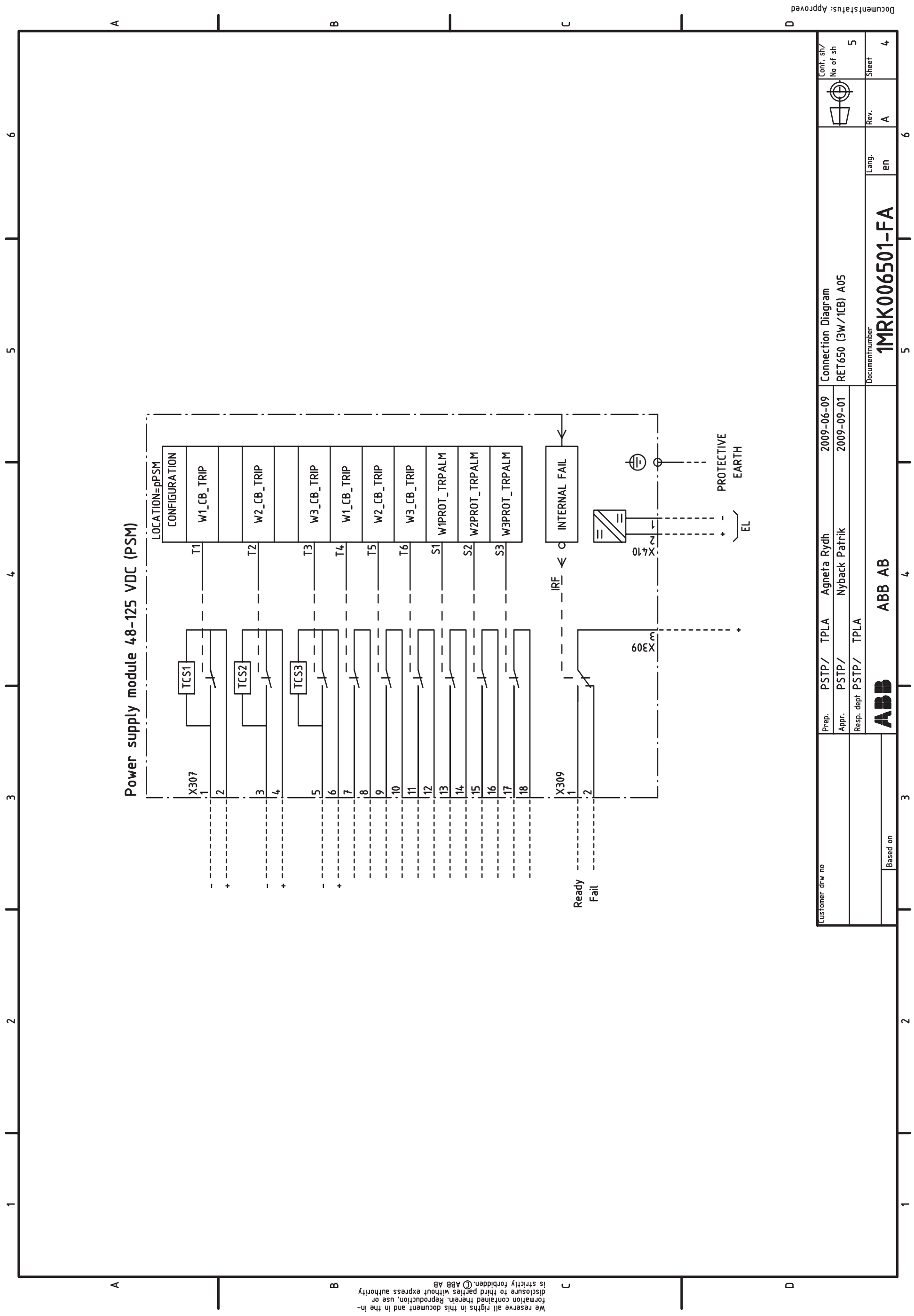
Document status: Approved
Power supply module 48-125 VDC (PSM)
LOCATION=pPSM
CONFIGURATION
W1_CB_TRIP
W2_CB_TRIP
W3_CB_TRIP
W1_CB_TRIP
W2_CB_TRIP
W3_CB_TRIP
W1PROT_TRPALM
W2PROT_TRPALM
W3PROT_TRPALM
INTERNAL FAIL
TCS1
TCS2
TCS3
X307
X309
X410
IRF
PROTECTIVE EARTH
EL
Ready
Fail
Connection Diagram
RET650 (3W/1CB) A05
1MRK006501-FA
ABB AB
Prep. PSTP/ TPLA Agneta Rydh 2009-06-09
Appr. PSTP/ Nyback Patrik 2009-09-01
Resp. dept PSTP/ TPLA
Lang. en
Rev. A
Sheet 4
No of sh 5
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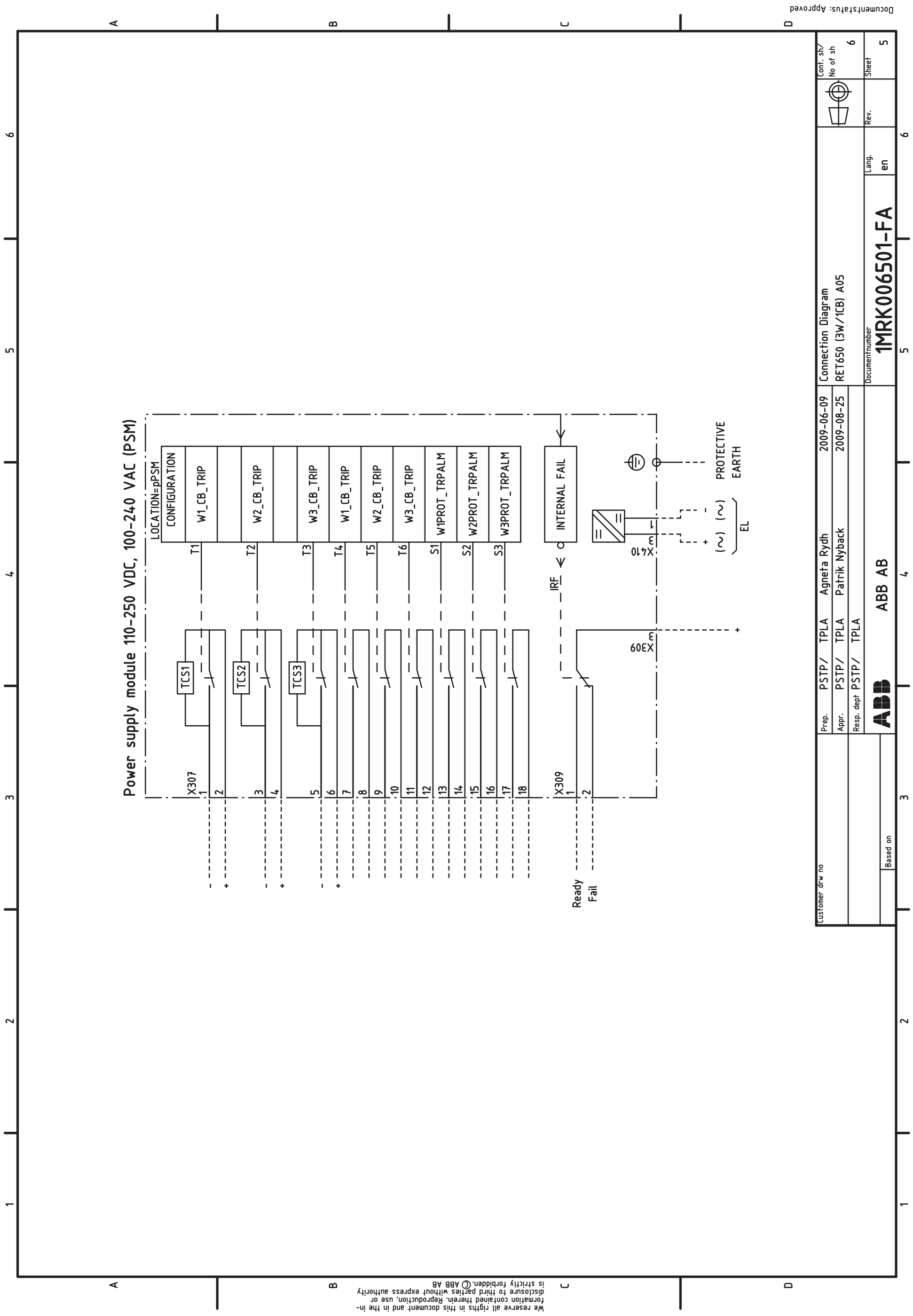
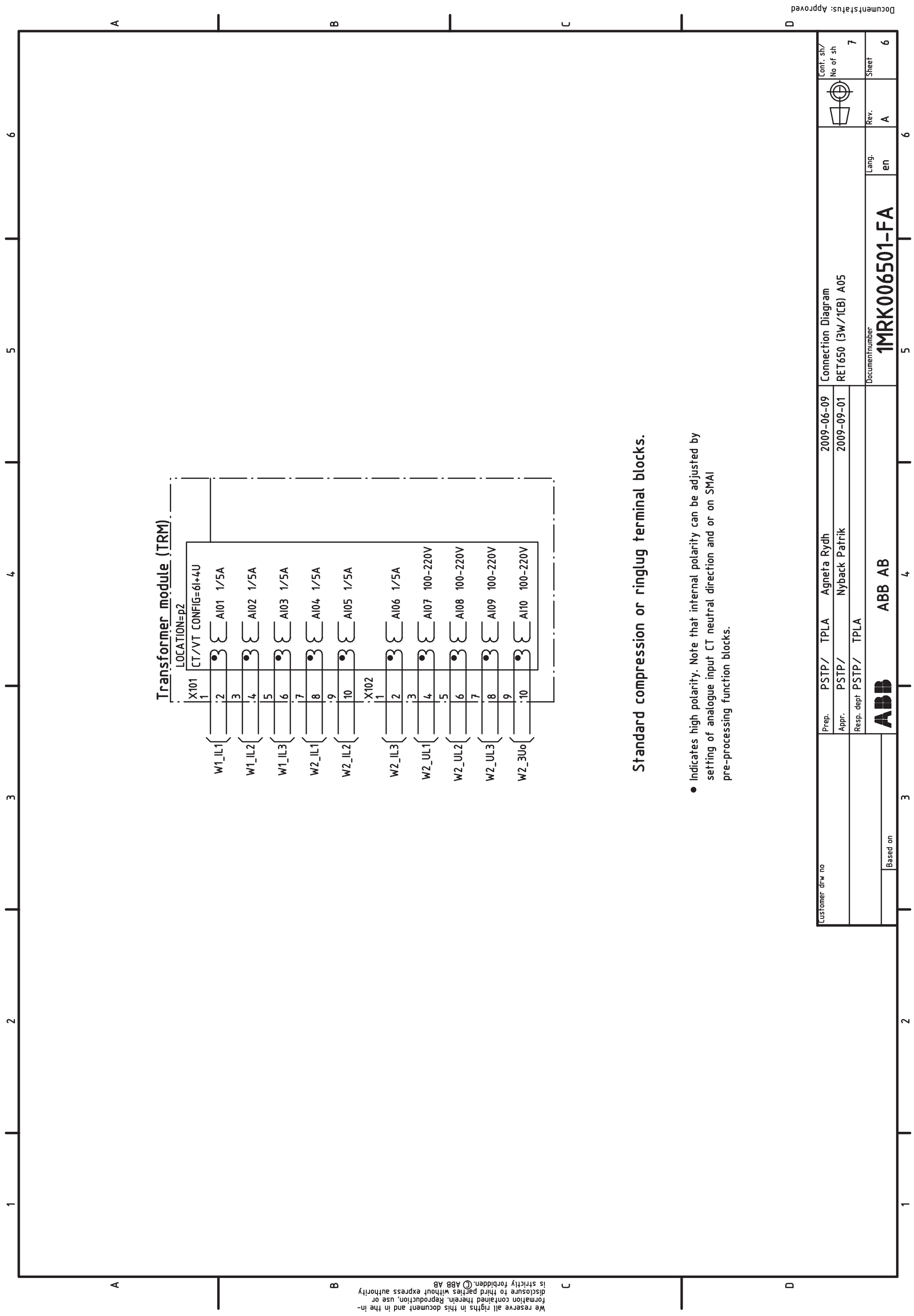

Power supply module 110-250 VDC, 100-240 VAC (PSM)
LOCATION=pSM
CONFIGURATION
W1_CB_TRIP
W2_CB_TRIP
W3_CB_TRIP
W1_CB_TRIP
W2_CB_TRIP
W3_CB_TRIP
W1PROT_TRPALM
W2PROT_TRPALM
W3PROT_TRPALM
INTERNAL FAIL
IRF
TCS1
TCS2
TCS3
X307
X309
X410
PROTECTIVE EARTH
EL
Ready
Fail
Connection Diagram
RET650 (3W/1CB) A05
Agneta Rydh
Patrik Nyback
2009-06-09
2009-08-25
ABB AB
1MRK006501-FA
Lang. en
Sheet 5
DocumentStatus: Approved


Transformer module (TRM)
LOCATION=p2
CT/VT CONFIG=6I+4U
X101
W1_IL1
W1_IL2
W1_IL3
W2_IL1
W2_IL2
AI01 1/5A
AI02 1/5A
AI03 1/5A
AI04 1/5A
AI05 1/5A
X102
W2_IL3
W2_UL1
W2_UL2
W2_UL3
W2_3Uo
AI06 1/5A
AI07 100-220V
AI08 100-220V
AI09 100-220V
AI10 100-220V
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 drw no
Based on
Prep. PSTP/ TPLA Agneta Rydh 2009-06-09
Appr. PSTP/ Nyback Patrik 2009-09-01
Resp. dept PSTP/ TPLA
ABB AB
Connection Diagram
RET650 (3W/1CB) A05
Documentnumber
1MRK006501-FA
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Rev. A
Sheet 6
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No of sh 7
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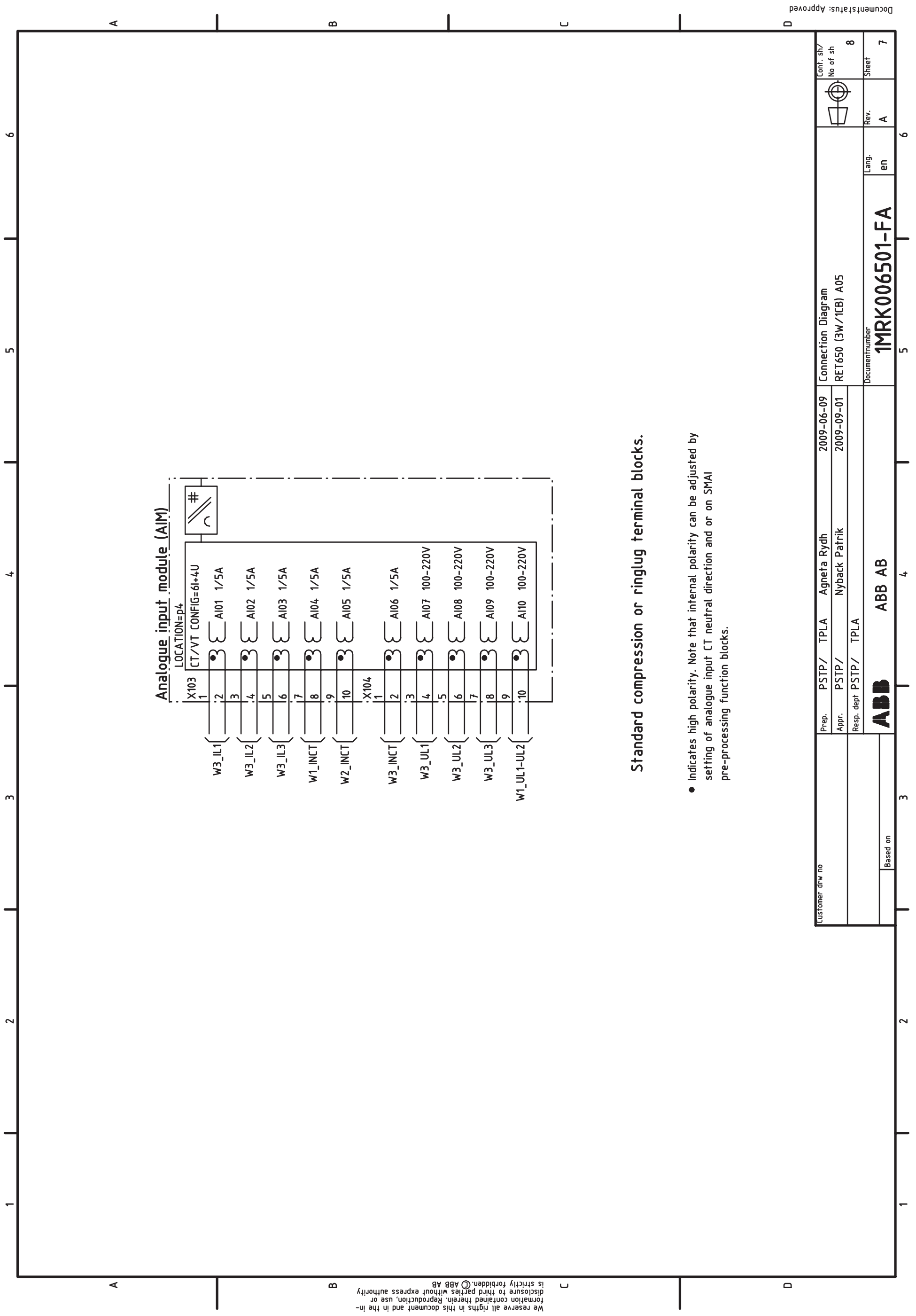
DocumentStatus: Approved
Analogue input module (AIM)
LOCATION=p4
CT/VT CONFIG=6I+4U
X103
X104
AI01 1/5A
AI02 1/5A
AI03 1/5A
AI04 1/5A
AI05 1/5A
AI06 1/5A
AI07 100-220V
AI08 100-220V
AI09 100-220V
AI10 100-220V
W3_IL1
W3_IL2
W3_IL3
W1_INCT
W2_INCT
W3_INCT
W3_UL1
W3_UL2
W3_UL3
W1_UL1-UL2
Standard compression 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 drw no
Prep. PSTP/ TPLA Agneta Rydh 2009-06-09
Appr. PSTP/ Nyback Patrik 2009-09-01
Resp. dept PSTP/ TPLA
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Based on
Connection Diagram
RET650 (3W/1CB) A05
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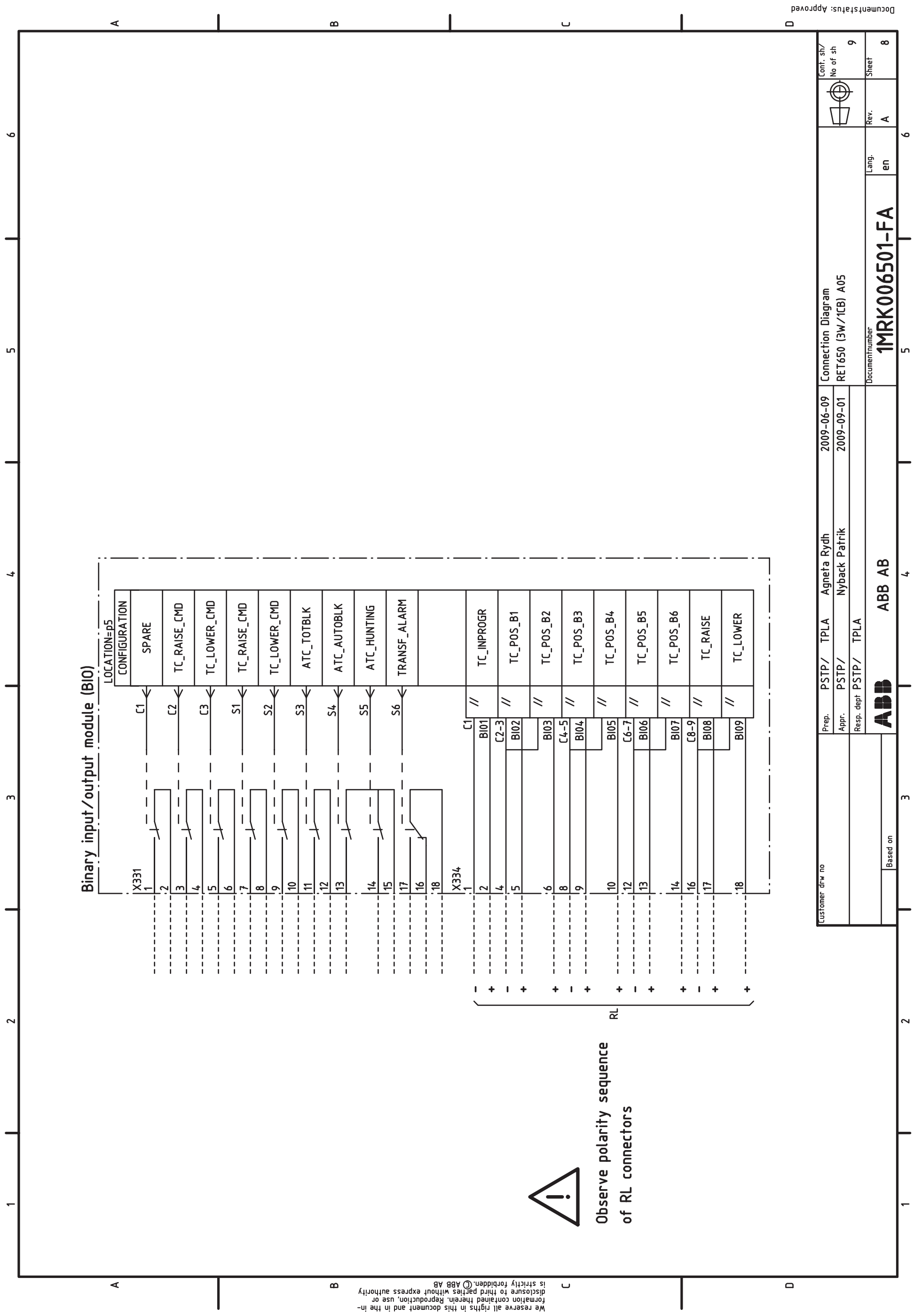
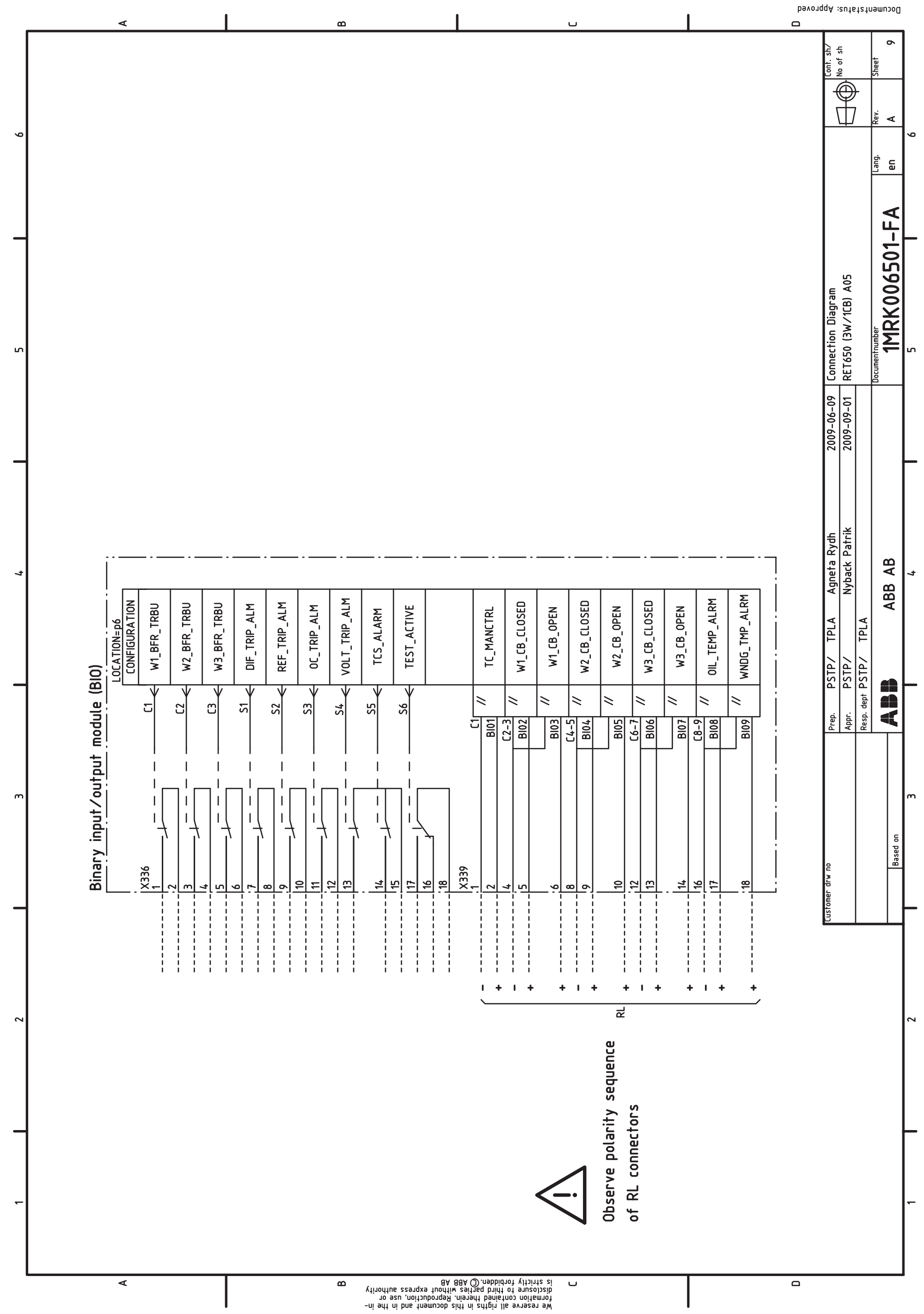

Binary input/output module (BIO)
LOCATION=p5
CONFIGURATION
SPARE
TC_RAISE_CMD
TC_LOWER_CMD
TC_RAISE_CMD
TC_LOWER_CMD
ATC_TOTBLK
ATC_AUTOBLK
ATC_HUNTING
TRANSF_ALARM
TC_INPROGR
TC_POS_B1
TC_POS_B2
TC_POS_B3
TC_POS_B4
TC_POS_B5
TC_POS_B6
TC_RAISE
TC_LOWER
X331
X334
RL
Observe polarity sequence of RL connectors
Connection Diagram
RET650 (3W/1CB) A05
1MRK006501-FA
Agneta Rydh
Nyback Patrik
2009-06-09
2009-09-01
ABB AB
DocumentStatus: Approved


Binary input/output module (BIO)
LOCATION=p6
CONFIGURATION
W1_BFR_TRBU
W2_BFR_TRBU
W3_BFR_TRBU
DIF_TRIP_ALM
REF_TRIP_ALM
OC_TRIP_ALM
VOLT_TRIP_ALM
TCS_ALARM
TEST_ACTIVE
TC_MANCTRL
W1_CB_CLOSED
W1_CB_OPEN
W2_CB_CLOSED
W2_CB_OPEN
W3_CB_CLOSED
W3_CB_OPEN
OIL_TEMP_ALRM
WNDG_TMP_ALRM
X336
X339
RL
Observe polarity sequence
of RL connectors
Connection Diagram
RET650 (3W/1CB) A05
Agneta Rydh 2009-06-09
Nyback Patrik 2009-09-01
ABB AB
1MRK006501-FA
DocumentStatus: Approved

Connection diagrams for RET650 A07

DocumentStatus: Approved

Table of contents

Part of product	Sheets
Designations for 6U, 1/2x19" casing with 1 TRM slot	2
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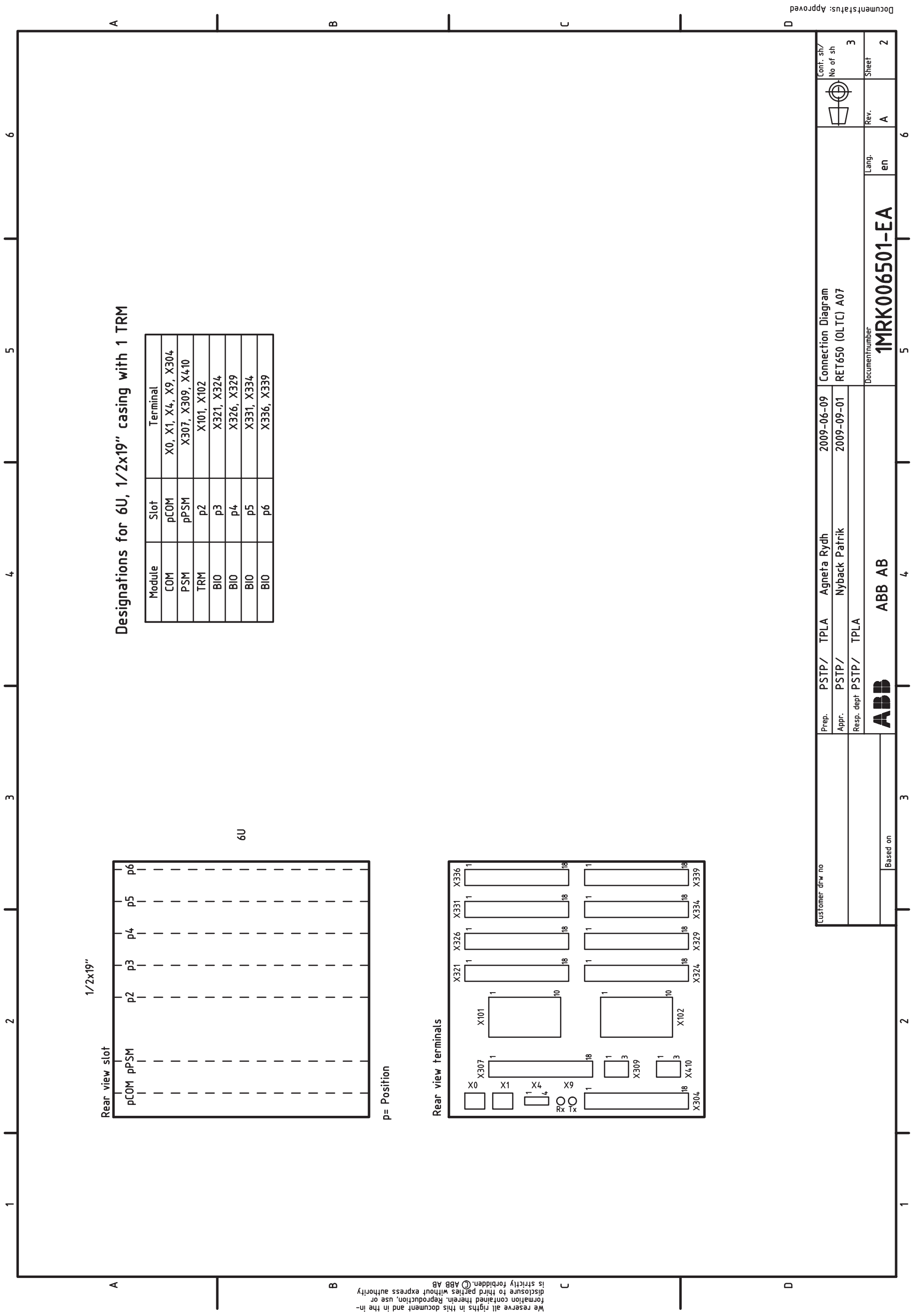
Power supply module 110-125 VDC, 100-240 VAC (PSM)	5
Transformer module (TRM)	6
Binary input/output module (BIO)	7
Binary input/output module (BIO)	8

Customer drw no	Prep. PSTP/ TPLA	Agneta Rydh	2009-06-09	Connection Diagram
	Appr. PSTP/	Nyback Patrik	2009-09-01	RET650 (OLTC) A07
Based on	Resp. dept PSTP/ TPLA			Documentnumber 1MRK006501-EA
	ABB	ABB AB		Lang. en · Rev. A · Sheet 1 · Cont. sh./No of sh 2


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"
pCOM pPSM p2 p3 p4 p5 p6
6U
p= Position
Rear view terminals
X0 X1 X4 X9
Rx Tx
X307 X309 X410 X304
X101 X102
X321 X326 X331 X336
X324 X329 X334 X339
Customer drw no
Based on
Prep. PSTP/ TPLA Agneta Rydh 2009-06-09
Appr. PSTP/ Nyback Patrik 2009-09-01
Resp. dept PSTP/ TPLA
ABB AB
Connection Diagram
RET650 (OLTC) A07
Document number
1MRK006501-EA
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Rev. A
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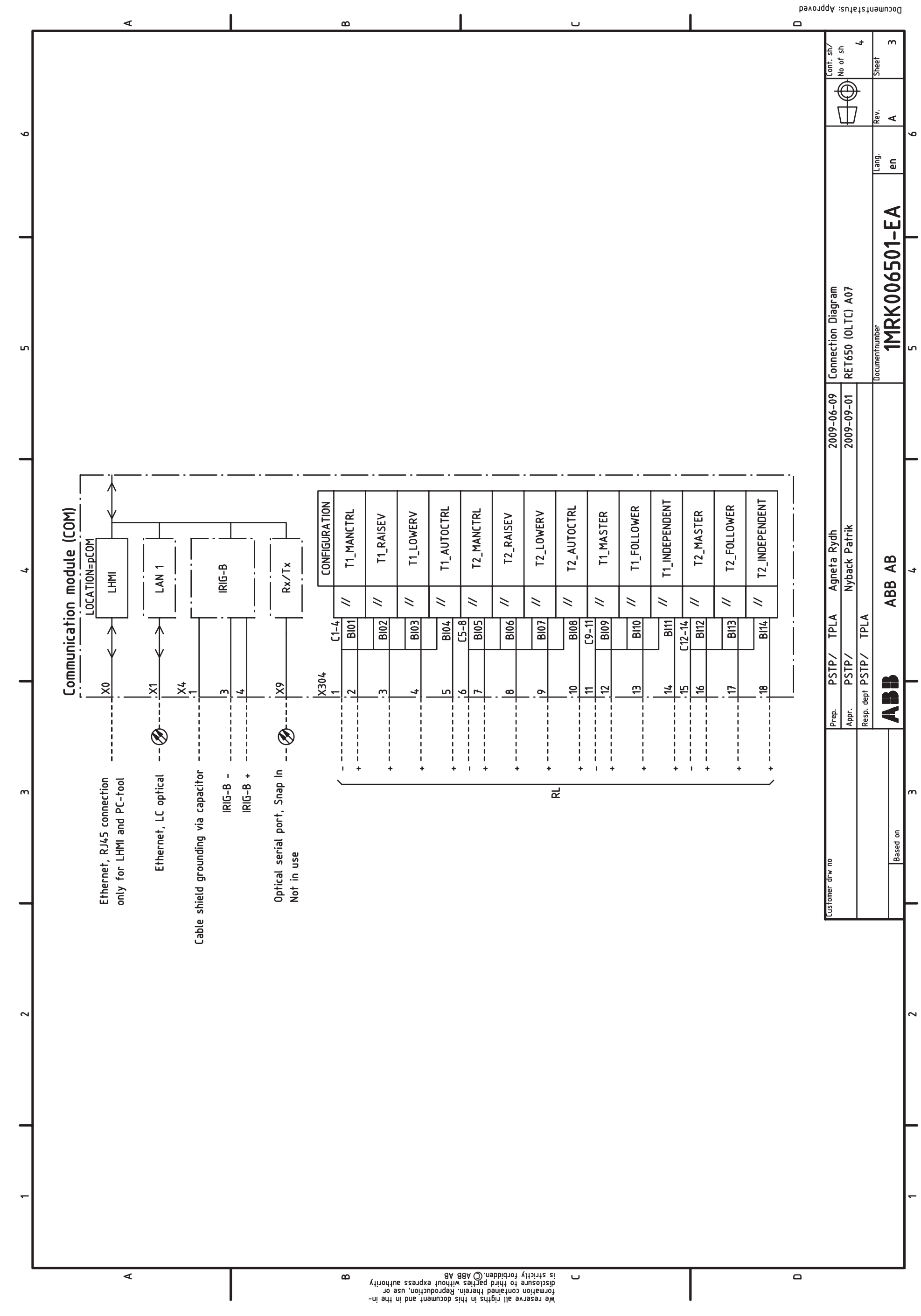
Communication module (COM)
LOCATION=pCOM
LHMI
LAN 1
IRIG-B
Rx/Tx
X0
X1
X4
X9
X304
Ethernet, RJ45 connection only for LHMI and PC-tool
Ethernet, LC optical
Cable shield grounding via capacitor
IRIG-B -
IRIG-B +
Optical serial port, Snap In Not in use
CONFIGURATION
T1_MANCTRL
T1_RAISEV
T1_LOWERV
T1_AUTOCTRL
T2_MANCTRL
T2_RAISEV
T2_LOWERV
T2_AUTOCTRL
T1_MASTER
T1_FOLLOWER
T1_INDEPENDENT
T2_MASTER
T2_FOLLOWER
T2_INDEPENDENT
C1-4
C5-8
C9-11
C12-14
BI01
BI02
BI03
BI04
BI05
BI06
BI07
BI08
BI09
BI10
BI11
BI12
BI13
BI14
RL
Prep. PSTP/ TPLA Agneta Rydh 2009-06-09
Appr. PSTP/ Nyback Patrik 2009-09-01
Resp. dept PSTP/ TPLA
Connection Diagram
RET650 (OLTC) A07
ABB AB
Documentnumber
1MRK006501-EA
Lang. en
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Customer drw no
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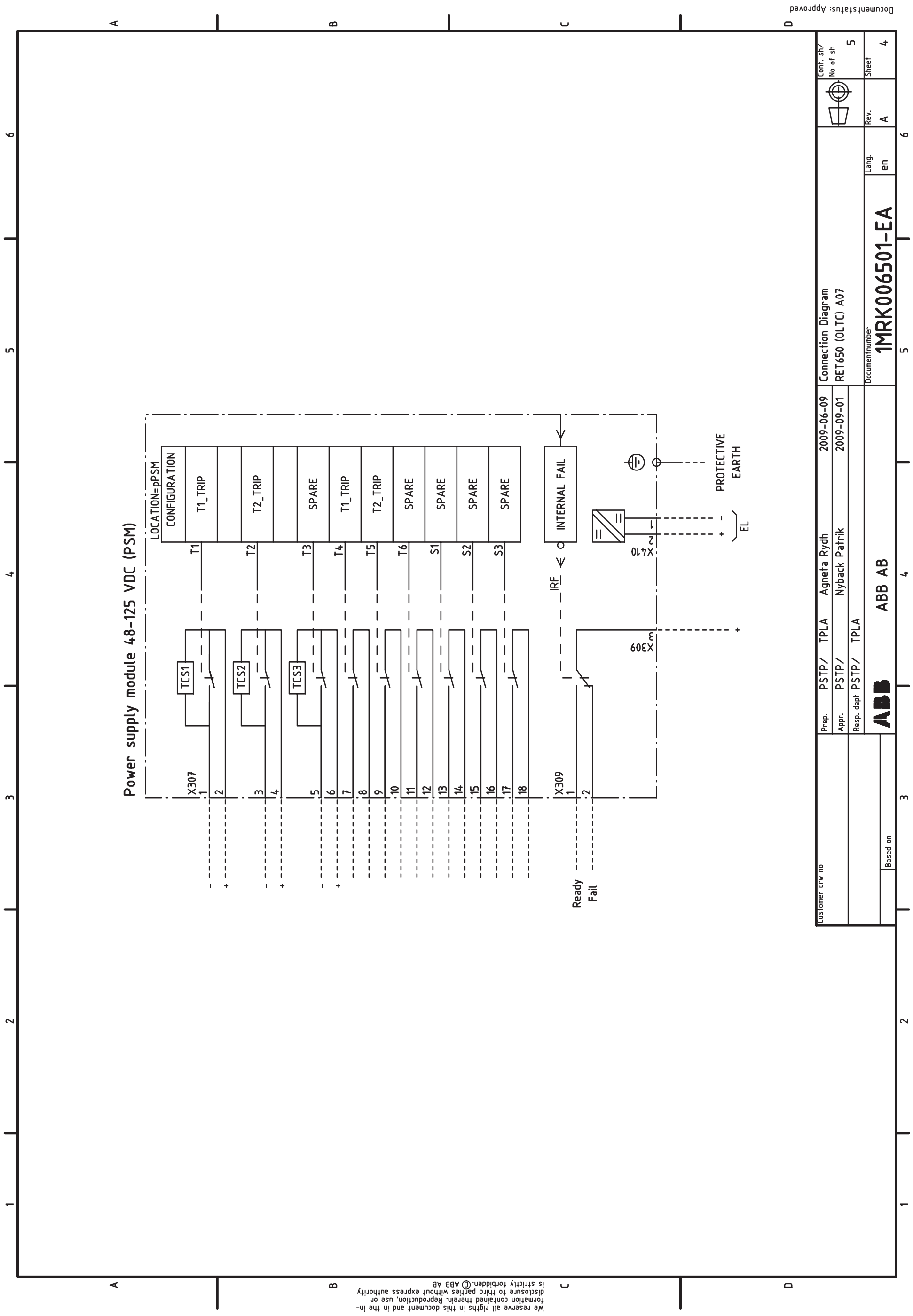
DocumentStatus: Approved
Power supply module 48-125 VDC (PSM)
LOCATION=pPSM
CONFIGURATION
T1_TRIP
T2_TRIP
SPARE
T1_TRIP
T2_TRIP
SPARE
SPARE
SPARE
SPARE
INTERNAL FAIL
IRF
PROTECTIVE EARTH
EL
X307
X309
X410
TCS1
TCS2
TCS3
Ready
Fail
Prep. PSTP/ TPLA Agneta Rydh 2009-06-09
Appr. PSTP/ Nyback Patrik 2009-09-01
Resp. dept PSTP/ TPLA
Connection Diagram
RET650 (OLTC) A07
ABB AB
Documentnumber
1MRK006501-EA
Lang. en
Rev. A
Sheet 4
Conf. sh/ No of sh 5
Customer drw no
Based on
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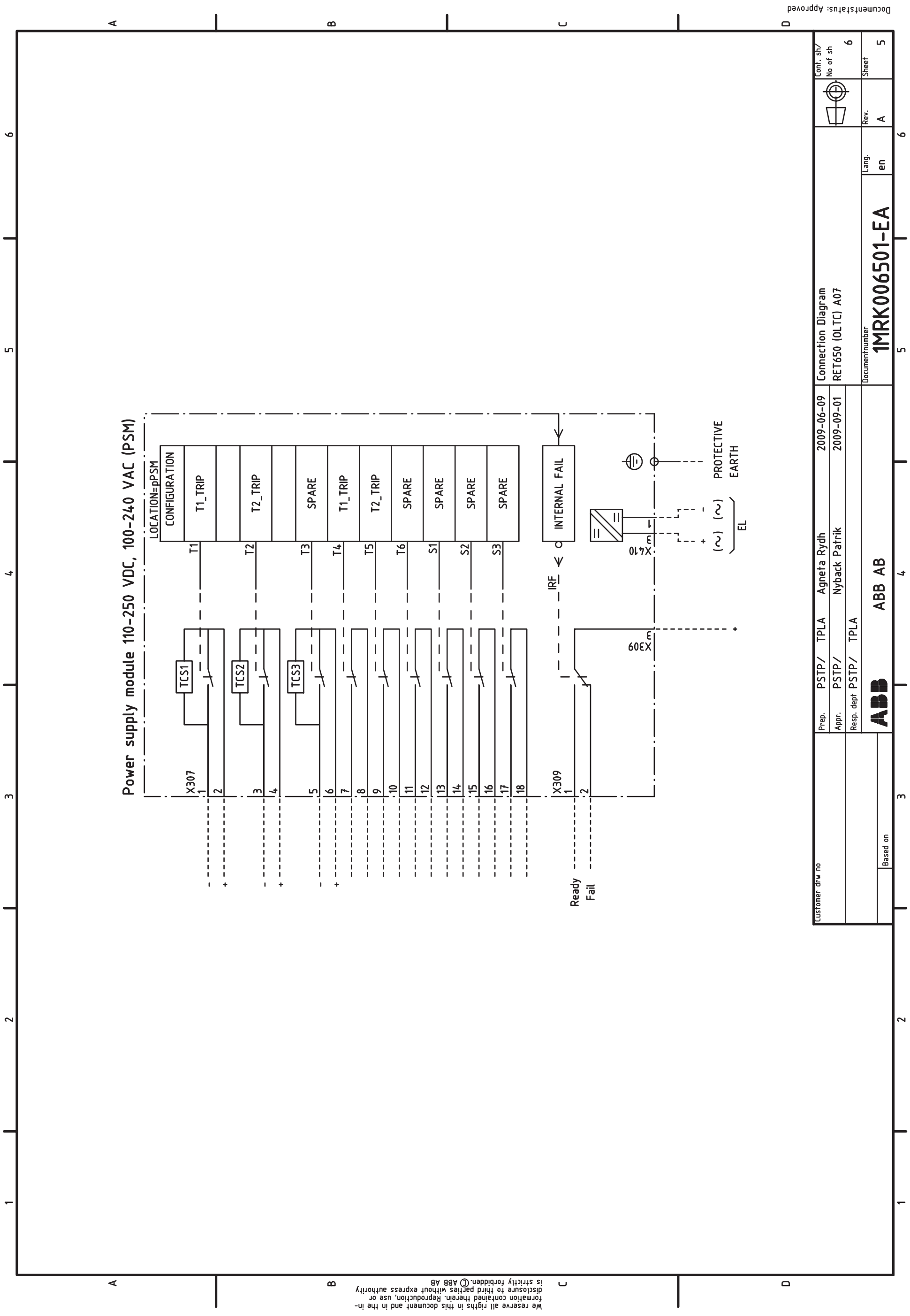
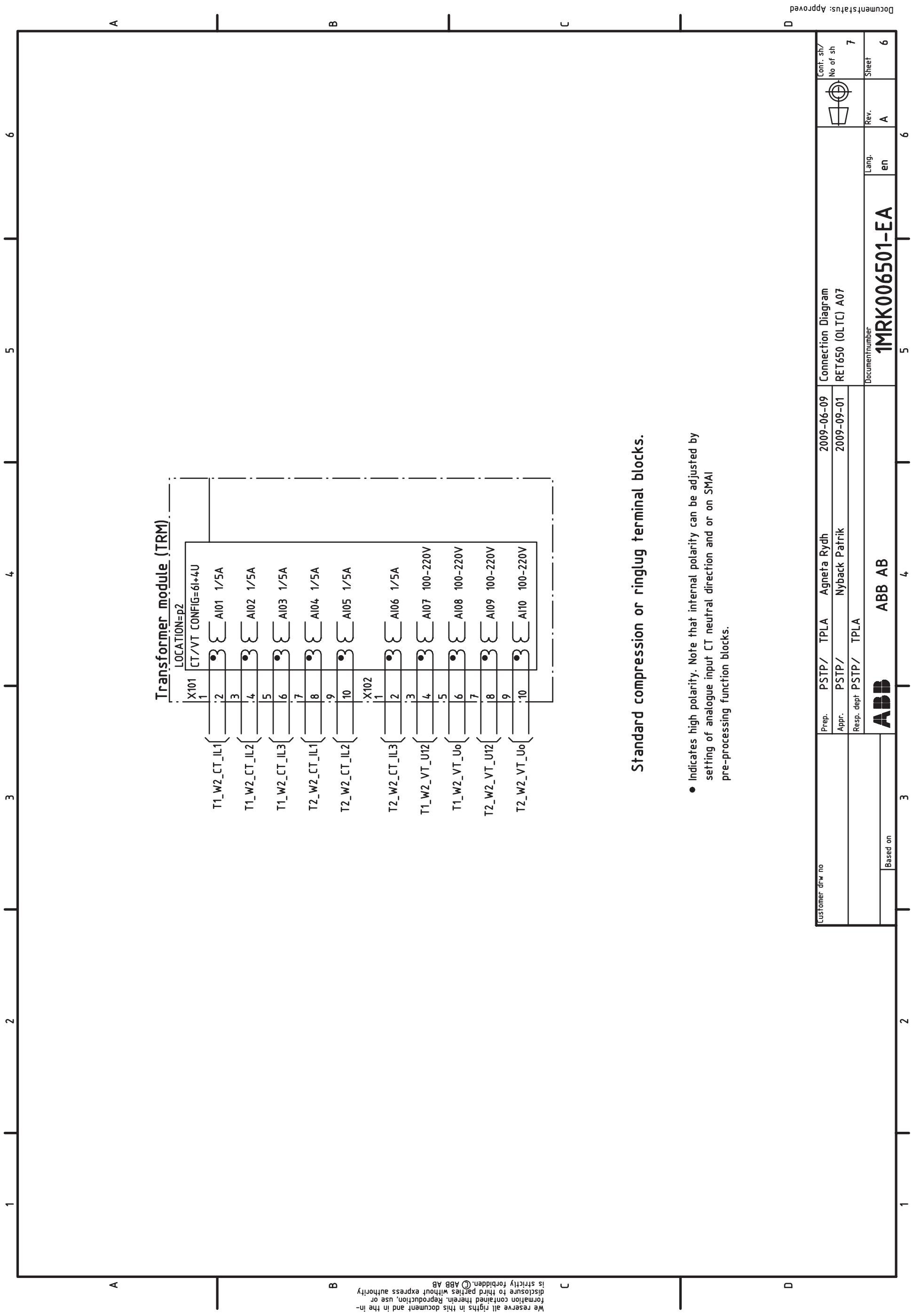

Power supply module 110-250 VDC, 100-240 VAC (PSM)
LOCATION=pPSM
CONFIGURATION
T1_TRIP
T2_TRIP
SPARE
INTERNAL FAIL
PROTECTIVE EARTH
EL
IRF
TCS1
TCS2
TCS3
X307
X309
X410
Ready
Fail
Connection Diagram
RET650 (OLTC) A07
1MRK006501-EA
ABB AB
Agneta Rydh
Nyback Patrik
2009-06-09
2009-09-01
DocumentStatus: Approved


DocumentStatus: Approved
Transformer module (TRM)
LOCATION=p2
CT/VT CONFIG=6I+4U
X101
AI01 1/5A
AI02 1/5A
AI03 1/5A
AI04 1/5A
AI05 1/5A
X102
AI06 1/5A
AI07 100-220V
AI08 100-220V
AI09 100-220V
AI10 100-220V
T1_W2_CT_IL1
T1_W2_CT_IL2
T1_W2_CT_IL3
T2_W2_CT_IL1
T2_W2_CT_IL2
T2_W2_CT_IL3
T1_W2_VT_U12
T1_W2_VT_Uo
T2_W2_VT_U12
T2_W2_VT_Uo
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 drw no
Prep. PSTP/ TPLA Agneta Rydh 2009-06-09
Appr. PSTP/ Nyback Patrik 2009-09-01
Resp. dept PSTP/ TPLA
ABB AB
Based on
Connection Diagram
RET650 (OLTC) A07
Document number
1MRK006501-EA
Lang. en
Rev. A
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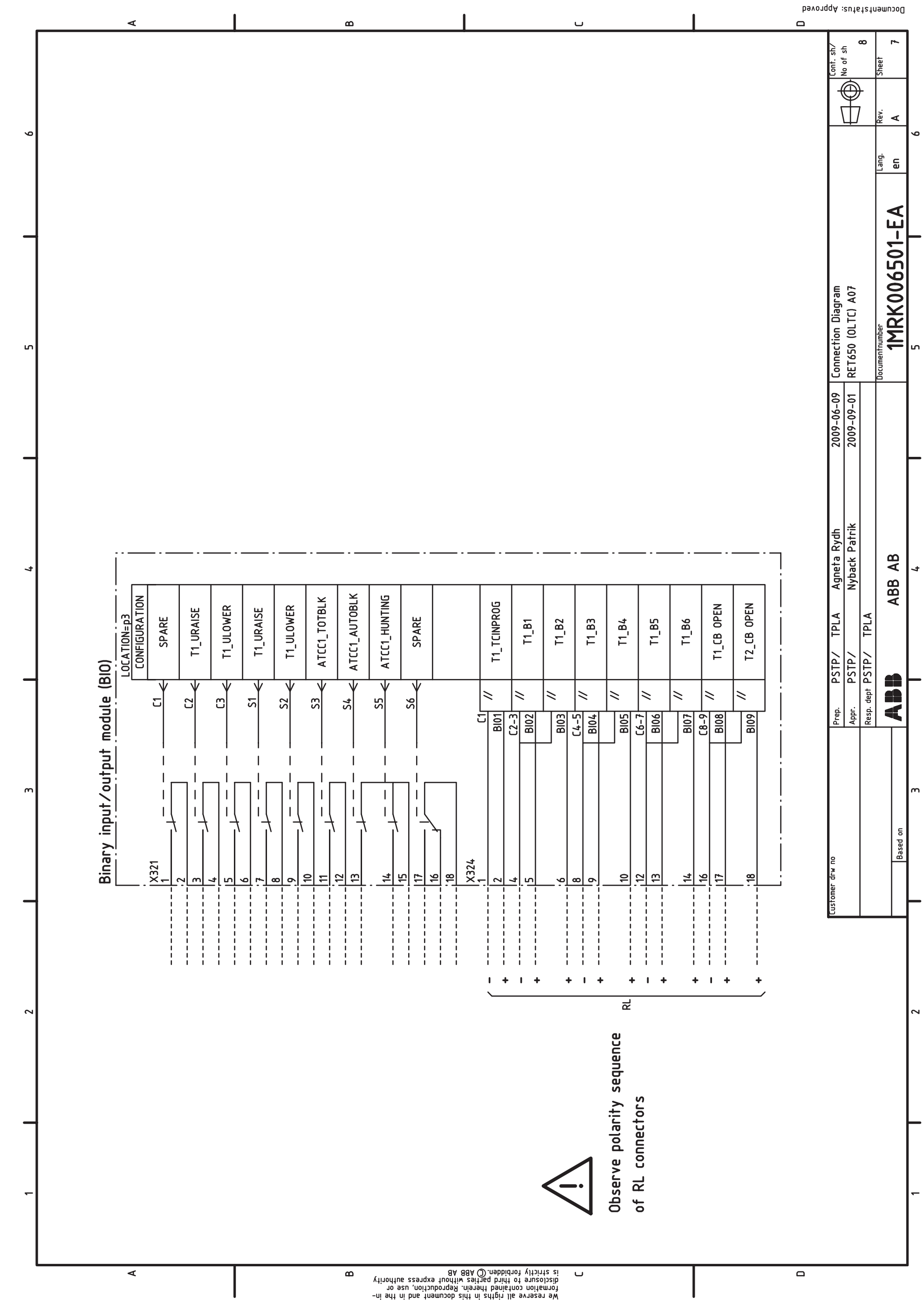
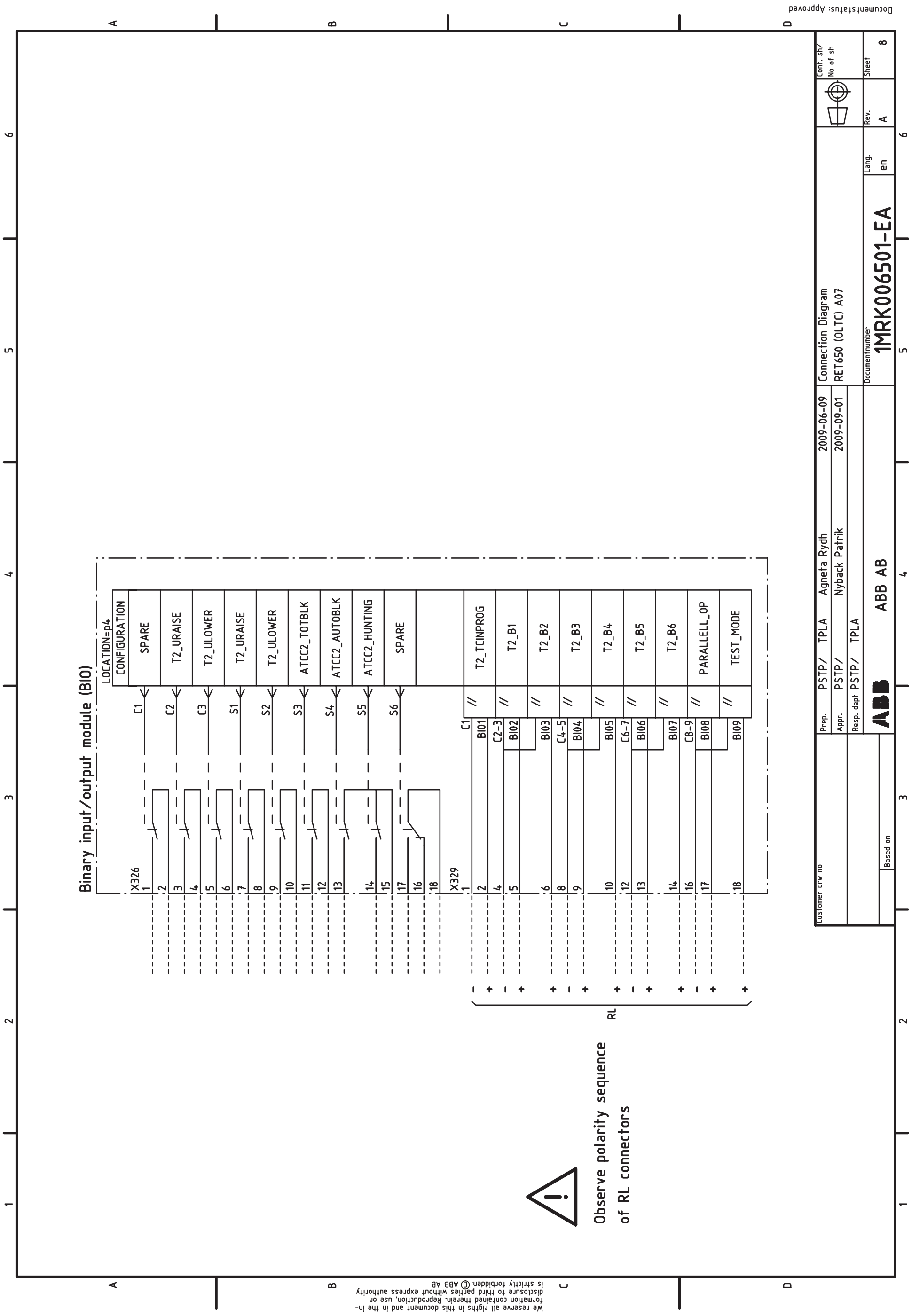

Binary input/output module (BIO)
LOCATION=p3
CONFIGURATION
X321
SPARE
T1_URAISE
T1_ULOWER
T1_URAISE
T1_ULOWER
ATCC1_TOTBLK
ATCC1_AUTOBLK
ATCC1_HUNTING
SPARE
X324
T1_TCINPROG
T1_B1
T1_B2
T1_B3
T1_B4
T1_B5
T1_B6
T1_CB OPEN
T2_CB OPEN
RL
Observe polarity sequence
of RL connectors
Connection Diagram
RET650 (OLTC) A07
1MRK006501-EA
ABB AB
Agneta Rydh
Nyback Patrik
2009-06-09
2009-09-01
DocumentStatus: Approved


Binary input/output module (BIO)
LOCATION=p4
CONFIGURATION
SPARE
T2_URAISE
T2_ULOWER
T2_URAISE
T2_ULOWER
ATCC2_TOTBLK
ATCC2_AUTOBLK
ATCC2_HUNTING
SPARE
T2_TCINPROG
T2_B1
T2_B2
T2_B3
T2_B4
T2_B5
T2_B6
PARALLELL_OP
TEST_MODE
X326
X329
RL
Observe polarity sequence
of RL connectors
Connection Diagram
RET650 (OLTC) A07
1MRK006501-EA
ABB AB

Section 16 Technical data

16.1 Dimensions

Table 396: 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)

16.2 Power supply

Table 397: Power supply

<table>
<tr><th>Description</th><th>Type 1</th><th>Type 2</th></tr>
<tr><td rowspan="2">U_{aux}nominal</td><td>100, 110, 120, 220, 240 V AC, 50 and 60 Hz</td><td rowspan="2">48, 60, 110, 125 V DC</td></tr>
<tr><td>110, 125, 220, 250 V DC</td></tr>
<tr><td rowspan="2">U_{aux}variation</td><td>85...110% of U_n (85...264 V AC)</td><td rowspan="2">80...120% of U_n (38.4...150 V DC)</td></tr>
<tr><td>80...120% of U_n (88...300 V DC)</td></tr>
<tr><td>Maximum load of auxiliary voltage supply</td><td colspan="2">35 W</td></tr>
<tr><td>Ripple in the DC auxiliary voltage</td><td colspan="2">Max 15% of the DC value (at frequency of 100 Hz)</td></tr>
<tr><td>Maximum interruption time in the auxiliary DC voltage without resetting the IED</td><td colspan="2">50 ms at U_{aux}</td></tr>
</table>

16.3 Energizing inputs

Table 398: 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 • For 1 s • For 10 s	 4 A 100 A 25 A	 20 A 500 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 • For 10 s	 2 x U_n (240 V) 3 x U_n (360 V)	
	Burden at rated voltage	<0.05 VA	

1) Residual current
2) Phase currents or residual current

16.4 Binary inputs

Table 399: 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)

16.5 Signal outputs

Table 400: 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

16.6 Power outputs

Table 401: 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 402: 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

16.7 Data communication interfaces

Table 403: 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 404: 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 405: 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 406: Serial rear interface

Type	Counter connector
Serial port (X9)	Optical serial port, snap-in (not in use)

16.8 Enclosure class

Table 407: Degree of protection of flush-mounted IED

Description	Value
Front side	IP 40
Rear side, connection terminals	IP 20

Table 408: Degree of protection of the LHMI

Description	Value
Front and side	IP 42

16.9 Environmental conditions and tests

Table 409: 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 410: 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 17 IED and functionality tests

17.1 Electromagnetic compatibility tests

Table 411: 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

17.2 Insulation tests

Table 412: 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

17.3 Mechanical tests

Table 413: 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

17.4 Product safety

Table 414: Product safety

Description	Reference
LV directive	2006/95/EC
Standard	EN 60255-27 (2005)

17.5 EMC compliance

Table 415: EMC compliance

Description	Reference
EMC directive	2004/108/EC
Standard	EN 50263 (2000) EN 60255-26 (2007)

Section 18 Time inverse characteristics

18.1 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.

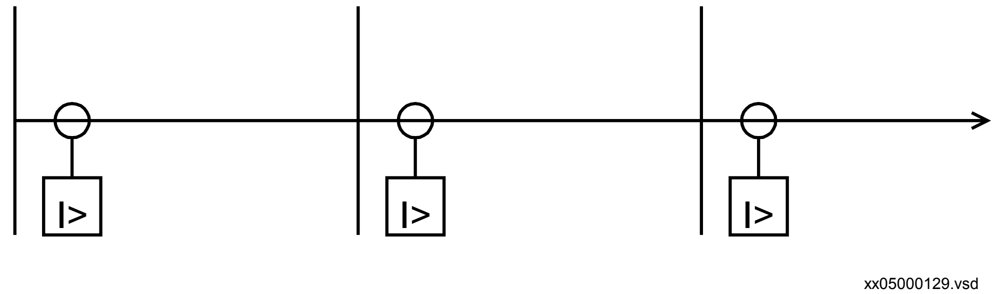


Figure 165: Three overcurrent protections connected in series

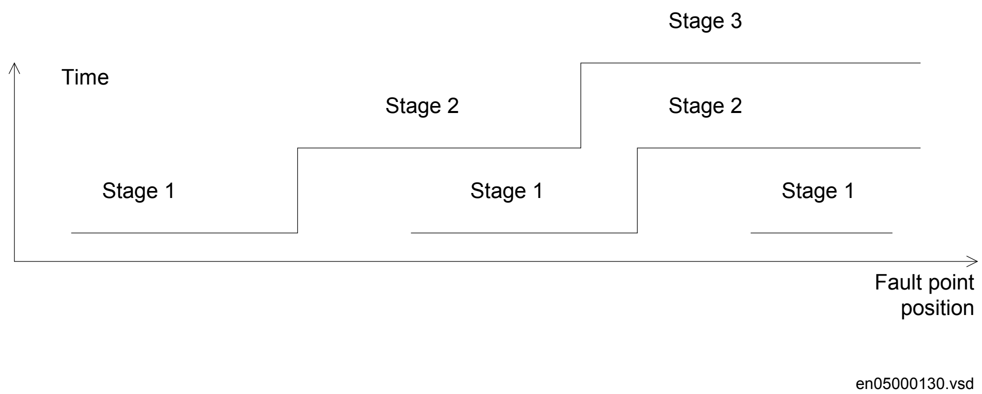


Figure 166: Definite time overcurrent characteristics

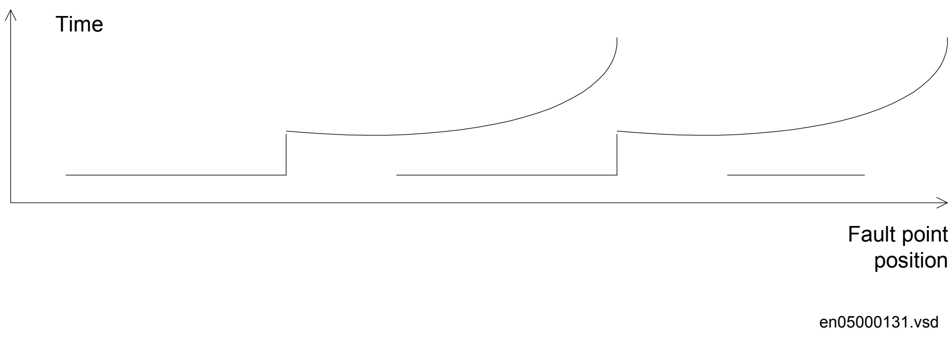


Figure 167: Inverse time overcurrent characteristics with inst. function

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.

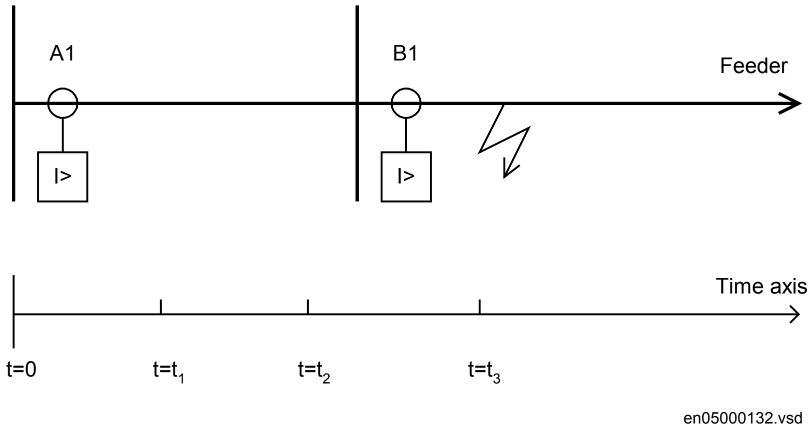


Figure 168: Selectivity steps for a fault on feeder B1

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.

18.2 Operation principle

18.2.1 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 76.

$$t[s] = \left(\frac{A}{\left(\frac{i}{in>}\right)^{p} - C} + B \right) \cdot k$$

(Equation 76)

where:	
p, A, B, C	are constants defined for each curve type,
in>	is the set start current for step n,
k	is set time multiplier for step n and
i	is the measured current.

For inverse time characteristics a time will be initiated when the current reaches the set start level. From the general expression of the characteristic the following can be seen:

$$(t_{op} - B \cdot k) \cdot \left(\left(\frac{i}{in >} \right)^{p} - C \right) = A \cdot k$$

(Equation 77)

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 78, in addition to the constant time delay:

$$\int_{0}^{t} \left(\left(\frac{i}{in >} \right)^{p} - C \right) \cdot dt \geq A \cdot k$$

(Equation 78)

For the numerical protection the sum below must fulfil the equation for trip.

$$\Delta t \cdot \sum_{j=1}^{n} \left(\left(\frac{i(j)}{in >} \right)^{p} - C \right) \geq A \cdot k$$

(Equation 79)

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 169.

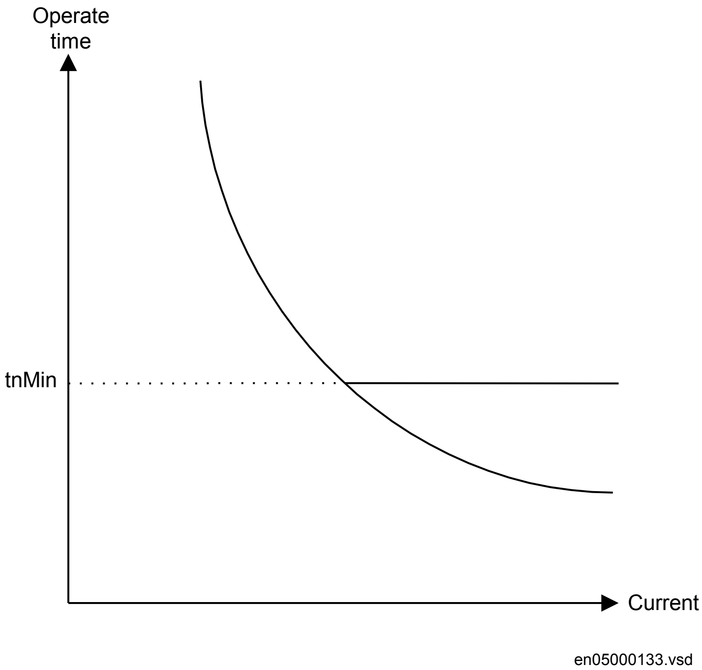


Figure 169: Minimum time-lag operation for the IEC curves

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 81:

$$t[s] = \left(\frac{k}{0.339 - 0.235 \cdot \frac{in>}{i}} \right)$$

(Equation 81)

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 82:

$$t[s] = 5.8 - 1.35 \cdot \ln\left(\frac{i}{k \cdot in >}\right)$$

(Equation 82)

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.

18.3 Inverse time characteristics

Table 416: 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 83) $I = I_{measured}/I_{set}$	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 417: IEC Inverse time characteristics

Function	Range or value	Accuracy
Operating characteristic: $$t = \left(\frac{A}{\left(I^{P} - 1 \right)} \right) \cdot k$$ (Equation 84) $I = I_{measured}/I_{set}$	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 418: RI and RD type inverse time characteristics

Function	Range or value	Accuracy
RI type inverse characteristic $$t = \frac{1}{0.339 - \frac{0.236}{I}} \cdot k$$ (Equation 85) $I = I_{measured}/I_{set}$	k=(0.05-999) in steps of 0.01	IEC 60255-3, class 5 + 40 ms
RD type logarithmic inverse characteristic $$t = 5.8 - \left(1.35 \cdot \ln \frac{I}{k} \right)$$ (Equation 86) $I = I_{measured}/I_{set}$	k=(0.05-1.10) in steps of 0.01	IEC 60255-3, class 5 + 40 ms

Table 419: Inverse time characteristics for Two step undervoltage protection UV2PTUV

Function	Range or value	Accuracy
Type A curve: $$t = \frac{k}{\left(\frac{U< - U}{U<}\right)}$$ (Equation 87) U< = U_{set} U = $UV_{measured}$	k = (0.05-1.10) in steps of 0.01	Class 5 +40 ms
Type B curve: $$t = \frac{k \cdot 480}{\left(32 \cdot \frac{U< - U}{U<} - 0.5\right)^{2.0}} + 0.055$$ (Equation 88) U< = U_{set} U = $U_{measured}$	k = (0.05-1.10) in steps of 0.01	

Table 420: Inverse time characteristics for Two step overvoltage protection OV2PTOV

Function	Range or value	Accuracy
Type A curve: $$t = \frac{k}{\left(\frac{U - U>}{U>}\right)}$$ (Equation 89) U> = U_{set} U = $U_{measured}$	k = (0.05-1.10) in steps of 0.01	Class 5 +40 ms
Type B curve: $$t = \frac{k \cdot 480}{\left(32 \cdot \frac{U - U>}{U>} - 0.5\right)^{2.0} - 0.035}$$ (Equation 90)	k = (0.05-1.10) in steps of 0.01	
Type C curve: $$t = \frac{k \cdot 480}{\left(32 \cdot \frac{U - U>}{U>} - 0.5\right)^{3.0} - 0.035}$$ (Equation 91)	k = (0.05-1.10) in steps of 0.01	

Table 421: Inverse time characteristics for Two step residual overvoltage protection ROV2PTOV

Function	Range or value	Accuracy
Type A curve: $$t = \frac{k}{\left(\frac{U - U>}{U>}\right)}$$ (Equation 92) U> = U_{set} U = $U_{measured}$	k = (0.05-1.10) in steps of 0.01	Class 5 +40 ms
Type B curve: $$t = \frac{k \cdot 480}{\left(32 \cdot \frac{U - U>}{U>} - 0.5\right)^{2.0} - 0.035}$$ (Equation 93)	k = (0.05-1.10) in steps of 0.01	
Type C curve: $$t = \frac{k \cdot 480}{\left(32 \cdot \frac{U - U>}{U>} - 0.5\right)^{3.0} - 0.035}$$ (Equation 94)	k = (0.05-1.10) in steps of 0.01	

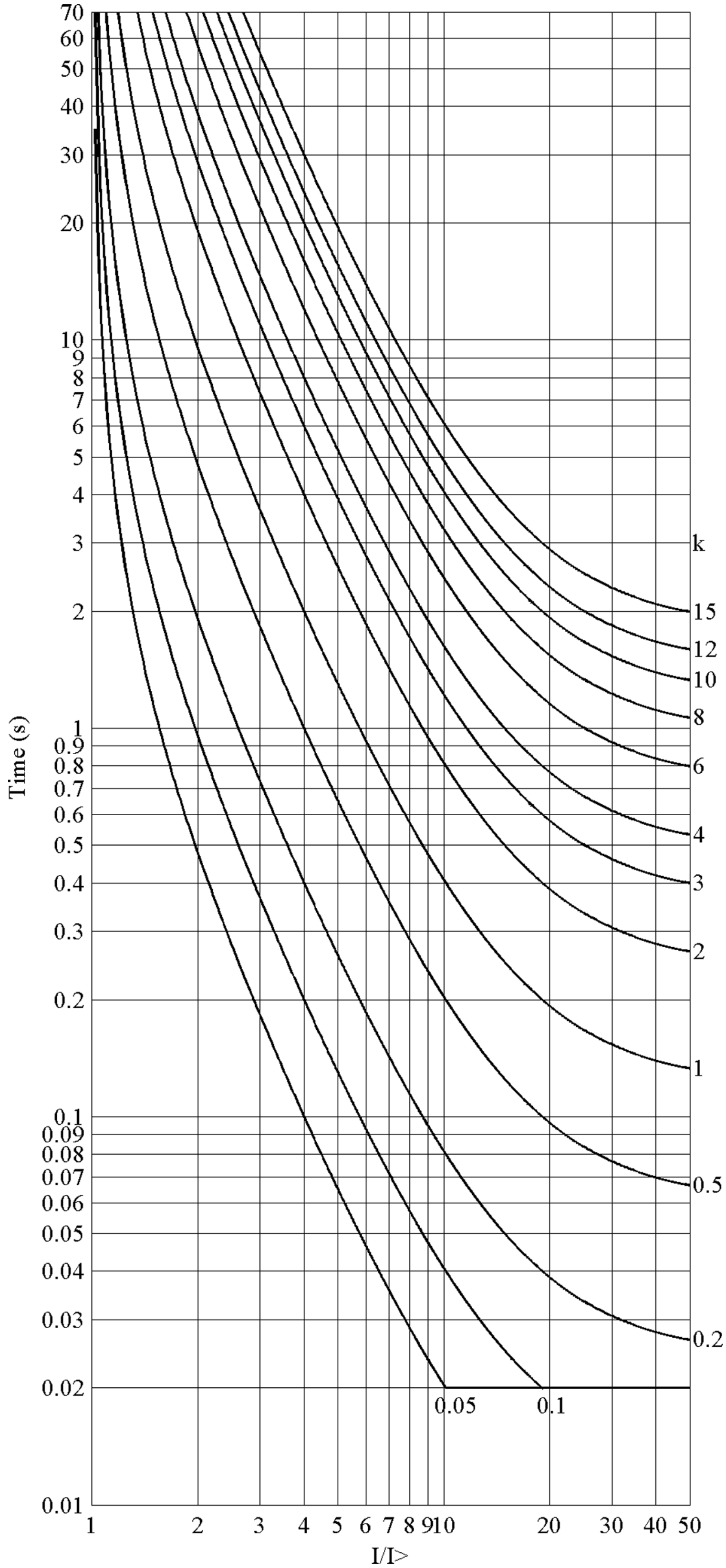


Figure 170: ANSI Extremely inverse time characteristics

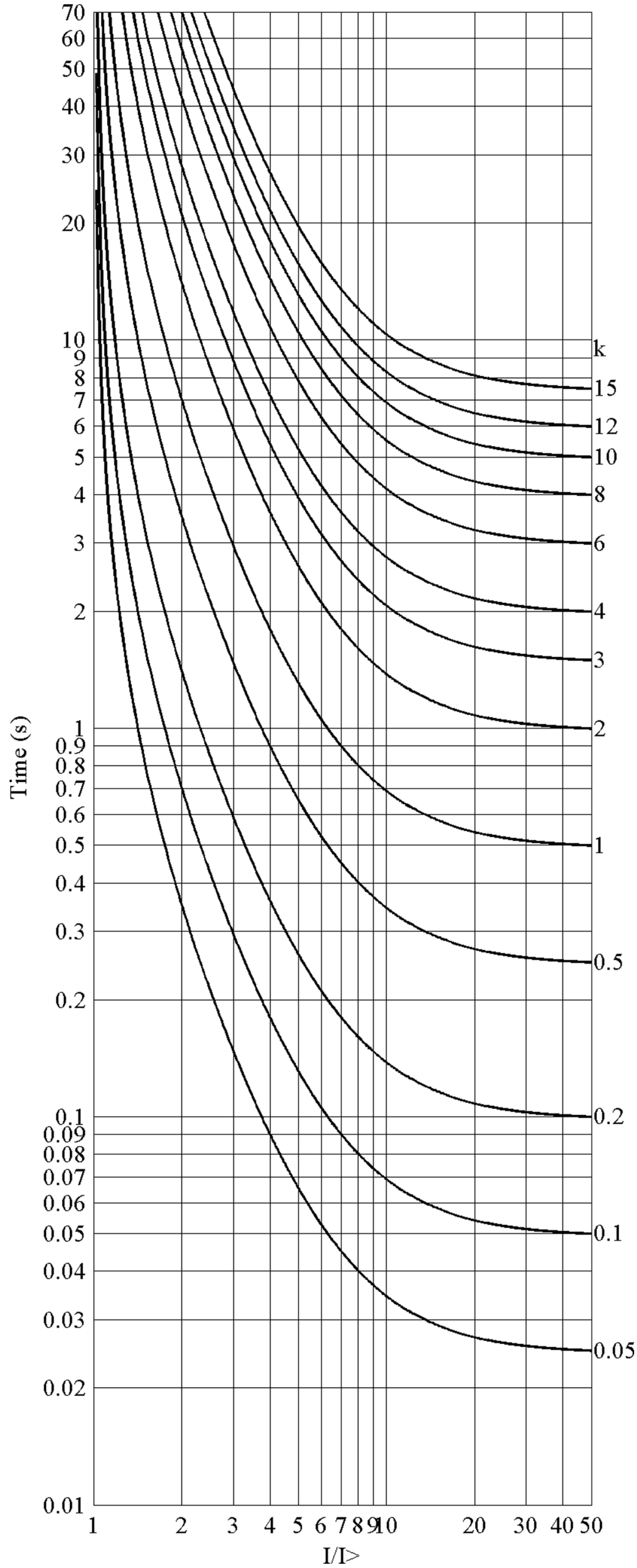


Figure 171: ANSI Very inverse time characteristics

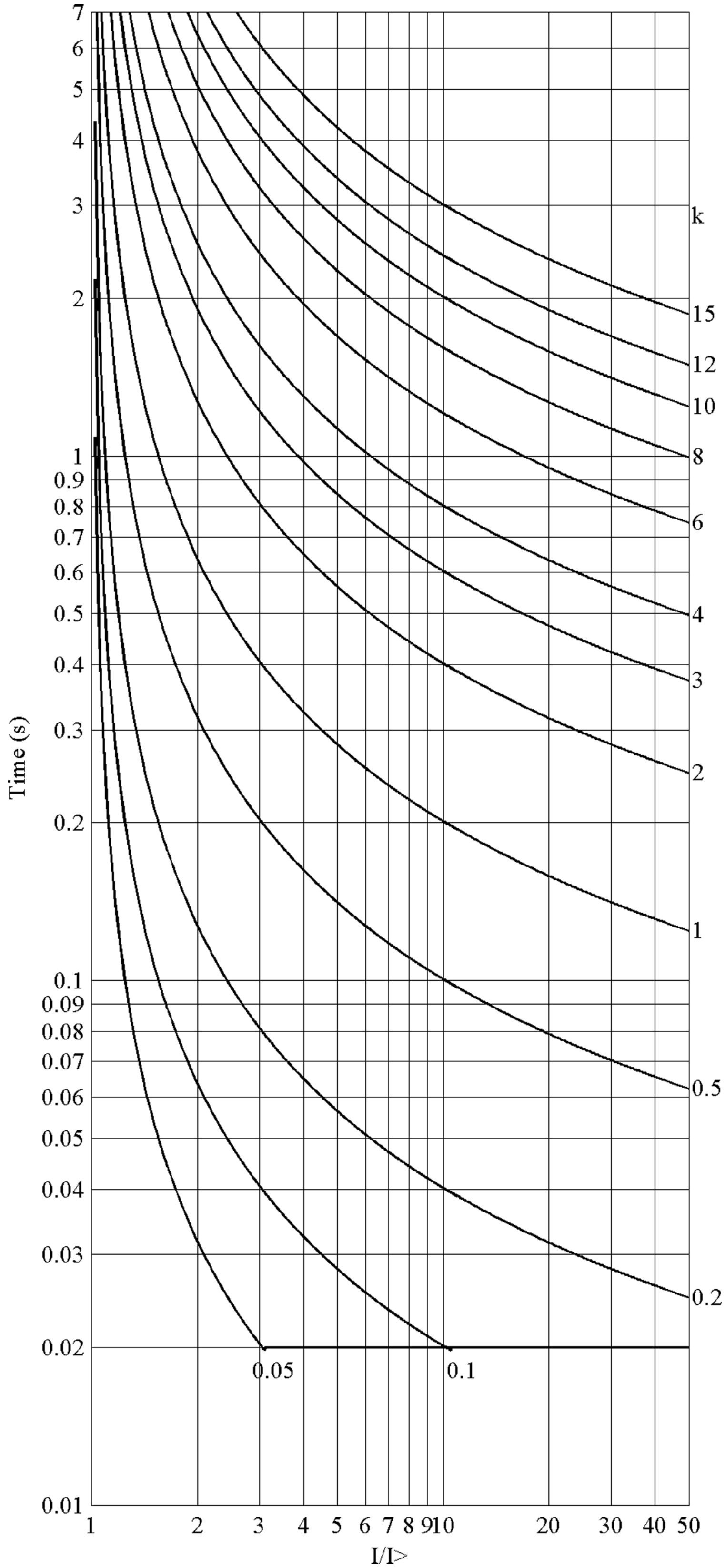


Figure 172: ANSI Normal inverse time characteristics

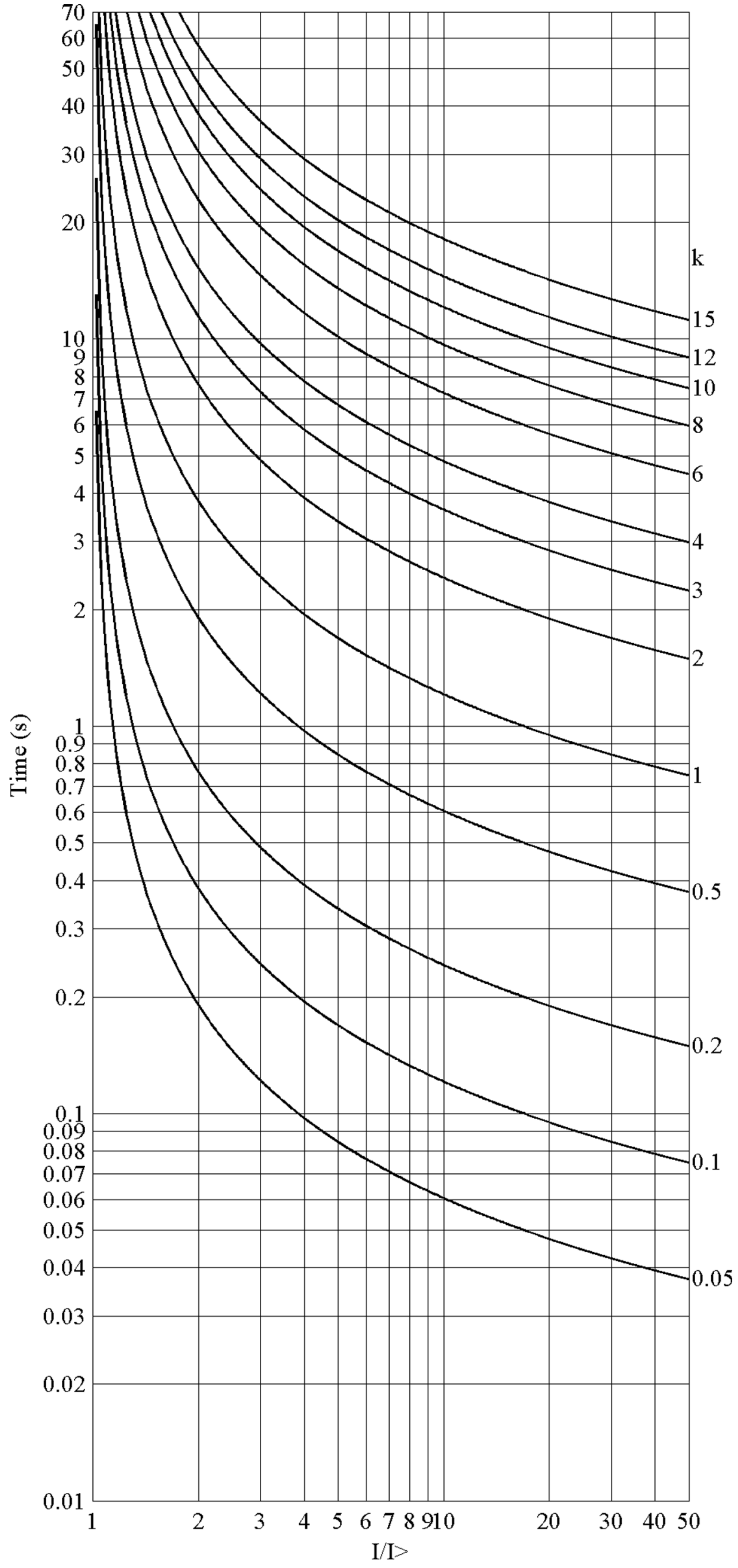


Figure 173: ANSI Moderately inverse time characteristics

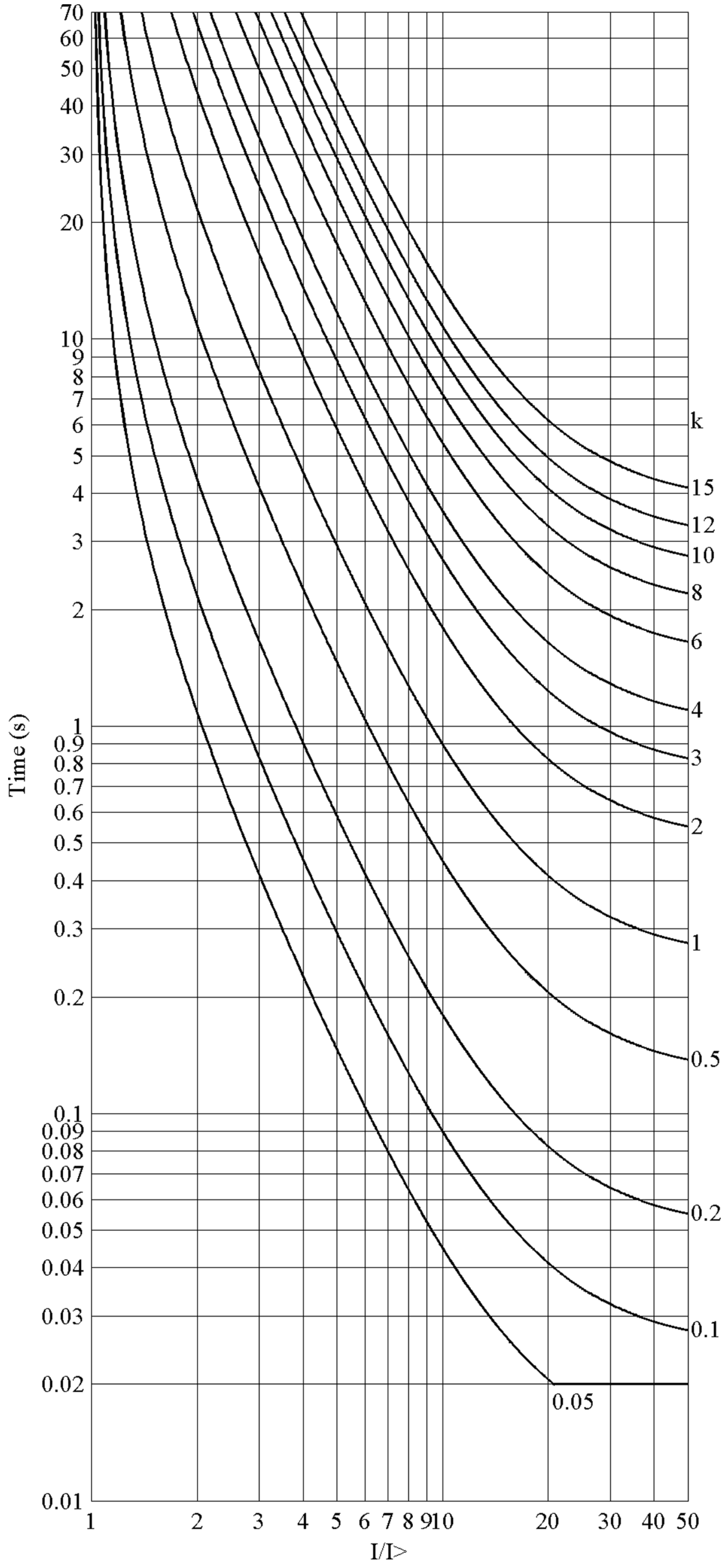


Figure 174: ANSI Long time extremely inverse time characteristics

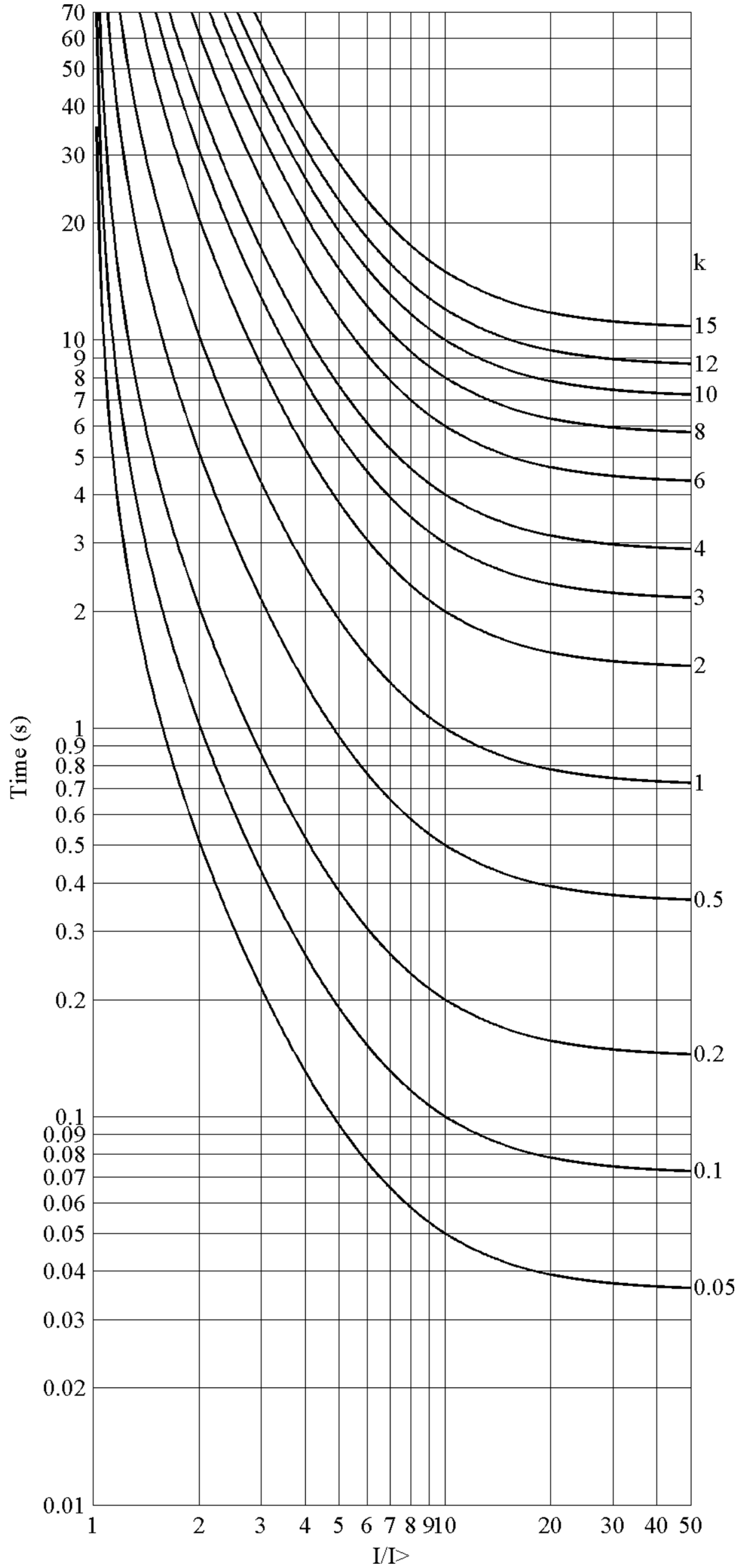


Figure 175: ANSI Long time very inverse time characteristics

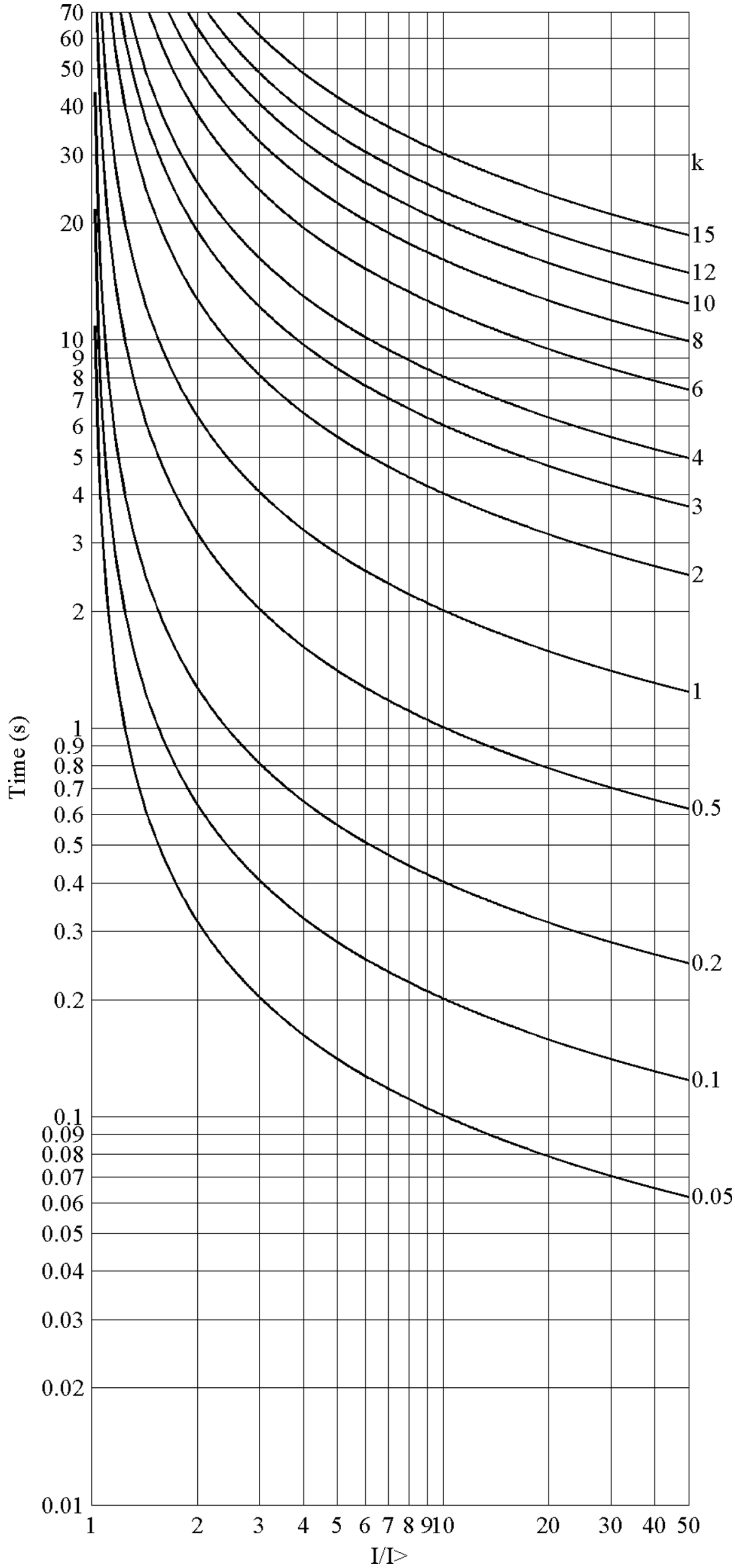


Figure 176: ANSI Long time inverse time characteristics

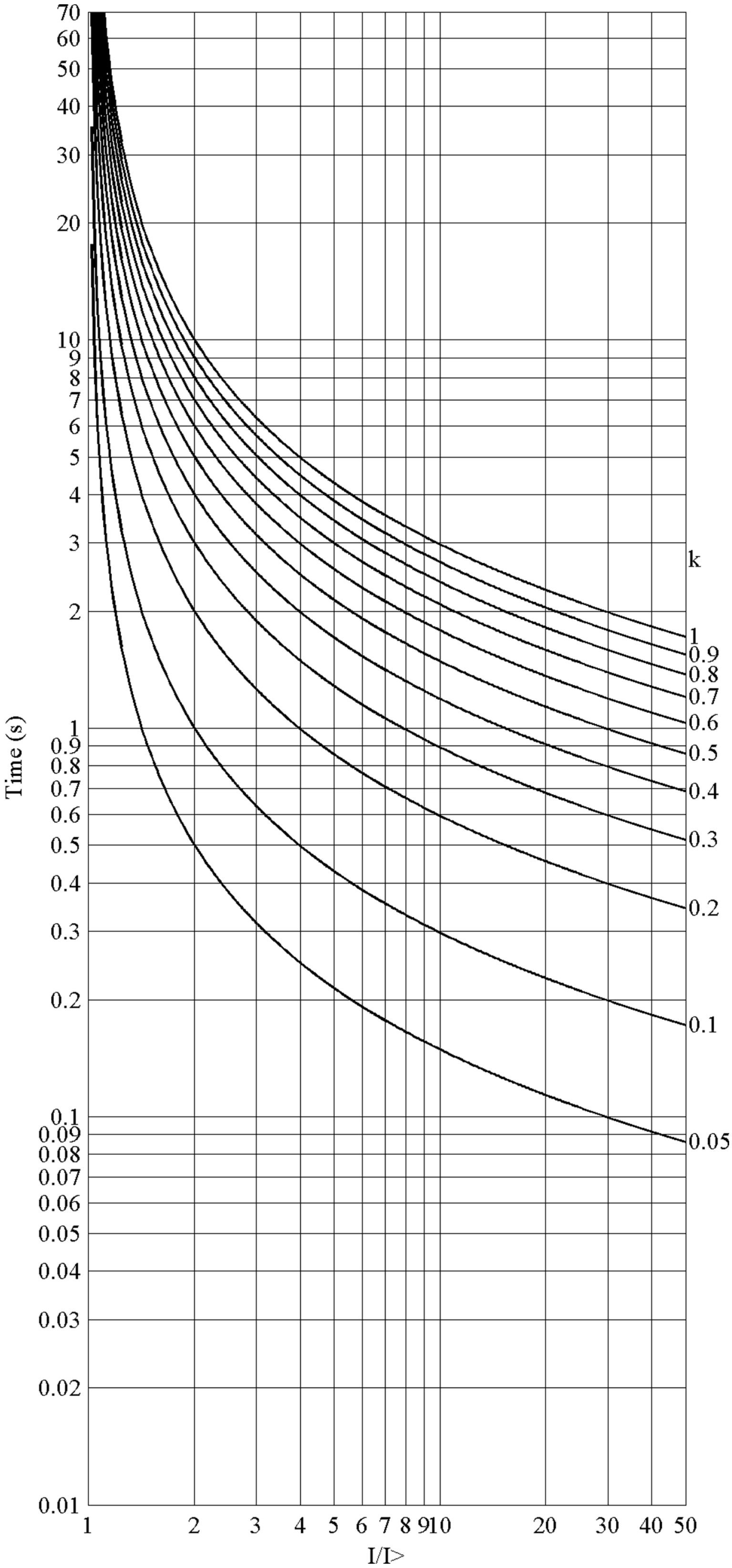


Figure 177: IEC Normal inverse time characteristics

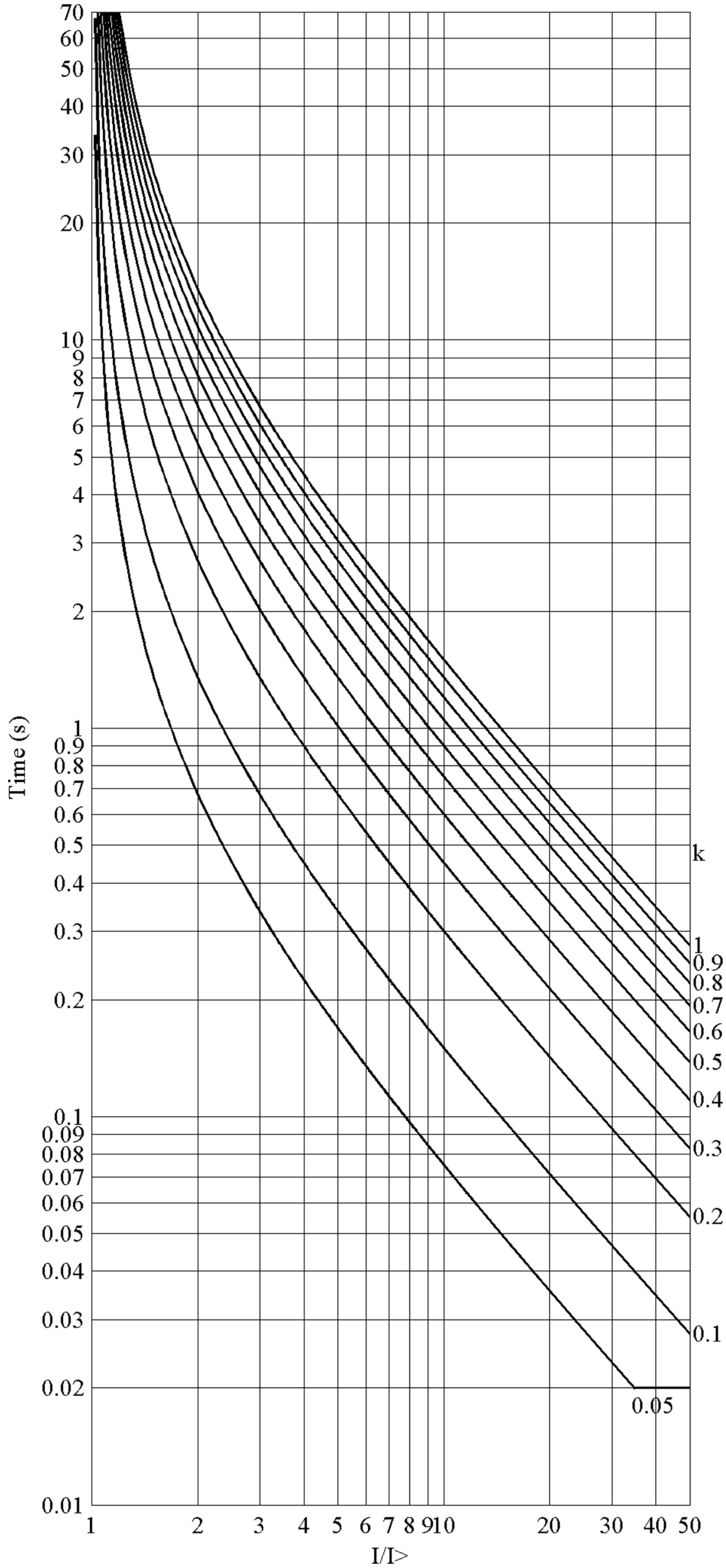


Figure 178: IEC Very inverse time characteristics

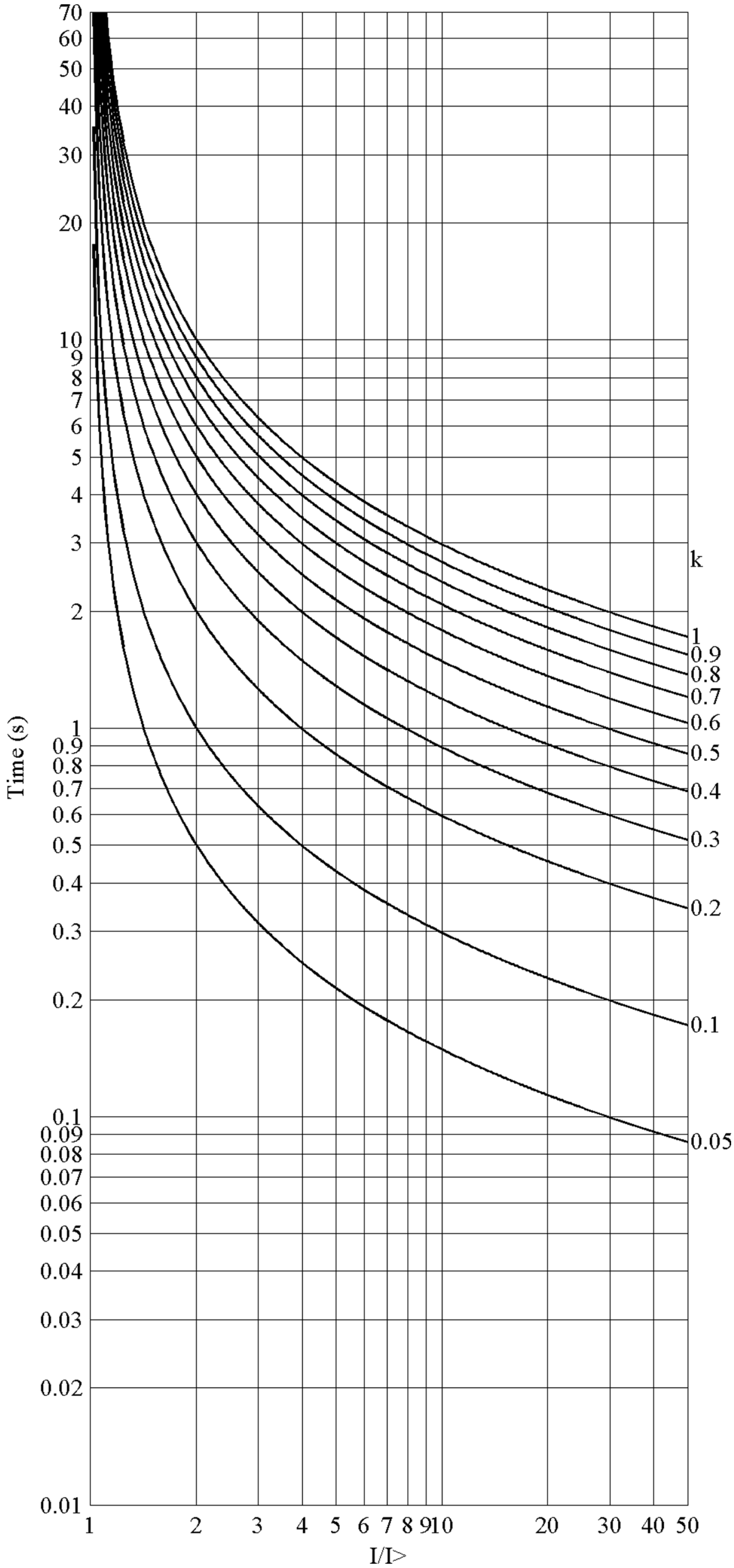


Figure 179: IEC Inverse time characteristics

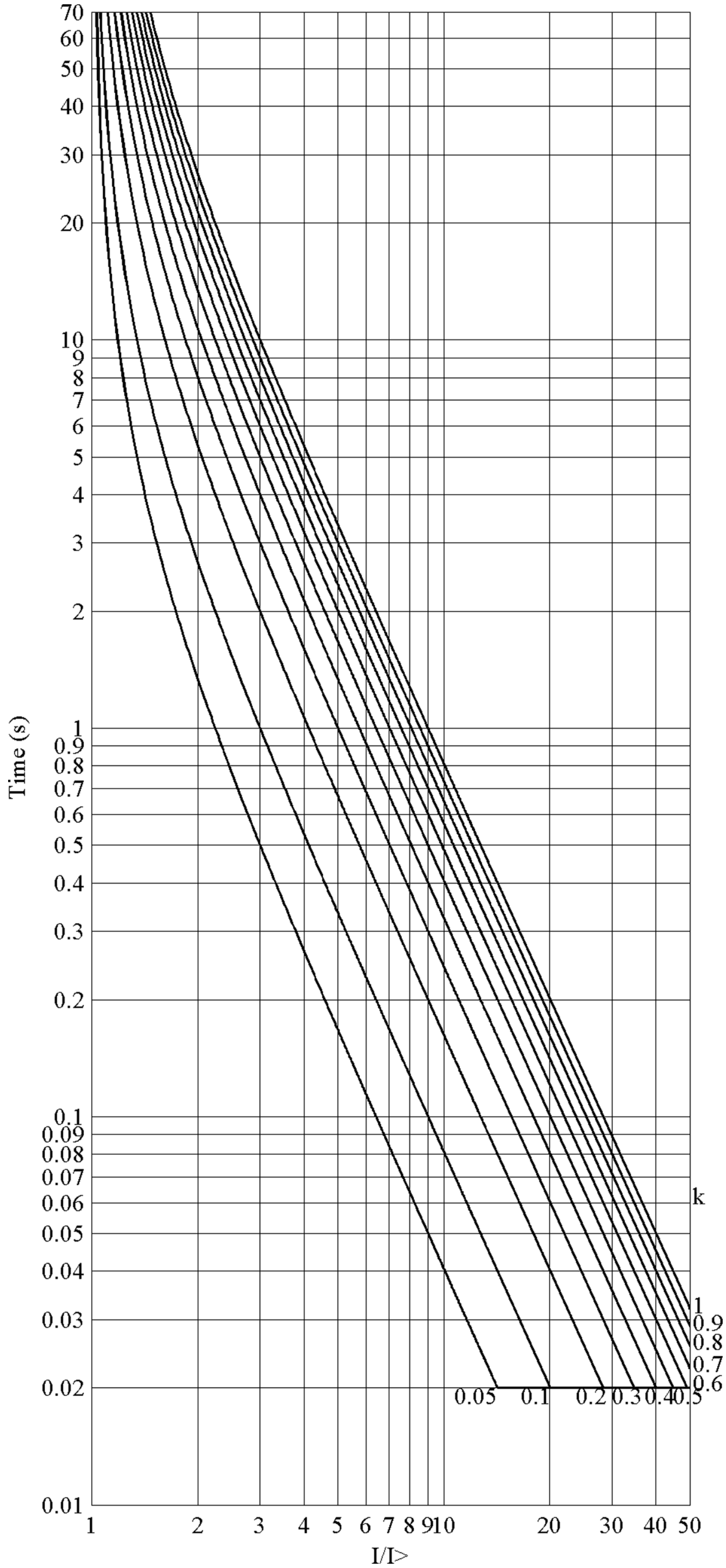


Figure 180: IEC Extremely inverse time characteristics

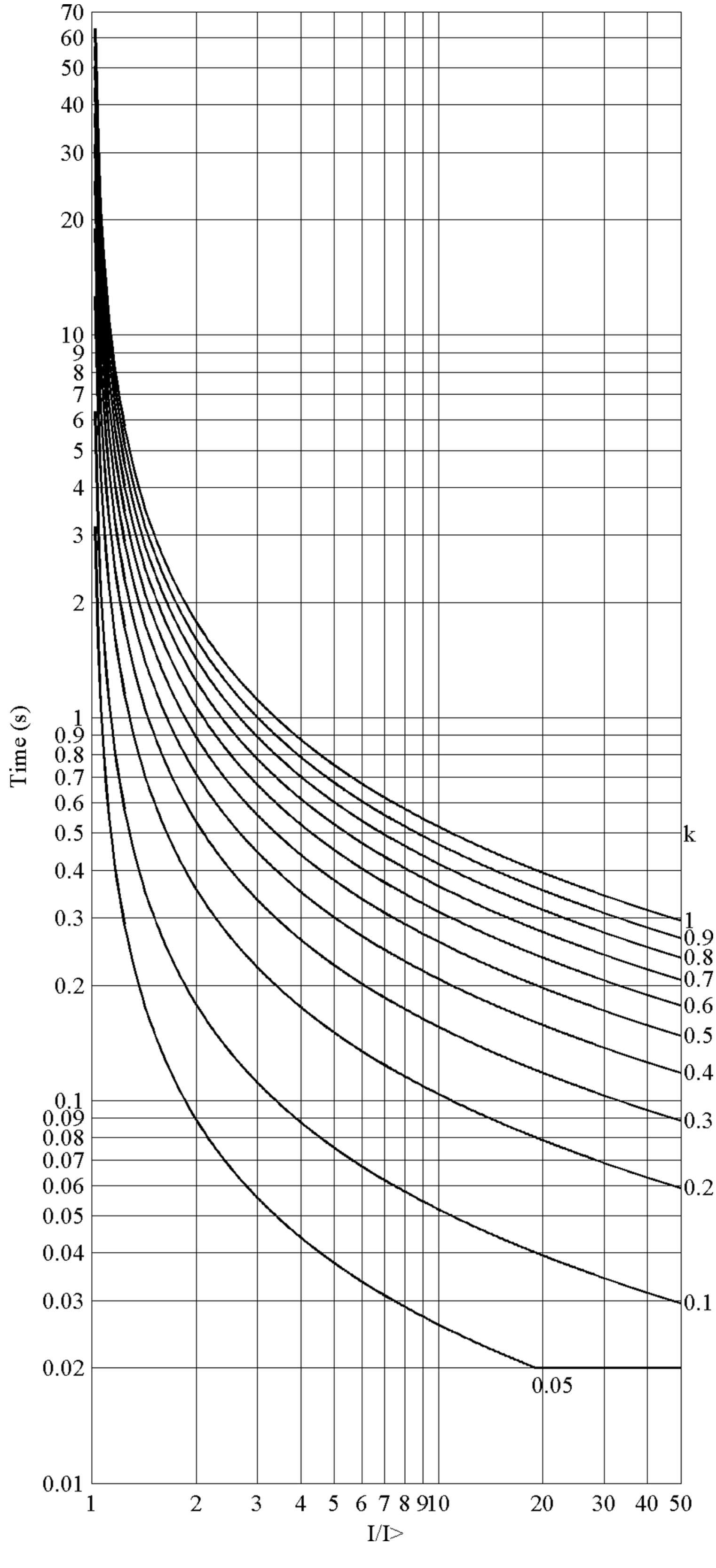


Figure 181: IEC Short time inverse time characteristics

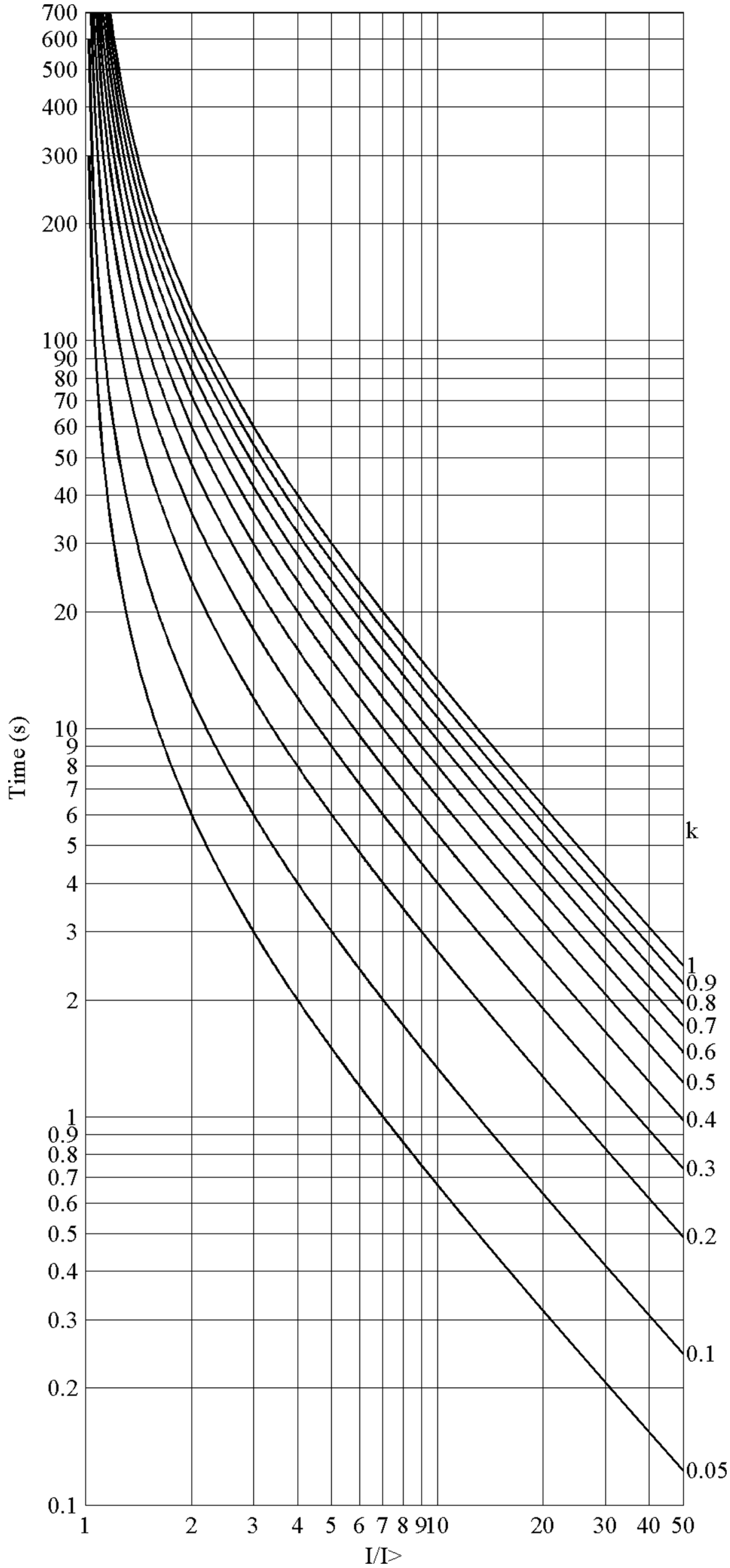


Figure 182: IEC Long time inverse time characteristics

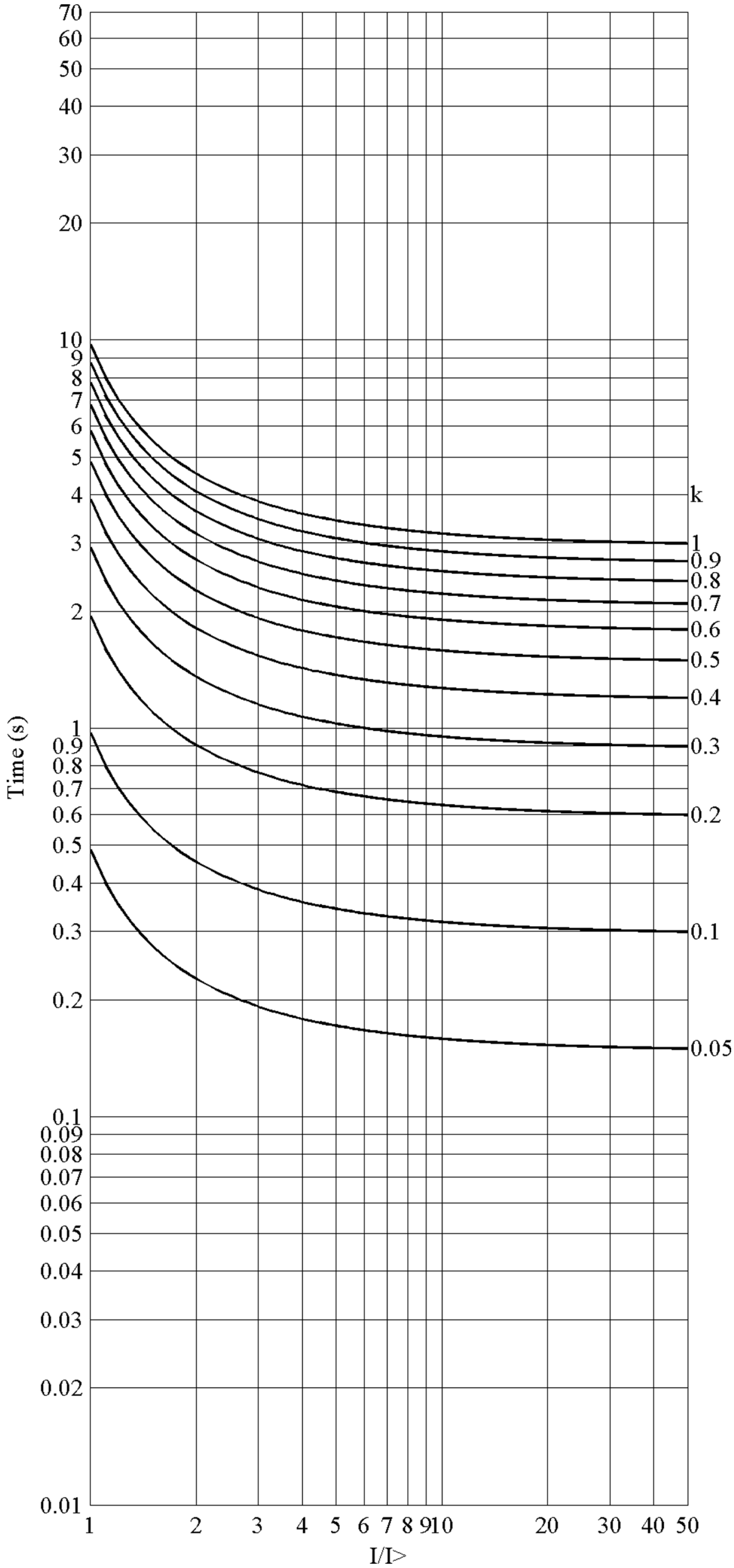


Figure 183: RI-type inverse time characteristics

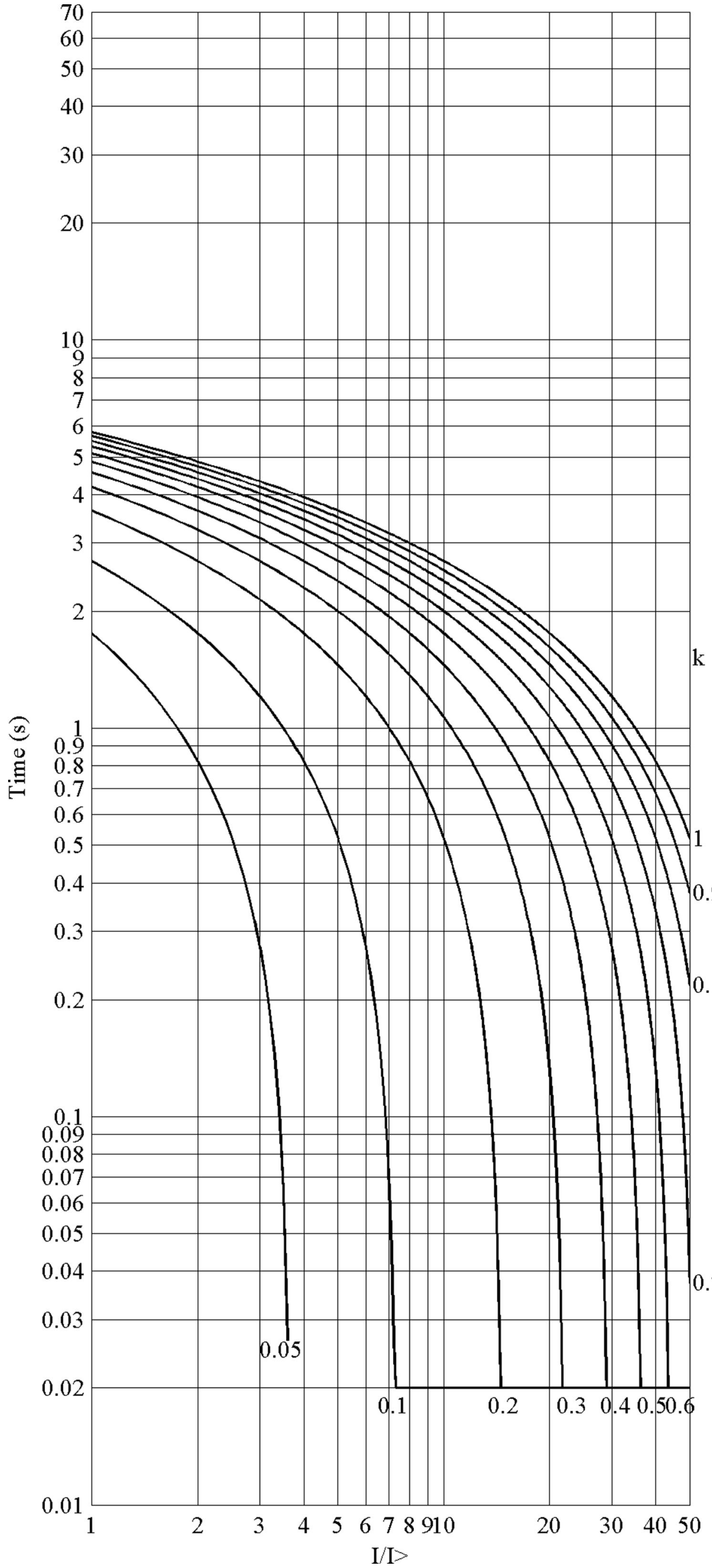


Figure 184: RD-type inverse time characteristics

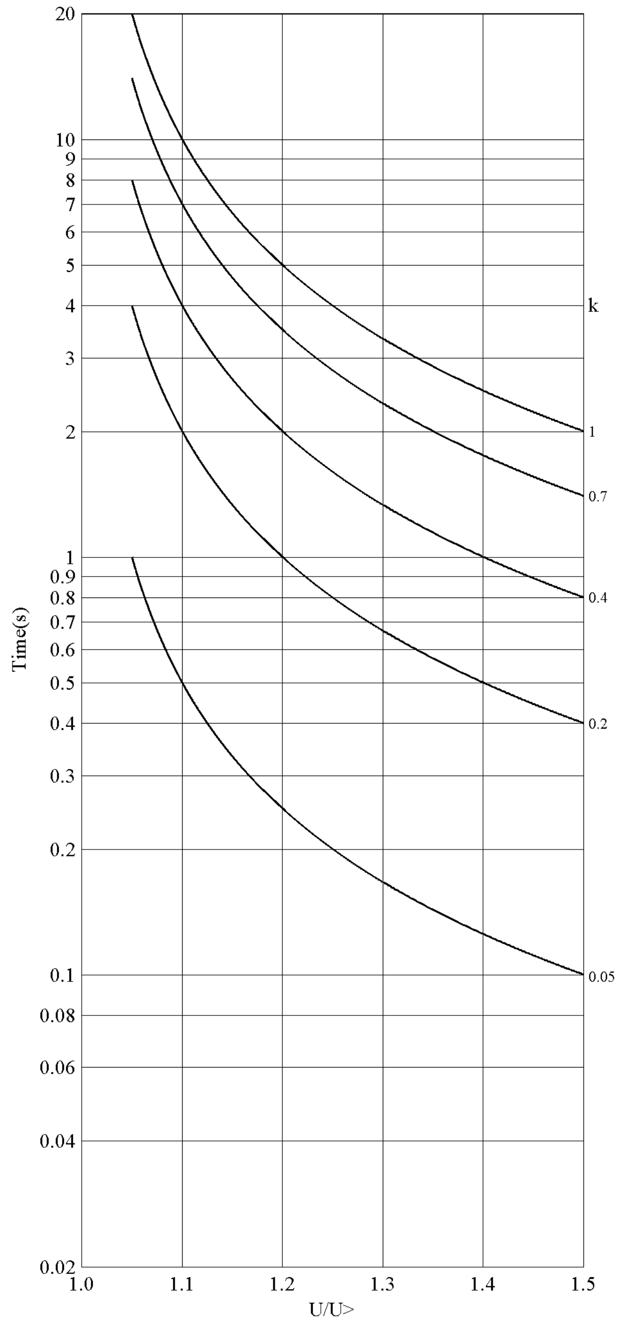


Figure 185: Inverse curve A characteristic of overvoltage protection

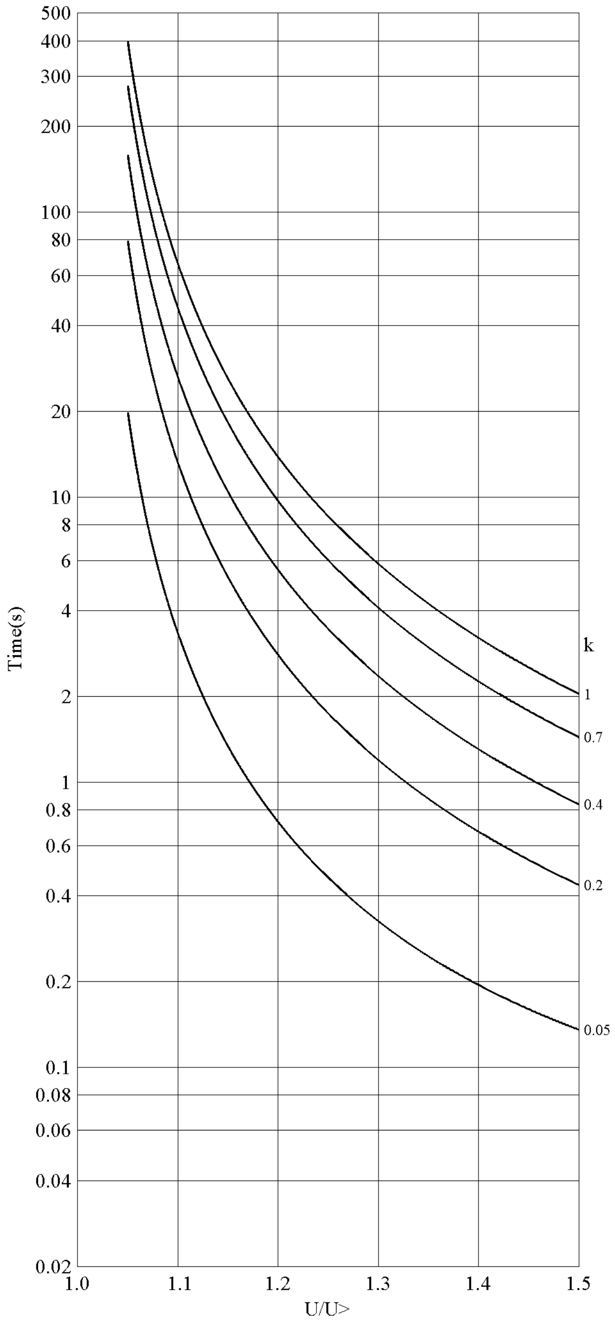


Figure 186: Inverse curve B characteristic of overvoltage protection

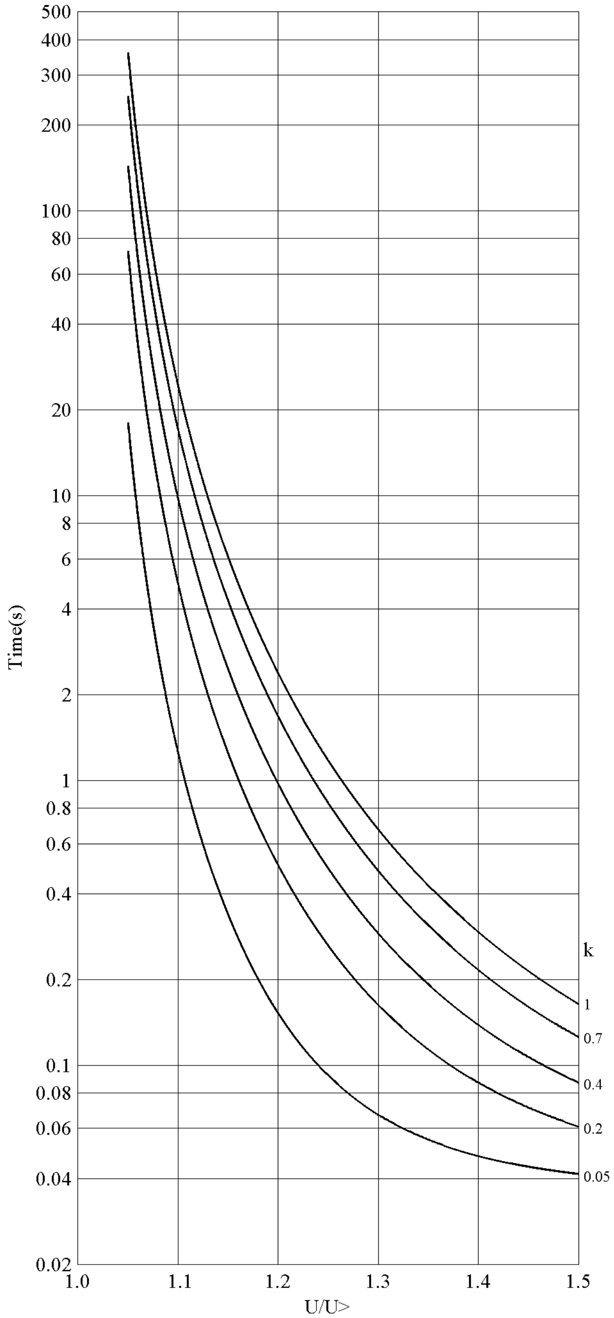


Figure 187: Inverse curve C characteristic of overvoltage protection

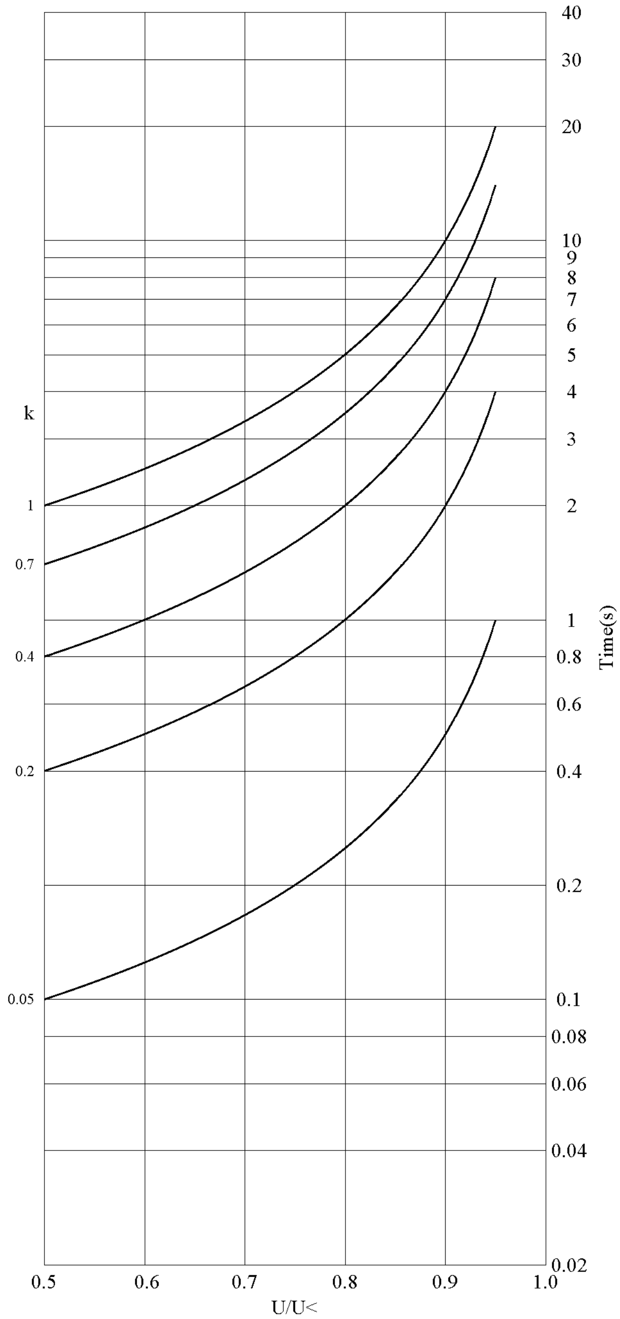


Figure 188: Inverse curve A characteristic of undervoltage protection

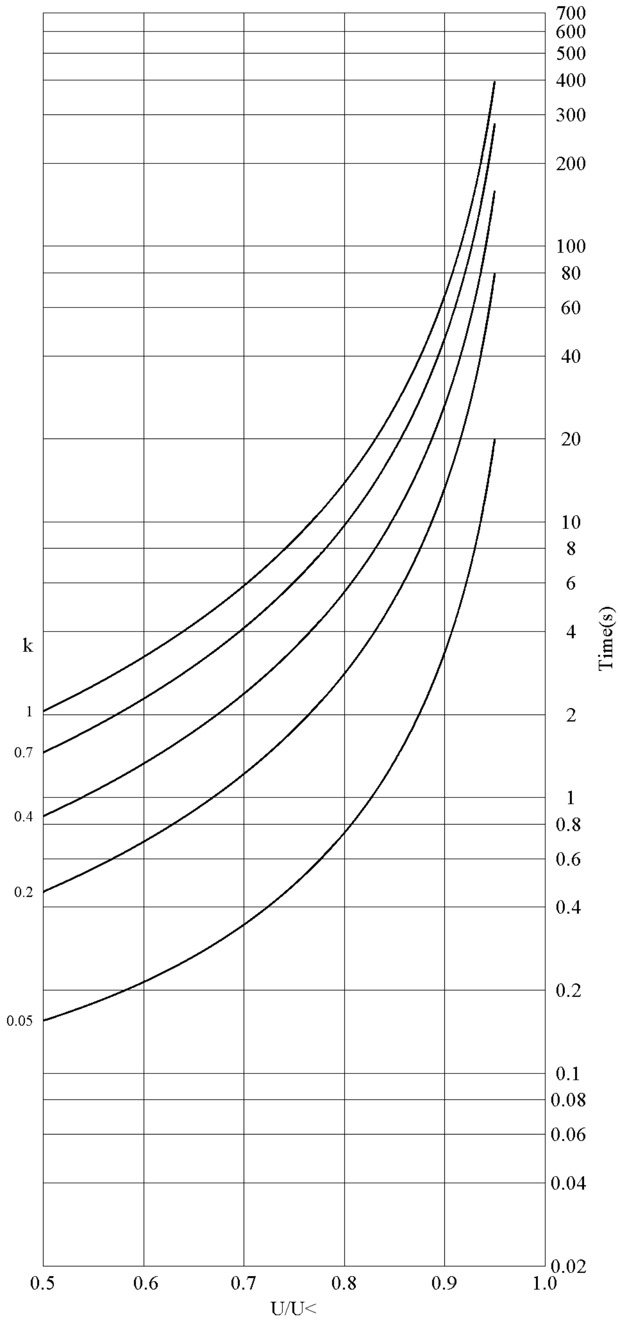


Figure 189: Inverse curve B characteristic of undervoltage protection

Section 19 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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