

Relion® 650 series

Switchsync™ PWC600 Version 1.2

Technical Manual





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Important

Commissioning a point-on-wave controller such as Switchsync PWC600 requires comprehensive knowledge on controlled switching in power systems, to assess and fully validate the performance of the controlled switching system.

Aside from well-known occupational hazards inherent to working in an energized substation, improper commissioning may introduce additional risks such as damage to neighboring primary equipment, accelerated equipment wear, or even severe physical harm to substation personnel.

Commissioning of PWC600 shall include live switching operations and shall be performed only by qualified personnel that is knowledgeable about this type of controller, technology, and field of implementation.

Conformity

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

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Section 1 Introduction

1.1 This manual

The user manual provides basic instructions on how to install and use Switchsync PWC600. The manual provides instructions for engineering, mechanical and electrical installing, commissioning and operating, to cover the common use cases of the product.

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 control and protection systems, control and protection equipment, control and monitoring 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

The user manual provides basic instructions on how to install and use Switchsync PWC600. The manual provides instructions for engineering, mechanical and electrical installing, commissioning and operating, to cover the common use cases of the product.

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

The cyber security deployment guideline describes setting up a secure system, including password procedures and levels of access in the system.

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.

1.3.1.1 Related documents

Documents related to Switchsync PWC600	Identity number
Communication protocol manual, IEC 61850	1MRK 511 554-UEN
Cyber Security deployment guidelines	1MRK 511 555-UEN
User Manual	1MRK 511 556-UEN
Technical manual	1MRK 511 557-UEN
MICS	1MRG 035 293

Table continues on next page

Documents related to Switchsync PWC600	Identity number
PICS	1MRG 035 460
PIXIT	1MRG 035 547 ¹⁾
TICS	1MRG 035 548 ¹⁾

- 1) Switchsync PWC600 1.2 is based on Relion 650 series, version 1.3. So the PIXIT and TICS from Relion 650 series, version 1.3 are applicable for Switchsync PWC600 1.2 too.

1.3.2 Document revision history

Document revision/date	Product version	History
A/2021-11	1.2	First release

1.4 Symbols and conventions

1.4.1 Symbols



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



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



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

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

1.4.2 Document conventions

- Abbreviations and acronyms in this manual are spelled out in the glossary. The 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.

Section 2 Available functions

2.1 Control and monitoring functions

IEC 61850 or function name	Function description	Switchsync	
		PWC600 (IX00)	PWC600 (AX00)
Control			
DPGGIO	IEC61850 generic communication I/O functions	20	20
POS_EVAL	Evaluation of position indication	7	7
VSGGIO	Selector mini switch	50	50
SSCPOW	Controlled switching strategy function	1	1
LOCREM	Handling of LR-switch positions	1	1
LOCREMCTRL	LHMI control of Permitted Source To Operate (PSTO)	1	1
General calculation			
ANSCAL	Curve shape description	63	63
DPISTTIM	Double point input status time monitoring	6	6
BINSTSAN	Binary status to analog conversion	10	10
ARITHMET	General arithmetic base function: ADD, SUB, MUL and DIV for real and Int values	15	15
Logic			
OR	Configurable logic blocks	240	240
INVERTER	Configurable logic blocks	100	100
PULSETIMER	Configurable logic blocks	50	50
GATE	Configurable logic blocks	20	20
XOR	Configurable logic blocks	25	25
LOOPDELAY	Configurable logic blocks	20	20
TIMERSET	Configurable logic blocks	50	50
AND	Configurable logic blocks	80	80
SRMEMORY	Configurable logic blocks	50	50
RSMEMORY	Configurable logic blocks	30	30
ANDQT	Configurable logic blocks Q/T	20	20
ORQT	Configurable logic blocks Q/T	20	20
INVERTERQT	Configurable logic blocks Q/T	24	24
XORQT	Configurable logic blocks Q/T	8	8
SRMEMORYQT	Configurable logic blocks Q/T	8	8
RSMEMORYQT	Configurable logic blocks Q/T	8	8
TIMERSETQT	Configurable logic blocks Q/T	8	8
PULSETIMERQT	Configurable logic blocks Q/T	8	8
INVALIDQT	Configurable logic blocks Q/T	3	3
INDCOMBSPQT	Configurable logic blocks Q/T	10	10
INDEXTSPQT	Configurable logic blocks Q/T	10	10
FXDSIGN	Fixed signal function block	1	1
Table continues on next page			

IEC 61850 or function name	Function description	Switchsync	
		PWC600 (IX00)	PWC600 (AX00)
B16I	Boolean 16 to Integer conversion	6	6
B16IFCVI	Boolean 16 to Integer conversion with Logic Node representation	6	6
IB16A	Integer to Boolean 16 conversion	6	6
IB16FCVB	Integer to Boolean 16 conversion with Logic Node representation	6	6
MINMAX	Logical function to determine the minimum and maximum value	20	20
TEIGGIO	Elapsed time integrator with limit transgression and overflow supervision	4	4
INTCOMP	Comparator for integer inputs	12	12
REALCOMP	Comparator for real inputs	18	18
Monitoring			
CVMMXN	Power system measurement	1	1
CMMXU	Current measurement	2	2
VMMXU	Voltage measurement phase-phase	2	2
CMSQI	Current sequence measurement	1	1
VMSQI	Voltage sequence measurement	2	2
VNMMXU	Voltage measurement phase-earth	3	3
AISVBAS	General service value presentation of analog inputs	1	1
CNGTGGIO	Event counter	3	3
L4UFCNT	Event counter with limit supervision	4	4
DRPRDRE, A1RADR-A4RADR, B1RBDR-B6RBDR	Disturbance report	1	1
SPGGIO	Generic communication function for single point indication	20	20
SP16GGIO	Generic communication function for single point indication 16 inputs	8	8
MVGGIO	Generic communication function for measured values	40	40
MVEXP	Measured value expander block	110	110
MONEVG	Monitoring Event Component for Acknowledgable alarms feature	4	4
OPERLOG	Operation Log Function	15	15
CBCOMP	Compensation of circuit breaker switching times	1	1
MONALM	Multilevel threshold alarm generation function	4	4
ACBMSCBR	Advanced circuit breaker operation and monitoring	3	3
CBLEARN	Circuit breaker contact operation time learning function	1	1
GFGDE	General Function to map to GDE	60	60
CLROPLOG	Clear operation log data	1	1
OPLOGTRIG	Trigger operation record	1	1
TRAFOSWT	Transformer Switching	2-T01	2-T01

IEC 61850 or function name	Function description	Switchsync	
		PWC600 (IX00)	PWC600 (AX00)
Secondary system supervision			
TCSSCBR	Breaker close/trip circuit monitoring	3	3

2.2 Station communication

IEC 61850 or function name	Function description	Switchsync	
		PWC600 (IX00)	PWC600 (AX00)
Station communication			
IEC61850-8-1	IEC61850 communication protocol	1	1
GOOSEBINRCV	Goose binary receive	4	4
GOOSEDPRCV	GOOSE function block to receive a double point value	6	6
GOOSEINTRCV	GOOSE function block to receive an integer value	6	6
GOOSEMVRCV	GOOSE function block to receive a measure and value	30	30
GOOSESPRCV	GOOSE function block to receive a single point value	15	15
ETHFRNT	Ethernet configuration of front port	1	1
GATEWAY	Ethernet configuration of gateway	1	1
ETHLAN1_AB	Ethernet configuration of LAN1 port	1	1
PRPSTATUS	System component for parallel redundancy protocol	1	1
CONFPROT	IED Configuration protocol	1	1
ACTIVLOG	Activity logging parameters	1	1
AGSAL	Generic security application component	1	1
FSTACCS		1	1

2.3 Basic IED functions

IEC 61850 or function name	Function description	Switchsync	
		PWC600 (IX00)	PWC600 (AX00)
Basic IED functions			
INTERRSIG	Self supervision with internal event list	1	1
SELSUPEVLST	Self supervision with internal event list	1	1
TIMESYNCHGEN	Time synchronization	1	1
SNTP	Time synchronization	1	1
DTSBEGIN	Time synchronization	1	1
DTSEND	Time synchronization	1	1
TIMEZONE	Time synchronization	1	1
IRIG-B	Time synchronization	1	1
SYNCHPPS	Time synchronization	1	1
SETGRPS	Setting group handling	1	1
ACTVGRP	Parameter setting groups	1	1
TESTMODE	Test Mode Functionality	1	1
CHNGLCK	Change lock function	1	1
Table continues on next page			

IEC 61850 or function name	Function description	Switchsync	
		PWC600 (IX00)	PWC600 (AX00)
Basic IED functions			
TERMINALID	IED identifiers	1	1
PRODINF	Product information	1	1
SYSTEMTIME	System time	1	1
RUNTIME	IED Runtime Comp	1	1
PRIMVAL	Primary system values	1	1
SMAI	Signal Matrix for analog inputs	1	1
3PHSUM	Summation block 3 phase	4	4
GBASVAL	Global base values for settings	6	6
ATHSTAT	Authority status	1	1
ATHCHCK	Authority check	1	1
AUTHMAN	Authority management	1	1
SPACOMMMAP	SPA communication mapping	1	1
FTPACCS	FTP access with password	1	1
DOSFRNT	Denial of service, frame rate control for front port	1	1
DOSLAN1	Denial of service, frame rate control for LAN1 port	1	1
DOSSCKT	Denial of service, socket flow control	1	1
SAFEFILECOPY	Safe file copy function	1	1
SPATD	Date and time via SPA protocol	1	1
BCSCONF	Basic communication system	1	1
WEBSERVER	WebServer	1	1
SRCSELECT	Source selection between transformer module and merging unit	5	5
MONMEMSUP	Monitoring component memory supervision configuration component	1	1
SSTCONF	SST Configuration holder for unmapped parameters	1	1
3PHSELECT	Selection between two 3-phase analog signals	6	6
OPLOGDRCORRELAT	Configuration for OpLog DR Correlation	1	1
ANALOGPROC	Processor for analog reference signals	1	1

IEC 61850 or function name	Function description	Switchsync	
		PWC600 (IX00)	PWC600 (AX00)
Local HMI functions			
LEDGEN	Basic part for CP HW LED indication module	1	1
GRP1_LED1 - GRP1_LED15	Basic part for CP HW LED indication module	1	1
GRP2_LED1 - GRP2_LED15	Basic part for CP HW LED indication module	1	1
GRP3_LED1 - GRP3_LED15	Basic part for CP HW LED indication module	1	1
LHMICTRL	Local HMI signals	1	1
LANGUAGE	Local human machine language	1	1
OPENCLOSE_LED	LHMI LEDs for open and close keys	1	1
Table continues on next page			

IEC 61850 or function name	Function description	Switchsync	
		PWC600 (IX00)	PWC600 (AX00)
Local HMI functions			
SCREEN	Local HMI Local human machine screen behavior	1	1
FNKEYTY1 - FNKEYTY5	LCD part for HMI Function Keys Control module	1	1
FNKEYMD1 - FNKEYMD5	LCD part for HMI Function Keys Control module	1	1

Section 3 Analog inputs

3.1 Introduction

Analog input channels in the IED must be set properly in order to ensure correct controlled switching operations. The directions of the input currents must be defined in order to reflect the way the current transformers are installed/connected in the field (primary and secondary connections). Control and monitoring algorithms in the IED use primary system quantities. Consequently, the setting values are expressed in primary quantities as well and therefore it is important to set the transformation ratio of the connected current transformers and voltage transformers properly.

The availability of CT and VT inputs, as well as setting parameters are fixed for Switchsync PWC600.

The IED has the ability to receive sampled voltage and current values from one or more (up to 4) merging units (MUs) via IEC 61850-9-2(LE) process bus. Mixed mode is possible, for example, conventional voltage transformers and electronic current sensors via MU, or vice versa.

A reference phase *AngleRef* must be defined to facilitate service values reading. This analog channel's phase angle will always be fixed to zero degrees and all other angle information will be shown in relation to this analog input. By default, *PhaseAngleRef* is assigned to TRM - Channel 5, which is used for the first reference voltage input (Source voltage L1) in the pre-configuration. If source voltage from TRM is not available (not connected), SST would next select TRM - Channel1 (Load current), MU1-L1U (Source voltage 9-2 LE) and MU1-L1I (Load current 9-2 LE). During testing and commissioning of the IED, the reference channel can be changed to facilitate testing and service values reading.

Refer to [Section 15](#) for details on the hardware interfaces of PWC600.

3.2 Operation principle

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

The convention of the directionality is defined as follows:

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

For directional functions the directional conventions are defined as follows (see [Figure 1](#)).

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

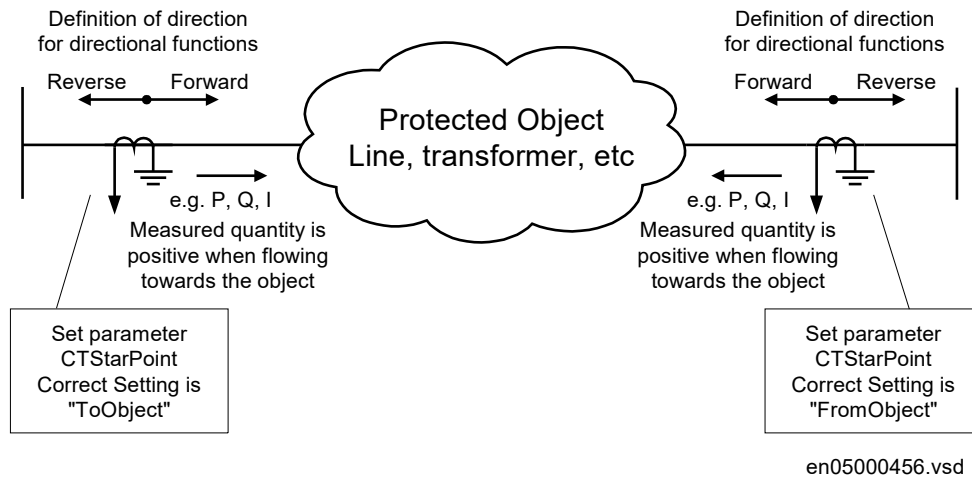


Figure 1: Internal convention of the directionality in the IED

If the settings of the primary CT is correct, that is *CTStarPoint* set as *FromObject* or *ToObject* according to the plant condition, then a positive quantity always flows towards the protected object, and a *Forward* direction always looks towards the protected object.

The settings of the IED are given in primary values. The ratios of the main CTs and VTs are therefore basic data for the IED. The user has to set the rated secondary and primary currents and voltages of the CTs and VTs to provide the IED with their rated ratios.

The CT and VT ratings are entered in SST, under the **Reference signals** milestone. Channel names are assigned in the pre-configuration. Manual changes can be done under **Main menu/Hardware / Analog modules** in the Parameter Settings tool or on the LHMI or WHMI.

3.3 Settings

Table 1: AISVBAS Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
PhaseAngleRef	TRM - Channel 1	-	-	TRM - Channel 1	Reference channel for phase angle presentation
	TRM - Channel 2				
	TRM - Channel 3				
	TRM - Channel 4				
	TRM - Channel 5				
	TRM - Channel 6				
	TRM - Channel 7				
	TRM - Channel 8				
	TRM - Channel 9				
	TRM - Channel 10				
	AIM - Channel 1				
	AIM - Channel 2				
	AIM - Channel 3				
	AIM - Channel 4				
	AIM - Channel 5				
	AIM - Channel 6				
	AIM - Channel 7				
	AIM - Channel 8				
	AIM - Channel 9				
	AIM - Channel 10				
	MU1 - L1I				
	MU1 - L2I				
	MU1 - L3I				
	MU1 - L4I				
	MU1 - L1U				
	MU1 - L2U				
	MU1 - L3U				
	MU1 - L4U				
	MU2 - L1I				
	MU2 - L2I				
	MU2 - L3I				
	MU2 - L4I				
	MU2 - L1U				
	MU2 - L2U				
	MU2 - L3U				
	MU2 - L4U				
	MU3 - L1I				
	MU3 - L2I				
	MU3 - L3I				
	MU3 - L4I				
	MU3 - L1U				
	MU3 - L2U				
	MU3 - L3U				
	MU3 - L4U				
	MU4 - L1I				
	MU4 - L2I				
	MU4 - L3I				
	MU4 - L4I				
	MU4 - L1U				
	MU4 - L2U				
	MU4 - L3U				
	MU4 - L4U				

Table 2: TRM_4I_6U Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
CTStarPoint1	FromObject ToObject	-	-	ToObject	ToObject= towards protected object, FromObject= the opposite
CTsec1	0.1 - 10.0	A	0.1	1.0	Rated CT secondary current
CTprim1	1 - 99999	A	1	1000	Rated CT primary current
CTStarPoint2	FromObject ToObject	-	-	ToObject	ToObject= towards protected object, FromObject= the opposite
CTsec2	0.1 - 10.0	A	0.1	1.0	Rated CT secondary current
CTprim2	1 - 99999	A	1	1000	Rated CT primary current
CTStarPoint3	FromObject ToObject	-	-	ToObject	ToObject= towards protected object, FromObject= the opposite
CTsec3	0.1 - 10.0	A	0.1	1.0	Rated CT secondary current
CTprim3	1 - 99999	A	1	1000	Rated CT primary current
CTStarPoint4	FromObject ToObject	-	-	ToObject	ToObject= towards protected object, FromObject= the opposite
CTsec4	0.1 - 10.0	A	0.1	1.0	Rated CT secondary current
CTprim4	1 - 99999	A	1	1000	Rated CT primary current
VTsec5	0.001 - 999.999	V	0.001	110.000	Rated VT secondary voltage
VTprim5	0.001 - 9999.999	kV	0.001	132.000	Rated VT primary voltage
VTsec6	0.001 - 999.999	V	0.001	110	Rated VT secondary voltage
VTprim6	0.001 - 9999.999	kV	0.001	132.000	Rated VT primary voltage
VTsec7	0.001 - 999.999	V	0.001	110.000	Rated VT secondary voltage
VTprim7	0.001 - 9999.999	kV	0.001	132.000	Rated VT primary voltage
VTsec8	0.001 - 999.999	V	0.001	110	Rated VT secondary voltage
VTprim8	0.001 - 9999.999	kV	0.001	132.000	Rated VT primary voltage
VTsec9	0.001 - 999.999	V	0.001	110.000	Rated VT secondary voltage
VTprim9	0.001 - 9999.999	kV	0.001	132.000	Rated VT primary voltage
VTsec10	0.001 - 999.999	V	0.001	110	Rated VT secondary voltage
VTprim10	0.001 - 9999.999	kV	0.001	132.000	Rated VT primary voltage

Table 3: MU1_4I_4U Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
SVId	0 - 35	-	1	ABB_MU0101	MU identifier
SmplGrp	0 - 65535	-	1	0	Sampling group
CTStarPoint1	FromObject ToObject	-	-	ToObject	ToObject= towards protected object, FromObject= the opposite
CTStarPoint2	FromObject ToObject	-	-	ToObject	ToObject= towards protected object, FromObject= the opposite
CTStarPoint3	FromObject ToObject	-	-	ToObject	ToObject= towards protected object, FromObject= the opposite
CTStarPoint4	FromObject ToObject	-	-	ToObject	ToObject= towards protected object, FromObject= the opposite

Table 4: MU1_4I_4U Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
SynchMode	NoSynch Init Operation	-	-	Operation	Synchronization mode



MU2_4I_4U, MU3_4I_4U and MU4_4I_4U have the same settings as MU1_4I_4U.

Section 4 Binary inputs and outputs

4.1 Binary inputs

A binary input mirrors the status (on/off) of an electrical DC signal and reports every status change with time stamp.

The BIO module provides 9 optically isolated binary inputs. Some of them share a common negative terminal; see the connection diagram for details.

The PIO module provides 12 optically isolated precision binary inputs with time stamp accuracy of 100 microseconds.

All binary inputs are equipped with digital filters, to eliminate bouncing and oscillations on the input signals.

4.1.1 Debounce filter

The debounce filter eliminates bounces and short disturbances on a binary input.

A time counter is used for filtering. The time counter is increased once in a millisecond when a binary input is high, or decreased when a binary input is low. A debounced status change is forwarded when the time counter reaches the set *DebounceTime* value and the debounced input value is high, or when the time counter reaches 0 and the debounced input value is low. The default setting of *DebounceTime* is 5 ms.

A binary input ON-event is assigned the time stamp of the first rising edge after which the counter does not reach 0 again. The same applies when the signal goes down to 0 again.

Each binary input has a filter time parameter *DebounceTimex*, where x is the number of the binary input of the module in question (for example *DebounceTime1*). For precision binary inputs, the debounce time can be specified separately for On and Off status changes.



The debounce time should be set to the same value for all channels on the board.

4.1.2 Oscillation filter

Binary input wiring can be very long in substations and there are electromagnetic fields from for example nearby breakers. An oscillation filter is used to reduce the disturbance from the system when a binary input starts oscillating.

Each debounced change of input status increments an oscillation counter. Periodically (every *OscillationTime*), the oscillation counter is checked and reset. If the counter value before reset is above the set *OscillationCount* value the signal is declared as oscillating and not valid. If the value is below the set *OscillationCount* value, the signal is declared as valid. During counting of the oscillation time the status of the signal remains unchanged, leading to a fixed delay in the status update, even if the signal has attained normal status again.

Each binary input has an oscillation count parameter *OscillationCountx* and an oscillation time parameter *OscillationTimex*, where x is the number of the binary input of the module in question. For precision binary inputs, the filter parameters can be specified separately for On and Off status changes.

4.1.3 Settings

4.1.3.1 Setting parameters for binary inputs

Table 5: BIO_9BI Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
BatteryVoltage	24 - 250	V	1	110	Station battery voltage

Table 6: BIO_9BI Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
Threshold1	6 - 900	%UB	1	65	Threshold in percentage of station battery voltage for input 1
DebounceTime1	0.000 - 0.100	s	0.001	0.005	Debounce time for input 1
OscillationCount1	0 - 255	-	1	0	Oscillation count for input 1
OscillationTime1	0.000 - 600.000	s	0.001	0.000	Oscillation time for input 1
Threshold2	6 - 900	%UB	1	65	Threshold in percentage of station battery voltage for input 2
DebounceTime2	0.000 - 0.100	s	0.001	0.005	Debounce time for input 2
OscillationCount2	0 - 255	-	1	0	Oscillation count for input 2
OscillationTime2	0.000 - 600.000	s	0.001	0.000	Oscillation time for input 2
Threshold3	6 - 900	%UB	1	65	Threshold in percentage of station battery voltage for input 3
DebounceTime3	0.000 - 0.100	s	0.001	0.005	Debounce time for input 3
OscillationCount3	0 - 255	-	1	0	Oscillation count for input 3
OscillationTime3	0.000 - 600.000	s	0.001	0.000	Oscillation time for input 3
Threshold4	6 - 900	%UB	1	65	Threshold in percentage of station battery voltage for input 4
DebounceTime4	0.000 - 0.100	s	0.001	0.005	Debounce time for input 4
OscillationCount4	0 - 255	-	1	0	Oscillation count for input 4
OscillationTime4	0.000 - 600.000	s	0.001	0.000	Oscillation time for input 4
Threshold5	6 - 900	%UB	1	65	Threshold in percentage of station battery voltage for input 5
DebounceTime5	0.000 - 0.100	s	0.001	0.005	Debounce time for input 5
OscillationCount5	0 - 255	-	1	0	Oscillation count for input 5
OscillationTime5	0.000 - 600.000	s	0.001	0.000	Oscillation time for input 5
Threshold6	6 - 900	%UB	1	65	Threshold in percentage of station battery voltage for input 6
DebounceTime6	0.000 - 0.100	s	0.001	0.005	Debounce time for input 6
OscillationCount6	0 - 255	-	1	0	Oscillation count for input 6
OscillationTime6	0.000 - 600.000	s	0.001	0.000	Oscillation time for input 6
Threshold7	6 - 900	%UB	1	65	Threshold in percentage of station battery voltage for input 7
DebounceTime7	0.000 - 0.100	s	0.001	0.005	Debounce time for input 7
OscillationCount7	0 - 255	-	1	0	Oscillation count for input 7
OscillationTime7	0.000 - 600.000	s	0.001	0.000	Oscillation time for input 7

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
Threshold8	6 - 900	%UB	1	65	Threshold in percentage of station battery voltage for input 8
DebounceTime8	0.000 - 0.100	s	0.001	0.005	Debounce time for input 8
OscillationCount8	0 - 255	-	1	0	Oscillation count for input 8
OscillationTime8	0.000 - 600.000	s	0.001	0.000	Oscillation time for input 8
Threshold9	6 - 900	%UB	1	65	Threshold in percentage of station battery voltage for input 9
DebounceTime9	0.000 - 0.100	s	0.001	0.005	Debounce time for input 9
OscillationCount9	0 - 255	-	1	0	Oscillation count for input 9
OscillationTime9	0.000 - 600.000	s	0.001	0.000	Oscillation time for input 9



For Switchsync PWC600, *Battery voltage* is usually entered in SST, under the **Power System** milestone, and distributed to all hardware modules.

4.1.3.2 Setting parameters for precision binary inputs

Table 7: PIO_12PBI Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
BatteryVoltage	24 - 250	-	1	110	Station battery voltage

Table 8: PIO_12PBI Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
Threshold1	15 - 221	-	1	65	Threshold in percentage of station battery voltage for input 1
DebounceTimeOn1	0.0000 - 0.1270	-	0.0001	0.0050	Debounce time On for input 1
DebounceTimeOff1	0.0000 - 0.1270	-	0.0001	0.0050	Debounce time Off for input 1
OscillationCntOn1	0 - 255	-	1	0	OscillationCountOn for input 1
OscillationCntOff1	0 - 255	-	1	0	OscillationCountOff for input 1
OscillationTimeOn1	0.000 - 600.000	-	0.001	0.000	OscillationTimeOn for input 1
OscillationTimeOff1	0.000 - 600.000	-	0.001	0.000	OscillationTimeOff for input 1
Threshold2	15 - 221	-	1	65	Threshold in percentage of station battery voltage for input 2
DebounceTimeOn2	0.0000 - 0.1270	-	0.0001	0.0050	Debounce time On for input 2
DebounceTimeOff2	0.0000 - 0.1270	-	0.0001	0.0050	Debounce time Off for input 2
OscillationCntOn2	0 - 255	-	1	0	OscillationCountOn for input 2
OscillationCntOff2	0 - 255	-	1	0	OscillationCountOff for input 2
OscillationTimeOn2	0.000 - 600.000	-	0.001	0.000	OscillationTimeOn for input 2
OscillationTimeOff2	0.000 - 600.000	-	0.001	0.000	OscillationTimeOff for input 2
Threshold3	15 - 221	-	1	65	Threshold in percentage of station battery voltage for input 3
DebounceTimeOn3	0.0000 - 0.1270	-	0.0001	0.0050	Debounce time On for input 3
DebounceTimeOff3	0.0000 - 0.1270	-	0.0001	0.0050	Debounce time Off for input 3
OscillationCntOn3	0 - 255	-	1	0	OscillationCountOn for input 3

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
OscillationCntOff 3	0 - 255	-	1	0	OscillationCountOff for input 3
OscillationTimeOn3	0.000 - 600.000	-	0.001	0.000	OscillationTimeOn for input 3
OscillationTimeOff3	0.000 - 600.000	-	0.001	0.000	OscillationTimeOff for input 3
Threshold4	15 - 221	-	1	65	Threshold in percentage of station battery voltage for input 4
DebounceTimeOn4	0.0000 - 0.1270	-	0.0001	0.0050	Debounce time On for input 4
DebounceTimeOff4	0.0000 - 0.1270	-	0.0001	0.0050	Debounce time Off for input 4
OscillationCntOn4	0 - 255	-	1	0	OscillationCountOn for input 4
OscillationCntOff4	0 - 255	-	1	0	OscillationCountOff for input 4
OscillationTimeOn4	0.000 - 600.000	-	0.001	0.000	OscillationTimeOn for input 4
OscillationTimeOff4	0.000 - 600.000	-	0.001	0.000	OscillationTimeOff for input 4
Threshold5	15 - 221	-	1	65	Threshold in percentage of station battery voltage for input 5
DebounceTimeOn5	0.0000 - 0.1270	-	0.0001	0.0050	Debounce time On for input 5
DebounceTimeOff5	0.0000 - 0.1270	-	0.0001	0.0050	Debounce time Off for input 5
OscillationCntOn5	0 - 255	-	1	0	OscillationCountOn for input 5
OscillationCntOff5	0 - 255	-	1	0	OscillationCountOff for input 5
OscillationTimeOn5	0.000 - 600.000	-	0.001	0.000	OscillationTimeOn for input 5
OscillationTimeOff5	0.000 - 600.000	-	0.001	0.000	OscillationTimeOff for input 5
Threshold6	15 - 221	-	1	65	Threshold in percentage of station battery voltage for input 6
DebounceTimeOn6	0.0000 - 0.1270	-	0.0001	0.0050	Debounce time On for input 6
DebounceTimeOff6	0.0000 - 0.1270	-	0.0001	0.0050	Debounce time Off for input 6
OscillationCntOn6	0 - 255	-	1	0	OscillationCountOn for input 6
OscillationCntOff6	0 - 255	-	1	0	OscillationCountOff for input 6
OscillationTimeOn6	0.000 - 600.000	-	0.001	0.000	OscillationTimeOn for input 6
OscillationTimeOff6	0.000 - 600.000	-	0.001	0.000	OscillationTimeOff for input 6
Threshold7	15 - 221	-	1	65	Threshold in percentage of station battery voltage for input 7
DebounceTimeOn7	0.0000 - 0.1270	-	0.0001	0.0050	Debounce time On for input 7
DebounceTimeOff7	0.0000 - 0.1270	-	0.0001	0.0050	Debounce time Off for input 7
OscillationCntOn7	0 - 255	-	1	0	OscillationCountOn for input 7
OscillationCntOff7	0 - 255	-	1	0	OscillationCountOff for input 7
OscillationTimeOn7	0.000 - 600.000	-	0.001	0.000	OscillationTimeOn for input 7
OscillationTimeOff7	0.000 - 600.000	-	0.001	0.000	OscillationTimeOff for input 7
Threshold8	15 - 221	-	1	65	Threshold in percentage of station battery voltage for input 8
DebounceTimeOn8	0.0000 - 0.1270	-	0.0001	0.0050	Debounce time On for input 8
DebounceTimeOff8	0.0000 - 0.1270	-	0.0001	0.0050	Debounce time Off for input 8
OscillationCntOn8	0 - 255	-	1	0	OscillationCountOn for input 8
OscillationCntOff8	0 - 255	-	1	0	OscillationCountOff for input 8
OscillationTimeOn8	0.000 - 600.000	-	0.001	0.000	OscillationTimeOn for input 8
OscillationTimeOff8	0.000 - 600.000	-	0.001	0.000	OscillationTimeOff for input 8

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
Threshold9	15 - 221	-	1	65	Threshold in percentage of station battery voltage for input 9
DebounceTimeOn9	0.0000 - 0.1270	-	0.0001	0.0050	Debounce time On for input 9
DebounceTimeOff9	0.0000 - 0.1270	-	0.0001	0.0050	Debounce time Off for input 9
OscillationCntOn9	0 - 255	-	1	0	OscillationCountOn for input 9
OscillationCntOff9	0 - 255	-	1	0	OscillationCountOff for input 9
OscillationTimeOn9	0.000 - 600.000	-	0.001	0.000	OscillationTimeOn for input 9
OscillationTimeOff9	0.000 - 600.000	-	0.001	0.000	OscillationTimeOff for input 9
Threshold10	15 - 221	-	1	65	Threshold in percentage of station battery voltage for input 10
DebounceTimeOn10	0.0000 - 0.1270	-	0.0001	0.0050	Debounce time On for input 10
DebounceTimeOff10	0.0000 - 0.1270	-	0.0001	0.0050	Debounce time Off for input 10
OscillationCntOn10	0 - 255	-	1	0	OscillationCountOn for input 10
OscillationCntOff10	0 - 255	-	1	0	OscillationCountOff for input 10
OscillationTimeOn10	0.000 - 600.000	-	0.001	0.000	OscillationTimeOn for input 10
OscillationTimeOff10	0.000 - 600.000	-	0.001	0.000	OscillationTimeOff for input 10
Threshold11	15 - 221	-	1	65	Threshold in percentage of station battery voltage for input 11
DebounceTimeOn11	0.0000 - 0.1270	-	0.0001	0.0050	Debounce time On for input 11
DebounceTimeOff11	0.0000 - 0.1270	-	0.0001	0.0050	Debounce time Off for input 11
OscillationCntOn11	0 - 255	-	1	0	OscillationCountOn for input 11
OscillationCntOff11	0 - 255	-	1	0	OscillationCountOff for input 11
OscillationTimeOn11	0.000 - 600.000	-	0.001	0.000	OscillationTimeOn for input 11
OscillationTimeOff11	0.000 - 600.000	-	0.001	0.000	OscillationTimeOff for input 11
Threshold12	15 - 221	-	1	65	Threshold in percentage of station battery voltage for input 12
DebounceTimeOn12	0.0000 - 0.1270	-	0.0001	0.0050	Debounce time On for input 12
DebounceTimeOff12	0.0000 - 0.1270	-	0.0001	0.0050	Debounce time Off for input 12
OscillationCntOn12	0 - 255	-	1	0	OscillationCountOn for input 12
OscillationCntOff12	0 - 255	-	1	0	OscillationCountOff for input 12
OscillationTimeOn12	0.000 - 600.000	-	0.001	0.000	OscillationTimeOn for input 12
OscillationTimeOff12	0.000 - 600.000	-	0.001	0.000	OscillationTimeOff for input 12

4.2 Binary outputs

4.2.1 Binary outputs

The PSM02 or PSM03 module provides 10 output relay contacts. 6 of these are rated for making and carrying high currents, and three of these include circuits for trip coil supervision. The remaining 4 relay contacts are intended for signaling; one of them is internally hardwired to indicate Internal Relay Failure (IRF).

The BIO module provides 9 output relay contacts. Out of these, 3 are rated for making and carrying high currents. The remaining 6 contacts are intended for signaling; some of them share a common terminal, see the connection diagram for details.

The PIO module provides 6 fast static outputs that are rated for making and carrying high currents. The switching instants of these precision binary outputs can be controlled at 100 microseconds' accuracy, which makes them ideal for controlled switching of circuit breakers.

Binary outputs rated for making and carrying high currents allow connection directly to breaker tripping and closing coils. If breaking capability is required to manage failure of the breaker auxiliary contacts normally breaking the coil current, parallel reinforcement by an external relay is required.



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.

Section 5 Local HMI

5.1 Local HMI elements



Figure 2: Local human-machine interface

The LHMI of the IED contains the following elements:

- Display (LCD)
- Buttons
- LED indicators
- Communication port for PCM600 or WHMI

The LHMI is used for setting, monitoring and controlling.

5.1.1 Display

The LHMI includes a graphical monochrome display 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.

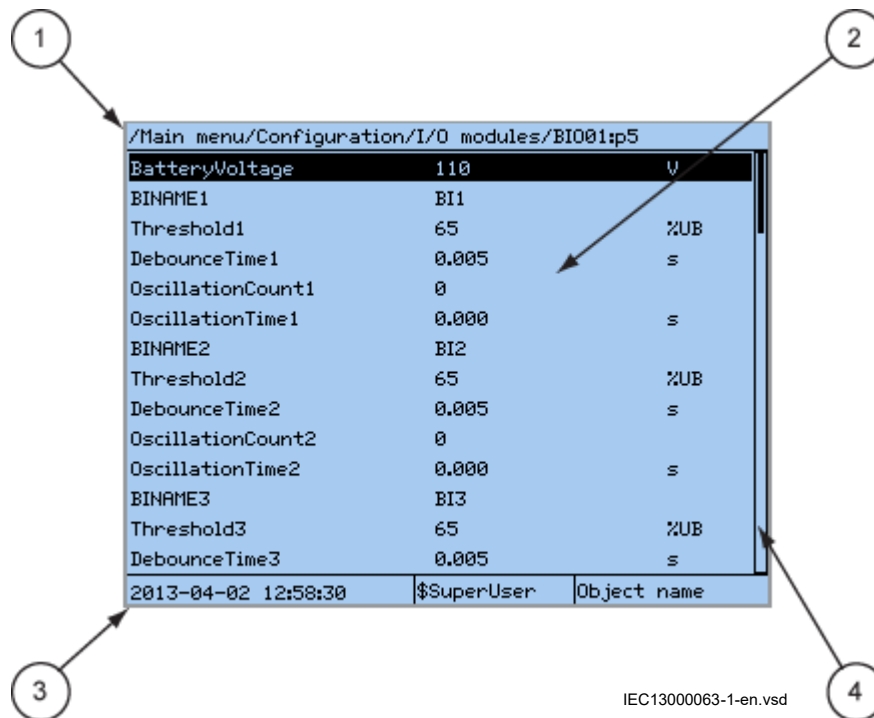


Figure 3: Display layout

- 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, graphics or other items do not fit in the content area, 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.

By pressing one of the function keys, the function key panel shows the possible action assigned to each function key.

Each function key has a LED indication that can be used as a feedback signal for the function key control action. The LED is connected to the required signal with PCM600.

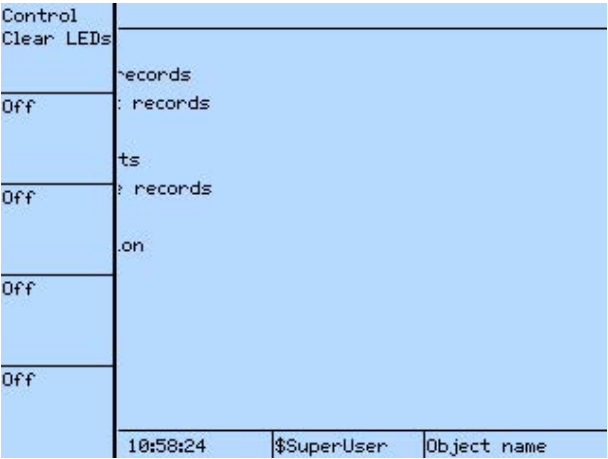


Figure 4: Function key panel

Upon pressing the Multipage button , the alarm LED panel shows the assigned text labels for the active alarm LEDs on the selected page. Three alarm LED pages are available.

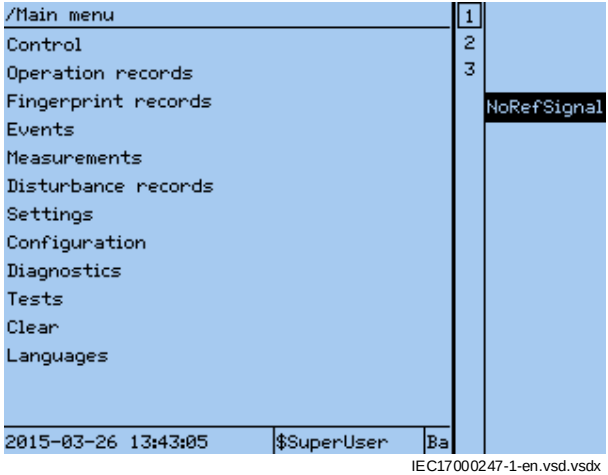


Figure 5: Alarm LED panel

The function key and alarm LED panels are not visible at the same time. 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.

5.1.2 LEDs

The LHMI includes three status LEDs above the display: Ready, Start, and Trip (or Normal, Pickup, and Trip on the ANSI-style LHMI). In Switchsync PWC600, only the Ready and Start LEDs are used.

15 programmable alarm LEDs are located to the right of the screen. 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 and can be browsed with the Multipage button.

There are 3 separate pages of LEDs available. 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.

In Switchsync PWC600, the functions and operation modes of the LEDs on page 1 are defined in the default pre-configuration.

5.1.3 Keypad

The LHMI keypad contains push-buttons which are used to navigate in different views or menus. The push-buttons are used to acknowledge alarms, reset indications or provide help.

The keypad also contains programmable push-buttons (function keys) that can be configured either as menu shortcut or control buttons. The first function key is assigned in the default pre-configuration for resetting the alarm LEDs.

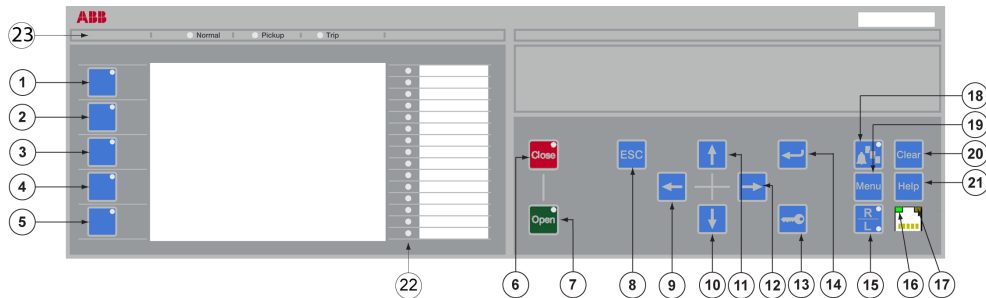


Figure 6: LHMI keypad with object control, navigation and command push buttons and RJ-45 communication port

- 1...5 Function key
- 6 Close
- 7 Open
- 8 Escape
- 9 Left
- 10 Down
- 11 Up
- 12 Right
- 13 User Log on
- 14 Enter
- 15 Remote/Local
- 16 Uplink LED
- 17 Ethernet communication port (RJ-45)
- 18 Multipage
- 19 Menu
- 20 Clear
- 21 Help
- 22 Programmable alarm LEDs
- 23 Protection status LEDs

5.2 Local HMI screen

5.2.1 Identification

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

5.2.2 Settings

Table 9: SCREEN Non group settings (basic)

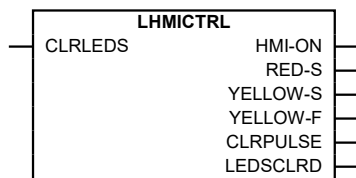
Name	Values (Range)	Unit	Step	Default	Description
DisplayTimeout	10 - 120	Min	10	60	Local HMI display timeout
ContrastLevel	-100 - 100	%	10	0	Contrast level for display
DefaultScreen	0 - 0	-	1	0	Default screen
EvListSrtOrder	Latest on top Oldest on top	-	-	Latest on top	Sort order of event list
AutoIndicationDRP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

5.3 Local HMI signals

5.3.1 Identification

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

5.3.2 Function block



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Figure 7: LHMICTRL function block

5.3.3 Signals

Table 10: LHMICTRL Input signals

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

Table 11: 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
LEDSCLR	BOOLEAN	Active when the LEDs on the LCD-HMI are not active

5.4 Status LEDs

There are three status LEDs on the LHMI, above the LCD screen: Ready (green), Start (yellow), Trip (red).

The green LED has a fixed function that present the healthy status of the IED. The yellow and red LEDs are user configured. The yellow LED can be used to indicate that a disturbance report is triggered (steady) or that the IED is in test mode (flashing). The red LED can be used to indicate a protection operation command.

The yellow and red status LEDs are configured in the disturbance recorder function, DRPRDRE, by connecting a start or trip signal from the actual function to a BxRBDR binary input function block in PCM600 and configuring the *SetLEDn* setting to *Off*, *Start* or *Trip* for that particular signal.

5.5 Indication LEDs

5.5.1 Identification

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

5.5.2 Functionality

The function blocks LEDGEN and GRP1_LEDx, GRP2_LEDx and GRP3_LEDx (x=1-15) control, and supply information about the status of the indication LEDs. 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, which determines the color and the operating mode.

By applying logical 1 to one of the inputs, a LED is activated in the corresponding color. In case more than one input is active at the same time, red has highest priority, followed by yellow and green.

Each indication LED on local HMI can be set individually to operate in 6 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.

5.5.3 Function block

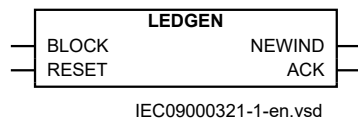


Figure 8: LEDGEN function block

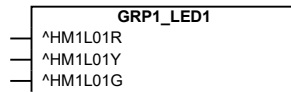


Figure 9: GRP1_LED1 function block

The GRP1_LED1 function block is shown as an example; each of the 15 LEDs in groups 1 - 3 has a similar function block.

5.5.4 Signals

Table 12: 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 13: 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 14: 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

5.5.5 Settings

Table 15: 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 16: 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

5.5.6 Operation principle

5.5.6.1 Operating modes

Collecting mode

LEDs that are used in collecting mode of operation are accumulated (latched on) 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.

5.5.6.2 Acknowledgment/reset

From local HMI

Active indications can be acknowledged/reset manually. Manual acknowledgment and manual reset have the same meaning and refer to a common signal for all the operating sequences and LEDs. The function is positive edge triggered, not level triggered. Acknowledgment/reset is performed via the  button and menus on the LHMI.

From function input

Active indications can also be acknowledged/reset from the RESET input to the *LEDGEN* 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

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

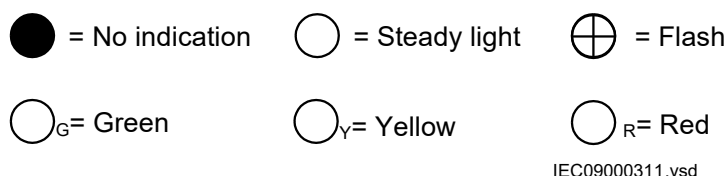
5.5.6.3 Operating sequence

The sequences can be of type Follow or Latched. For the Follow type the LED follow the input signal continuously. For the Latched type the LED is switched ON whenever the corresponding input signal is activated, and remains ON until the active indications are 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 working 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.

Upon activation of the input signal, LED is switched ON in the 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:

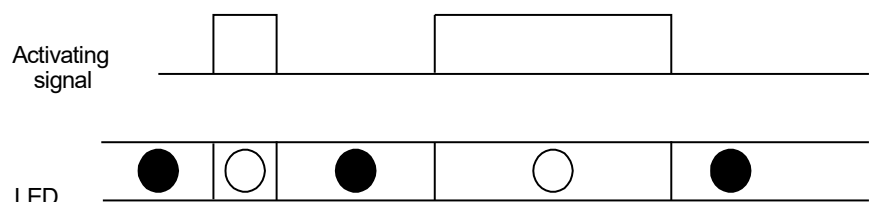


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Figure 10: Symbols used in the sequence diagrams

Sequence 1 (Follow-S)

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



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Figure 11: 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 [Figure 12](#).

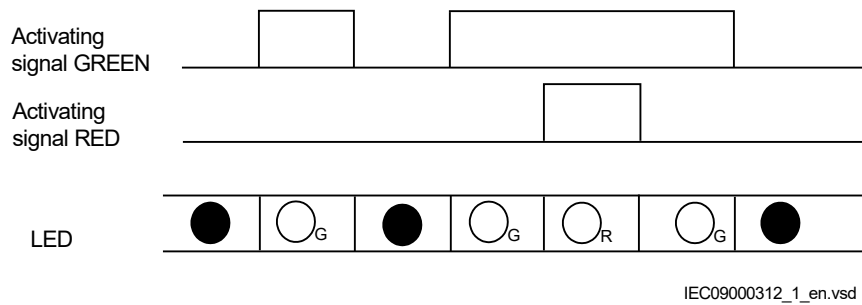


Figure 12: Operating sequence 1, two colors

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.

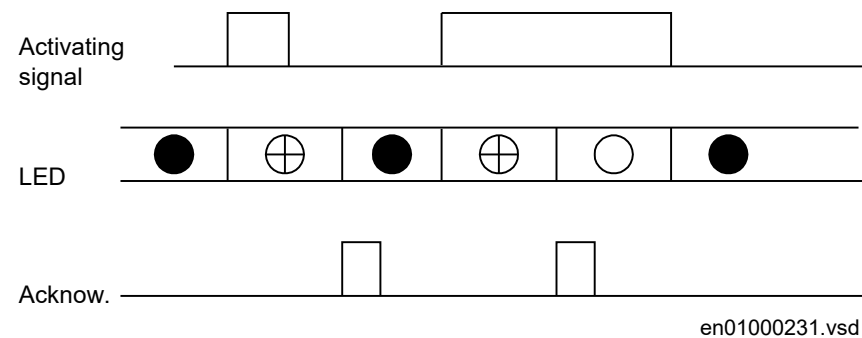


Figure 13: Operating Sequence 3 LatchedAck-F-S

When acknowledgment is given, all indications that have appeared before the indication with higher priority has been reset, will be acknowledged, independent of if the low priority indication appeared before or after acknowledgment. [Figure 14](#) shows 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.

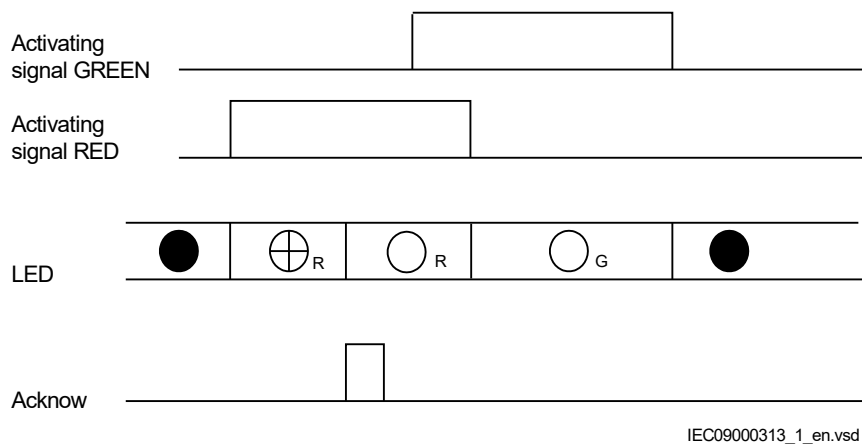


Figure 14: Operating Sequence 3 (LatchedAck-F-S), 2 colors involved

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 15](#).

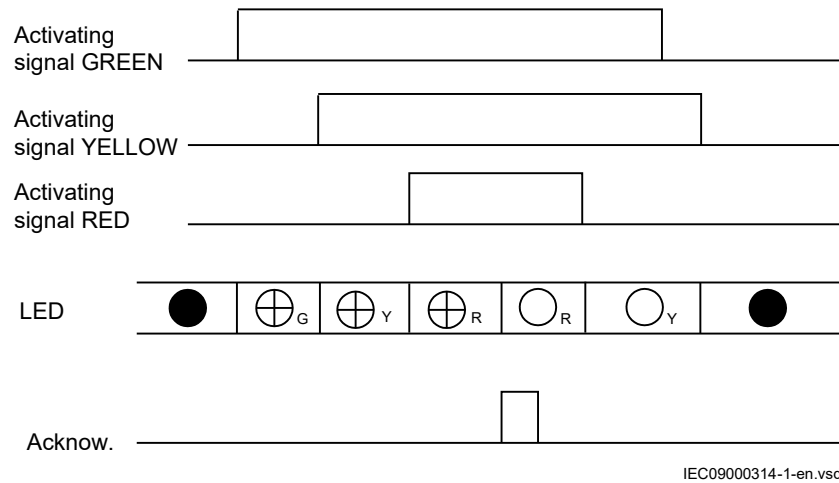


Figure 15: Operating sequence 3, three colors involved, alternative 1

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 16](#).

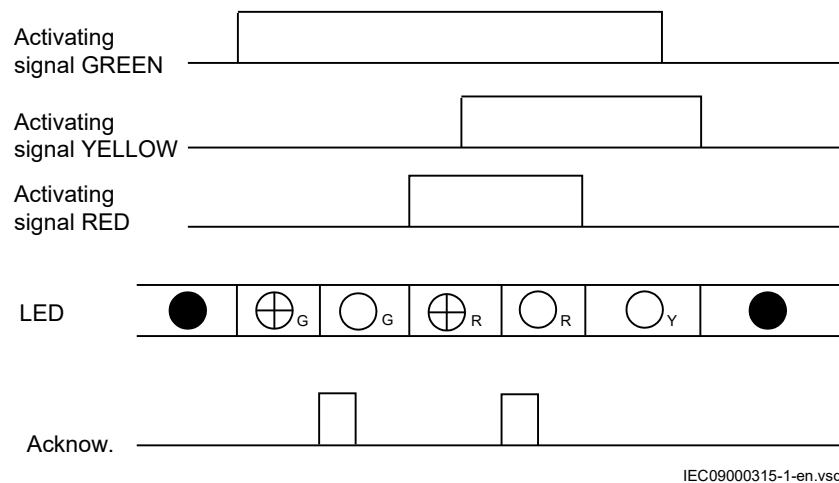


Figure 16: Operating sequence 3, three colors involved, alternative 2

Sequence 4 (LatchedAck-S-F)

This sequence has the same functionality as sequence 3, but steady and flashing light are swapped.

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.

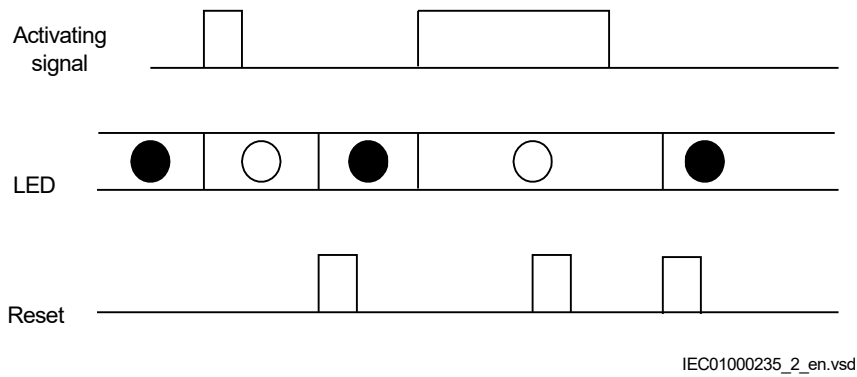


Figure 17: Operating Sequence 5 LatchedColl-S

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 18](#).

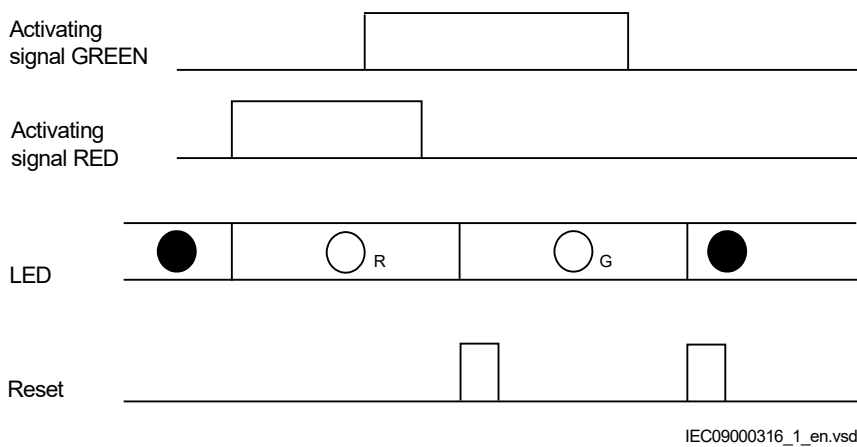


Figure 18: Operating sequence 5, two colors

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 19](#) shows the timing diagram for two indications within one disturbance.

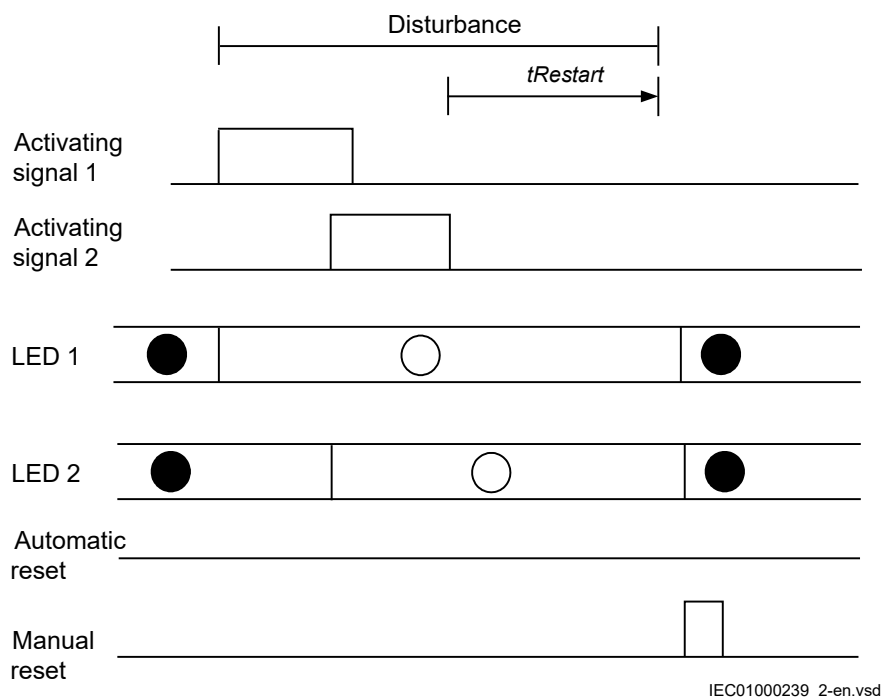


Figure 19: Operating sequence 6 (LatchedReset-S), two indications within same disturbance

Figure 20 shows the timing diagram for a new indication after $t_{Restart}$ time has elapsed.

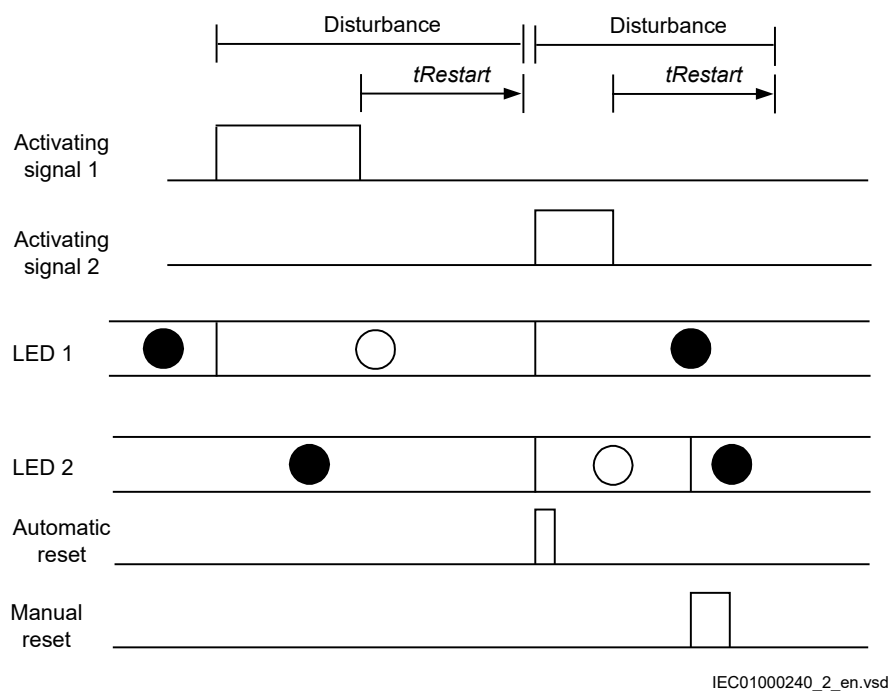


Figure 20: Operating sequence 6 (LatchedReset-S), two different disturbances

Figure 21 shows the timing diagram when a new indication appears after the first one has reset but before $t_{Restart}$ has elapsed.

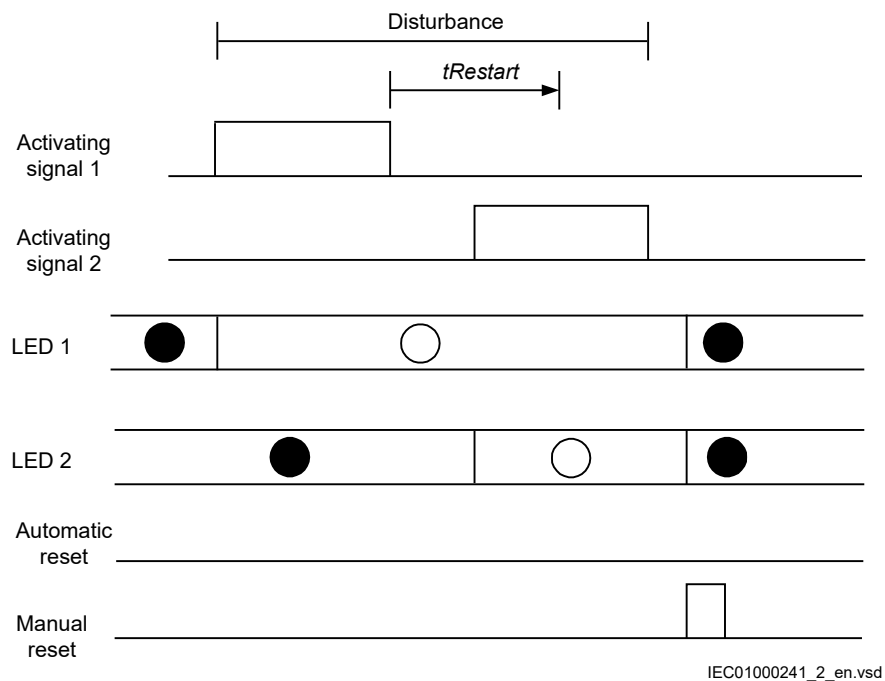


Figure 21: Operating sequence 6 (LatchedReset-S), two indications within same disturbance but with reset of activating signal between

[Figure 22](#) shows the timing diagram for manual reset.

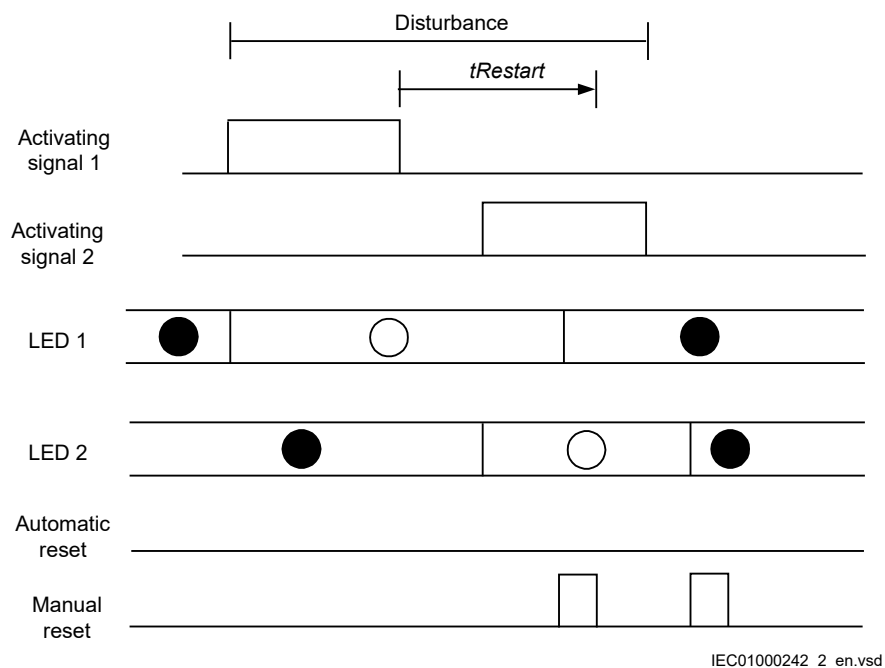


Figure 22: Operating sequence 6 (LatchedReset-S), manual reset

5.6 Function keys

5.6.1 Identification

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

5.6.2 Functionality

Local Human-Machine-Interface (LHMI) has five function keys, 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 key 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.

Pressing any function key will first display the list of corresponding labels on the LHMI screen. Only when this list is displayed, the associated functions can be executed, see User manual for more information.

5.6.3 Function block

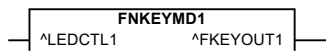


Figure 23: FNKEYMD1 function block

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

5.6.4 Signals

Table 17: FNKEYMD1 Input signals

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

Table 18: FNKEYMD1 Output signals

Name	Type	Description
FKEYOUT1	BOOLEAN	Output controlled by function key

5.6.5 Settings

Table 19: 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 20: FNKEYTY1 Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Type	Off Menu shortcut Control	-	-	Off	Function key type
MenuShortcut		-		0	Menu shortcut for function key

5.6.6 Operation principle

Each output on the FNKEYMD1 - FNKEYMD5 function blocks can be controlled from the LHMI function keys. When used in operation mode (*Type* setting) 'Control', pressing a function key controls the output signal of the respective function block. 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 govern its behavior. These settings and parameters are normally defined in the pre-configuration and can be modified by using the PST.

5.6.6.1 Operating sequence in Control mode

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

Setting *OFF*

This mode always keeps the output at 0 (low). Pressing the function key does not affect the output value.

Setting *TOGGLE*

In this mode, pressing the function key for minimum 0.5 seconds (detection period, not changeable) toggles the output between 0 (low) and 1 (high). Key presses shorter than the detection period are ignored.

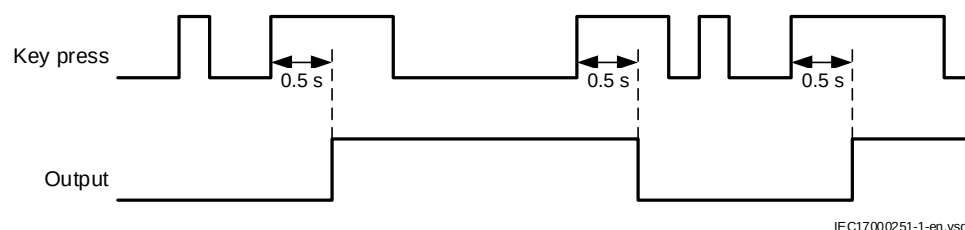


Figure 24: Sequence diagram for setting *TOGGLE*

Setting *PULSED*

In this mode, pressing the function key for minimum 0.5 seconds (detection period, not changeable) changes the output to 1 (high). After a time defined by *PulseTime*, the output will return to 0 (low) irrespective of the status of the function key.

If the function key is pressed again, a new pulse will be generated only if the output is 0 at the end of the detection period. See [Figure 25](#).

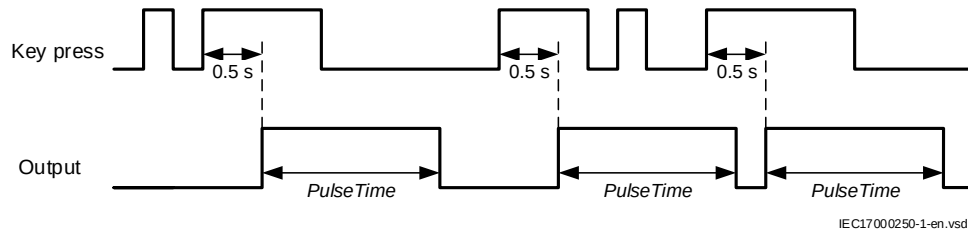


Figure 25: Sequence diagram for setting *PULSED*

5.6.6.2 Input function

The binary input LEDCTL is active only when *Type* is set to 'Control'. In this mode, the status (ON/OFF) of the yellow LED on the function key directly follows the status of LEDCTL. This functionality is independent of the *Mode* setting.

Section 6 Web HMI (WHMI)

The WHMI provides a remote user interface on a common Internet browser via Ethernet link. The functionality is explained in the User manual.

Basic operation of the WHMI is configured by the WEBSERVER function block.

After storing an operation record or waveform record, a background function updates an internal table of matching records: If the time stamps of an operation record and a waveform record are within ± 20 ms of each other, they are assumed to describe the same switching operation. In WHMI, this information is used for creating hyperlinks, to allow directly jumping between views.

Section 7 Controlled Switching and Monitoring

7.1 Introduction

The function blocks described in this section are at the core of the controlled switching functionality. These function blocks have strong interdependency and are combined in this section to explain the concept and the functional interactions.



Controlled switching is not a category of function blocks in PCM600 and LHMI.

Controlled switching (also known as point-on-wave switching or synchronous switching) is defined as controlling the circuit breaker in such a manner that the instant of current inception (on closing) or contact separation (on opening) occurs at an instant that is optimal for the circuit breaker, the load, and/or power quality.

A Switchsync PWC600 IED controls the instants at which the circuit breaker operates, monitors the switching operation and logs the monitored data. To achieve this, various function blocks perform specific functionalities; they are listed in [Table 21](#).

Table 21: Core application functions in PWC600

Function name	Description	Instances in pre-configuration	Function category in PCM600, LHMI, WHMI
ANSGPROC	Extracts zero crossings, amplitudes, and half cycle times from reference voltage and current signals	1	Basic IED functions
SSCPOW	Determines and releases controlled switching commands to the circuit breaker	1	Control
ACBMSCBR	Monitors switching operation of the circuit breaker	3 (one per phase)	Monitoring
TRAFOSWT (PWC600-HT only)	Calculates residual fluxes and derives optimal energization targets for power transformer	1	Monitoring
OPERLOG, OPLOGTRIG	Stores monitored data in the operation log database	12+1	Monitoring

This section explains the operation principle from the product user's view point.

7.2 Operation principle

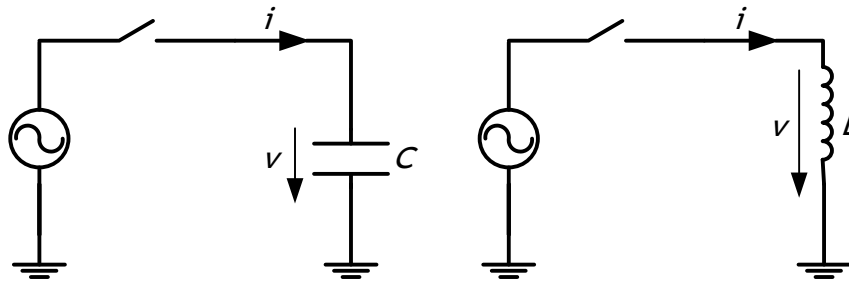
A random instant of switching the circuit breaker might impact the load, power system or circuit breaker contacts because of high voltage or current transients or re-ignitions/re-strikes in the CB. Conversely, controlled switching of the circuit breaker can avoid harmful transients in the network and also increase the life time of the circuit breaker and/or the switched load.

The selection of the target phase angles for energization (making targets) depends on the basic capacitive or reactive nature of the load. Capacitive loads should be energized at voltage zero across the circuit breaker. This switching strategy ensures low inrush currents and low transient voltages. Refer [Equation 1](#) for relation of voltage across the capacitive load and current through it.

$$i = C \cdot \frac{dv}{dt}$$

(Equation 1)

If energization happens at zero voltage, the instantaneous current drawn is marginal.



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Figure 26: Capacitive and inductive loads

Inductive loads without residual magnetic flux are energized at a reference voltage maximum (peak). This switching strategy ensures symmetric current and thus prevents saturation. Refer to [Equation 2](#) for the relation of voltage across the inductive load and current through it.

$$i = \frac{1}{L} \int v \cdot dt$$

(Equation 2)

If energization occurs at voltage peak, the inductive current is symmetric from the start.

For CB opening, the phase angle of current interruption cannot be specified by the user but it is determined by the breaker and the load. After opening the primary contacts of the circuit breaker, current flow will continue until the next natural current zero for most load types. However, controlled opening (contact separation) at the optimal phase angle will minimize the likelihood of harmful re-ignitions or re-strikes in the circuit breaker.

Capacitive loads need to be de-energized such that by the time the current is interrupted at its natural zero, the circuit breaker contacts have separated sufficiently far for the dielectric strength of the contact gap more to exceed the voltage appearing across it. This switching strategy ensures that the circuit breaker won't restrike.

[Figure 27](#) shows the CB primary contacts opening at time t_{open} . The current continues to flow till its natural current zero (t_{int}). Restrike can be avoided if the circuit breaker regains its dielectric strength after current interruption such that it is always greater than the voltage appearing across it.

For de-energizing capacitive loads, the arcing time ($T_{arc} = t_{int} - t_{open}$) should be set such that it allows the circuit breaker to gain as much dielectric strength as possible by the time of interruption, subject to the condition that mechanical scatter doesn't shift t_{open} beyond the preceding current zero crossing.

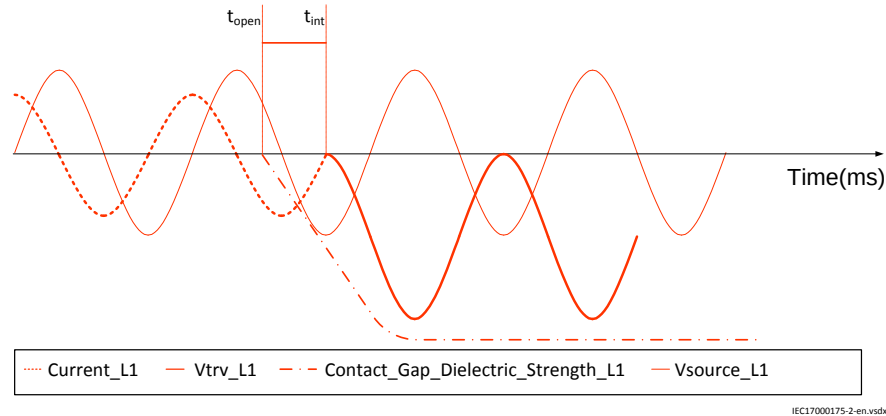


Figure 27: Capacitive load de-energization

Inductive loads, upon interruption of current, create high-frequency Transient Recovery Voltages (TRV). Similar to the case of de-energization of capacitive loads, the circuit breaker should have gained sufficient dielectric strength to avoid re-ignitions after current interruption.

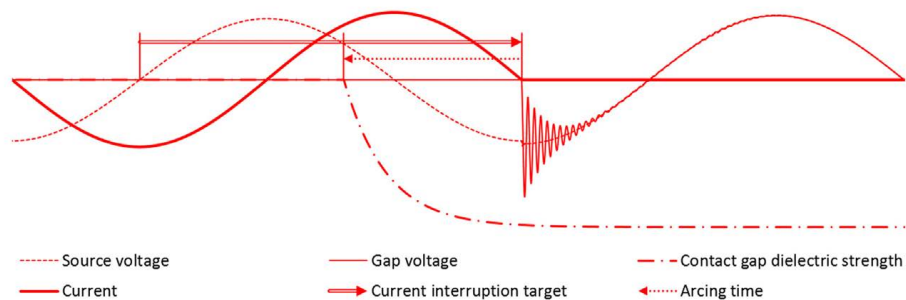


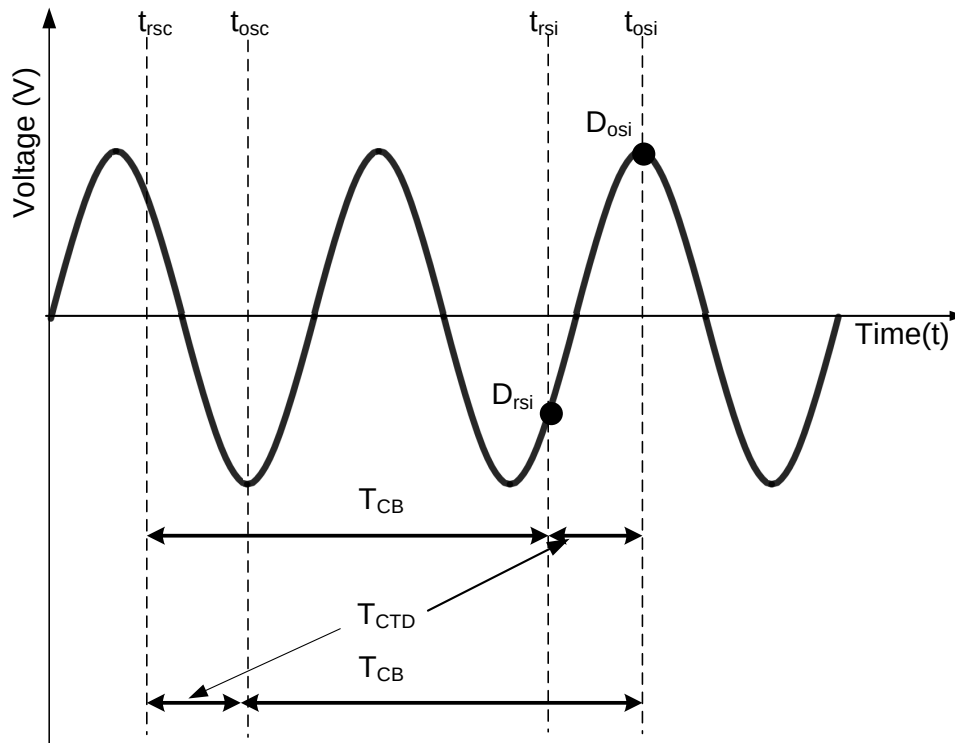
Figure 28: Reactor de-energization

Generally, targeting high arcing time for interrupting inductive current can increase the current chopping, thus creating higher TRV. Conversely, targeting low arcing time can help in reducing the TRV but the circuit breaker might not gain sufficient dielectric strength to withstand the TRV after initial interruption. The minimum arcing time for re-ignition free interruption of a circuit breaker can be deduced from inductive switching type tests for the specific circuit. By default, PWC600 applies a compromise strategy of opening the primary contacts in the middle between the minimum arcing time defined for the specific circuit breaker model and the nominal half cycle length of power frequency. This algorithm is implemented in Switchsync Setting Tool (SST) and described in more detail in the User Manual.

In case of a transformer, the charging current is usually so small that a modern circuit-breaker will extinguish it by chopping within a very short time, usually not exceeding a millisecond. Thus, the instant of contact separation will essentially coincide with the interruption instant.

[Figure 29](#) shows an ideal circuit breaker closing on a grounded single phase reactive load. Assuming no energy is stored in the reactor prior to energization, the source voltage wave shown in the figure will appear across the circuit breaker contacts until the circuit breaker closes electrically. If a command is given at any random instant t_{rsc} to the circuit breaker, the circuit breaker will close electrically at t_{rsi} and mechanically after the circuit breaker operating time T_{CB} . However, the random point on wave D_{rsi} at which this switching happens might create undesirable transients. In such circumstances, it is recommended to optimize the switching targets based on the design and connection configuration of connected load that need to be switched. A point-on-wave controller such as PWC600 analyzes the reference voltage signal and identifies a favorable switching target (D_{osi} , at

time t_{osi}) for the reactive load. Now the controller delays the command by $T_{CTD} = t_{osi} - t_{rsi}$ (controller time delay) and releases it to circuit breaker at t_{osc} . This will result into making of the current at instant t_{osi} considering the circuit breaker closing time of T_{CB} .



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Figure 29: Principle of controlled switching (single phase)

Where

t_{rsc} = instant of random switching command

t_{osc} = instant of delayed (point-on-wave controlled) switching command

t_{rsi} = instant of random switching instant without point-on-wave control

t_{osi} = instant of optimal switching instant

T_{CB} = circuit breaker operating time

T_{CTD} = controller time delay

D_{rsi} = point on wave for random switching

D_{osi} = optimal (target) point on wave

After releasing the switching command, the controller monitors the switching operation to evaluate various electrical and mechanical parameters of CB, like electrical operating time, mechanical operating time etc. These monitored parameters are used for assessing the success of the performed operation and the health of the circuit breaker, as well as for adapting the operating parameters for subsequent operations so as to achieve optimal point-on-wave performance. Key parameters will also be logged for future analysis.

Actual switching operations can be monitored by analyzing the timing of mechanical status feedback contacts (precision auxiliary contacts) and/or the primary current or load voltage signals. [Figure 30](#) and [Figure 31](#) show single-line diagrams with possible feedback options.

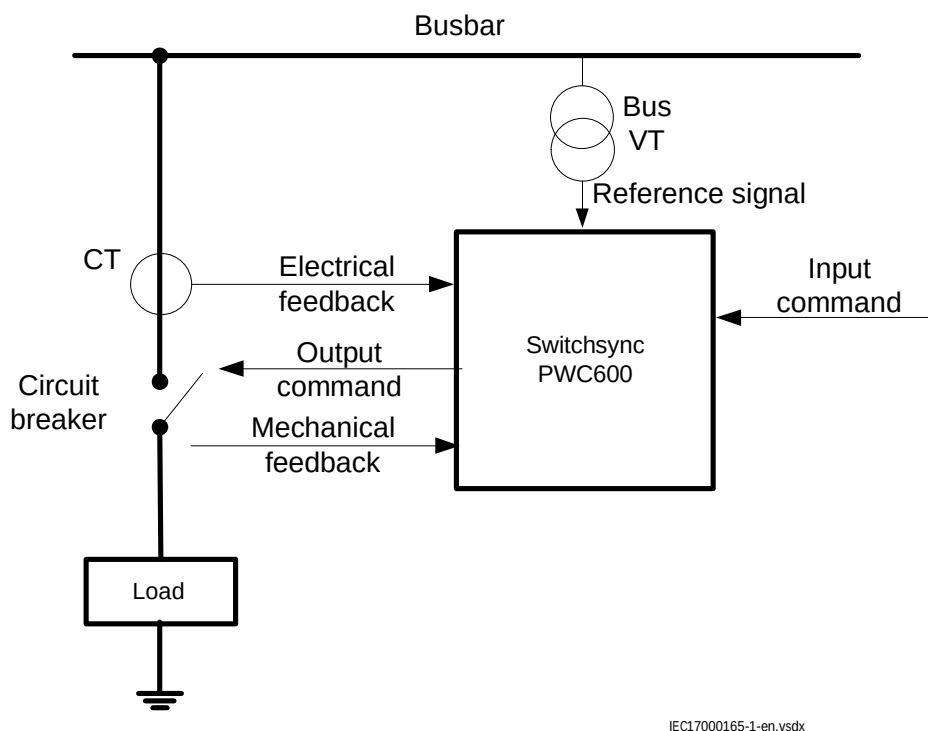


Figure 30: Controlled switching with current feedback

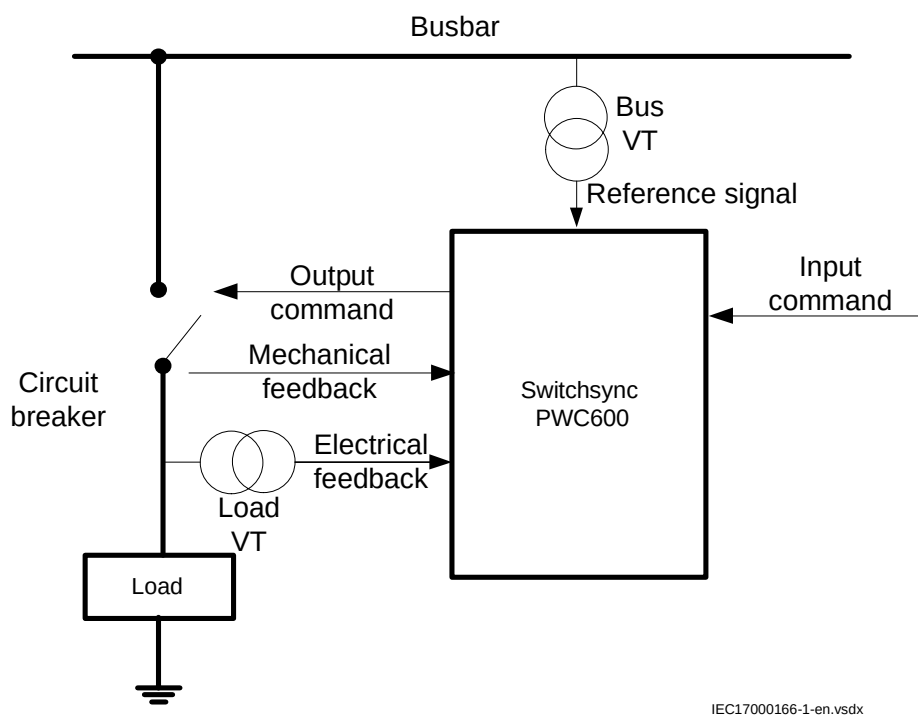


Figure 31: Controlled switching with load voltage feedback

To achieve the desired control, monitoring and data logging functionality in PWC600, several function blocks work in close coordination. [Figure 32](#) shows the main involved function blocks with their interconnections. Control functionality is mainly handled by SSCPOW function. Monitoring and data acquisition is handled by ACBMSCBR function, individually per phase. CBCOMP takes the external parameters like idle time, drive pressure, temperature and spring charge as inputs and provides the corresponding compensation values per phase.

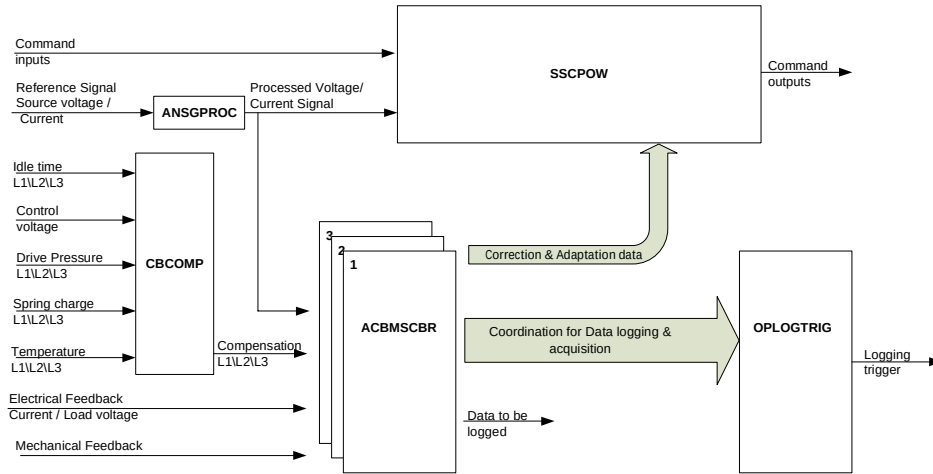


Figure 32: Main application functions in PWC600

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
Breaker close/trip circuit monitoring	TCSSCBR	-	-

8.1.2 Functionality

The trip circuit supervision function TCSSCBR is designed to supervise the control circuit of the circuit breaker. The trip circuit supervision generates a current of approximately 1 mA through the supervised control circuit. The validity supervision of a control circuit is provided for power output contacts T1, T2 and T3.

The trip circuit supervision operates after a settable definite operating time and resets after a settable definite time when the fault disappears.

8.1.3 Function block



Figure 33: Function block

8.1.4 Signals

Table 22: 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 23: TCSSCBR Output signals

Name	Type	Description
ALARM	BOOLEAN	Trip circuit fault indication

8.1.5 Settings

Table 24: 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
tReset	0.020 - 60.000	s	0.001	0.500	Reset time delay

8.1.6 Operation principle

The TCSSCBR function expects the logical state of the supervised control circuit at its TCS_STATE input: 0 indicates intact circuit, whereas 1 indicates a circuit fault (short circuit or open circuit).

Activating TCS_STATE (input value changed to 1) starts an internal operation timer. This timer continues counting even if TCS_STATE is deactivated again. When the operation timer has reached the limit set by *tDelay* and TCS_STATE is 1, the ALARM output is activated. It remains active for as long as both conditions are fulfilled.

Deactivating TCS_STATE starts an internal reset timer. This timer is reset whenever TCS_STATE is activated. When the reset timer has reached the limit set by *tReset* and TCS_STATE is still 0, it resets the operation timer. This can be used to suppress short spikes in the supervision signal.

Activation of the BLOCK input deactivates the ALARM output and resets the internal timers.

Section 9 Control

9.1 Selector mini switch VSGGIO

9.1.1 Identification

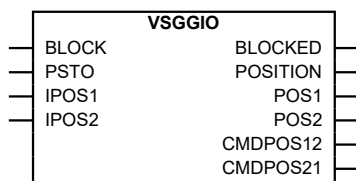
Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Selector mini switch	VSGGIO	-	-

9.1.2 Functionality

The Selector mini switch VSGGIO can be used for a variety of applications, as a general purpose switch. It can be used for two purposes:

- Acquiring an external switch position at its inputs. This information can be represented on the single line diagram by a controllable switch symbol, or used further in the application.
- Issuing switching commands on its outputs. Here, VSGGIO can be controlled from the menu or from a symbol on the single line diagram (SLD) on the local HMI.

9.1.3 Function block



IEC09000341-1-en.vsd

9.1.4 Signals

Table 25: 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 26: VSGGIO Output signals

Name	Type	Description
BLOCKED	BOOLEAN	The function is active but the functionality is blocked
POSITION	INTEGER	Position indication, integer
POS1	BOOLEAN	Position 1 indication, logical signal
Table continues on next page		

Name	Type	Description
POS2	BOOLEAN	Position 2 indication, logical signal
CMDPOS12	BOOLEAN	Execute command from position 1 to position 2
CMDPOS21	BOOLEAN	Execute command from position 2 to position 1

9.1.5 Settings

Table 27: 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 length
PosUndefined	13 characters	-	-	P00	User defined string for undefined position
Position1	13 characters	-	-	P01	User defined string for position 1
Position2	13 characters	-	-	P10	User defined string for position 2
PosBadState	13 characters	-	-	P11	User defined string for bad state

9.1.6 Operation principle

Selector mini switch (VSGGIO) function can be used for dual purpose.

- For indicating the position of a switch, or for displaying a text string based on the input position value, on the single line diagram (SLD). The position is obtained as bit-wise combination of the IPOS1 and IPOS2 inputs as per [Table 28](#). In the application, the position information is made available as integer value on the POSITION output, or on POS1 and POS2 for the individual bits. On an IEC 61850 station bus, the position can be distributed to MMS clients through reporting, or to other IEDs as a double-point GOOSE message.
- 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.



For indication in the SLD, associate VSGGIO (in GDE tool in PCM600) with the *Input signal* of a switchgear symbol (indication only) or of a Dynamic Text.

The PSTO input selects the operator's location, either from local HMI (Local) or through IEC 61850 (Remote). Input value 1 will allow operation from local HMI.

Both indications and commands use double-point representation, where a combination of two binary signals represents the switch position. The following table shows the relationship between IPOS1/ IPOS2 inputs and the corresponding positions.

Table 28: Mapping of binary input signals to switch position

IPOS1	IPOS2	Position	Setting name of display string	Default display string
0	0	0	<i>PosUndefined</i>	P00
1	0	1	<i>Position1</i>	P01
0	1	2	<i>Position2</i>	P10
1	1	3	<i>PosBadState</i>	P11

Activating the BLOCK input will freeze all indication outputs at their current values and activate the BLOCKED output. Setting *Operation* to "Off" will force all outputs to 0.

9.2 IEC 61850 generic communication I/O functions DPGGIO

9.2.1 Identification

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

9.2.2 Functionality

The IEC 61850 generic communication I/O functions DPGGIO function block is used to send double point indications to other systems or equipment in the substation via IEC61850 station bus. It is especially used in the interlocking and reservation station-wide logics.

9.2.3 Function block

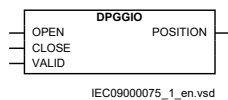


Figure 34: DPGGIO function block

9.2.4 Signals

Table 29: DPGGIO Input signals

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

Table 30: DPGGIO Output signals

Name	Type	Description
POSITION	INTEGER	Double point indication

9.2.5 Settings

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

9.2.6 Operation principle

When receiving the input signals, DPGGIO sends the signals over IEC 61850-8-1 to the systems, equipment or functions that requests and thus subscribes on these signals. To be able to get the signals into other systems, equipment or functions, one must use other tools, described in the Engineering manual, and define which function block in which systems, equipment or functions should receive this information.

More specifically, DPGGIO function reports a combined double point position indication output POSITION evaluated from its input values.

When the input signal VALID is active, the values of the OPEN and CLOSE inputs determine the two-bit integer value of the output POSITION. The output timestamp will be set to the system time when the function block actually executed.

When the input signal VALID is inactive, DPGGIO function forces the position to intermediate state.

When the value of the input signal VALID changes, the output timestamp will be set to the system time when the function block actually executed.

Refer to [Table 31](#) for the input-output relationship in terms of the value and the quality attributes.

Table 31: Logic table of DPGGIO

VALID	OPEN	CLOSE	POSITION	
			Value	Description
0	-	-	0	Intermediate
1	0	0	0	Intermediate
1	1	0	1	Open
1	0	1	2	Closed
1	1	1	3	Bad State

9.3 Point-on-wave switching control SSCPOW

9.3.1 Identification

Function description	IEC 61850 identification
Point-on-wave switching control	SSCPOW

9.3.2 Functionality

Traditionally, closing and opening commands will switch the circuit breaker at random instant of voltage or current wave, without considering the optimal point of switching. Controlled switching defines the use of numerical IEDs to determine the optimal switching point of the load on the system voltage wave. To cater the above requirement, a POW (point-on-wave) controller must be able to deliver synchronized switching commands for future switching instants on the voltage or current waveform for independent poles or phases. This optimal switching operation leads to minimization of stress across the arcing contacts of the circuit breaker and minimizes the inrush current. The POW controller also takes into account the statistical nature of circuit breaker in terms of mechanical and

electrical scatter of switching times. Furthermore, it optimizes the targeting accuracy by compensating the dependency of mechanical operating times on ambient parameters such as control voltage, temperature, drive pressure, and by adaptively correcting the CB release instants based on the target errors in the last operation.

SSCPOW provides the core functionality of controlled switching, which is to generate synchronized closing and opening commands to the three poles of the circuit breaker based on information from other functions.

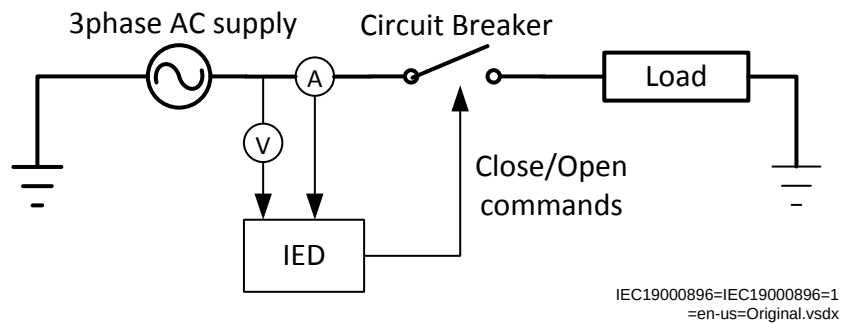


Figure 35: Application of a controlled switching device (POW controller, IED)

[Figure 35](#) displays a general application of a controlled switching device where the IED controls the closing and/or opening of a circuit breaker connected to a 3-phase AC source and to a load. The IED determines optimal switching instants based on the user defined settings and thus issues close/open commands to the CB.

9.3.3 Function block

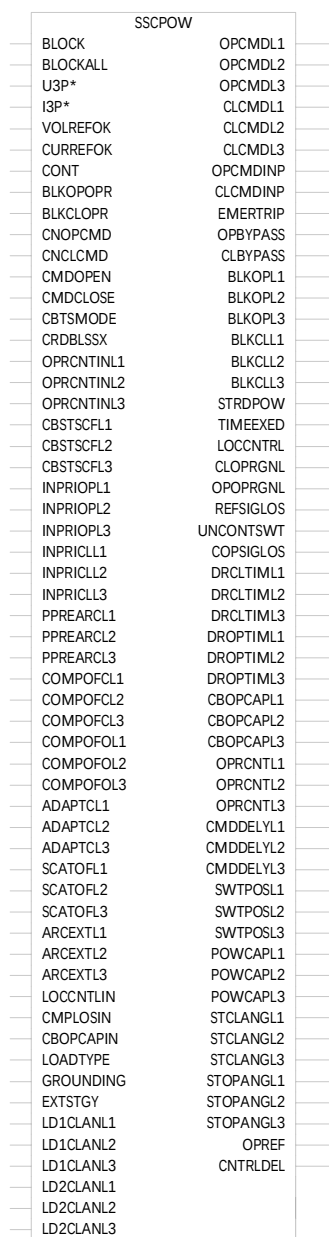


Figure 36: Function block diagram

* Denotes grouped input connections.

9.3.4 Signals

Table 32: SSCPOW Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block all binary outputs
BLOCKALL	BOOLEAN	0	Block all switching operations and triggering of operation log
U3P	GROUP SIGNAL	-	Three-phase reference voltage
I3P	GROUP SIGNAL	-	Three-phase reference current
VOLREFOK	BOOLEAN	0	Voltage signal is suitable as reference
CURREFOK	BOOLEAN	0	Current signal is suitable as reference
CONT	BOOLEAN	0	Apply contingency mode (block/bypass) to switching commands
BLKOPOPR	BOOLEAN	0	Block CB opening operations
BLKCLOPR	BOOLEAN	0	Block CB closing operations
CNOPCMD	BOOLEAN	0	Cancel signal from PIO board for unsuccessful opening command operation
CNCLCMD	BOOLEAN	0	Cancel signal from PIO board for unsuccessful closing command operation
CMDOPEN	BOOLEAN	0	Incoming controlled opening command
CMDCLOSE	BOOLEAN	0	Incoming controlled closing command
CBTSMODE	BOOLEAN	0	Circuit breaker timing test mode activated
CRDBLSSX	INTEGER	0	Coordination input from CBLEARN to SSCPOW
OPRCNTINL1	INTEGER	0	Operation count of phase L1
OPRCNTINL2	INTEGER	0	Operation count of phase L2
OPRCNTINL3	INTEGER	0	Operation count of phase L3
CBSTSCFL1	INTEGER	0	Circuit breaker position input from ACBMSCBR for phase L1
CBSTSCFL2	INTEGER	0	Circuit breaker position input from ACBMSCBR for phase L2
CBSTSCFL3	INTEGER	0	Circuit breaker position input from ACBMSCBR for phase L3
INPRIOPL1	REAL	0.0	Nominal time from Open command to main contact separation in phase L1
INPRIOPL2	REAL	0.0	Nominal time from Open command to main contact separation in phase L2
INPRIOPL3	REAL	0.0	Nominal time from Open command to main contact separation in phase L3
INPRICLL1	REAL	0.0	Nominal time from Close command to main contact touch in phase L1
INPRICLL2	REAL	0.0	Nominal time from Close command to main contact touch in phase L2
INPRICLL3	REAL	0.0	Nominal time from Close command to main contact touch in phase L3
PPREARCL1	REAL	0.0	Predicted pre-arcing time for closing of phase L1
PPREARCL2	REAL	0.0	Predicted pre-arcing time for closing of phase L2
PPREARCL3	REAL	0.0	Predicted pre-arcing time for closing of phase L3
COMPOFCL1	REAL	0.0	Mechanical compensation offset for closing instant in phase L1
COMPOFCL2	REAL	0.0	Mechanical compensation offset for closing instant in phase L2

Table continues on next page

Name	Type	Default	Description
COMPOFCL3	REAL	0.0	Mechanical compensation offset for closing instant in phase L3
COMPOFOL1	REAL	0.0	Mechanical compensation offset for opening instant in phase L1
COMPOFOL2	REAL	0.0	Mechanical compensation offset for opening instant in phase L2
COMPOFOL3	REAL	0.0	Mechanical compensation offset for opening instant in phase L3
ADAPTCL1	REAL	0.0	Adaptive switching correction offset for phase L1
ADAPTCL2	REAL	0.0	Adaptive switching correction offset for phase L2
ADAPTCL3	REAL	0.0	Adaptive switching correction offset for phase L3
SCATOF1	REAL	0.0	Switching target offset for mechanical closing time scatter in phase L1
SCATOF2	REAL	0.0	Switching target offset for mechanical closing time scatter in phase L2
SCATOF3	REAL	0.0	Switching target offset for mechanical closing time scatter in phase L3
ARCEXTL1	REAL	0.0	Adaptive extension of target arcing time for opening of phase L1
ARCEXTL2	REAL	0.0	Adaptive extension of target arcing time for opening of phase L2
ARCEXTL3	REAL	0.0	Adaptive extension of target arcing time for opening of phase L3
LOCNTLIN	BOOLEAN	0	Local control indication
CMPLOSIN	BOOLEAN	0	Loss of compensation input signal
CBOPCAPIN	INTEGER	0	Circuit breaker operating capability input from MONALM
LOADTYPE	INTEGER	1	Type of switched load for selecting opening and closing strategy
GROUNDING	INTEGER	0	Type of grounding for selected load type
EXTSTGY	BOOLEAN	0	Apply external switching targets
LD1CLANL1	REAL	0.0	Load 1 external target making angle in degrees for phase L1
LD1CLANL2	REAL	0.0	Load 1 external target making angle in degrees for phase L2
LD1CLANL3	REAL	0.0	Load 1 external target making angle in degrees for phase L3
LD2CLANL1	REAL	0.0	Load 2 external target making angle in degrees for phase L1
LD2CLANL2	REAL	0.0	Load 2 external target making angle in degrees for phase L2
LD2CLANL3	REAL	0.0	Load 2 external target making angle in degrees for phase L3

Table 33: SSCPOW Output signals

Name	Type	Description
OPCMDL1	BOOLEAN	Time activated synchronous open command for phase L1
OPCMDL2	BOOLEAN	Time activated synchronous open command for phase L2
OPCMDL3	BOOLEAN	Time activated synchronous open command for phase L3
CLCMDL1	BOOLEAN	Time activated synchronous close command for phase L1
CLCMDL2	BOOLEAN	Time activated synchronous close command for phase L2
CLCMDL3	BOOLEAN	Time activated synchronous close command for phase L3
OPCMDINP	BOOLEAN	Latched received Open command
CLCMDINP	BOOLEAN	Latched received Close command
EMERTRIP	BOOLEAN	Emergency trip indication for immediate trip operation
OPBYPASS	BOOLEAN	Open command bypasses point-on-wave control
CLBYPASS	BOOLEAN	Close command bypasses point-on-wave control
BLKOPL1	BOOLEAN	Open operation blocked in phase L1
Table continues on next page		

Name	Type	Description
BLKOPL2	BOOLEAN	Open operation blocked in phase L2
BLKOPL3	BOOLEAN	Open operation blocked in phase L3
BLKCLL1	BOOLEAN	Close operation blocked in phase L1
BLKCLL2	BOOLEAN	Close operation blocked in phase L2
BLKCLL3	BOOLEAN	Close operation blocked in phase L3
STRDPOW	BOOLEAN	Point-on-wave switching operation active
TIMEEXED	BOOLEAN	Maximum allowed time for operation exceeded
LOCNTRL	BOOLEAN	Local control indication
CLOPRGNL	BOOLEAN	CB Close operation initiated
OPOPRGNL	BOOLEAN	CB Open operation initiated
REFSIGLOS	BOOLEAN	Loss of reference signal
UNCONTSWT	BOOLEAN	Last switching operation was not point-on-wave controlled
COPSIGLOS	BOOLEAN	Loss of any enabled compensation signal
DRCLTIML1	BOOLEAN	Synchronous close command time of phase L1 for disturbance recording
DRCLTIML2	BOOLEAN	Synchronous close command time of phase L2 for disturbance recording
DRCLTIML3	BOOLEAN	Synchronous close command time of phase L3 for disturbance recording
DROPTIML1	BOOLEAN	Synchronous open command time of phase L1 for disturbance recording
DROPTIML2	BOOLEAN	Synchronous open command time of phase L2 for disturbance recording
DROPTIML3	BOOLEAN	Synchronous open command time of phase L3 for disturbance recording
CBOPCAPL1	INTEGER	Circuit breaker operating capability for phase L1
CBOPCAPL2	INTEGER	Circuit breaker operating capability for phase L2
CBOPCAPL3	INTEGER	Circuit breaker operating capability for phase L3
OPRCNTL1	INTEGER	Operation count output for phase L1
OPRCNTL2	INTEGER	Operation count output for phase L2
OPRCNTL3	INTEGER	Operation count output for phase L3
CMDDELYL1	REAL	Time difference from command input to command output for phase L1, in ms
CMDDELYL2	REAL	Time difference from command input to command output for phase L2, in ms
CMDDELYL3	REAL	Time difference from command input to command output for phase L3, in ms
SWTPOSL1	INTEGER	CB position indication for phase L1
SWTPOSL2	INTEGER	CB position indication for phase L2
SWTPOSL3	INTEGER	CB position indication for phase L3
POWCAPL1	INTEGER	Point-on-wave switching capability indication for phase L1
POWCAPL2	INTEGER	Point-on-wave switching capability indication for phase L2
POWCAPL3	INTEGER	Point-on-wave switching capability indication for phase L3
STCLANGL1	REAL	Target current making angle for phase L1, in deg
STCLANGL2	REAL	Target current making angle for phase L2, in deg
Table continues on next page		

Name	Type	Description
STCLANGL3	REAL	Target current making angle for phase L3, in deg
STOPANGL1	REAL	Target current interruption angle for phase L1, in deg
STOPANGL2	REAL	Target current interruption angle for phase L2, in deg
STOPANGL3	REAL	Target current interruption angle for phase L3, in deg
OPREF	BOOLEAN	Reference signal used in last controlled opening operation
CNTRLDEL	REAL	Controller delay from command input to last command output in last switching operation, in ms

9.3.5 Settings

Table 34: SSCPOW Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	On	Operation Mode Off / On
CompSigLosAlm	Disable Enable	-	-	Disable	Enable / Disable alarm for loss of compensation signal
ContDelayExdAlm	Disable Enable	-	-	Disable	Enable / Disable alarm for maximum controller delay exceeded
RefSignalLossAlm	Disable Enable	-	-	Disable	Enable / Disable alarm for reference signal lost
UncontSwitchAlm	Disable Enable	-	-	Disable	Enable / disable alarm for uncontrolled switching operation executed

Table 35: SSCPOW Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
CntrlOperType	Close Open Open & Close	-	-	Close	Switching operation(s) to be controlled
CloseTargetL1	-1800 - 1800	Deg	1	0	Target making angle (relative to positive zero crossing) for L1 phase
CloseTargetL2-L1	-1800 - 1800	Deg	1	0	Target making angle (relative to CloseTargetL1) for L2 phase
CloseTargetL3-L1	-1800 - 1800	Deg	1	0	Target making angle (relative to CloseTargetL1) for L3 phase
InputSelect	Load 1 Load 2	-	-	Load 1	Source of external target making angles to be used for controlled closing
OpenTargetL1	-1800 - 1800	Deg	1	0	Target contact separation angle (relative to positive zero crossing) for L1 phase
OpenTargetL2-L1	-1800 - 1800	Deg	1	0	Target contact separation angle (relative to OpenTargetL1) for L2 phase
OpenTargetL3-L1	-1800 - 1800	Deg	1	0	Target contact separation angle (relative to OpenTargetL1) for L3 phase
OpenRef	Voltage Current	-	-	Voltage	Reference signal for controlled opening operations

Table 36: SSCPOW Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
CmdOffTime	100.0 - 950.0	ms	1.0	100.0	Duration of output commands
MaxContDelay	45.00 - 200.00	ms	1.00	50.00	Alarm threshold for maximum controller delay time
POWCapSet	N/A None Close Open Close & Open	-	-	N/A	Point on wave capability of circuit breaker

Table 37: SSCPOW Group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
ByPassMode	No bypass Close Open Open & Close	-	-	No bypass	Bypass open or close operations - overrules CntrlrOperType
ContingencyMode	Block Open & Close Bypass Open & Close Block Open, bypass Close Bypass Open, block Close	-	-	Bypass Open & Close	Actions to take in case controlled switching is not possible
CloseStrategySrc	Internal External control External only External / block External / bypass	-	-	Internal	Closing strategy source and fallback to be applied based on EXTSTGY

9.3.6 Monitored data

Table 38: SSCPOW Monitored data

Name	Type	Values (Range)	Unit	Description
LOCCNTRL	BOOLEAN	0=Remote 1=Local	-	Local control indication
CBOPCAPL1	INTEGER	1=None 2=Open 3=Close-Open 4=Open-Close-Open 5=Close-Open-Close-Open	-	Circuit breaker operating capability for phase L1
CBOPCAPL2	INTEGER	1=None 2=Open 3=Close-Open 4=Open-Close-Open 5=Close-Open-Close-Open	-	Circuit breaker operating capability for phase L2
CBOPCAPL3	INTEGER	1=None 2=Open 3=Close-Open 4=Open-Close-Open 5=Close-Open-Close-Open	-	Circuit breaker operating capability for phase L3
Table continues on next page				

Name	Type	Values (Range)	Unit	Description
CMDDELYL1	REAL	-	ms	Time difference from command input to command output for phase L1, in ms
CMDDELYL2	REAL	-	ms	Time difference from command input to command output for phase L2, in ms
CMDDELYL3	REAL	-	ms	Time difference from command input to command output for phase L3, in ms
SWTPOSL1	INTEGER	0=Intermediate / unknown 1=Open 2=Close	-	CB position indication for phase L1
SWTPOSL2	INTEGER	0=Intermediate / unknown 1=Open 2=Close	-	CB position indication for phase L2
SWTPOSL3	INTEGER	0=Intermediate / unknown 1=Open 2=Close	-	CB position indication for phase L3
POWCAPL1	INTEGER	1=None 2=Close 3=Open 4=Close & Open	-	Point-on-wave switching capability indication for phase L1
POWCAPL2	INTEGER	1=None 2=Close 3=Open 4=Close & Open	-	Point-on-wave switching capability indication for phase L2
POWCAPL3	INTEGER	1=None 2=Close 3=Open 4=Close & Open	-	Point-on-wave switching capability indication for phase L3
STCLANGL1	REAL	-	deg	Target current making angle for phase L1, in deg
STCLANGL2	REAL	-	deg	Target current making angle for phase L2, in deg
STCLANGL3	REAL	-	deg	Target current making angle for phase L3, in deg
STOPANGL1	REAL	-	deg	Target current interruption angle for phase L1, in deg
STOPANGL2	REAL	-	deg	Target current interruption angle for phase L2, in deg
STOPANGL3	REAL	-	deg	Target current interruption angle for phase L3, in deg
OPREF	BOOLEAN	0=Voltage 1=Current	-	Reference signal used in last controlled opening operation
CNTRLDEL	REAL	-	ms	Controller delay from command input to last command output in last switching operation, in ms

9.3.7 Operation principle

SSCPOW function can be enabled or disabled by the *Operation* setting.

The overall functionality of the SSCPOW function is shown in [Figure 37](#). This function operates on the sub-functional aspects described below.

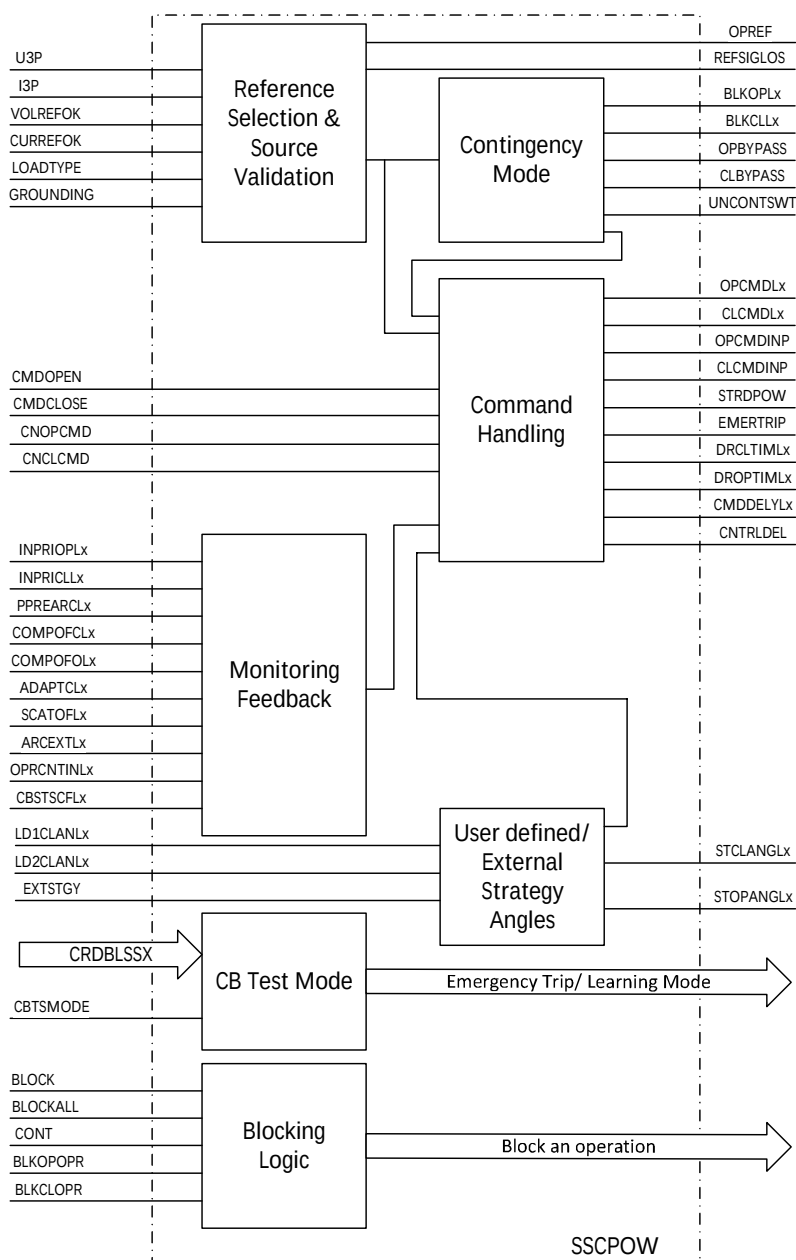


Figure 37: Overall block diagram of SSCPOW functionality

9.3.7.1 Nominal Mechanical Breaker Operating Times

The nominal mechanical breaker operating times are an integral part of the switching functionality. These characteristics are given to the function via inputs described in [Table 39](#). These inputs are used to determine the inception or interruption instants of a circuit breaker. Refer [Section 9.3.7.4](#) for a detailed elaboration. For an explanation on all the circuit breaker characteristics, refer to the chapter on ACBMSCBR function.

Table 39: Nominal operating times of circuit breaker

Interface	Type	Description
INPRIOPL1	Input	Nominal time from trip command to main contact separation for phase L1.
INPRIOPL2	Input	Nominal time from trip command to main contact separation for phase L2.
INPRIOPL3	Input	Nominal time from trip command to main contact separation for phase L3.
INPRICLL1	Input	Nominal time from close command to main contact touch for phase L1.
INPRICLL2	Input	Nominal time from close command to main contact touch for phase L2.
INPRICLL3	Input	Nominal time from close command to main contact touch for phase L3.

9.3.7.2 Reference Selection and Source Validation

To perform a controlled switching operation, the function requires a valid reference signal against which the optimal point-on-wave control must be achieved.

The function block interfaces for receiving voltage and current signal related processed data, as provided by the ANGSCAL function, are described in [Table 40](#).

Table 40: Reference voltage and current inputs

Interface	Type	Description
U3P	Input	Information on zero crossings, half-cycle times, and amplitudes in the three phases of the source voltage signals
I3P	Input	Information on zero crossings, half-cycle times, and amplitudes in the three phases of the load current signals
VOLREFOK	Input	Indicates the healthiness of connected source voltage
CURREFOK	Input	Indicates the healthiness of connected load current

The reference signal for any controlled switching operation can be:

1. Source voltage for a controlled closing operation
2. Either source voltage or load current for a controlled opening operation

The reference for an open operation described above can be selected by setting *OpenRef* as shown in [Table 41](#). The same information is updated at the output **OPREF**.

Table 41: Selection of reference signal for controlled opening operations

Interface	Type	Description
<i>OpenRef</i>	Setting	Defines the reference signal for controlled opening operation. There are two options for the setting: • Voltage (meaning source voltage) • Current (meaning load current)

Any selected reference signal is validated to be healthy, that is, suitable as reference for controlled switching before being used. If the reference signal cannot be used, reference missing condition is declared, and switching is either bypassed or blocked according to the *ContingencyMode* setting (see below). The function obtains status information of the healthiness of source at its inputs **VOLREFOK** or **CURREFOK** from other functions (usually ANSGPROC) and uses this information for its reference selection.

The conditions for using the available reference signal and for declaring missing reference are summarized in [Table 42](#).

Table 42: Use and status of reference signals

CB Status	OpenRef	VOLREFOK	CURREFOK	REFSIGLOS	Reference signal used
Open	(any)	1	(any)	0	Source voltage
Open	(any)	0	(any)	1	None
Closed	Voltage	1	(any)	0	Source voltage
Closed	Voltage	0	(any)	1	None
Closed	Current	(any)	1	0	Load current
Closed	Current	(any)	0	1	None

9.3.7.3 Controlled switching strategies

The main purpose of SSCPOW is controlling CB switching operations to occur at a desired phase angle of the reference signal in each phase. For a controlled closing operation, the function has the provision to either apply user-defined target making angles (via settings *CloseTargetLx*) or to receive the target making angles externally from other AFL functions (via inputs **LD1CLANLx/ LD2CLANLx**). For a controlled opening operation, the settings *OpenTargetLx* alone define the target switching angles. The next sub-sections describe how the function executes target switching angles for controlled closing and opening operations separately.

Controlled opening operation with user-defined target angles

For a controlled opening operation, the target switching angles define the intended point of primary contact separation in the CB. Based on the switching angles fed, SSCPOW issues open commands once an input command is received.

The target phase angles for an open operation are specified through the settings described in [Table 43](#).

Table 43: User defined controlled opening targets

Interface	Type	Description
<i>OpenTargetL1</i>	Setting	CB opening (i.e. contact separation) target in electrical degrees relative to a positive-going zero crossing of the selected reference signal, for phase L1
<i>OpenTargetL2-L1</i>	Setting	CB opening (i.e. contact separation) target in electrical degrees relative to <i>OpenTargetL1</i> , for phase L2
<i>OpenTargetL3-L1</i>	Setting	CB opening (i.e. contact separation) target in electrical degrees relative to <i>OpenTargetL1</i> , for phase L3

For example; if *OpenTargetL1* = 60°, *OpenTargetL2-L1* = -120° and *OpenTargetL3-L1* = 90°, the lead phase here is set as L2 and the contact separation instants are as shown in [Figure 38](#).

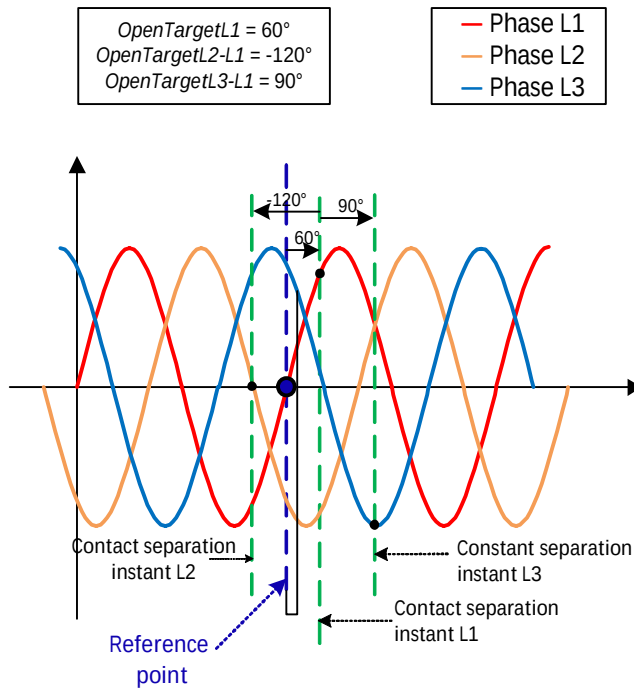


Figure 38: Target contact separation instants for all three phases

Controlled closing operation with user-defined/ external target angles based on load type

For controlled closing on any load type, the target points for current making in each phase are usually defined by the settings that are described in [Table 44](#).

Table 44: Interfaces for defining controlled closing targets

Interface	Type	Description
<i>CloseTargetL1</i>	Setting	Current making target in electrical degrees relative to a positive-going reference voltage zero crossing, for phase L1
<i>CloseTargetL2-L1</i>	Setting	Current making target in electrical degrees relative to <i>CloseTargetL1</i> , for phase L2
<i>CloseTargetL3-L1</i>	Setting	Current making target in electrical degrees relative to <i>CloseTargetL1</i> , for phase L3
LD1CLANL1	Input	External (channel 1) current making target for phase L1, in electrical degrees relative to a positive-going reference voltage zero crossing
LD1CLANL2	Input	External (channel 1) current making target for phase L2, in electrical degrees relative to LD1CLANL1
LD1CLANL3	Input	External (channel 1) current making target for phase L3, in electrical degrees relative to LD1CLANL1
LD2CLANL1	Input	External (channel 2) current making target for phase L1, in electrical degrees relative to a positive-going reference voltage zero crossing
LD2CLANL2	Input	External (channel 2) current making target for phase L2, in electrical degrees relative to LD2CLANL1
LD2CLANL3	Input	External (channel 2) current making target for phase L3, in electrical degrees relative to LD2CLANL1

Table continues on next page

Interface	Type	Description
<i>CloseStrategySrc</i>	Setting	Selection of the source of current making targets to be applied for transformer loads
<i>InputSelect</i>	Setting	Selection between external channels 1 and 2 for dynamic making targets for transformer loads
EXTSTGY	Input	Indicates valid making targets at the LD1CLANLx or LD2CLANLx inputs

For *LOADTYPE* = "Power transformer" or "Coupled transformer", dynamically determined target making angles may also be read from the inputs **LD1CLANLx** or **LD2CLANLx**. The source of making targets to be applied is selected by the *CloseStrategySrc* and *InputSelect* settings in combination with the EXTSTGY input.

For all other load types the function disregards the setting *CloseStrategySrc* and operates only on the user-defined target settings.

Target making instants (defined by settings or input signals) are defined as phase angles relative to a positive-going voltage zero crossing in L1 phase (reference phase). Although the zero-crossing time stamps are received for individual phases, all the further calculations thereafter are made w.r.t their own phases. Since the target making instants for phase L2 and phase L3 given by the user to this function are specified relative to the phase L1 making target, the function internally converts them into target making instants w.r.t their individual phases as elaborated below.

Example 1; If *CloseTargetL1* = 90°, *CloseTargetL2-L1* = 120° and *CloseTargetL3-L1* = 60° and if the phase sequence is L1-L2-L3, then the target making angles calculated from their respective phase signals as follows:

Target making angle for phase L1 (based on phase L1) = 90°

Target making angle for phase L2 (based on phase L2) = (90° + 120°) - 120° = 90°

Target making angle for phase L3 (based on phase L3) = (90° + 60°) - 240° = -90°

The target making angles defined externally or by the user via settings are available as outputs **STCLANGLx** from the function. The **STCLANGL1** output value refers to L1 phase positive going zero-crossing.

[Table 45](#) summarizes the handling of input close command for all load types. The outputs **STCLANGL1**, **STCLANGL2** and **STCLANGL3** are continuously updated with the closing target angle values displayed in [Table 45](#).

Table 45: Handling of Close commands for different load types

Load Type	CloseStrategySrc	EXTSTGY	Closing Targets taken from	Type of operation
Capacitor, (coupled) reactor, transmission line, power cable	(any)	(any)	CloseTargetL1 CloseTargetL2-L1 , CloseTargetL3-L1	Controlled closing
(Coupled) transformer	Internal only	(any)	CloseTargetL1 CloseTargetL2-L1 , CloseTargetL3-L1	Controlled closing
		0	CloseTargetL1 CloseTargetL2-L1 , CloseTargetL3-L1	Controlled closing
	External control	1	LDxCLANL1, LDxCLANL2, LDxCLANL3	Controlled closing
		(any)	LDxCLANL1, LDxCLANL2, LDxCLANL3	Controlled closing
	External/ block	0		No switching/ Operation blocked
		1	LDxCLANL1, LDxCLANL2, LDxCLANL3	Controlled closing
	External/bypass	0		Uncontrolled closing/ Operation bypassed
		1	LDxCLANL1, LDxCLANL2, LDxCLANL3	Controlled closing

Example 2; If **LOADTYPE** = "Power transformer" or "Coupled transformer", **InputSelect** = "Load1", **LD1CLANL1** = 90°, **LD1CLANL2** = 120° and **LD1CLANL3** = -60°, then L3 will be first to close and the target instants are as shown in [Figure 39](#).

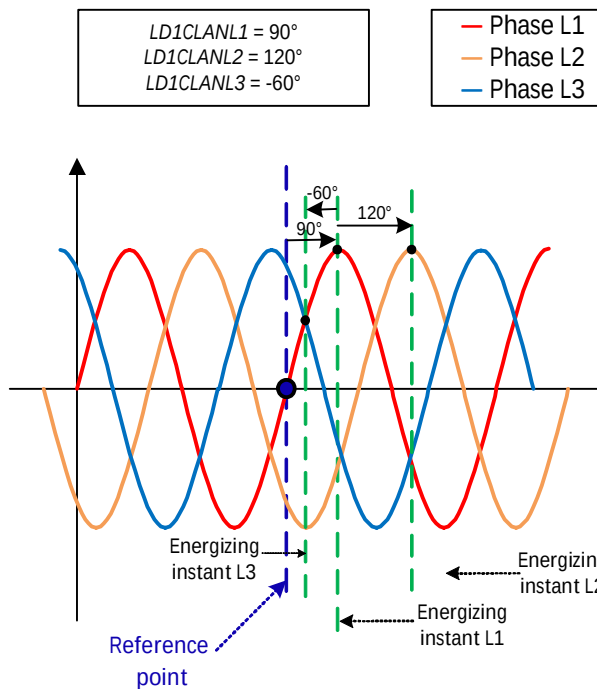


Figure 39: Target energization instants for all three phases

9.3.7.4 Controlled switching operations

Upon receiving a controlled switching command, SSCPOW converts the target switching angles into release instants for each circuit breaker pole, and transmits three different output commands with these individual time stamps to the respective PBOs. The principle is outlined in [Figure 40](#).

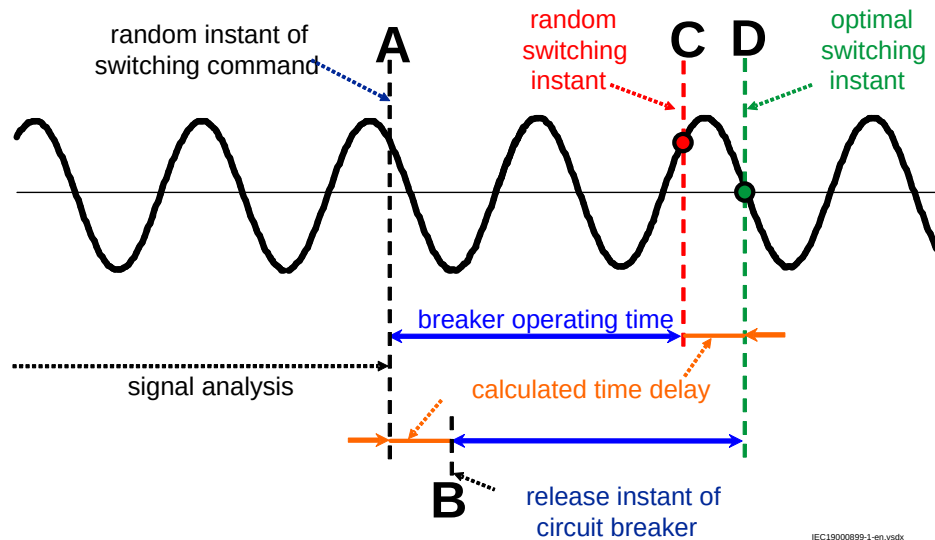


Figure 40: Principle of controlled switching

In [Figure 40](#), the analog signal displayed is either a voltage or current signal, which is used as a reference for controlled switching of the circuit breaker. Point A represents a random instant of switching command given by the user. Without controlled switching, the CB would close/open at point C (random switching instant), which is presumably not ideal for the CB, the switched load, and/or power quality. Controlled switching delays the CB operation command to occur at the optimal switching instant (point D) to minimize the transients.

SSCPOW reacts to switching commands received (point A) at its inputs described in [Table 46](#). If a switching command is received while the function is still executing another controlled switching operation, the later command is ignored.

Table 46: Command inputs

Interface	Type	Description
CMDOPEN	Input	CB opening command (from binary input)
CMDCLOSE	Input	CB closing command (from binary input)



For proper execution of a controlled switching operation, SSCPOW requires the time stamp when the original Close or Open signal input was activated. Therefore, if inserting additional logic between the respective binary inputs (in the application configuration) and the CMDOPEN / CMDCLOSE inputs of SSCPOW, make sure to use only "QT" logic functions with propagation of quality and time information.

Controlled closing and controlled opening operations are described separately below.

Controlled closing operations

Controlled closing is the technique of issuing the CB closing commands such that primary current is initiated at a desired phase angle in each phase, to minimize switching transients.

For controlled closing of a CB, consider the reference voltage in [Figure 40](#). When the user gives a CB closing command (CMDCLOSE input) at point A, which is at a random phase angle of the

reference signal, the function needs to evaluate optimal switching instants to close the CB at point D. The breaker operating time (from point A to C) is a property of each CB pole; the predicted operating times are received from other functions. Hence, the function needs to calculate this additional time delay required to reach point D.

The calculated time delay is a function of various components such as the latest zero crossing [1], the current making target, pre-arcing time, mechanical operating time, environmental factor compensation, adaptive correction of target errors, and breaker scatter correction. Starting from the latest received voltage zero crossing, as displayed in Figure 41 the function further moves ahead to the electrical (target) making instant X by adding the current making target.

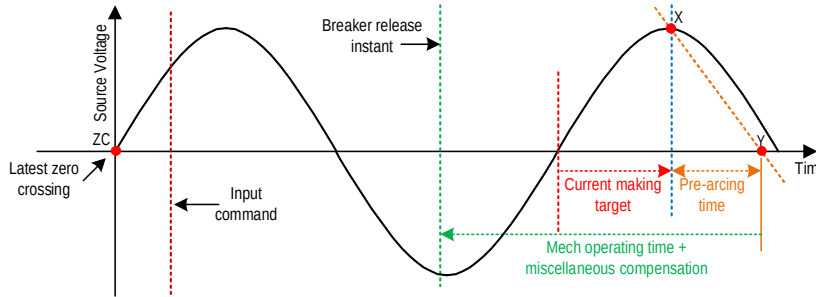


Figure 41: Evaluation of controlled closing switching instants

The current making target for each phase (relative to a positive-going voltage zero crossing in the same phase) is defined using the equations:

$$\text{Current making target}_{L1} = \text{CloseTargetL1},$$

$$\text{Current making target}_{L2} = \text{CloseTargetL1} + \text{CloseTargetL2-L1} - 120^\circ \text{ (based on the positive-going zero crossing of phase L2),}$$

$$\text{Current making target}_{L3} = \text{CloseTargetL1} + \text{CloseTargetL3-L1} - 240^\circ \text{ (based on the positive-going zero crossing of phase L3)}$$

The target making instant X is obtained by extrapolating future zero crossings (using the received average half cycle time) and selecting a reachable one, that is, farther in the future than the expected mechanical closing time. From that, the mechanical closing instant Y is achieved by adding the predicted pre-arcing time (**PPREARCLx** input) to the instant X. The breaker release instant is defined using the equation:

$$\text{Breaker release instant} = Y - (\text{Mech operating time} + \text{miscellaneous compensation})$$

where,

$$\text{Mech operating time} = \text{INPRICLLx input value}$$

$$Y = X + \text{PPREARCLx},$$

$$\text{miscellaneous compensation} = \text{COMPOFCLx} + \text{ADAPTCLx} + \text{SCATOFLx input values}$$

where,

COMPOFCLx is the total compensation of environmental factors affecting CB closing time;

ADAPTCLx is the adaptive correction value for previous targeting errors;

[1] Latest zero crossing is the last zero crossing seen by the function prior to activation of the function CMDCLOSE input.

SCATOFLx is a correction value for statistical scatter of the CB closing time.

These calculations are performed for the three phases to obtain the respective CB release instants (time stamps). Finally, the function checks whether these timestamps are farther in the future than 25ms (PIO hardware time). If this condition holds true, the function issues the same instants as three close commands on the **CLCMDL1**, **CLCMDL2**, and **CLCMDL3** outputs. Otherwise, the function adds a safe time of one power cycle to the determined timestamps and then issues the close commands.

The function raises two outputs **CLCMDINP** (issued with a timestamp) and **CLOPRGNL** (issued without a timestamp) upon receiving the input command **CMDCLOSE**. The duration of **CLCMDINP** output is same as the duration of input command received by the function. The output **CLOPRGNL** is activated by the function as soon as one of the switching commands **CLCMDL1**, **CLCMDL2** or **CLCMDL3** is activated and remains active until all three commands are deactivated.

Controlled opening operations

Controlled opening is the technique of issuing the CB opening commands such that primary contact separation will occur at a desired phase angle in each phase, to minimize the risk of re-ignitions or re-strikes in the CB or to ensure pre-determined electrical or magnetic conditions in the load.

Controlled opening of a CB can be done by using either a voltage or a current reference signal. If the current signal is not suitable as reference for current-based opening, the function fails to set a reference for controlled switching and enters contingency mode as explained in [Section 9.3.7.5.1](#).

[Figure 40](#) shows the calculated time delay for a controlled opening operation, which is a function of the latest zero crossings, the target contact separation angle, expected arcing time, mechanical operating time, environmental factor compensation and adaptive correction after detection of re-strike or re-ignition. When the voltage or current reference signal is found healthy and a CB Open command is received on the **CMDOPE**n input, the function starts from the latest received zero crossing of the reference signal, as shown in [Figure 42](#). Instant X refers to the electrical (target) interruption instant, which is usually expected to occur at a natural current zero for all load types other than (coupled) transformer. Contact separation (instant Y) is expected to precede current interruption by the target arcing time (not in the scope of this function) to allow sufficient time for build-up of dielectric strength in the interrupter.

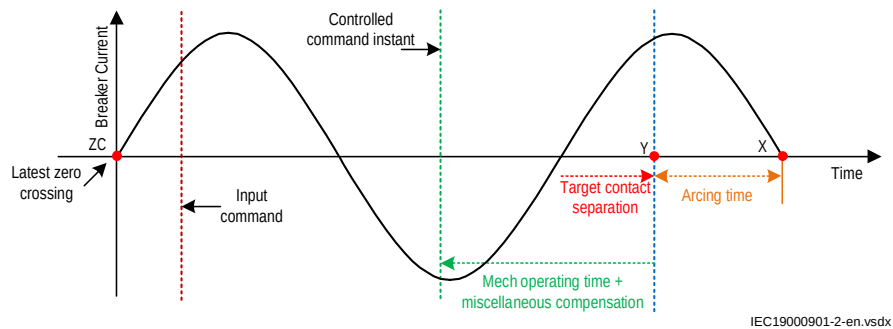


Figure 42: Evaluation of controlled opening switching instants based on breaker current

From the zero crossing, the function further moves ahead to achieve the mechanical (target) contact separation instant Y by first adding the target contact separation angle. The target contact separation for each phase (based on the respective phase) is defined by:

Contact separation target_{L1} = *OpenTargetL1*,

Contact separation target_{L2} = *OpenTargetL1* + *OpenTargetL2-L1* – 120° (based on positive going zero crossing of phase L2), and

Contact separation target_{L3} = $OpenTargetL1 + OpenTargetL3-L1 - 240^\circ$ (based on positive going zero crossing of phase L3)

The target contact separation instant Y is obtained by extrapolating future zero crossings (using the received average half cycle time) and selecting a reachable one, that is, farther in the future than the expected mechanical opening time. The breaker release instant is then defined as:

Breaker release instant = Y – (Mech operating time + miscellaneous compensation)

where,

Mech operating time = **INPRIOPLx** input value

miscellaneous compensation = **COMPOFOLx + ARCEXTLx**

where,

COMPOFOLx is the total compensation of environmental factors affecting CB opening time;

ARCEXTLx is the adaptive correction value for re-ignitions / re-strikes, received from ACBMSCBR.

These calculations are performed for the three phases to obtain the respective CB release instants (time stamps). Finally, the function checks whether these timestamps are farther in the future than 25ms (PIO hardware time). If this condition holds true, the function issues the same instants as three open commands on the **OPCMDL1**, **OPCMDL2**, and **OPCMDL3** outputs. Otherwise, the function adds a safe time of one power cycle to the determined timestamps and then issues the open commands.

The function raises two outputs **OPCMDINP** (issued with a timestamp) and **OPOPGRNL** (issued without a timestamp) upon receiving the input command **CMDOPEN**. The duration of **OPCMDINP** is same as the duration of input command received by the function. The output **OPOPGRNL** is activated by the function as soon as one of the switching commands **OPCMDL1**, **OPCMDL2** or **OPCMDL3** is activated and remains active until all three commands are deactivated.



For controlled opening, the mechanical target contact separation instants are defined by settings.

Information common to controlled closing/opening operations

The time difference between the controlled switching command for each phase and the input command is given by the outputs **CMDDELYLx**, where,

CMDDELYLx = time diff (**OPCMDLx**, **CMDOPEN**) or

CMDDELYLx = time diff (**CLCMDLx**, **CMDCLOSE**),

based on the type of input command received (either open or close command).

These values are updated when the function issues controlled switching commands and are published for a duration of 2 seconds if no input command is received within this duration. For an uncontrolled operation, these outputs are published as 0.0.

When the function receives an input command, it issues a binary output **STRDPOW** in the very next task-time indicating the start of point-on-wave controlling. This output remains active until the last controlled command output is deactivated. Since this output is an indication of controlled switching operation, it does not get activated during a bypassed or a blocked operation.

Deactivation of switching command outputs

Once the controlled switching commands are released by the function, the outputs must remain active for some time to guarantee reliable execution of the CB operation. SSCPOW uses a

configurable time for deactivating the command outputs (PBOs) after initiating a switching operation. This time is configured by the setting *CmdOffTime*.

The generated controlled switching commands are switched off after *CmdOffTime* in milliseconds for each phase individually.

9.3.7.5 Switching command handling

Contingency mode

Contingency means that SSCPOW is unable to perform a controlled switching operation. The IED is declared to be in contingency mode under any of these conditions:

1. Configured reference signal is low (**VOLREFOK/CURREFOK** = 0)
2. Application related obstacles to proper controlled switching (**CONT** = 1), e.g. due to changeover of variable reference signals

Under contingency mode, the function either:

1. Blocks the command, that is, no switching command is emitted to the CB.
2. Bypasses the command, that is, the switching commands to the CB are emitted with minimum delay for all three phases simultaneously.

Contingency actions can be individually configured for CB Open and Close operations using the setting *ContingencyMode*. For example, it can be configured to bypass Open operations and block Close operations in contingency situations.

Bypass mode

Whenever *ByPassMode* is selected by the user for any load type, any input command received by the function is executed without applying controlled switching strategies for all the three phases simultaneously. The *ByPassMode* setting provides a flexibility to selectively bypass Close or Open operations or both. These are indicated by outputs **OPBYPASS** or **CLBYPASS**. In this case, the corresponding output is activated as soon as the setting is applied by the user and will remain active until the setting is changed.

For transformer or coupled transformer load type, if *CloseStrategySrc* = "External/bypass" and **EXTSTGY** = 0, the function bypasses any close input command and it is indicated by output **CLBYPASS**. In this case, the output is activated when **EXTSTGY** = 0 and remains active until **EXTSTGY** becomes 1.

In bypass mode, SSCPOW will release the output commands 25ms (intentional delay) after receiving the input command.

Response to input command

The specific reaction to a received switching command is governed by different settings and inputs as shown in [Table 47](#). Blocking an operation means that no switching command is forwarded to the CB. Bypass indicates operation of the CB without point-on-wave control.

Table 47: SSCPOW interfaces related to responding to switching commands

Interface	Type	Description
<i>CntrlOperType</i>	Setting	Select the type of operations to be enabled (performed). It can be selected as • Open • Close • Open & Close If "Open" option is selected, closing operations are blocked. Similarly, if "Close" option is selected, opening operations are blocked.
<i>ByPassMode</i>	Setting	The operation type(s) selected in this setting are permanently bypassed if they are enabled in <i>CntrlOperType</i> setting. Options are: • No Bypass • Open • Close • Open & Close
BLKOOPR	Input	Opening operations (if enabled by <i>CntrlOperType</i> setting) will be blocked if this input is high (1).
BLKCLOPR	Input	Closing operations (if enabled by <i>CntrlOperType</i> setting) will be blocked if this input is high (1).
CONT	Input	If this input is high (1), operations enabled by <i>CntrlOperType</i> will be blocked or bypassed as per the <i>ContingencyMode</i> setting.
BLOCKALL	Input	If this input is high (1), all switching operations are blocked.
<i>ContingencyMode</i>	Setting	When conditions are not suitable for performing controlled switching, as explained above, contingency mode is activated. All permitted operations are either blocked or bypassed depending on the selection in this setting. It can be set to: • Block opening and block closing • Bypass opening and bypass closing • Block opening and bypass closing • Bypass opening and block closing
<i>CloseStrategySrc</i>	Setting	Closing strategy to be adapted based on EXTSTGY status. The following options are available: • Internal • External control (based on the status of EXTSTGY) • External only (disregards EXTSTGY status) • External / block (blocks the operation if EXTSTGY = 0) • External / bypass (performs a bypassed operation if EXTSTGY = 0) Applicable for load types of (coupled) transformer.
EXTSTGY	Input	Applies external switching targets when <i>CloseStrategySrc</i> = "External control", "External / block", or "External/bypass". Applicable for load types of (coupled) transformer.

[Table 48](#) describes the overall effect of these signals and settings on opening and closing operations for load types of capacitor, (coupled) reactor, transmission line, and power cable.

Table 48: Possible responses to switching commands

CntrlIdOperType	ByPassMode	BLKOPPR	BLKCLOPR	CONT or contingency condition	ContingencyMode	Opening operation	Closing operation
Open	No Bypass / Close	0	(any)	0	(any)	Controlled	Blocked
Open	No Bypass / Close	0	(any)	1	Block open (any option for close)	Blocked	Blocked
Open	No Bypass / Close	1	(any)	(any)	(any)	Blocked	Blocked
Open	No Bypass / Close	0	(any)	1	Bypass open (any option for close)	Bypassed	Blocked
Open	Open / Open & Close	0	(any)	1	Block open (any option for close)	Blocked	Blocked
Open	Open / Open & Close	1	(any)	(any)	(any)	Blocked	Blocked
Open	Open / Open & Close	0	(any)	0	(any)	Bypassed	Blocked
Open	Open / Open & Close	0	(any)	1	Bypass open (any option for close)	Bypassed	Blocked
Close	No Bypass / Open	(any)	0	0	(any)	Blocked	Controlled
Close	No Bypass / Open	(any)	0	1	Block close (any option for open)	Blocked	Blocked
Close	No Bypass / Open	(any)	1	(any)	(any)	Blocked	Blocked
Close	No Bypass / Open	(any)	0	1	Bypass close (any option for open)	Blocked	Bypassed
Close	Close / Open & Close	(any)	0	1	Block close (any option for open)	Blocked	Blocked
Close	Close / Open & Close	(any)	1	(any)	(any)	Blocked	Blocked
Close	Close / Open & Close	(any)	0	0	(any)	Blocked	Bypassed
Close	Close / Open & Close	(any)	0	1	Bypass close (any option for open)	Blocked	Bypassed
Open & Close	No Bypass	0	0	0	(any)	Controlled	Controlled
Open & Close	No Bypass	0	1	0	(any)	Controlled	Blocked
Open & Close	No Bypass	1	0	0	(any)	Blocked	Controlled
Open & Close	Close	0	1	0	(any)	Controlled	Blocked
Open & Close	Close	0	0	0	(any)	Controlled	Bypassed
Open & Close	Close	1	0	0	(any)	Blocked	Bypassed
Open & Close	Open	1	0	0	(any)	Blocked	Controlled
Open & Close	Open	0	0	0	(any)	Bypassed	Controlled

Table continues on next page

CntrlOperType	ByPassMode	BLKOPOPR	BLKCLOPR	CONT or contingency condition	ContingencyMode	Opening operation	Closing operation
Open & Close	Open	0	1	0	(any)	Bypassed	Blocked
Open & Close	Open/Close	1	0	0	(any)	Blocked	Bypassed
Open & Close	Open/Close	0	1	0	(any)	Bypassed	Blocked
Open & Close	Open/Close	0	0	0	(any)	Bypassed	Bypassed
Open & Close	(any)	1	1	0	(any)	Blocked	Blocked

For load type of (coupled) transformer, [Table 49](#) describes the overall effect of these signals and settings on closing operation.

Table 49: Possible responses to close commands when load type is (coupled) transformer

CloseStrategy Src	ByPassMode	EXTSTGY	BLKCLOPR	CONT or contingency condition	ContingencyMode	Closing operation
Internal/ External control/ External only	No Bypass / Open	0	0	0	(any)	Controlled
Internal/ External control/ External only	No Bypass / Open	1	0	0	(any)	Controlled
Internal/ External control/ External only	No Bypass / Open	(any)	1	0	(any)	Blocked
Internal/ External control/ External only	No Bypass / Open	(any)	0	1	Block close (any option for open)	Blocked
Internal/ External control/ External only	No Bypass / Open	(any)	0	1	Bypass close (any option for open)	Bypassed
Internal/ External control/ External only	Bypass Close (any option for open)	(any)	0	(any)	(any)	Bypassed
Internal/ External control/ External only	Bypass Close (any option for open)	(any)	1	(any)	(any)	Blocked
External / block	No Bypass / Open	1	0	0	(any)	Controlled
External / block	No Bypass / Open	0	0	0	(any)	Blocked
External / block	No Bypass / Open	(any)	1	(any)	(any)	Blocked
External / block	No Bypass / Open	(any)	0	1	Block close (any option for open)	Blocked
External / block	No Bypass / Open	0	0	1	Bypass close (any option for open)	Blocked

Table continues on next page

CloseStrategy Src	ByPassMode	EXTSTGY	BLKCLOPR	CONT or contingency condition	ContingencyM ode	Closing operation
External / block	Bypass Close (any option for open)	(any)	0	(any)	(any)	Bypassed
External / block	Bypass Close (any option for open)	(any)	1	(any)	(any)	Blocked
External / bypass	No Bypass / Open	1	0	0	(any)	Controlled
External / bypass	No Bypass / Open	0	0	0	(any)	Bypassed
External / bypass	No Bypass / Open	(any)	1	(any)	(any)	Blocked
External / bypass	No Bypass / Open	0	0	1	Block close (any option for open)	Bypassed
External / bypass	No Bypass / Open	(any)	0	1	Bypass close (any option for open)	Bypassed
External / bypass	Bypass Close (any option for open)	(any)	0	(any)	(any)	Bypassed
External / bypass	Bypass Close (any option for open)	(any)	1	(any)	(any)	Blocked

If any command is blocked or bypassed as per [Table 48](#) and [Table 49](#), the outputs BLKOPL1 / BLKOPL2 / BLKOPL3, BLKCLL1 / BLKCLL2 / BLKCLL3, OPBYPASS or CLBYPASS, get activated (1) for the respective open or close operation. If the condition for blocking or bypassing is persisting (example: BLOCK input is high, or *ByPassMode* setting is enabled), these outputs remain high; conversely, if the conditions are temporary, for example, because of the loss of reference signal and others, these signals are generated for as long as the condition persists, minimum one task time. The outputs are defined in [Table 50](#).

Table 50: Block and bypass information outputs

Interface	Type	Description
BLKOPL1 BLKOPL2 BLKOPL3	Output	Indication that CB Open commands are blocked for phase L1 / L2 / L3
BLKCLL1 BLKCLL2 BLKCLL3	Output	Indication that CB Close commands are blocked for phase L1 / L2 / L3
OPBYPASS	Output	Indication that CB Open commands are bypassed (uncontrolled opening)
CLBYPASS	Output	Indication that CB Close commands are bypassed (uncontrolled closing)

For controlled switching operations, SSCPOW delays the release of the output commands to the three phases of the circuit breaker to achieve point-on-wave switching according to the set target strategy. Minimum controller delay is 20 milliseconds and depends on operating time and switching angle.

All the output commands are issued on three individual outputs for opening and three outputs for closing operations. These output signals include time stamp information to activate the IED's static outputs (PBOs) on the PIO card at the specified times.

The **STRDPOW** output indicates the controlled switching status i.e. a valid operation command (Close or Open) has been received and the output command is for controlled operation of the breaker. STRDPOW will not be set if a bypass command is received. The output is set immediately after detecting a valid controlled operation command and is reset when the last control output is deactivated at the end of the operation.

9.3.7.6 Waveform (disturbance) records

For recording the actual time stamps of the controlled switching command outputs in the disturbance records (waveform records) and event lists, SSCPOW triggers outputs **DRCLTIMLx** or **DROPTIMLx** for an input Close or Open command respectively. Each output is activated at the time stamp of the associated command output and remains active until the switching operation in that phase is completed.

9.3.7.7 Circuit breaker test mode

In CB test mode, SSCPOW initiates mechanical CB operations under control from CBLEARN, in order to obtain (learn) the mechanical switching times of each CB pole. This mode is activated via the **CBTSMODE** input.

With **CBTSMODE** active, **SSCPOW** receives switching commands (from **CBLEARN**) through the coordination input **CRDBLSSX**, to generate Close, Open, or Emergency Trip commands at its outputs.

9.3.7.8 Circuit Breaker Operating Capability

The operating capability of a circuit breaker is defined as its capability to perform a sequence of Close and Open operations, based on the actual drive energy. This information is received by **SSCPOW** (usually from MONALM function) at the input **CBOPCAPIN**. SSCPOW further updates the CB's operating capability on its outputs **CBOPCAPL1**, **CBOPCAPL2** and **CBOPCAPL3** as shown in [Table 51](#).

Table 51: Circuit Breaker Operating Capability

Interface	Type	Description
CBOPCAPIN	Input	Operating capability (possible operations sequence) of the circuit breaker
CBOPCAPLx	Outputs	0: invalid 1: CB is not capable of performing any operation 2: CB is capable of performing one Open operation 3: CB is capable of performing C-O operations 4: CB is capable of performing O-C-O operations

9.3.7.9 Circuit Breaker Position

The circuit breaker (or switch) position is defined by its electrical and mechanical status. This information is received by **SSCPOW** (usually from ACBMSCBR function) at the inputs **CBSTSCFLx**. Without any modification, SSCPOW further updates the received CB position status on its outputs **SWTPOSLx**.

9.3.7.10 Emergency Trip

An emergency trip is an immediate trip or open operation issued by SSCPOW. The function issues an emergency trip when:

1. A cancel command is received from PIO (at the inputs **CNOPCMD/CNCLCMD**).
2. The function is in CB test mode (CBTSMODE=1; refer section [Section 9.3.7.7](#)) and SSCPOW is instructed to immediately open all three poles.

The function indicates an emergency trip on its output **EMERTRIP** under any of the above conditions. This output remains active for one task time.

9.3.7.11 Generation of alarms

SSCPOW provides flexibility to raise alarms under certain pre-defined conditions. The generation of these alarms is mostly based on enabling a few settings.

The function raises alarms under these conditions.

1. Loss of reference signal
2. Last CB operation was uncontrolled, that is, without point-on-wave control
3. Maximum controller delay exceeded
4. Loss of compensation input signal

These conditions are explained below.

Loss of reference signal

This alarm is raised when the reference signal is missing and the *RefSignalLossAlm* setting is enabled. See [Section 9.3.7.2](#). If the breaker is detected open and the source voltage is found not healthy, the function has no reference for controlled closing. Similarly, if the breaker is detected closed and, based on the *OpenRef* setting, if either the source voltage or the load current is found not healthy, the function has no reference for controlled opening operation. For as long as this condition persists, the function raises a **REFSIGLOS** alarm as shown in [Table 52](#).

Table 52: Loss of reference signal

Interface	Type	Description
REFSIGLOS	Output	Status of the reference signal: Logical 1 indicates reference signal is missing.
<i>RefSignalLossAlm</i>	Setting	Enable or disable the REFSIGLOS alarm

Uncontrolled switching

When *UncontSwitchAlm* is set to "Enable", this alarm is raised to indicate CB switching operation without point-on-wave control: It is permanently active when *ByPassMode* is set to anything other than "No bypass". It is temporarily activated when the last operation was performed uncontrolled due to a Bypass in contingency condition. The alarm is provided as an output **UNCONTSWT** from the function as shown in [Table 53](#).

Table 53: Uncontrolled Switching

Interface	Type	Description
UNCONTSWT	Output	Indicates that the last CB switching operation (open or close) was performed without point-on-wave control. This signal gets activated as soon as an input command is received by the function and remains active for 2 seconds.
<i>UncontSwitchAlm</i>	Setting	Enable or disable the UNCONTSWT alarm

Maximum controller delay exceeded

Controller delay is the time difference between the detection of an incoming switching command and the activation of the last command output. This value is provided on the **CNTRLDEL** output. If the delay exceeds the *MaxContDelay* threshold, the **TIMEEXED** output is activated. This alarm is generated only when *ContDelayExdAlm* setting is enabled as shown in [Table 54](#).

Table 54: Maximum Controller Delay Alarm

Interface	Type	Description
CNTRLDEL	Output	Indication of controller delay. This output gets activated on arrival of an input command and remains active for a duration of 2 seconds from the input command activation
<i>MaxContDelay</i>	Setting	Configurable threshold for maximum controller delay time; raises TIMEEXED alarm if CNTRLDEL > <i>MaxContDelay</i>
TIMEEXED	Output	Indicates CNTRLDEL has exceeded <i>MaxContDelay</i> setting. When the condition holds true, this output gets activated for one task time.
<i>ContDelayExdAlm</i>	Setting	Enable or disable the TIMEEXED alarm

Loss of compensation alarm

This alarm is enabled by setting *CompSigLossAlm* to "Enable". Whenever the binary input **CMPLOSIN** is activated, the function raises a **COPSIGLOS** alarm as an output as shown in [Table 55](#).

Table 55: Loss of Compensation alarm interfaces

Interface	Type	Description
CMPLOSIN	Input	Indicates loss of compensation input
COPSIGLOS	Output	When activated, replicates the status of the CMPLOSIN input.
<i>CompSigLossAlm</i>	Setting	Enable or disable the COPSIGLOS alarm

9.3.7.12 Remote/Local Control

SSCPOW has a dedicated input **LOCCNTLIN** and an output **LOCCNTRL** to indicate remote or local control as shown in [Table 56](#).

These signals have no impact on the functionality of SSCPOW.

Table 56: Local and Remote Control

Interface	Type	Description
LOCCNTLIN	Input	If TRUE, defines the control is local; If FALSE, defines the control is remote.
LOCCNTRL	Output	Replication of LOCCNTLIN input

9.4 Position evaluation POS_EVAL**9.4.1 Identification**

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

9.4.2 Functionality

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

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

9.4.3 Function block

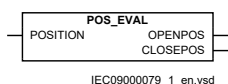
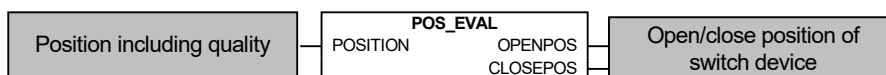


Figure 43: POS_EVAL function block

9.4.4 Logic diagram



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Only the value, open/close, and status is used in this function. Time information is not used.

Input position (Value)	Signal quality	Output OPENPOS	Output CLOSEPOS
0 (Breaker intermediate)	Good	0	0
1 (Breaker open)	Good	1	0
2 (Breaker closed)	Good	0	1
3 (Breaker faulty)	Good	0	0
Any	Invalid	0	0
Any	Oscillatory	0	0

9.4.5 Signals

Table 57: POS_EVAL Input signals

Name	Type	Default	Description
POSITION	INTEGER	0	Position status including quality

Table 58: POS_EVAL Output signals

Name	Type	Description
OPENPOS	BOOLEAN	Open position
CLOSEPOS	BOOLEAN	Close position

9.4.6 Settings

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

Section 10 General calculation

10.1 Analog scaling ANSCAL

10.1.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Analog scaling	ANSCAL	-	-

10.1.2 Functionality

The Analog scaling ANSCAL function transforms an input value, for example from a monitoring function or an input interface, into an output value either through piece-wise linear interpolation or through an algebraic function. Input values are limited to a specified range. Warning and alarm outputs carry information on the range and condition of the input signals, to ensure integrity of the data processing chain.

10.1.3 Function block

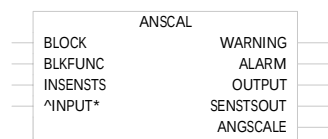


Figure 44: Function block

10.1.4 Signals

Table 59: ANSCAL Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block binary outputs
BLKFUNC	BOOLEAN	0	Block function
INSENSTS	BOOLEAN	0	Input sensor status not healthy
INPUT	REAL	0.0	Input signal

Table 60: ANSCAL Output signals

Name	Type	Description
WARNING	BOOLEAN	Warning signal for out of range output.
ALARM	BOOLEAN	Alarm signal for out of range input
OUTPUT	REAL	Output signal
SENSTSOUT	BOOLEAN	Sensor status output
ANGSCALE	GROUP SIGNAL	Group output containing scaled value and alarm

10.1.5 Settings

Table 61: ANSCAL Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
FnType	Chart Equation	-	-	Chart	Functional mode selection
LowLimit	-99999.9 - 99999.9	-	0.1	-1.0	Input signal lower limiting value
HighLimit	-99999.9 - 99999.9	-	0.1	1.0	Input signal higher limiting value
LimitScaleVal	Limit value Limit value w/o alm Default value	-	-	Limit value	Select output to be limited to scale value or default value in case alarm, block or invalid
DefValue	-99999.9 - 99999.9	-	0.1	0.000	Default value to be shown in output
a	-9999.999 - 9999.999	-	0.001	0.000	Constant a in equation output = $ax^m + bx^n + c + d \cdot e^{(f \cdot x)}$
b	-9999.999 - 9999.999	-	0.001	0.000	Constant b in equation output = $ax^m + bx^n + c + d \cdot e^{(f \cdot x)}$
c	-9999.999 - 9999.999	-	0.001	0.000	Constant c in equation output = $ax^m + bx^n + c + d \cdot e^{(f \cdot x)}$
d	-9999.999 - 9999.999	-	0.001	0.000	Constant d in equation output = $ax^m + bx^n + c + d \cdot e^{(f \cdot x)}$
e	-10.000 - 10.000	-	0.001	0.000	Constant e in equation output = $ax^m + bx^n + c + d \cdot e^{(f \cdot x)}$
f	-10.000 - 10.000	-	0.001	1.000	Constant f in equation output = $ax^m + bx^n + c + d \cdot e^{(f \cdot x)}$
m	-10.000 - 10.000	-	0.001	1.000	Constant m in equation output = $ax^m + bx^n + c + d \cdot e^{(f \cdot x)}$
n	-10.000 - 10.000	-	0.001	1.000	Constant n in equation output = $ax^m + bx^n + c + d \cdot e^{(f \cdot x)}$
CurvePoints	2 - 8	-	1	2	Number of curve points in piecewise linear function
X1	-99999.9 - 99999.9	-	0.1	0.0	Input value for curve point 1
X2	-99999.9 - 99999.9	-	0.1	0.0	Input value for curve point 2
X3	-99999.9 - 99999.9	-	0.1	0.0	Input value for curve point 3
X4	-99999.9 - 99999.9	-	0.1	0.0	Input value for curve point 4
X5	-99999.9 - 99999.9	-	0.1	0.0	Input value for curve point 5
X6	-99999.9 - 99999.9	-	0.1	0.0	Input value for curve point 6
X7	-99999.9 - 99999.9	-	0.1	0.0	Input value for curve point 7
X8	-99999.9 - 99999.9	-	0.1	0.0	Input value for curve point 8
Y1	-99999.9 - 99999.9	-	0.1	0.0	Output value for curve point 1
Y2	-99999.9 - 99999.9	-	0.1	0.0	Output value for curve point 2
Y3	-99999.9 - 99999.9	-	0.1	0.0	Output value for curve point 3
Y4	-99999.9 - 99999.9	-	0.1	0.0	Output value for curve point 4
Y5	-99999.9 - 99999.9	-	0.1	0.0	Output value for curve point 5
Y6	-99999.9 - 99999.9	-	0.1	0.0	Output value for curve point 6
Y7	-99999.9 - 99999.9	-	0.1	0.0	Output value for curve point 7
Y8	-99999.9 - 99999.9	-	0.1	0.0	Output value for curve point 8

Table 62: ANSCAL Group settings (basic)

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

10.1.6 Operation principle

Analog scaling ANSCAL function transforms an input signal, for example, from a monitoring function or input interface, either through linear or non-linear scaling or interpolation between known relational values for further use.

The overall functionality is defined in the logic diagram as shown in Figure 45. The limit module limits the input value, whenever the input value exceeds the set limits. The chart function and equation function scale the output value based on either linear interpolation and constant extrapolation or as a function of the input based on the constants declared. Use *FnType* setting to choose between "Chart" mode and "Equation" mode.

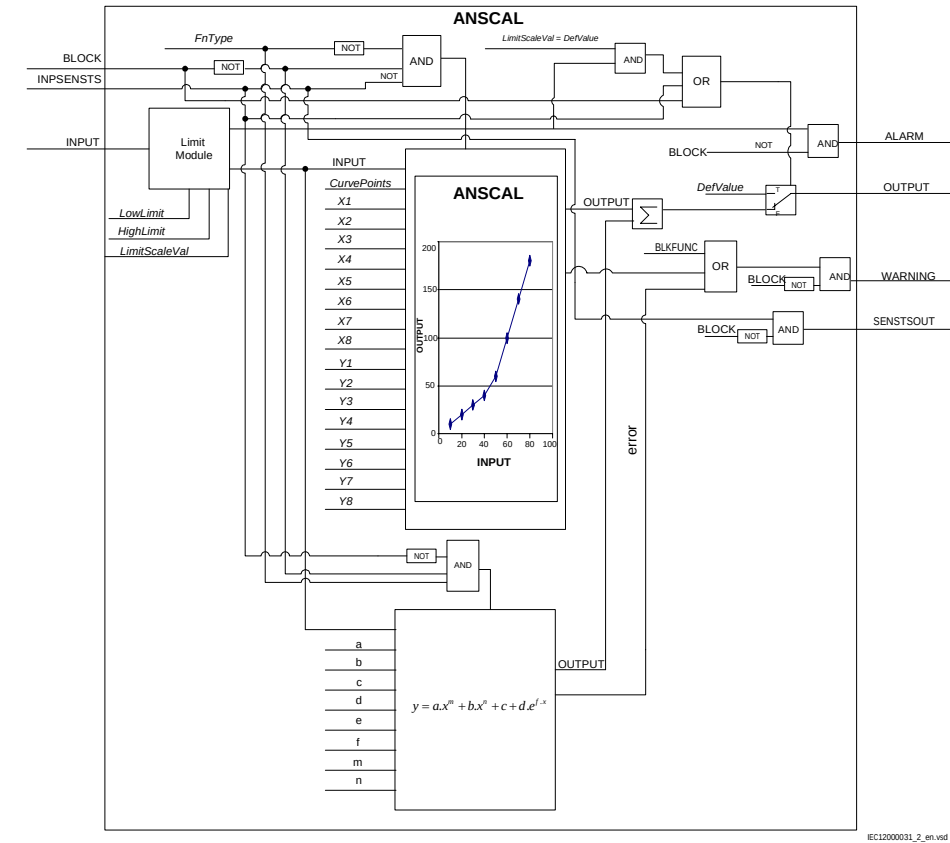


Figure 45: Functional overview of ANSCAL

10.1.6.1 Limit module

The limit module limits the input value to the range between the low limit and the high limit values specified by the settings *LowLimit* and *HighLimit*.

If the input value falls outside the range spanned by *LowLimit* and *HighLimit*:

- The ALARM output is activated (1).
- Depending on the *LimitScaleVal* setting, the OUTPUT value is assigned either the scaled limited input value (*LimitScaleVal* = "Limit value" or "Limit value w/o alarm") or the configurable *DefValue* (*LimitScaleVal* = "Default value").

10.1.6.2 Chart function

Set *FnType* to "Chart" mode to enable this functionality. In this mode, the output is evaluated based on linear interpolation and constant extrapolation using up to eight data points specified by the settings $\{X1, Y1\}$ and $\{X2, Y2\}$ up to $\{X8, Y8\}$. Set *CurvePoints* to select the required number of input and output relations. The functionality provides linear interpolation between the points and constant extrapolation beyond the defined points.



The setting points shall be set in such a manner that $X2$ is greater than $X1$, $X3$ is greater than $X2$ and so on till $X8$ is greater than $X7$. The settings of *LowLimit* and *HighLimit* limit the input values. Hence the setting of $X1$ below *LowLimit* results in output value for a limited proportional input value of *LowLimit*. Same is the case for the last selected curve points based on the setting *CurvePoints*.

For example, if the input value is lower than $X1$, the output is set to $Y1$. For every setting n for *CurvePoints* defined, the output is set to Yn if the input is greater than Xn . For every input value greater than $X1$ and less than Xn , the output is calculated according to the following conditions:

Maximum incremental value of i starting from 2 till maximum of n ($n \leq 8$):

X_i such that $INPUT \geq X_i$ and

X_{i+1} such that $INPUT < X_{i+1}$

$$OUTPUT = Y_i + ((INPUT - X_i) \cdot (Y_{i+1} - Y_i)) / (X_{i+1} - X_i)$$

The WARNING output goes high whenever the input signal is outside the scaling range but still within the supervision limits. See [Table 63](#).

Table 63: Assessment of input signal range

Range of INPUT signal	OP SIGNAL	WARNING	ALARM
$INPUT < LowLimit$	$Y1$ or <i>DefValue</i> (as selected by <i>LimitScaleVal</i>)	0	1
$LowLimit \leq INPUT < X1$	$Y1$	1	0
$X1 \leq INPUT \leq Xn$	scaled value	0	0
$Xn < INPUT \leq HighLimit$	Yn	1	0
$INPUT > HighLimit$	Yn or <i>DefValue</i> (as selected by <i>LimitScaleVal</i>)	0	1

10.1.6.3 Equation function

Set *FnType* to "Equation" mode to enable this functionality. In this mode, the output is calculated as a function of the input based on the constants declared in the following equation:

$$y = ax^m + bx^n + c + d \cdot e^{f \cdot x}$$

Where,

a,b,c,d,e,f,m, n = Constants (settings)

x = Input value

y = Output value



If x is large and m, n, e are not set to small values, the output will overflow. Similarly, if x can be negative then m and n must be natural numbers.

In equation mode, the WARNING output goes high when large output value numbers, typically above 8388607 (absolute), are rounded to the last decimal point.

10.1.6.4 Status information

The following table summarizes the status information generated by the ANSCAL function.

Table 64: ANSCAL status output signals

Name	Description
WARNING	Combined warning signal, TRUE (1) on any of the following conditions: - In Chart mode, when the input signal is inside the permitted range but outside the compensation range (see Table 63.) - In Equation mode, if the absolute output value is too large to ensure full numerical accuracy
ALARM	Combined alarm signal, TRUE (1) if any of the following conditions is detected: - Faulty sensor - Settings X for curve point input values in Chart mode are out of sequence - INPUT value is lower than <i>LowLimit</i> or higher than <i>HighLimit</i> - BLKFUNC input is 1
SENSTSOUT	Sensor status output for IEC 61850 reporting purpose: TRUE (1) – Sensor status is unhealthy FALSE (0) – Sensor status is healthy

10.2 Double point input status time monitoring DPISTTIM

10.2.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Double point input status time monitoring	DPISTTIM	-	-

10.2.2 Functionality

The Double point indication status times DPISTTIM function computes the status times of a double point indication (DPI) by counting the times since the last status changeovers. The inputs for this function are two boolean signals of a DPI. The outputs provide the time either in milliseconds, seconds, minutes, or hours from the last status changeover. DPISTTIM function can be used for computing the idle times, that is, time since the last open and close operations of a switch.

10.2.3 Function block

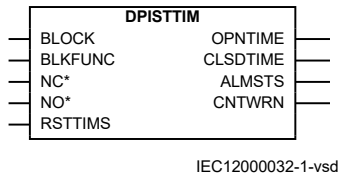


Figure 46: DPISTTIM function block

10.2.4 Signals

Table 65: DPISTTIM Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block binary outputs
BLKFUNC	BOOLEAN	0	Block function
NC	BOOLEAN	0	Status input information of NC contact in DPI
NO	BOOLEAN	0	Status input information of NO contact in DPI
RSTTIMS	BOOLEAN	0	Reset position timers to zero

Table 66: DPISTTIM Output signals

Name	Type	Description
OPNTIME	REAL	Time count from previous closed status
CLSDTIME	REAL	Time count from previous open status
ALMSTS	BOOLEAN	Alarm for invalid status of input NO and input NC
CNTWRN	BOOLEAN	Warning for output having alarm stage since last update

10.2.5 Settings

Table 67: DPISTTIM Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Mode Off / On
TimeToAlm	0.000 - 100.000	-	0.001	0.000	Time setting to declare invalid or faulty status alarm
ModeStsCntSenErr	Reset to default Freeze counters Keep counting	-	-	Reset to default	Setting mode for status counters during sensor error condition
DefValue	-999999.0 - 999999.0	-	1.0	0.0	Default value to be set upon reset depending on the errStsCountMode
TimeScale	milliSeconds Seconds Minutes Hours	-	-	milliSeconds	Setting for output times scale selection

10.2.6 Operation principle

The Double point indication status times DPISTTIM function computes the status times of a double point indication (DPI) by counting the times since the last status changeovers. The inputs for this function are two boolean signals of a DPI. DPISTTIM function is intended for computing the idle times (that is, time since the last open and close operations) of a switch.

The function interprets DPI input combinations as switch status according to [Table 68](#).

Table 68: Input status combination in DPISTTIM

NO	NC	Status
0	0	Invalid
0	1	Open
1	0	Closed
1	1	Invalid

Invalid input status combinations will generate an alarm or warning if applied for longer than a grace period defined by *TimeToAlm*. ALMSTS directly indicates detection of an invalid input status. CNTWRN indicates that an invalid condition has been detected even though the outputs show valid time count values; it will be reset on a valid status transition.

The outputs provide the elapsed time from the last status changeover in the unit specified by *TimeScale* (milliseconds, seconds, minutes, or hours). OPNTIME gives the time since the last closed → open transition; CLSDTIME gives the time since the last open → closed transition.

A rising edge (0 to 1 change) on the RSTTIMS input will reset both OPNTIME and CLSDTIME to 0.0. The setting *ModeStsCntSenErr* controls the behavior of the internal counters and the outputs when an invalid input status is detected for longer than *TimeToAlm*.

- If 'Reset to default' is selected then both counters will be reset to *DefValue*.
- If 'Freeze counters' is selected the counter outputs are frozen at the current values. However, internally the counters continue as per the previous valid input status. If the input status is restored to the same valid status, the outputs are re-activated to show the updated counter values. If the input status is restored to the opposite valid status then the counters behave as during a regular change between valid statuses.
- If 'Keep counting' is selected the counters continue counting the last valid status.

[Table 69](#) summarizes the behavior of the DPISTTIM function block.

Table 69: *DPISTTIM* truth table

Input status	Previous input status	ModeStsCntSen Err	Input status before previous invalid	OPNTIME	CLSDTIME	ALMSTS	CNTWRN
Open	Closed	(Any)	-	Time count from last valid closed → open status change	0.0	0	0
	Invalid	Freeze counters	Open	Time count from last valid closed → open status change		0	1
		Keep counting					
		Freeze counters	Closed	Time count from last invalid → open status change		0	1
		Keep counting					
		Reset to default	(Any)	Time count from last invalid → open status change		0	0
Closed	Open	(Any)	-	0.0	Time count from last valid open → closed status change	0	0
	Invalid	Freeze counters	Open		Time count from last invalid → closed status change	0	1
		Keep counting					
		Freeze counters	Closed		Time count from last valid open → closed status change	0	1
		Keep counting					
		Reset to default	(Any)		Time count from last invalid → closed status change	0	0

Table continues on next page

Input status	Previous input status	ModeStsCntSen Err	Input status before previous invalid	OPNTIME	CLSDTIME	ALMST S	CNTWR N
Invalid	Open	Freeze counters	-	OPNTIME value frozen at the time of detecting invalid status	0.0	1	1
	Closed		-	0.0	CLSDTIME value frozen at the time of detecting invalid status	1	1
	Open	Keep counting	-	Time count from last valid closed → open status change	0.0	1	1
	Closed		-	0.0	Time count from last valid open → closed status change	1	1
	(Any)	Reset to default	-	DefValue	DefValue	1	0

Once started, the counters will internally continue the count as per the previous valid input status even through a power cycle of the IED.

10.3 Binary status to analog conversion BINSTSAN

10.3.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Binary status signal to analog conversion	BINSTSAN	-	-

10.3.2 Functionality

The binary status signal to analog conversion BINSTSAN function evaluates the equivalent analog value for a combination of eight binary input signals that show the status levels of analog quantities. The output signal value is used for further processing in other functions.

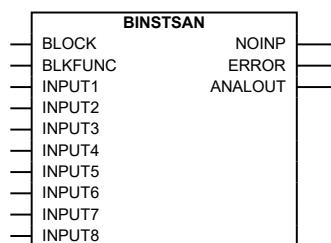
There are three modes which can be used to calculate output signals:

- *1 of n*: only one of the inputs can be set to high. If more than one input is high, an error is detected and the output value is set to the default output.
- *Incremental*: inputs can go high sequentially and the output value is a sum of the scaled input values. If the inputs are not going high sequentially, an error is detected as the inputs are invalid and the output value is set to the default output.
- *Summation*: one or more inputs are high in a random order and the output is the cumulative sum of the scaled input values.



At least one input must be high for a valid output. Else, NOINP signal is set to TRUE and the output value is set to the default output.

10.3.3 Function block



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Figure 47: Function block

10.3.4 Signals

Table 70: BINSTSAN Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block binary outputs
BLKFUNC	BOOLEAN	0	Block function
INPUT1	BOOLEAN	0	Binary input 1 status
INPUT2	BOOLEAN	0	Binary input 2 status
INPUT3	BOOLEAN	0	Binary input 3 status
INPUT4	BOOLEAN	0	Binary input 4 status
INPUT5	BOOLEAN	0	Binary input 5 status
INPUT6	BOOLEAN	0	Binary input 6 status
INPUT7	BOOLEAN	0	Binary input 7 status
INPUT8	BOOLEAN	0	Binary input 8 status

Table 71: BINSTSAN Output signals

Name	Type	Description
NOINP	BOOLEAN	Signal for input not detected
ERROR	BOOLEAN	Signal for indicating wrong combination of inputs detected
ANALOUT	REAL	Analog output after conversion

10.3.5 Settings

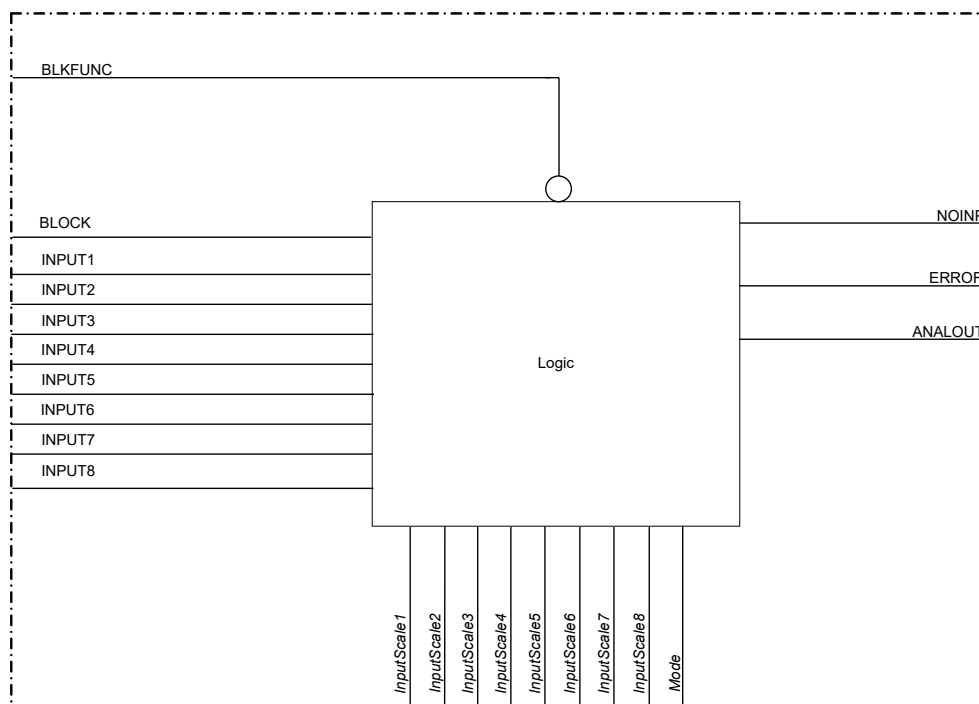
Table 72: BINSTSAN Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Mode Off / On
Mode	1 of n Incremental Summation	-	-	1 of n	Mode selection
DefValue	-999999.999 - 999999.999	-	0.001	0.000	Default Value
InputScale1	-999999.999 - 999999.999	-	0.001	0.000	Equivalent output for input status 1
InputScale2	-999999.999 - 999999.999	-	0.001	0.000	Equivalent output for input status 2
InputScale3	-999999.999 - 999999.999	-	0.001	0.000	Equivalent output for input status 3
InputScale4	-999999.999 - 999999.999	-	0.001	0.000	Equivalent output for input status 4
InputScale5	-999999.999 - 999999.999	-	0.001	0.000	Equivalent output for input status 5
InputScale6	-999999.999 - 999999.999	-	0.001	0.000	Equivalent output for input status 6
InputScale7	-999999.999 - 999999.999	-	0.001	0.000	Equivalent output for input status 7
InputScale8	-999999.999 - 999999.999	-	0.001	0.000	Equivalent output for input status 8

10.3.6 Operation principle

The binary status signal to analog conversion BINSTSAN function evaluates the equivalent analog value for a combination of eight binary input signals that shows the status levels of analog quantities. The output signal value is used for further processing in other functions.

The overall functionality is defined in the logic diagram as shown in [Figure 48](#).



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Figure 48: Functional overview of BINSTAN

BINSTAN functionality is explained using an example, where the status switches of an analog source are connected to BINSTAN function and is configured for input scaling as shown in [Table 73](#).



If the output value exceeds 8388607, an error is detected and the ERROR output is set to TRUE.

Table 73: BINSTAN example settings

Input	InputScale
1	5
2	10
3	20
4	40
5	80
6	160
7	320
8	640

10.3.6.1 Calculating output values using 1 of n mode

Set *Mode* to 1 of n to enable this functionality. In this mode, only one of the inputs can go high at any given time. If more than one input goes high, an error is detected and the ERROR output is set TRUE. If none of the inputs are high, the input is not detected and the NOINP output is set to TRUE. The output is set to the default output if ERROR and/or NOINP outputs are TRUE. The output evaluated as per the setting of input mode is as shown in [Table 74](#).

Table 74: *BINSTAN setting mode 1 of n*

Input	Status				
	Mode - 1 of n				
1	1	0	0	0	0
2	0	1	0	0	0
3	0	0	0	0	0
4	0	0	0	0	1
5	0	0	1	0	0
6	0	0	0	0	0
7	0	0	0	0	0
8	0	0	0	1	1
Output	5	10	80	640	DefValue

10.3.6.2 Calculating output values using incremental mode

Set *Mode* to Incremental to enable this functionality. In this mode, inputs are set to high sequentially starting with INPUT1, and the output value is a sum of the scaled input values. If the inputs are not set to high sequentially, an error is detected as the inputs are invalid and the ERROR output is set TRUE. If none of the inputs are high, the input is not detected and the NOINP output is set to TRUE. The output is set to the default output if ERROR and/or NOINP outputs are TRUE. The output evaluated as per the setting of input mode is as shown in [Table 75](#).

Table 75: *BINSTAN setting mode Incremental*

Input	Status				
	Mode - Incremental				
1	1	1	1	1	1
2	0	1	1	1	1
3	0	0	1	1	0
4	0	0	1	1	1
5	0	0	1	1	1
6	0	0	1	1	1
7	0	0	1	1	1
8	0	0	0	1	1
Output	5	15	635	1275	DefValue

10.3.6.3 Calculating output values using summation mode

Set *Mode* to Summation to enable this functionality. In this mode, one or more inputs can be high in a random order and the output is the cumulative sum of the scaled input values. If none of the inputs are high, the input is not detected and the NOINP output is set to TRUE. The output is set to the default output if ERROR and/or NOINP outputs are TRUE. The output evaluated as per the setting of input mode is as shown in [Table 76](#).

Table 76: *BINSTSAN setting mode Summation*

Input	Status				
	Mode - Summation				
1	1	0	1	0	1
2	0	1	1	0	1
3	0	0	0	0	0
4	0	0	0	0	1
5	0	0	0	0	1
6	0	0	0	0	1
7	0	0	0	0	1
8	0	0	0	1	1
Output	5	10	15	640	1255

10.4 General arithmetic base function ARITHMET

10.4.1 Identification

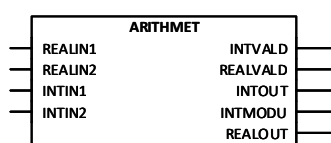
Table 77:

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
General arithmetic base function	ARITHMET		

10.4.2 Functionality

The General arithmetic base function ARITHMET performs a basic arithmetic operation on two input values, which are taken from either integer or real signals. Available operations comprise addition, subtraction, multiplication, and division.

10.4.3 Function block



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Figure 49: *Function Block Diagram*

10.4.4 Signals

Table 78: ARITHMET Input signals

Name	Type	Default	Description
REALIN1	REAL	0.0	Real input 1
REALIN2	REAL	0.0	Real input 2
INTIN1	INTEGER	0	Integer input 1
INTIN2	INTEGER	0	Integer input 2

Table 79: ARITHMET Output signals

Name	Type	Description
INTVALD	BOOLEAN	Integer output validity
REALVALD	BOOLEAN	Real output validity
INTOUT	INTEGER	Integer output
INTMODU	INTEGER	Integer output division modulo
REALOUT	REAL	Real output

10.4.5 Settings

Table 80: ARITHMET Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
EnableInt	False True	-	-	False	Selection int or real (TRUE = int, FALSE = real)
Operation	Off On	-	-	On	Operation Mode Off / On
AritmetType	Addition Subtraction Multiplication Division	-	-	Addition	Type of arithmetic 1: ADD 2: SUB 3: MUL 4: DIV
Real limit divider	0.0000001 - 20.0000000	-	0.00000 01	0.0000100	Real limit compare with divider
Int limit divider	1-20	-	1	1	Integer limit compare with divider

10.4.6 Operation Principle

This is a basic arithmetic function with real and integer data types. The setting *AritmetType* selects the arithmetic operation to be performed on the two inputs.

AritmetType = "Addition"

- $REALOUT = REALIN1 + REALIN2$
- $INTOUT = INTIN1 + INTIN2$

AritmetType = "Subtraction"

- $REALOUT = REALIN1 - REALIN2$
- $INTOUT = INTIN1 - INTIN2$

AritmetType = "Multiplication"

- $REALOUT = REALIN1 \cdot REALIN2$
- $INTOUT = INTIN1 \cdot INTIN2$

AritmetType = "Division"

- $REALOUT = REALIN1 / REALIN2$
- $INTOUT = INTIN1 / INTIN2$
- $INTMODU = INTIN1 \bmod INTIN2$

For all real value operations, the input values are limited to the range -1.8447e19 ... +1.8447e19.

For multiply integer value operations, the input values are limited to the range -46339 ... +46339.

For addition and subtraction, the input values are limited to the range -1073741823 ... +1073741823.

The function includes precautions against division by zero, which are applied when *AritmetType* = "Division":

- For division of real numbers, if the absolute value of *REALIN2* is less or equal *Real limit divider*, $REALOUT = (REALIN1 / Real\ limit\ divider)$ and $REALVALD = 0$.
- For division of integer numbers, if the absolute value of *INTIN2* is less or equal *Int limit divider*, $INTOUT = (INTIN1 / Int\ limit\ divider)$ and $INTVALD = 0$.

Section 11 Logic

11.1 Configurable logic blocks

11.1.1 Standard configurable logic blocks

11.1.1.1 Functionality

A number of logic blocks and timers are available for the user to adapt the configuration to the specific application needs.

- **OR** function block. Each block has 6 inputs and two outputs where one is inverted.
- **INVERTER** function blocks that invert the input signal.
- **PULSETIMER** function block can be used, for example, for pulse extensions or limiting of operation of outputs, settable pulse time.
- **GATE** function block is used for whether or not a signal should be able to pass from the input to the output.
- **XOR** function block. Each block has two outputs where one is inverted.
- **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 must be On for the input signal to activate the output with the appropriate time delay.
- **AND** function block. Each block has four inputs and two outputs where one is inverted
- **SRMEMORY** function block is a flip-flop that can set or reset an output from two inputs respectively. Each block has two outputs where one is inverted. The memory setting controls if the block's output should reset or return to the state it was, after a power interruption. The SET input has priority if both SET and RESET inputs are operated simultaneously.
- **RSMEMORY** function block is a flip-flop that can reset or set an output from two inputs respectively. Each block has two outputs where one is inverted. The memory setting controls if the block's output should reset or return to the state it was, after a power interruption. The RESET input has priority if both SET and RESET are operated simultaneously.

Configurable logic Q/T

A number of logic blocks and timers, with the capability to propagate timestamp and quality of the input signals, are available. The function blocks assist the user to adapt the IEDs configuration to the specific application needs.

- **ORQT** OR function block that also propagates timestamp and quality of input signals. Each block has six inputs and two outputs where one is inverted.
- **INVERTERQT** function block that inverts the input signal and propagates timestamp and quality of input signal.
- **PULSETIMERQT** Pulse timer function block can be used, for example, for pulse extensions or limiting of operation of outputs. The function also propagates timestamp and quality of input signal.
- **XORQT** XOR function block. The function also propagates timestamp and quality of input signals. Each block has two outputs where one is inverted.

- **TIMERSETQT** function has pick-up and drop-out delayed outputs related to the input signal. The timer has a settable time delay. The function also propagates timestamp and quality of input signal.
- **ANDQT** AND function block. The function also propagates timestamp and quality of input signals. Each block has four inputs and two outputs where one is inverted.
- **SRMEMORYQT** function block is a flip-flop that can set or reset an output from two inputs respectively. Each block has two outputs where one is inverted. The memory setting controls if the block after a power interruption should return to the state before the interruption, or be reset. The function also propagates timestamp and quality of input signal.
- **RSMEMORYQT** function block is a flip-flop that can reset or set an output from two inputs respectively. Each block has two outputs where one is inverted. The memory setting controls if the block after a power interruption should return to the state before the interruption, or be reset. The function also propagates timestamp and quality of input signal.
- **INVALIDQT** function which sets quality invalid of outputs according to a "valid" input. Inputs are copied to outputs. If input VALID is 0, or if its quality invalid bit is set, all outputs invalid quality bit will be set to invalid. The timestamp of an output will be set to the latest timestamp of INPUT and VALID inputs.
- **INDCOMBSPQT** combines single input signals to group signal. Single position input is copied to value part of SP_OUT output. TIME input is copied to time part of SP_OUT output. Quality input bits are copied to the corresponding quality part of SP_OUT output.
- **INDEXTSPQT** extracts individual signals from a group signal input. Value part of single position input is copied to SI_OUT output. Time part of single position input is copied to TIME output. Quality bits in common part and indication part of inputs signal is copied to the corresponding quality output.

11.1.1.2 OR function block

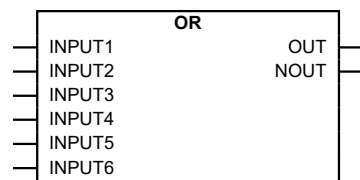
Identification

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. The output signal is 1 if at least one input signal is 1.

Function block



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Figure 50: OR function block

Signals

Table 81: 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 82: 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).

11.1.1.3 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

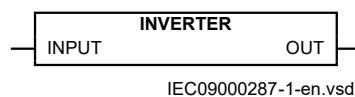


Figure 51: INVERTER function block

Signals

Table 83: INVERTER Input signals

Name	Type	Default	Description
INPUT	BOOLEAN	0	Input signal

Table 84: 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).

11.1.1.4 PULSETIMER function block

Identification

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

Functionality

Triggered by a positive-going edge (logical 0 to 1 transition) on its input, PULSETIMER outputs a pulse of settable duration. While the output is on, further transitions on the input signal will be ignored.

Function block

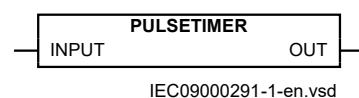


Figure 52: PULSETIMER function block

Signals

Table 85: PULSETIMER Input signals

Name	Type	Default	Description
INPUT	BOOLEAN	0	Input signal

Table 86: PULSETIMER Output signals

Name	Type	Description
OUT	BOOLEAN	Output signal

Settings

Table 87: 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

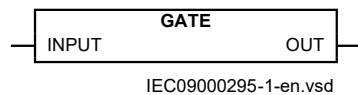
11.1.1.5 Controllable gate function block GATE

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 the setting.

Function block*Figure 53: GATE function block***Signals***Table 88: GATE Input signals*

Name	Type	Default	Description
INPUT	BOOLEAN	0	Input signal

Table 89: GATE Output signals

Name	Type	Description
OUT	BOOLEAN	Output signal

Settings*Table 90: GATE Group settings (basic)*

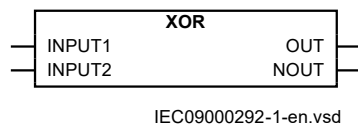
Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off/On

11.1.1.6 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. 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 the same.

Function block*Figure 54: XOR function block***Signals***Table 91: XOR Input signals*

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

Table 92: 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).

11.1.1.7 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 Logic loop delay function block (LOOPDELAY) function is used to delay the input signal one execution cycle.

Function block

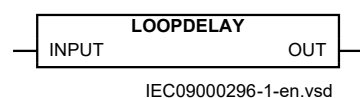


Figure 55: LOOPDELAY function block

Signals

Table 93: LOOPDELAY Input signals

Name	Type	Default	Description
INPUT	BOOLEAN	0	Input signal

Table 94: 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).

11.1.1.8 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).

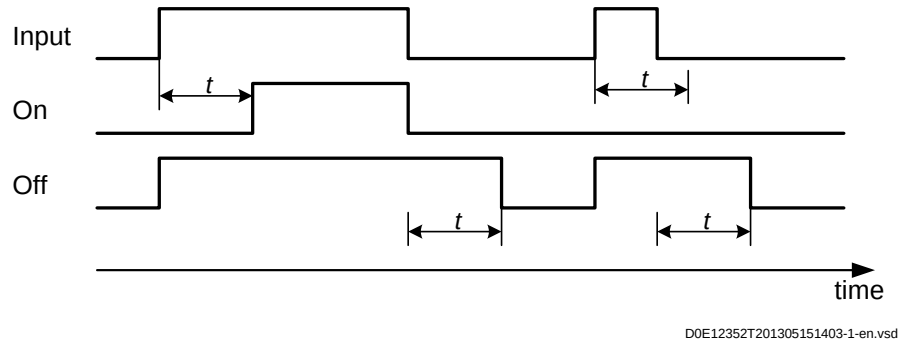


Figure 56: *TIMERSET* Status diagram

Function block

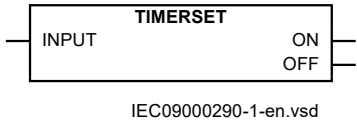


Figure 57: *TIMERSET* function block

Signals

Table 95: *TIMERSET* Input signals

Name	Type	Default	Description
INPUT	BOOLEAN	0	Input signal

Table 96: *TIMERSET* Output signals

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

Settings

Table 97: *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

11.1.1.9 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. One of the outputs is inverted. The output signal is 1 if all input signals are 1.

Default value on all four inputs is logical 1 which makes it possible for the user to just use the required number of inputs and leave the rest unconnected. 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

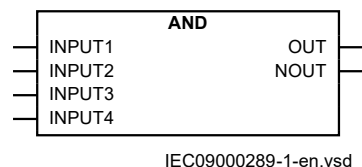


Figure 58: AND function block

Signals

Table 98: 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 99: 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).

11.1.1.10 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 to the state it had before or if it will be reset. In SRMEMORY, the SET input has priority over RESET input.

Table 100: 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	Last value	Inverted last value

Function block

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Figure 59: SRMEMORY function block

Signals

Table 101: SRMEMORY Input signals

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

Table 102: SRMEMORY Output signals

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

Settings

Table 103: SRMEMORY Group settings (basic)

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

11.1.1.11 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	-	-

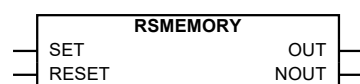
Functionality

The Reset-set with memory function block (RSMEMORY) is a flip-flop with memory that can reset or set an output from two inputs respectively. Each RSMEMORY function block has two outputs, where one is inverted. The memory setting controls if the flip-flop after a power interruption will return to the state it had before or if it will be reset. In RSMEMORY, the RESET input has priority over SET input.

Table 104: Truth table for RSMEMORY function block

RESET	SET	OUT	NOUT
0	0	Last value	Inverted last value
0	1	1	0
1	0	0	1
1	1	0	1

Function block



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Figure 60: RSMEMORY function block

Signals

Table 105: RSMEMORY Input signals

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

Table 106: RSMEMORY Output signals

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

Settings

Table 107: RSMEMORY Group settings (basic)

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

11.1.2 Configurable logic with propagation of timestamp and quality

11.1.2.1 Functionality

A number of logic blocks and timers with the capability to propagate timestamp and quality of the input signals are available. The function blocks assist the user to adapt the IED's configuration to the specific application needs.

11.1.2.2 ORQT function block

Identification

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

Functionality

ORQT function block (ORQT) is used to form general combinatory expressions with boolean variables. ORQT function block has six inputs and two outputs. One of the outputs is inverted. The output signal is 1 if at least one of the input signals is 1.

Function block

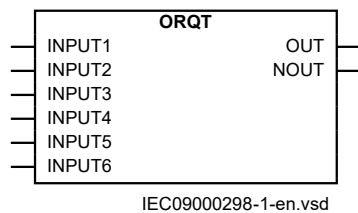


Figure 61: ORQT function block

Signals

Table 108: ORQT Input signals

Name	Type	Default	Description
INPUT1	BOOLEAN	0	Input signal 1
INPUT2	BOOLEAN	0	Input signal 2
INPUT3	BOOLEAN	0	Input signal 3
INPUT4	BOOLEAN	0	Input signal 4
INPUT5	BOOLEAN	0	Input signal 5
INPUT6	BOOLEAN	0	Input signal 6

Table 109: ORQT Output signals

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

Settings

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

11.1.2.3 INVERTERQT function block

Identification

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

Function block

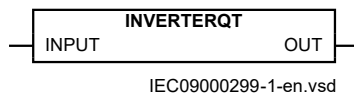


Figure 62: INVERTERQT function block

Signals

Table 110: INVERTERQT Input signals

Name	Type	Default	Description
INPUT	BOOLEAN	0	Input signal

Table 111: INVERTERQT Output signals

Name	Type	Description
OUT	BOOLEAN	Output signal

Settings

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

11.1.2.4 Pulse timer function block PULSTIMERQT

Identification

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

Functionality

Triggered by a positive-going edge (logical 0 to 1 transition) on its input, the output of PULSTIMERQT is activated (1) for a settable duration. During that time, changes in input value are ignored.

When the output changes value, the timestamp of the output signal is updated.

The supported “quality” state bits are propagated from the input each execution to the output. A change of these bits will not lead to an updated timestamp on the output.

Function block

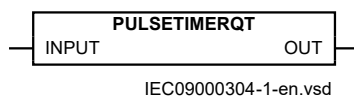


Figure 63: PULSTIMERQT function block

Signals

Table 112: PULSTIMERQT Input signals

Name	Type	Default	Description
INPUT	BOOLEAN	0	Input signal

Table 113: PULSETIMERQT Output signals

Name	Type	Description
OUT	BOOLEAN	Output signal

Settings

Table 114: PULSETIMERQT Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
t	0.000 - 90000.000	s	0.001	0.010	Pulse time length

11.1.2.5 XORQT function block

Identification

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

Functionality

The exclusive OR function (XORQT) function is used to generate combinatory expressions with boolean variables. XORQT function 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

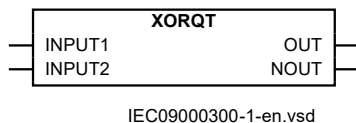


Figure 64: XORQT function block

Signals

Table 115: XORQT Input signals

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

Table 116: XORQT Output signals

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

Settings

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

11.1.2.6 Settable timer function block TIMERSETQT

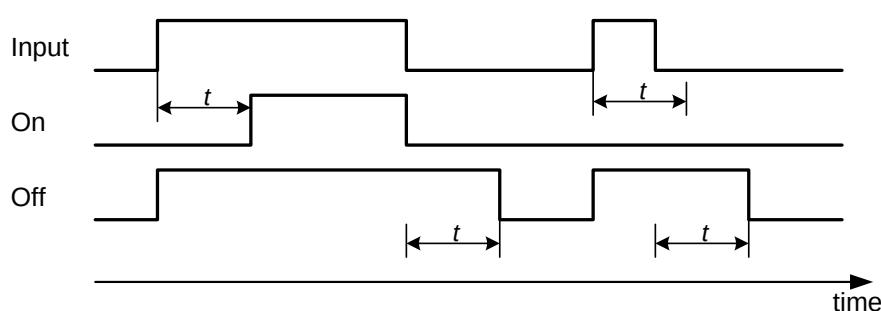
Identification

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

Functionality

The Settable timer function block (TIMERSETQT) has pick-up and drop-out delayed outputs related to the input signal. The timer has a settable time delay (t).

When either of the outputs changes value, the timestamp of that output signal is updated. The supported “quality” state bits are propagated from the input each execution to both outputs. A change of these bits will not lead to an updated timestamp on the output.



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Figure 65: *TIMERSETQT Status diagram*

Function block



IEC09000303-1-en.vsd

Figure 66: *TIMERSETQT function block*

Signals

Table 117: *TIMERSETQT Input signals*

Name	Type	Default	Description
INPUT	BOOLEAN	0	Input signal

Table 118: *TIMERSETQT Output signals*

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

Settings

Table 119: *TIMERSETQT Group settings (basic)*

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off/On
t	0.000 - 90000.000	s	0.001	0.000	Delay for settable timer n

11.1.2.7 ANDQT function block

Identification

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

Functionality

ANDQT function is used to form general combinatory expressions with boolean variables. ANDQT function block has four inputs and two outputs. One of the outputs is inverted. The output signal is 1 if all of the input signals are 1.

Default value on all four inputs is logical 1 which makes it possible for the user to just use the required number of inputs and leave the rest unconnected. The output OUT has a default value 0 initially, which will suppress one cycle pulse if the function has been put in the wrong execution order.

Function block

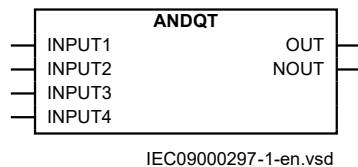


Figure 67: *ANDQT function block*

Signals

Table 120: *ANDQT Input signals*

Name	Type	Default	Description
INPUT1	BOOLEAN	1	Input signal 1
INPUT2	BOOLEAN	1	Input signal 2
INPUT3	BOOLEAN	1	Input signal 3
INPUT4	BOOLEAN	1	Input signal 4

Table 121: *ANDQT Output signals*

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

Settings

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

11.1.2.8 Set-reset function block SRMEMORYQT

Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Set/reset logic component	SRMEMORYQT	-	-

Functionality

The Set-reset function (SRMEMORYQT) is a flip-flop with memory that can set or reset an output from two inputs respectively. Each SRMEMORYQT function block has two outputs, where one is inverted. The memory setting controls if the flip-flop after a power interruption will return the state it had before or if it will be reset. In SRMEMORYQT, the SET input has priority over the RESET input.

SRMEMORYQT propagates quality and time as well as value.

Table 122: Truth table for SRMEMORYQT function block

SET	RESET	OUT	NOUT
0	0	Last value	Inverted last value
0	1	0	1
1	0	1	0
1	1	1	0

If *Memory* parameter is On, the output result is stored in semi-retained memory.

Function block

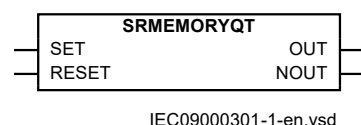


Figure 68: SRMEMORYQT function block

Signals

Table 123: SRMEMORYQT Input signals

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

Table 124: SRMEMORYQT Output signals

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

Settings

Table 125: SRMEMORYQT Group settings (basic)

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

11.1.2.9 Reset-set function block RSMEMORYQT

Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Reset/set logic component	RSMEMORYQT	-	-

Functionality

The Reset-set function (RSMEMORYQT) is a flip-flop with memory that can reset or set an output from two inputs respectively. Each RSMEMORYQT function block has two outputs, where one is inverted. The memory setting controls if the flip-flop after a power interruption will return the state it had before or if it will be reset. In RSMEMORYQT, the RESET input has priority over the SET input.

Table 126: Truth table for RSMEMORYQT function block

SET	RESET	OUT	NOUT
0	0	Last value	Inverted last value
0	1	0	1
1	0	1	0
1	1	0	1

RSMEMORYQT propagates quality and time as well as value.

Function block

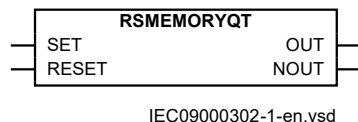


Figure 69: RSMEMORYQT function block

Signals

Table 127: RSMEMORYQT Input signals

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

Table 128: RSMEMORYQT Output signals

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

Settings

Table 129: RSMEMORYQT Group settings (basic)

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

11.1.2.10 INVALIDQT function block

Identification

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

Function which sets the quality flag of binary signals to invalid according to a "valid" input.

Inputs are copied to outputs. If input VALID is 0, or if its quality invalid bit is set, all outputs invalid quality bit will be set. The timestamp of an output will be set to the latest timestamp of INPUT and VALID input.

Function block

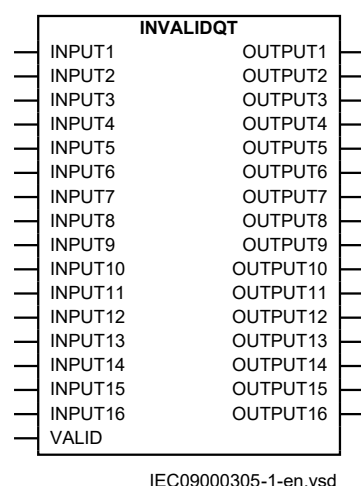


Figure 70: INVALIDQT function block

Signals

Table 130: INVALIDQT Input signals

Name	Type	Default	Description
INPUT1	BOOLEAN	0	Indication input 1
INPUT2	BOOLEAN	0	Indication input 2
INPUT3	BOOLEAN	0	Indication input 3
INPUT4	BOOLEAN	0	Indication input 4
INPUT5	BOOLEAN	0	Indication input 5
INPUT6	BOOLEAN	0	Indication input 6
INPUT7	BOOLEAN	0	Indication input 7
Table continues on next page			

Name	Type	Default	Description
INPUT8	BOOLEAN	0	Indication input 8
INPUT9	BOOLEAN	0	Indication input 9
INPUT10	BOOLEAN	0	Indication input 10
INPUT11	BOOLEAN	0	Indication input 11
INPUT12	BOOLEAN	0	Indication input 12
INPUT13	BOOLEAN	0	Indication input 13
INPUT14	BOOLEAN	0	Indication input 14
INPUT15	BOOLEAN	0	Indication input 15
INPUT16	BOOLEAN	0	Indication input 16
VALID	BOOLEAN	1	Inputs are valid or not

Table 131: INVALIDQT Output signals

Name	Type	Description
OUTPUT1	BOOLEAN	Indication output 1
OUTPUT2	BOOLEAN	Indication output 2
OUTPUT3	BOOLEAN	Indication output 3
OUTPUT4	BOOLEAN	Indication output 4
OUTPUT5	BOOLEAN	Indication output 5
OUTPUT6	BOOLEAN	Indication output 6
OUTPUT7	BOOLEAN	Indication output 7
OUTPUT8	BOOLEAN	Indication output 8
OUTPUT9	BOOLEAN	Indication output 9
OUTPUT10	BOOLEAN	Indication output 10
OUTPUT11	BOOLEAN	Indication output 11
OUTPUT12	BOOLEAN	Indication output 12
OUTPUT13	BOOLEAN	Indication output 13
OUTPUT14	BOOLEAN	Indication output 14
OUTPUT15	BOOLEAN	Indication output 15
OUTPUT16	BOOLEAN	Indication output 16

Settings

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

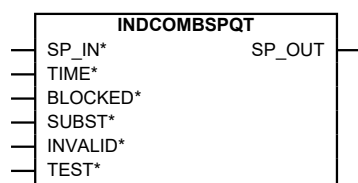
11.1.2.11 Indication combining single position function block INDCOMBSPQT**Identification**

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Single indication signal combining function block	INDCOMBSPQT	-	-

Functionality

Single position input is copied to value part of SP_OUT output. TIME input is copied to time part of SP_OUT output. State input bits are copied to the corresponding state part of SP_OUT output. If the state or value on the SP_OUT output changes, the Event bit in the state part is toggled.

Function block



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Figure 71: INDCOMBSPQT function block

Signals

Table 132: INDCOMBSPQT Input signals

Name	Type	Default	Description
SP_IN	BOOLEAN	0	Single point indication
TIME	GROUP SIGNAL	0	Timestamp
BLOCKED	BOOLEAN	0	Blocked for update
SUBST	BOOLEAN	0	Substituted
INVALID	BOOLEAN	0	Invalid value
TEST	BOOLEAN	0	Testmode

Table 133: INDCOMBSPQT Output signals

Name	Type	Description
SP_OUT	BOOLEAN	Single point indication

Settings

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

11.1.2.12 Indication extractor single position function block INDEXTSPQT

Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Single indication signal extractor function block	INDEXTSPQT	-	-

Functionality

Value part of single position input is copied to SI_OUT output.

Time part of single position input is copied to TIME output.

State bits in common part and indication part of inputs signal is copied to the corresponding state output.

Function block

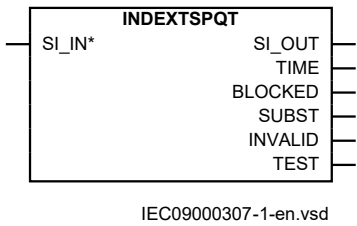


Figure 72: INDEXTSPQT function block

Signals

Table 134: INDEXTSPQT Input signals

Name	Type	Default	Description
SI_IN	BOOLEAN	0	Single indication

Table 135: INDEXTSPQT Output signals

Name	Type	Description
SI_OUT	BOOLEAN	Single indication
TIME	GROUP SIGNAL	Timestamp of input
BLOCKED	BOOLEAN	Blocked for update
SUBST	BOOLEAN	Substituted
INVALID	BOOLEAN	Invalid value
TEST	BOOLEAN	Testmode

Settings

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

11.2 Fixed signals FXDSIGN

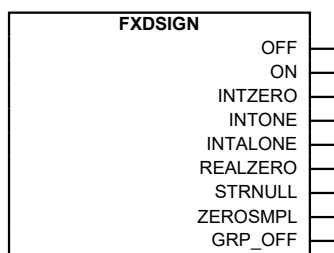
11.2.1 Identification

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

11.2.2 Functionality

The Fixed signals function FXDSIGN generates nine pre-set (fixed) signals that can be used in the configuration of an IED, either for forcing the unused inputs in other function blocks to a certain level/ value, or for creating certain logic. Boolean, integer, floating point, string, and group types of signals are available.

11.2.3 Function block



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Figure 73: FXDSIGN function block

11.2.4 Signals

Table 136: 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

11.2.5 Settings

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

11.2.6 Operation principle

There are nine outputs from FXDSIGN function block:

- OFF is a boolean signal, fixed to OFF (boolean 0) value
- ON is a boolean signal, fixed to ON (boolean 1) value
- INTZERO is an integer number, fixed to integer value 0
- INTONE is an integer number, fixed to integer value 1
- INTALONE is an integer value FFFF (hex)
- REALZERO is a floating point real number, fixed to 0.0 value
- STRNULL is a string, fixed to an empty string (null) value
- ZEROSMPL is the channel index of an analog signal, fixed to 0 value
- GRP_OFF is a group signal, fixed to 0 value

11.3 Boolean 16 to integer conversion B16I

11.3.1 Identification

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

11.3.2 Functionality

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

11.3.3 Function block

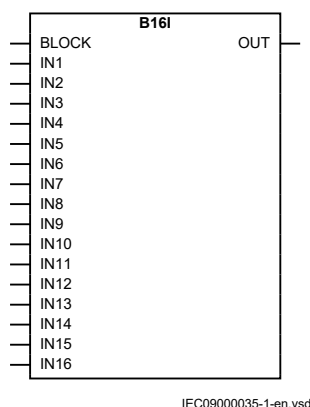


Figure 74: B16I function block

11.3.4 Signals

Table 137: 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
Table continues on next page			

Name	Type	Default	Description
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 138: B16I Output signals

Name	Type	Description
OUT	INTEGER	Output value

11.3.5 Settings

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

11.3.6 Monitored data

Table 139: B16I Monitored data

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

11.3.7 Operation principle

Boolean 16 to integer conversion function (B16I) is used to transform a set of 16 binary (logical) signals into an integer (0...65535), with IN1 mapped to the least significant bit. Activating the BLOCK input will freeze the output at the last value.

11.4 Boolean 16 to integer conversion with logic node representation B16IFCVI

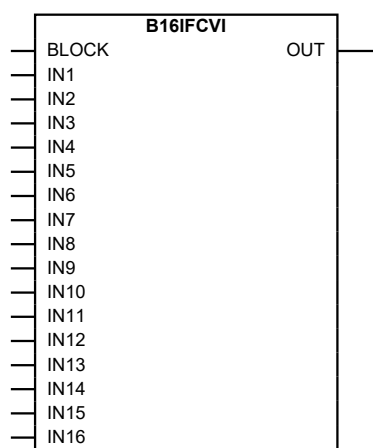
11.4.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Boolean 16 to integer conversion with logic node representation	B16IFCVI	-	-

11.4.2 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. The block input will freeze the output at the last value.

11.4.3 Function block



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Figure 75: B16IFCVI function block

11.4.4 Signals

Table 140: 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 141: B16IFCVI Output signals

Name	Type	Description
OUT	INTEGER	Output value

11.4.5 Settings

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

11.4.6 Monitored data

Table 142: B16IFCVI Monitored data

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

11.4.7 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 (0...65535), where IN1 represents the least significant bit (LSB). Activating the BLOCK input will freeze the output at the last value.

11.5 Integer to boolean 16 conversion IB16A

11.5.1 Identification

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

11.5.2 Functionality

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

11.5.3 Function block

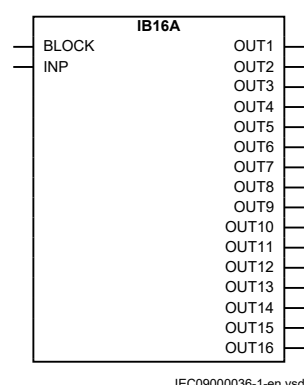


Figure 76: IB16A function block

11.5.4 Signals

Table 143: IB16A Input signals

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

Table 144: 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

11.5.5 Settings

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

11.5.6 Operation principle

Integer to boolean 16 conversion function (IB16A) is used to transform an integer (0...65535) into a set of 16 binary (logical) signals, with the least significant bit mapped to OUT1. IB16A function is designed for receiving the integer input locally. Activating the BLOCK input will freeze the logical outputs at the last value.

11.6 Integer to boolean 16 conversion with logic node representation IB16FCVB

11.6.1 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	-	-

11.6.2 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 IEC61850 when the operator position input PSTO is in position remote. The block input will freeze the output at the last value.

11.6.3 Function block

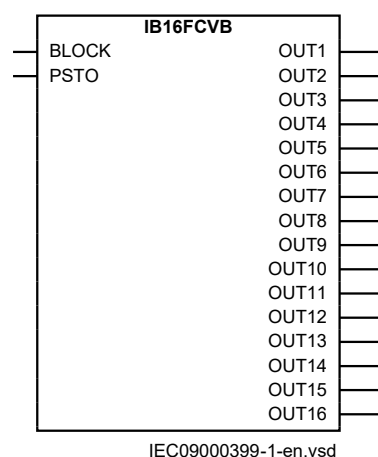


Figure 77: IB16FCVB function block

11.6.4 Signals

Table 145: IB16FCVB Input signals

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

Table 146: 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

11.6.5 Settings

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

11.6.6 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 (0...65535) from the station bus. Activating 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.

11.7 Logical function to determine the minimum and maximum value MINMAX

11.7.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Logical function to determine the minimum and maximum value	MINMAX	-	-

11.7.2 Functionality

MINMAX function is used to determine the maximum and the minimum values out of all the inputs. This function is also used to identify the input channel number that has the minimum (MIN) and maximum (MAX) value.

11.7.3 Function block

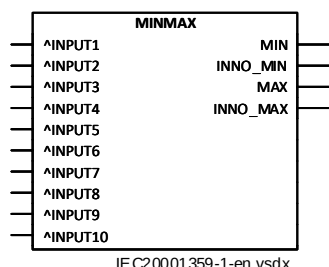


Figure 78: MINMAX function block

11.7.4 Signals

Table 147: MINMAX Input signals

Name	Type	Default	Description
INPUT1	REAL	0.0	Input signal 1
INPUT2	REAL	0.0	Input signal 2
INPUT3	REAL	0.0	Input signal 3
INPUT4	REAL	0.0	Input signal 4
INPUT5	REAL	0.0	Input signal 5
INPUT6	REAL	0.0	Input signal 6
INPUT7	REAL	0.0	Input signal 7
INPUT8	REAL	0.0	Input signal 8
INPUT9	REAL	0.0	Input signal 9
INPUT10	REAL	0.0	Input signal 10

Table 148: MINMAX Output signals

Name	Type	Description
MIN	REAL	Minimum value of the inputs
INNO_MIN	INTEGER	Channel number having the minimum value
MAX	REAL	Maximum value of the inputs
INNO_MAX	INTEGER	Channel number having the maximum value

11.7.5 Settings

Table 149: MINMAX Non group settings (basic)

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

11.7.6 Monitored data

Table 150: MINMAX Monitored data

Name	Type	Values (Range)	Unit	Description
MIN	REAL	-	-	Minimum value of the inputs
INNO_MIN	INTEGER	-	-	Channel number having the minimum value
MAX	REAL	-	-	Maximum value of the inputs
INNO_MAX	INTEGER	-	-	Channel number having the maximum value

11.7.7 Operation principle

MINMAX is used to determine the minimum and the maximum values out of the inputs. This function is also used to identify the input channel number that has the minimum (MIN) and maximum (MAX) value. If more than one input has the same value as the maximum, then the input channel number of maximum value (INNO_MAX) provides the value with the lowest input channel number. Similarly, if more than one input has the same value as the minimum, then the input channel number of minimum value (INNO_MIN) provides the value with the lowest input channel number.



All channels should be connected to the functionality to work properly. This can be achieved by connecting the last input signal to all the unused inputs of the function block.

11.8 Elapsed time integrator with limit transgression and overflow supervision TEIGGIO

11.8.1 Identification

Function Description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Elapsed time integrator	TEIGGIO	-	-

11.8.2 Functionality

Elapsed Time Integrator (TEIGGIO) is a function that accumulates the elapsed time for which a binary input signal has been high.

The main features of TEIGGIO are

- Applicable to long time integration ($\leq 999\,999.9$ seconds).
- Supervision of limit transgression conditions and overflow.
- Possibility defining a warning or alarm with resolution of 10 milliseconds.
- Retain the integration value at a warning/alarm/overflow.
- Possibilities for blocking and reset.
- Report the integrated time

11.8.3 Function block

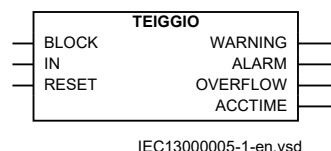


Figure 79: TEIGGIO function block

11.8.4 Signals

Table 151: TEIGGIO Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Freeze the integration and block the other outputs
IN	BOOLEAN	0	The input signal that is used to measure the elapsed time, when its value is high
RESET	BOOLEAN	0	Reset the integration time

Table 152: TEIGGIO Output signals

Name	Type	Description
WARNING	BOOLEAN	Indicator of the integrated time has reached the warning limit
ALARM	BOOLEAN	Indicator of the integrated time has reached the alarm limit
OVERFLOW	BOOLEAN	Indicator of the integrated time has reached the overflow limit
ACCTIME	REAL	Integrated elapsed time in seconds

11.8.5 Settings

Table 153: TEIGGIO Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	0 - 1	-	1	1	Operation Off / On
tWarning	1.00 - 999999.99	s	0.01	600.00	Time limit for warning supervision
tAlarm	1.00 - 999999.99	s	0.01	1200.00	Time limit for alarm supervision

11.8.6 Operation principle

The elapsed time integrator (TEIGGIO) provides

- time integration, accumulating the elapsed time when a given binary signal has been high.
- blocking and reset.
- supervision of limit transgression and overflow.
- retaining of the integrated value if any warning, alarm or overflow occurs.

Figure 80 describes the simplified logic of the function where “Time Integration” covers the logics for the first two items listed above while “Transgression Supervision Plus Retain” contains the logics for the last two.

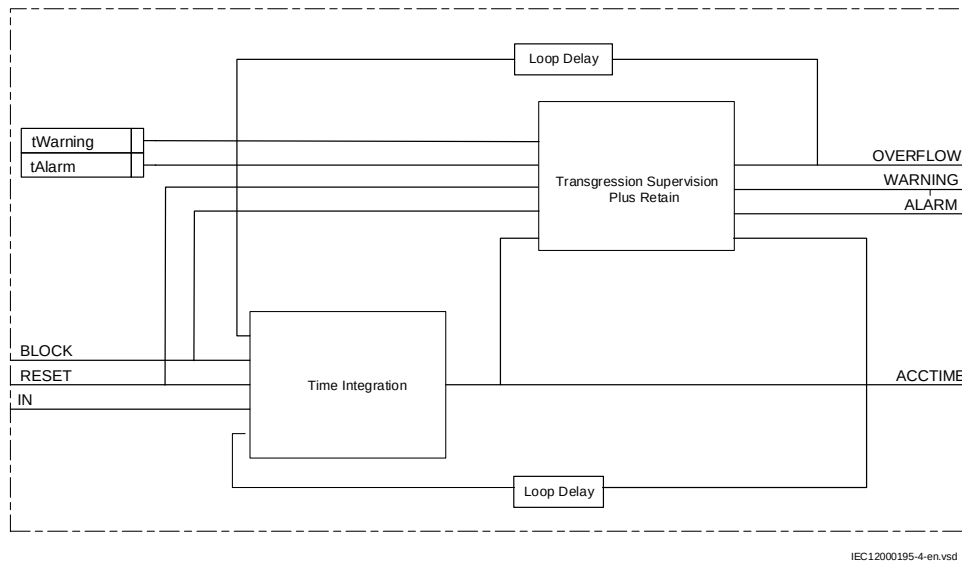


Figure 80: TEIGGIO Simplified logic

TEIGGIO main functionalities are

- integrate the elapsed time when IN has been high
 - applicable to long time integration ($\leq 999\,999.9$ seconds)
 - output ACCTIME presents integrated value in seconds to all tools
 - integrated value is retained in non-volatile memory, if any warning, alarm or overflow occurs
 - any retained value with a warning/alarm/overflow shall be available as the initiation value for the integration followed by a restart.
- RESET: Reset the integration value. Consequently all other outputs are also reset
 - regardless of the input IN value
 - reset the value of the non-volatile memory to zero.
- BLOCK: Freeze the integration and block/reset the other outputs
 - regardless of the other input signal values
 - BLOCK input overrides RESET input.
- Monitor and report the conditions of limit transgression
 - overflow if output ACCTIME > $t_{Overflow}$
 - alarm if ACCTIME > t_{Alarm}
 - warning if ACCTIME > $t_{Warning}$.

The ACCTIME output represents the integrated time in seconds while $t_{Overflow}$, t_{Alarm} and $t_{Warning}$ are the time limit parameters in seconds.

t_{Alarm} and $t_{Warning}$ are user settable limits. They are independent, that is, there is no check if $t_{Alarm} > t_{Warning}$.

t_{Alarm} and $t_{Warning}$ can be defined with a resolution of 10 ms, depending on the level of the defined values for the parameters.

$t_{Overflow}$ is for the overflow supervision with a default value $t_{Overflow} = 999\,999.9$ seconds. The outputs freeze if an overflow occurs.

11.8.6.1 Operation Accuracy

The accuracy of TEIGGIO depends on essentially three factors

- task cycle time
- the pulse length
- the number of pulses, that is the number of rising and falling flank pairs

In principle, a shorter task cycle time, longer integrated time length or more pulses may lead to reduced accuracy.

11.8.6.2 Memory storage

The value of the integrated elapsed time is retained in a non-volatile memory, only if any warning, alarm or/and overflow occurs. Consequently there is a risk of data loss in the integrated time at a power failure.

11.8.7 Technical data

Table 154: TEIGGIO Technical data

Function	Cycle time (ms)	Range or value	Accuracy
Elapsed time integration	5	0 ~ 999999.9 s	±0.05% or ±0.01 s

11.9 Comparator for integer inputs INTCOMP

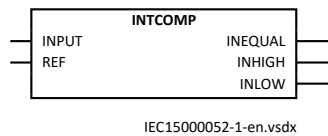
11.9.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Comparison of integer values	INTCOMP	Int<=>	

11.9.2 Functionality

The function gives the possibility to monitor the level of integer values in the system relative to each other or to a fixed value. It is a basic arithmetic function that can be used for monitoring, supervision, interlocking and other logics.

11.9.3 Function block



11.9.4 Signals

Table 155: INTCOMP Input signals

Name	Type	Default	Description
INPUT	INTEGER	0	Input value to be compared with reference value
REF	INTEGER	0	Reference value to be compared with input value

Table 156: INTCOMP Output signals

Name	Type	Description
INEQUAL	BOOLEAN	Input value is equal to the reference value
INHIGH	BOOLEAN	Input value is higher than the reference value
INLOW	BOOLEAN	Input value is lower than the reference value

11.9.5 Settings

Table 157: INTCOMP Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
EnaAbs	Signed Absolute	-	-	Signed	Selection for absolute or signed comparison
RefSource	Set Value Input REF	-	-	Set Value	Selection for reference value either input or setting
SetValue	-2000000000 - 2000000000	-	1	100	Set value for reference

11.9.6 Monitored data

Table 158: INTCOMP Monitored data

Name	Type	Values (Range)	Unit	Description
INEQUAL	BOOLEAN	-	-	Input value is equal to the reference value
INHIGH	BOOLEAN	-	-	Input value is higher than the reference value
INLOW	BOOLEAN	-	-	Input value is lower than the reference value

11.9.7 Operation principle

The comparison can be done in two ways,

- Between 2 inputs, INPUT and REF
- Between INPUT and the value set by the user *SetValue*.

The selection of reference value for comparison is done through setting *RefSource*. If *RefSource* is selected as "Input REF" then the reference value for comparison is taken from second input signal (REF). If *RefSource* is selected as "Set Value" then the reference value for comparison is taken from setting (*SetValue*).

The comparison can be done either between absolute values or signed values, which is governed by on the setting *EnaAbs*. If *EnaAbs* is selected as "Absolute" then both input and reference values are converted into absolute values and comparison is done. If *EnaAbs* is selected as "Signed" then the comparison is done without any conversion.

The function has three binary outputs representing the result of the comparison:

- If the input is above the reference value then INHIGH is set HIGH
- If the input is below the reference value then INLOW is set HIGH
- If the input is equal to reference value then INEQUAL is set HIGH

11.10 Comparator for real inputs REALCOMP

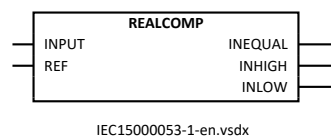
11.10.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Comparator for real inputs	REALCOMP	Real<=>	

11.10.2 Functionality

The function gives the possibility to monitor the level of real value signals in the system relative to each other or to a fixed value. It is a basic arithmetic function that can be used for monitoring, supervision, interlocking and other logics.

11.10.3 Function block



11.10.4 Signals

Table 159: REALCOMP Input signals

Name	Type	Default	Description
INPUT	REAL	0.000	Input value to be compared with reference value
REF	REAL	0.000	Reference value to be compared with input value

Table 160: REALCOMP Output signals

Name	Type	Description
INEQUAL	BOOLEAN	Input value is equal to the reference value
INHIGH	BOOLEAN	Input value is higher than the reference value
INLOW	BOOLEAN	Input value is lower than the reference value

11.10.5 Settings

Table 161: REALCOMP Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
EnaAbs	Signed Absolute	-	-	Signed	Selection for absolute or signed comparison
RefSource	Set Value Input REF	-	-	Set Value	Selection for reference value either input or setting
SetValue	-999.999 - 999.999	-	0.001	0.001	Set value for reference
SetValPrefix	milli unit kilo Mega Giga	-	-	unit	Multiplication factor for SetValue
EqualBandHigh	0.10 - 50.00	%	0.01	0.50	Equal band high limit in % of reference value
EqualBandLow	0.10 - 50.00	%	0.01	0.50	Equal band low limit in % of reference value

11.10.6 Operation principle

The comparison can be done in two ways,

1. Between 2 inputs, INPUT and REF
2. Between INPUT and the *SetValue* setting

The selection of reference value for comparison is done through setting *RefSource*. If *RefSource* is selected as "Input REF" then the reference value for comparison is taken from second input signal (REF). If *RefSource* is selected as "Set Value" then the reference value for comparison is taken from setting (*SetValue*).

Generally the inputs to the function are in units, but when the comparison is to be done with respect to set level, then the user can scale the reference value in steps of 1000, as per the setting *RefPrefix*. Internally the function handles the reference value for comparator as $SetValue * RefPrefix$.

Additionally the comparison can be done either between absolute values or signed values, which is determined by the setting *EnaAbs*. If *EnaAbs* is selected as "Absolute" then both input and reference values are converted into absolute values and then comparison is done. If *EnaAbs* is selected as "Signed" then the comparison is done without absolute conversion.

This function has two settings *EqualBandHigh* and *EqualBandLow* to provide margins from reference value for equal to condition. When the INPUT value is within high and low band around the reference value, output INEQUAL will get set.

In order to avoid oscillations at boundary conditions of equal band low limit and high limit, hysteresis has been provided. If the INPUT is above the equal high level margin including hysteresis, then INHIGH will set. Similarly if the INPUT is below the equal low level margin including hysteresis, then INLOW will set.

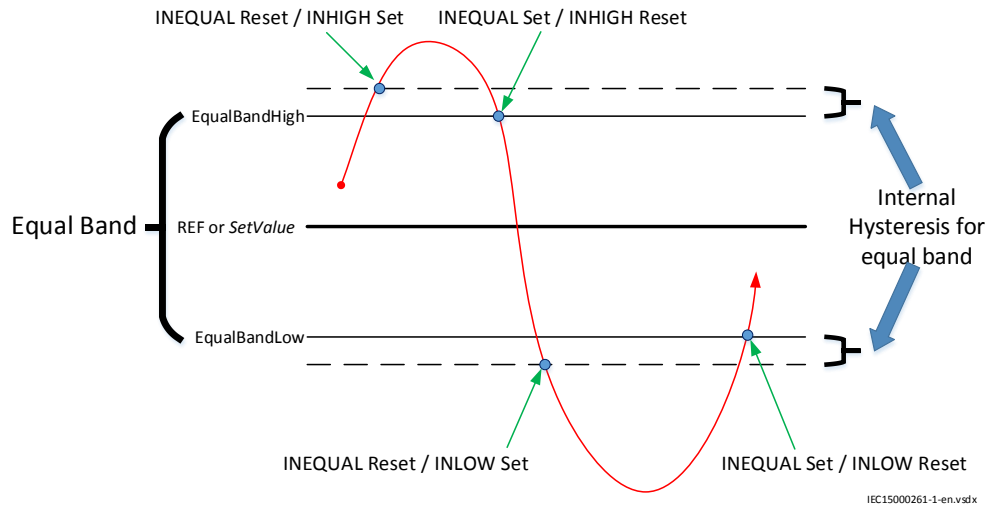


Figure 81: Operation principle of REALCOMP



When *EnaAbs* is set as absolute comparison and *SetValue* is set less than 0.1% of the set unit then INLOW output will never pick up. During the above mentioned condition, due to marginal value for avoiding oscillations of function outputs, the INLOW output will never set.

11.10.7 Technical data

REALCOMP function can compare the values from milli value level to giga value level and the maximum expectable accuracy level from the function is 10 μ .

Section 12 Monitoring

12.1 Measurements

12.1.1 Functionality

Measurement functions are used for power system measurement, supervision and reporting to the local HMI, monitoring tool within PCM600 or to station level for example, via IEC 61850. The possibility to continuously monitor measured values of active power, reactive power, currents, voltages, frequency, power factor etc. is vital for efficient production, transmission and distribution of electrical energy. It provides to the system operator fast and easy overview of the present status of the power system. Additionally, it can be used during testing and commissioning of protection and control IEDs in order to verify proper operation and connection of instrument transformers (CTs and VTs). During normal service by periodic comparison of the measured value from the IED with other independent meters the proper operation of the IED analog measurement chain can be verified.



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, namely 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 *ULZeroDb* 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. Measured 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 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 as averaged values over a period of time (low pass filtered) depending on the selected settings.

The output values can be displayed in the local HMI under **Main menu /Tests /Function status / Monitoring /CVMMXN /Outputs**

The measuring functions CMMXU, VNMMXU and VMMXU provide physical quantities:

- I: phase currents (amplitude and angle) (CMMXU)
- U: voltages (phase-to-earth and phase-to-phase voltage, amplitude and angle) (VMMXU, VNMMXU)

It is possible to calibrate the measuring function above to get better than class 0.5 presentation. This is accomplished by angle and amplitude compensation at 5, 30 and 100% of rated current and at 100% of rated voltage.



The power system quantities provided, depends on the actual hardware, (TRM) and the logic configuration made in PCM600.

The measuring functions CMSQI and VMSQI provide sequence component quantities:

- I: sequence currents (positive, zero, negative sequence, amplitude and angle)
- U: sequence voltages (positive, zero and negative sequence, amplitude and angle).

12.1.2 Measurements CVMMXN

12.1.2.1 Identification

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

12.1.2.2 Function block

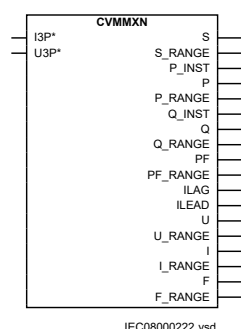


Figure 82: CVMMXN function block

12.1.2.3 Signals

Table 162: 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 163: 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
Table continues on next page		

Name	Type	Description
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	Calculated 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

12.1.2.4 Settings

Table 164: 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

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
PMax	-2000.0 - 2000.0	%SB	0.1	200.0	Maximum value in % of SBase
PRepTyp	Cyclic Dead band Int deadband	-	-	Cyclic	Reporting type
QMin	-2000.0 - 2000.0	%SB	0.1	-200.0	Minimum value in % of SBase
QMax	-2000.0 - 2000.0	%SB	0.1	200.0	Maximum value in % of SBase
QRepTyp	Cyclic Dead band Int deadband	-	-	Cyclic	Reporting type
PfMin	-1.000 - 1.000	-	0.001	-1.000	Minimum value
PfMax	-1.000 - 1.000	-	0.001	1.000	Maximum value
PfRepTyp	Cyclic Dead band Int deadband	-	-	Cyclic	Reporting type
UMin	0.0 - 200.0	%UB	0.1	50.0	Minimum value in % of UBase
UMax	0.0 - 200.0	%UB	0.1	200.0	Maximum value in % of UBase
URepTyp	Cyclic Dead band Int deadband	-	-	Cyclic	Reporting type
IMin	0.0 - 500.0	%IB	0.1	50.0	Minimum value in % of IBase
IMax	0.0 - 500.0	%IB	0.1	200.0	Maximum value in % of IBase
IRepTyp	Cyclic Dead band Int deadband	-	-	Cyclic	Reporting type
FrMin	0.000 - 100.000	Hz	0.001	0.000	Minimum value
FrMax	0.000 - 100.000	Hz	0.001	70.000	Maximum value
FrRepTyp	Cyclic Dead band Int deadband	-	-	Cyclic	Reporting type

Table 165: 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)

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
QDbReplInt	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)
UGenZeroDb	1 - 100	%UB	1	5	Zero point clamping in % of Ubase
PFDbReplInt	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
IGenZeroDb	1 - 100	%IB	1	5	Zero point clamping in % of Ibase
PFHiHiLim	-1.000 - 1.000	-	0.001	1.000	High High limit (physical value)
PFHiLim	-1.000 - 1.000	-	0.001	0.800	High limit (physical value)
PFLowLim	-1.000 - 1.000	-	0.001	-0.800	Low limit (physical value)
PFLowLowLim	-1.000 - 1.000	-	0.001	-1.000	Low Low limit (physical value)
PFLimHyst	0.000 - 100.000	%	0.001	5.000	Hysteresis value in % of range (common for all limits)
UDbReplInt	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)
IDbReplInt	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)
FrDbReplInt	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)

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
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
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

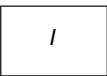
12.1.2.5 Monitored data

Table 166: 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	-	MVA _r	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

12.1.3 Phase current measurement CMMXU

12.1.3.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Phase current measurement	CMMXU		-

12.1.3.2 Function block

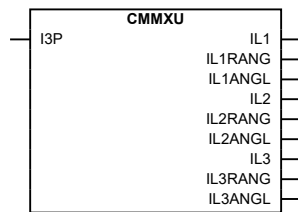


Figure 83: CMMXU function block

12.1.3.3 Signals

Table 167: CMMXU Input signals

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

Table 168: 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

12.1.3.4 Settings

Table 169: CMMXU 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
ILDbRepInt	1 - 300	Type	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	Type	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s

Table 170: CMMXU Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
ILZeroDb	0 - 100000	m%	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	0	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

12.1.3.5 Monitored data

Table 171: 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

12.1.4 Phase-phase voltage measurement VMMXU

12.1.4.1 Identification

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

12.1.4.2 Function block

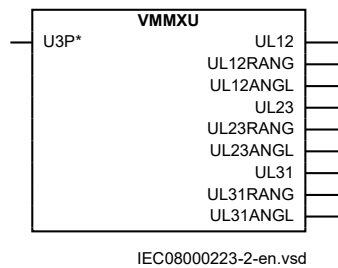


Figure 84: VMMXU function block

12.1.4.3 Signals

Table 172: VMMXU Input signals

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

Table 173: 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	UL31 Amplitude range
UL31ANGL	REAL	UL31 Angle

12.1.4.4 Settings

Table 174: VMMXU 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
ULDbRepInt	1 - 300	Type	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s
ULMax	0 - 4000000	V	1	170000	Maximum value
ULRepTyp	Cyclic Dead band Int deadband	-	-	Dead band	Reporting type
ULAngDbRepInt	1 - 300	Type	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s

Table 175: VMMXU Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
ULZeroDb	0 - 100000	m%	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	%	0.001	5.000	Hysteresis value in % of range and is common for all limits

12.1.4.5 Monitored data

Table 176: 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

12.1.5 Current sequence component measurement CMSQI

12.1.5.1 Identification

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

12.1.5.2 Function block

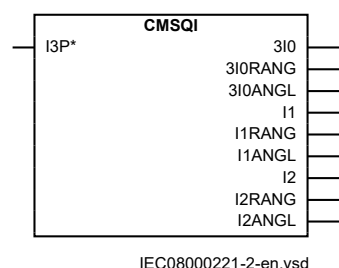


Figure 85: CMSQI function block

12.1.5.3 Signals

Table 177: CMSQI Input signals

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

Table 178: 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

12.1.5.4 Settings

Table 179: CMSQI Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
3I0DbReplnt	1 - 300	Type	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
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
3I0AngDbReplnt	1 - 300	Type	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s
I1DbReplnt	1 - 300	Type	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
I1AngDbReplnt	1 - 300	Type	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s
I2DbReplnt	1 - 300	Type	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
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	Type	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s

Table 180: CMSQI Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
3I0ZeroDb	0 - 100000	m%	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	m%	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	m%	1	500	Zero point clamping
I2HiHiLim	0 - 500000	A	1	1200	High High limit (physical value)
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)

12.1.5.5 Monitored data

Table 181: 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

12.1.6 Voltage sequence measurement VMSQI

12.1.6.1 Identification

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

12.1.6.2 Function block

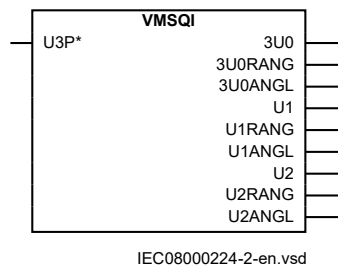


Figure 86: VMSQI function block

12.1.6.3 Signals

Table 182: VMSQI Input signals

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

Table 183: 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

12.1.6.4 Settings

Table 184: VMSQI Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
3U0DbReplnt	1 - 300	Type	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
3U0AngDbReplnt	1 - 300	Type	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s
U1DbReplnt	1 - 300	Type	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
U1AngDbReplnt	1 - 300	Type	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s
U2DbReplnt	1 - 300	Type	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
U2AngDbReplnt	1 - 300	Type	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s

Table 185: VMSQI Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
3U0ZeroDb	0 - 100000	m%	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	m%	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)

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
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	m%	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)

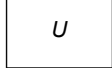
12.1.6.5 Monitored data

Table 186: VMSQI Monitored data

Name	Type	Values (Range)	Unit	Description
3U0	REAL	-	kV	3U0 Amplitude
3U0ANGL	REAL	-	deg	3U0 Angle
U1	REAL	-	kV	U1 Amplitude
U1ANGL	REAL	-	deg	U1 Angle
U2	REAL	-	kV	U2 Amplitude
U2ANGL	REAL	-	deg	U2 Angle

12.1.7 Phase-neutral voltage measurement VNMMXU

12.1.7.1 Identification

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

12.1.7.2 Function block

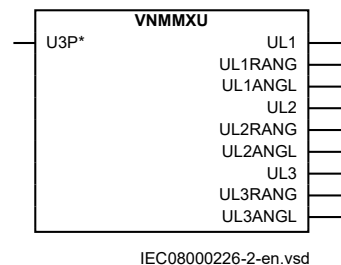


Figure 87: VNMMXU function block

12.1.7.3 Signals

Table 187: VNMMXU Input signals

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

Table 188: VNMMXU Output signals

Name	Type	Description
UL1	REAL	UL1 Amplitude, magnitude of reported value
UL1RANG	INTEGER	UL1 Amplitude range
UL1ANGL	REAL	UL1 Angle, magnitude of reported value
UL2	REAL	UL2 Amplitude, magnitude of reported value
UL2RANG	INTEGER	UL2 Amplitude range
UL2ANGL	REAL	UL2 Angle, magnitude of reported value
UL3	REAL	UL3 Amplitude, magnitude of reported value
UL3RANG	INTEGER	UL3 Amplitude range
UL3ANGL	REAL	UL3 Angle, magnitude of reported value

12.1.7.4 Settings

Table 189: 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	Selection of one of the Global Base Value groups
UDbReplnt	1 - 300	Type	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	%	0.001	5.000	Hysteresis value in % of range and is common for all limits
UAngDbReplnt	1 - 300	Type	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s

Table 190: VNMMXU Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
UZeroDb	0 - 100000	m%	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

12.1.7.5 Monitored data

Table 191: 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

12.1.8 Operation principle

12.1.8.1 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 88](#). 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 88](#).

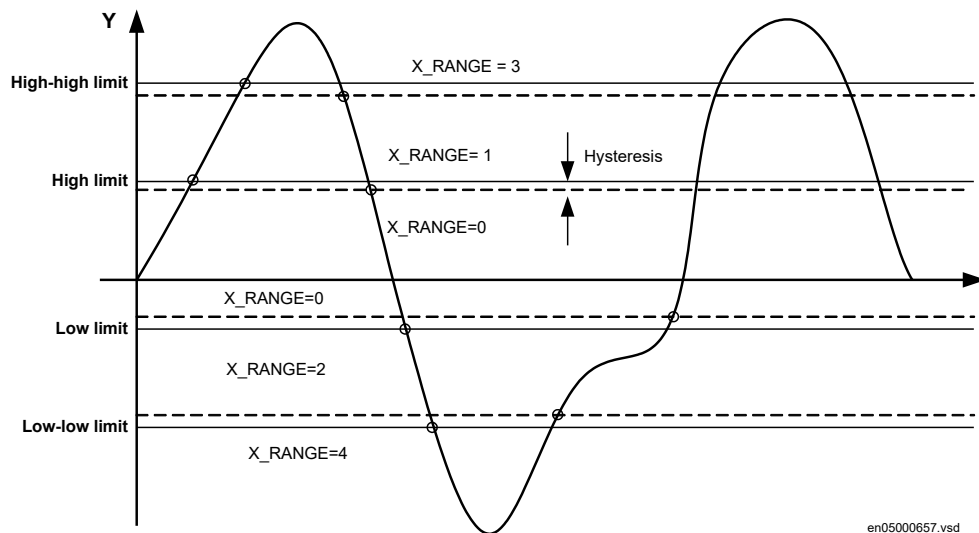


Figure 88: Presentation of operating limits

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 (MVEXP) to get measurement supervision as binary signals.

The logical value of the functional output signals changes according to [Figure 88](#).

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.

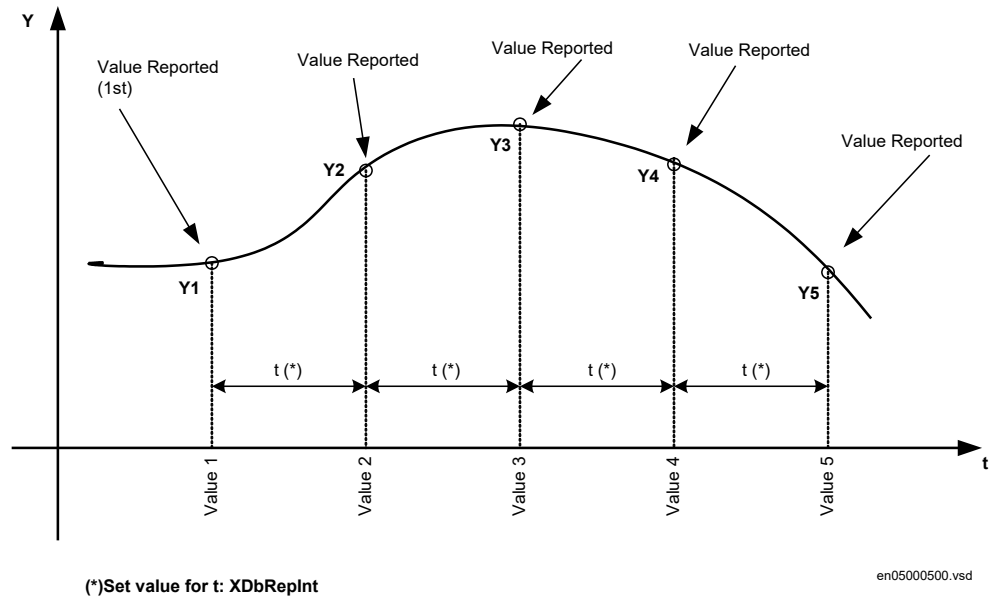


Figure 89: Periodic reporting

Amplitude dead-band supervision

If a measuring value is changed, compared to the last reported value, and the change is larger than the $\pm\Delta Y$ pre-defined limits that are set by user (*UDbRepln*), then the measuring channel reports the new value to a higher level. This limits the information flow to a minimum necessary. Figure 90 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.

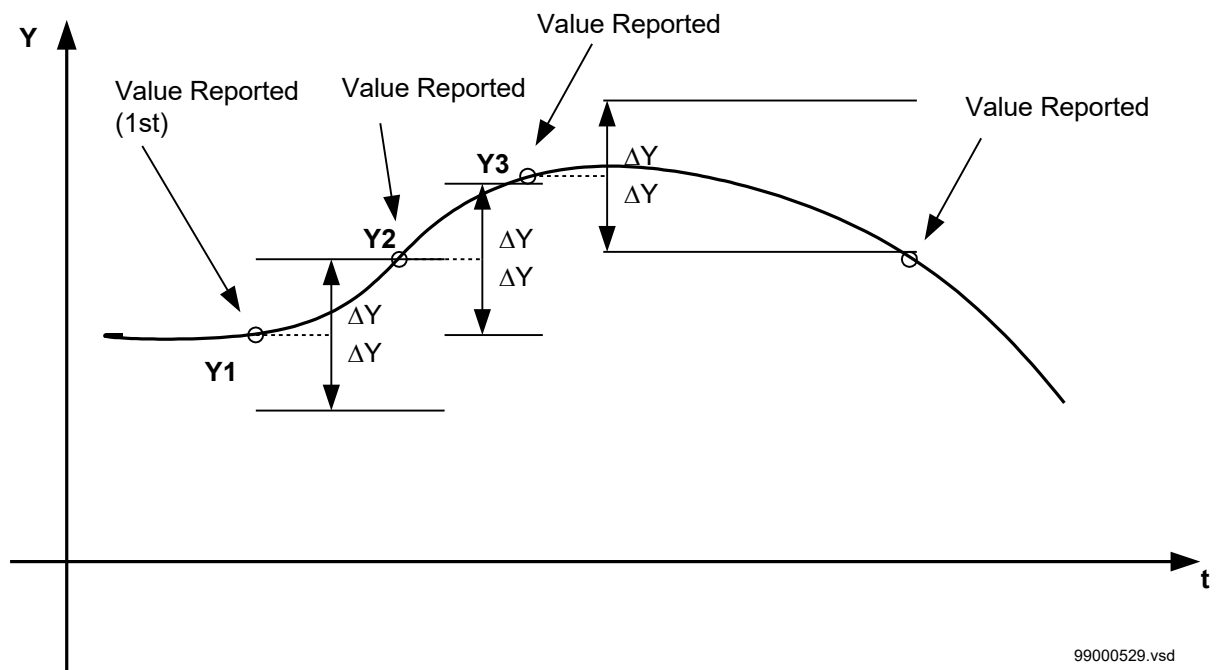


Figure 90: Amplitude dead-band supervision reporting

After the new value is reported, the $\pm\Delta Y$ limits for dead-band are automatically set around it. The new value is reported only if the measured quantity changes more than defined by the $\pm\Delta Y$ set limits.

Integral dead-band reporting

The measured value is reported if the time integral of all changes exceeds the pre-set limit ($XDbRepInt$), [Figure 91](#), 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 91](#) 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.

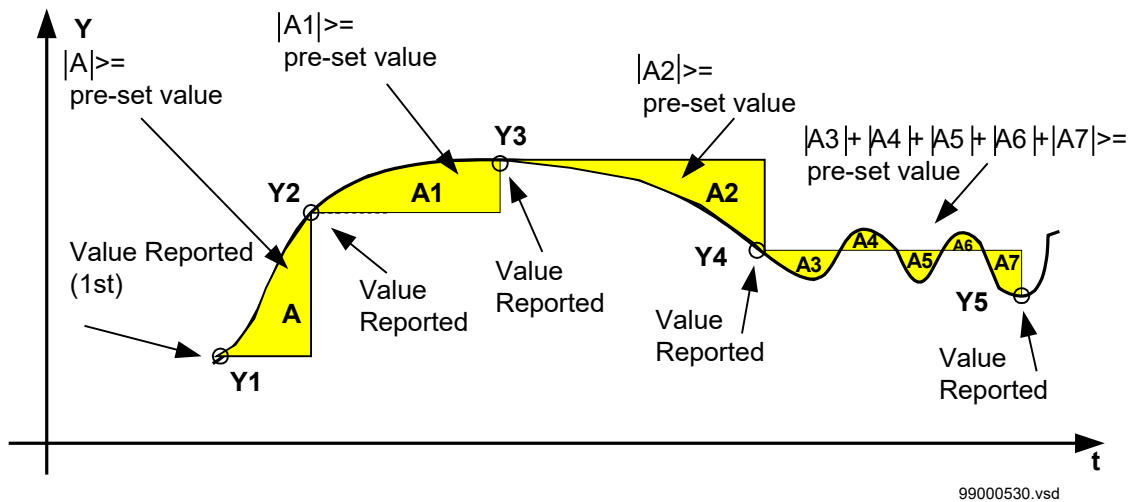


Figure 91: Reporting with integral dead-band supervision

12.1.8.2 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	$\bar{S} = \overline{U_{L1}} \cdot \overline{I_{L1}^*} + \overline{U_{L2}} \cdot \overline{I_{L2}^*} + \overline{U_{L3}} \cdot \overline{I_{L3}^*}$	$U = (\left \overline{U_{L1}} \right + \left \overline{U_{L2}} \right + \left \overline{U_{L3}} \right) / \sqrt{3}$ $I = (\left \overline{I_{L1}} \right + \left \overline{I_{L2}} \right + \left \overline{I_{L3}} \right) / 3$	Used when three phase-to-earth voltages are available
2	Arone	$\bar{S} = \overline{U_{L1L2}} \cdot \overline{I_{L1}^*} - \overline{U_{L2L3}} \cdot \overline{I_{L3}^*}$ (Equation 3)	$U = (\left \overline{U_{L1L2}} \right + \left \overline{U_{L2L3}} \right) / 2$ $I = (\left \overline{I_{L1}} \right + \left \overline{I_{L3}} \right) / 2$ (Equation 4)	Used when three two phase-to-phase voltages are available
3	PosSeq	$\bar{S} = 3 \cdot \overline{U_{PosSeq}} \cdot \overline{I_{PosSeq}^*}$ (Equation 5)	$U = \sqrt{3} \cdot \left \overline{U_{PosSeq}} \right $ $I = \left \overline{I_{PosSeq}} \right $ (Equation 6)	Used when only symmetrical three phase power shall be measured
4	L1L2	$\bar{S} = \overline{U_{L1L2}} \cdot (\overline{I_{L1}^*} - \overline{I_{L2}^*})$ (Equation 7)	$U = \left \overline{U_{L1L2}} \right $ $I = (\left \overline{I_{L1}} \right + \left \overline{I_{L2}} \right) / 2$ (Equation 8)	Used when only U_{L1L2} phase-to-phase voltage is available
5	L2L3	$\bar{S} = \overline{U_{L2L3}} \cdot (\overline{I_{L2}^*} - \overline{I_{L3}^*})$ (Equation 9)	$U = \left \overline{U_{L2L3}} \right $ $I = (\left \overline{I_{L2}} \right + \left \overline{I_{L3}} \right) / 2$ (Equation 10)	Used when only U_{L2L3} phase-to-phase voltage is available
6	L3L1	$\bar{S} = \overline{U_{L3L1}} \cdot (\overline{I_{L3}^*} - \overline{I_{L1}^*})$ (Equation 11)	$U = \left \overline{U_{L3L1}} \right $ $I = (\left \overline{I_{L3}} \right + \left \overline{I_{L1}} \right) / 2$ (Equation 12)	Used when only U_{L3L1} phase-to-phase voltage is available
7	L1	$\bar{S} = 3 \cdot \overline{U_{L1}} \cdot \overline{I_{L1}^*}$ (Equation 13)	$U = \sqrt{3} \cdot \left \overline{U_{L1}} \right $ $I = \left \overline{I_{L1}} \right $ (Equation 14)	Used when only U_{L1} phase-to-earth voltage is available
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
8	L2	$\bar{S} = 3 \cdot \overline{U_{L2}} \cdot \overline{I_{L2}^*}$ (Equation 15)	$U = \sqrt{3} \cdot \overline{U_{L2}} $ $I = \overline{I_{L2}} $ (Equation 16)	Used when only U _{L2} phase-to-earth voltage is available
9	L3	$\bar{S} = 3 \cdot \overline{U_{L3}} \cdot \overline{I_{L3}^*}$ (Equation 17)	$U = \sqrt{3} \cdot \overline{U_{L3}} $ $I = \overline{I_{L3}} $ (Equation 18)	Used when only U _{L3} phase-to-earth voltage is available
* means complex conjugated value				

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

$$P = \text{Re}(\bar{S})$$

(Equation 19)

$$Q = \text{Im}(\bar{S})$$

(Equation 20)

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

(Equation 21)

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

(Equation 22)

Additionally to the power factor value the two binary output signals from the function are provided which indicates the angular relationship between current and voltage phasors. Binary output signal ILAG is set to one when current phasor is lagging behind voltage phasor. Binary output signal ILEAD is set to one when current phasor is leading the voltage phasor.

Each analogue output has a corresponding supervision level output (X_RANGE). The output signal is an integer in the interval 0-4, see section ["Measurement supervision"](#).

Calibration of analog inputs

Measured currents and voltages used in the CVMMXN function can be calibrated to get class 0.5 measuring accuracy. This is achieved by amplitude and angle compensation at 5, 30 and 100% of rated current and voltage. The compensation below 5% and above 100% is constant and linear in between, see example in [Figure 92](#).

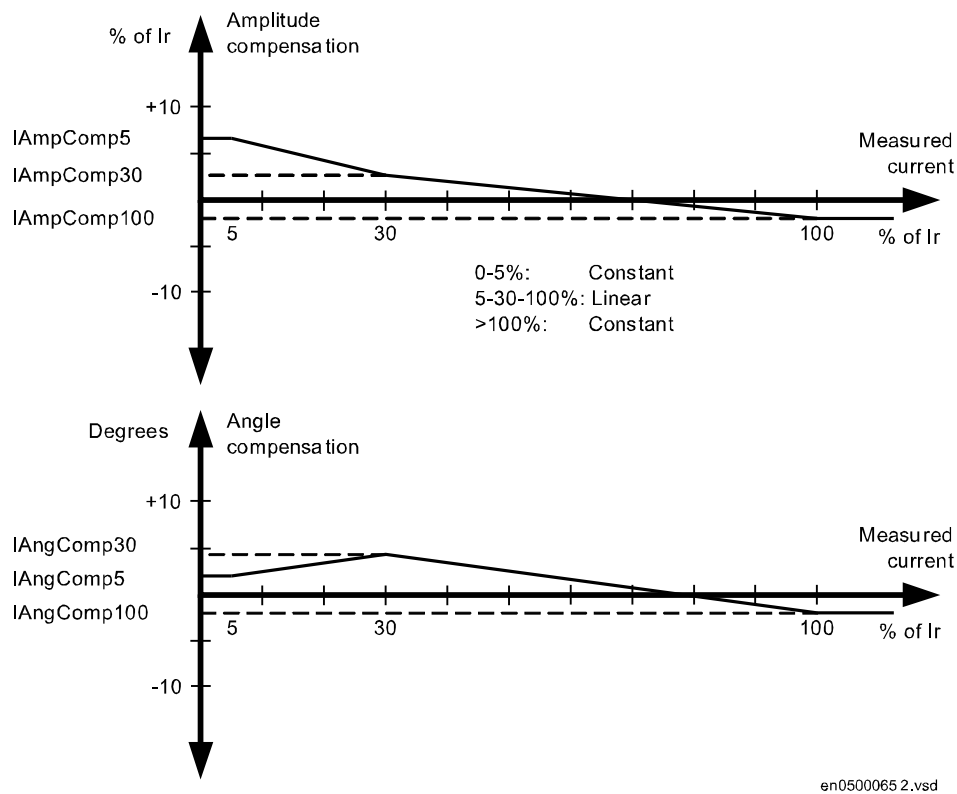


Figure 92: Calibration curves

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 23)

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 and so on.) it is possible to perform on-site calibration of the power measurement. This is achieved by setting the complex constant which is then internally used within the function to multiply the calculated complex apparent power S . This constant is set as amplitude (setting parameter *PowAmpFact*, default value 1.000) and angle (setting parameter *PowAngComp*, default value 0.0 degrees). Default values for these two parameters are done in such way that they do not influence internally calculated value (complex constant has default value 1). In this way calibration, for specific operating range (for example, around rated power) can be done at site. However, to perform this calibration it is necessary to have an external power meter with high accuracy class available.

Directionality

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.

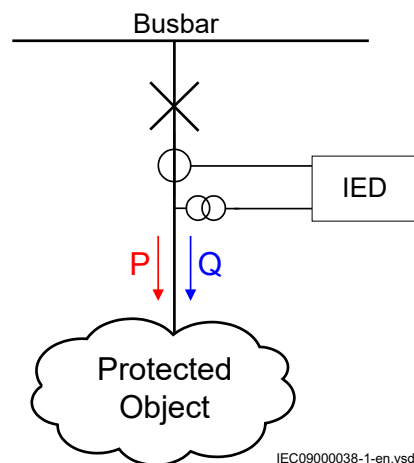


Figure 93: Internal IED directionality convention for P & Q measurements

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.

12.1.8.3 Phase current measurement CMMXU

The Phase current measurement (CMMXU) function must be connected to three-phase current input in the configuration tool to be operable. Currents handled in the function can be calibrated to get better than 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 92](#).

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 12.1.8.1](#).

12.1.8.4 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 12.1.8.1](#).

12.1.8.5 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, other than X_RANG, are calculated within the measuring blocks 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 12.1.8.1](#).

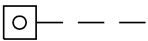
12.1.9 Technical data

Table 192: CVMMXN, CMMXU, VMMXU, CMSQI, VMSQI, VNMMXU

Function	Range or value	Accuracy
Voltage	$(0.1-1.5) \times U_r$	$\pm 0.5\%$ of U_r at $U \leq U_r$ $\pm 0.5\%$ of U at $U > U_r$
Connected current	$(0.2-4.0) \times I_r$	$\pm 0.5\%$ of I_r at $I \leq I_r$ $\pm 0.5\%$ of I at $I > I_r$
Active power, P	$0.1 \times U_r < U < 1.5 \times U_r$ $0.2 \times I_r < I < 4.0 \times I_r$	$\pm 1.0\%$ of S_r at $S \leq S_r$ $\pm 1.0\%$ of S at $S > S_r$
Reactive power, Q	$0.1 \times U_r < U < 1.5 \times U_r$ $0.2 \times I_r < I < 4.0 \times I_r$	$\pm 1.0\%$ of S_r at $S \leq S_r$ $\pm 1.0\%$ of S at $S > S_r$
Apparent power, S	$0.1 \times U_r < U < 1.5 \times U_r$ $0.2 \times I_r < I < 4.0 \times I_r$	$\pm 1.0\%$ of S_r at $S \leq S_r$ $\pm 1.0\%$ of S at $S > S_r$
Apparent power, S Three phase settings	$\cos \phi = 1$	$\pm 0.5\%$ of S at $S > S_r$ $\pm 0.5\%$ of S_r at $S \leq S_r$
Power factor, $\cos(\phi)$	$0.1 \times U_r < U < 1.5 \times U_r$ $0.2 \times I_r < I < 4.0 \times I_r$	< 0.02

12.2 Event Counter CNTGGIO

12.2.1 Identification

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

12.2.2 Functionality

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

12.2.3 Function block

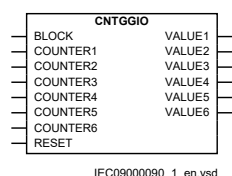


Figure 94: CNTGGIO function block

12.2.4 Signals

Table 193: 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 194: 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

12.2.5 Settings

Table 195: CNTGGIO Group settings (basic)

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

12.2.6 Monitored data

Table 196: 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

12.2.7 Operation principle

Event counter CNTGGIO comprises six independent counters. Each counter is incremented upon activation (0 to 1 transition) of its corresponding COUNTER input. The updated count number is presented at its VALUE output.

All counter values are stored in flash memory once per hour, to preserve the information against power loss.



To prevent loss of counter values, always wait for minimum one hour from the last counter event to powering off the IED.

Activation (0 to 1 transition) of the RESET input resets all six counters to 0, which takes precedence over any simultaneous COUNTER input activation. Continuous 1 on the RESET input has no effect.

When the BLOCK input is 1 all counters are blocked, that is, they do not react to changes on their inputs. This takes precedence over any simultaneous COUNTER input activation. However, RESET will still work even with active BLOCK.

12.2.7.1 Reporting

The content of the counters can be read in the local HMI.

Reset of counters can be performed in the local HMI or through 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.

12.2.8 Technical data

Table 197: CNTGGIO technical data

Function	Range or value	Accuracy
Counter value	0-100000	-
Max. count up speed	With 5ms task time, the maximum count up speed can go until 100 pulses/s	-

12.3 Limit counter L4UFCNT

12.3.1 Function description

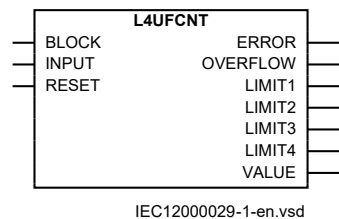
Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Limit counter	L4UFCNT		-

12.3.2 Introduction

Limit counter (L4UFCNT) provides a settable counter with four independent limits where the number of positive and/or negative edges on the input signal are counted against the setting values for limits. The output for each limit is activated when the counted value reaches that limit.

12.3.3 Function block

L4UFCNT function block



12.3.4 Signals

Table 198: L4UFCNT Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of function
INPUT	BOOLEAN	0	Input for counter
RESET	BOOLEAN	0	Reset of function

Table 199: L4UFCNT Output signals

Name	Type	Description
ERROR	BOOLEAN	Error indication on counter limit and/or initial value settings
OVERFLOW	BOOLEAN	Overflow indication on count of greater than MaxValue
LIMIT1	BOOLEAN	Counted value is larger than or equal to CounterLimit1
LIMIT2	BOOLEAN	Counted value is larger than or equal to CounterLimit2
LIMIT3	BOOLEAN	Counted value is larger than or equal to CounterLimit3
LIMIT4	BOOLEAN	Counted value is larger than or equal to CounterLimit4
VALUE	INTEGER	Counted value

12.3.5 Settings

Table 200: L4UFCNT Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
CountType	Set Reset Both	-	-	Set	Select counting on positive and/or negative flanks
CounterLimit1	1 - 65535	-	1	100	Value of the first limit
CounterLimit2	1 - 65535	-	1	200	Value of the second limit
CounterLimit3	1 - 65535	-	1	300	Value of the third limit
CounterLimit4	1 - 65535	-	1	400	Value of the fourth limit
MaxValue	1 - 65535	-	1	500	Maximum count value
OnMaxValue	Stop Rollover Steady Rollover Pulsed	-	-	Stop	Select if counter stops or rolls over after reaching maxValue with steady or pulsed overflow flag
InitialValue	0 - 65535	-	1	0	Initial count value after reset of the function

12.3.6 Monitored data

Table 201: L4UFCNT Monitored data

Name	Type	Values (Range)	Unit	Description
VALUE	INTEGER	-	-	Counted value

12.3.7 Operation principle

Limit counter (L4UFCNT) counts the number of positive and/or negative flanks on the binary INPUT signal depending on the function settings. L4UFCNT also checks if the accumulated value is equal or greater than any of its four settable limits. The four limit outputs will be activated relatively on reach of each limit and remain activated until the reset of the function.

The counter value is stored in flash memory once per hour and will not be lost at auxiliary power interruption.

12.3.7.1 Design

Figure 95 illustrates the general logic diagram of the function.

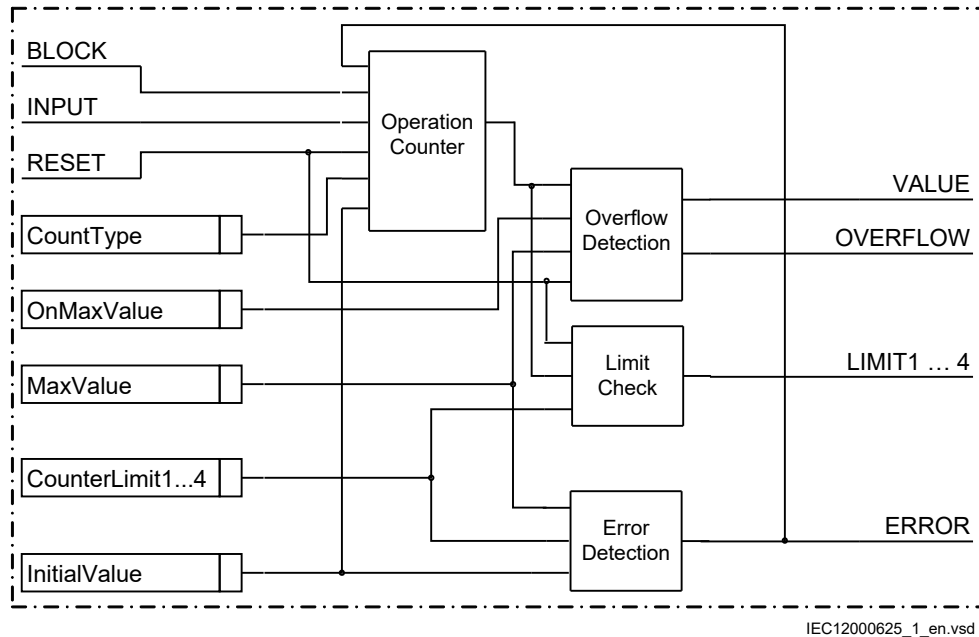


Figure 95: Logic diagram

The counter can be initialized to count from a settable non-zero value *InitialValue*. The counter value is set to this initial value by activating the RESET input.

The maximum permitted counter value is defined by *MaxValue*.

The three possibilities after reaching the maximum counted value are:

- Stops counting and activates a steady overflow indication for the next count
- Rolls over to zero and activates a steady overflow indication for the next count
- Rolls over to zero and activates a pulsed overflow indication for the next count

The pulsed overflow output remains active until the first count after rolling over to zero, as illustrated in Figure 96.

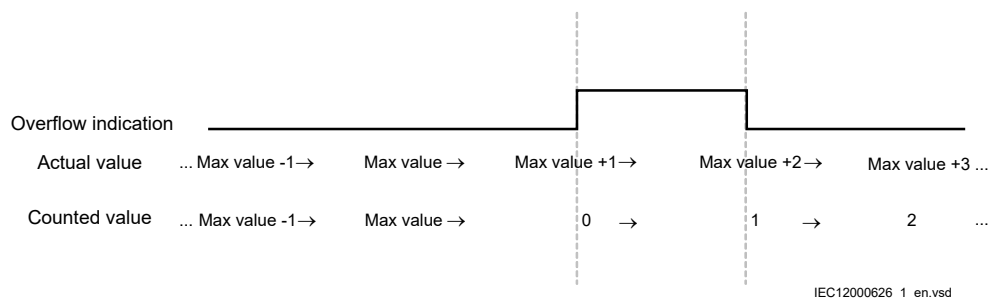


Figure 96: Overflow indication when *OnMaxValue* is set to rollover pulsed

The ERROR output is activated as an indicator of setting the counter limits and/or initial value setting(s) greater than the maximum value. The counter stops counting the input and all the outputs except ERROR are forced to zero. The error condition remains until valid settings for counter limits and/or initial value are applied.

The function can be blocked through the BLOCK input. While BLOCK is active, status changes on INPUT are not counted and outputs remain in their previous states. However, the counter can still be

initialized by activating the RESET input. In this case the outputs remain in their initial states until release of the BLOCK input.

12.3.7.2 Reporting

The content of the counter can be read on the local HMI.

Reset of the counter can be performed from the local HMI or via the RESET input.

Reading of content and resetting of the function can also be performed remotely, for example from a IEC 61850 client. The value can also be presented as a measurement on the local HMI graphical display.

12.3.8 Technical data

Table 202: L4UFCNT technical data

Function	Range or value	Accuracy
Counter value	0-65535	-
Max. count up speed	With 5ms task time, the maximum count up speed can go until 100 pulses/s	-

12.4 Disturbance report

12.4.1 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 DRPRDRE, always included in the IED, acquires sampled data of all selected analog input and binary signals connected to the function block with a, maximum of 40 analog and 96 binary signals.

The Disturbance report functionality is a common name for several functions:

- Event list
- Indications
- Event recorder
- Trip value recorder
- Disturbance recorder

The Disturbance report function is characterized by great flexibility regarding configuration, starting conditions, recording times, and large storage capacity.

A disturbance is defined as an activation of an input to the AnRADR or BnRBDR function blocks, which are set to trigger the disturbance recorder. All connected 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 as a set of three files comprising header file HDR, configuration file CFG, and data file DAT. Similarly, all events are continuously saved in a ring-buffer. The local HMI is used to get information about the recordings. The disturbance report files may be uploaded to PCM600 for further analysis using the disturbance handling tool, or viewed online in the web HMI.

12.4.2 Disturbance report DRPRDRE

12.4.2.1 Identification

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

12.4.2.2 Function block

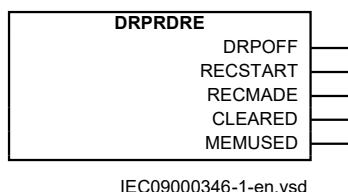


Figure 97: DRPRDRE function block

12.4.2.3 Signals

Table 203: 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

12.4.2.4 Settings

Table 204: DRPRDRE Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off/On
PreFaultRecT	0.05 - 3.00	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 - 8.0	s	0.1	1.0	Fault recording time limit
PostRetrig	Off On	-	-	Off	Post-fault retrig enabled (On) or not (Off)
MaxNoStoreRec	10 - 200	-	1	200	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

12.4.2.5 Monitored data

Table 205: 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
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
Table continues on next page				

Name	Type	Values (Range)	Unit	Description
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
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
Table continues on next page				

Name	Type	Values (Range)	Unit	Description
OvTrigStatCh25	BOOLEAN	-	-	Over level trig for analog channel 25 activated
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
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
Table continues on next page				

Name	Type	Values (Range)	Unit	Description
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

12.4.3 Analog input signals AxRADR

12.4.3.1 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	-	-

12.4.3.2 Function block

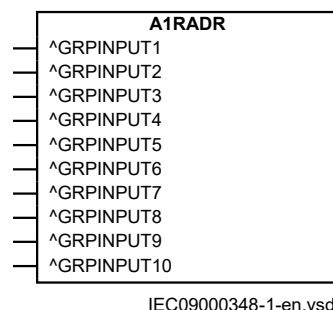


Figure 98: A1RADR function block, analog inputs, example for A1RADR, A2RADR and A3RADR

12.4.3.3 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 206: 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

12.4.3.4 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 207: 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
Table continues on next page					

Name	Values (Range)	Unit	Step	Default	Description
Operation08	Off On	-	-	Off	Operation On/Off
Operation09	Off On	-	-	Off	Operation On/Off
Operation10	Off On	-	-	Off	Operation On/Off

Table 208: 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)
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

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
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
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

12.4.4 Analog input signals A4RADR

12.4.4.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Analog input signals	A4RADR	-	-

12.4.4.2 Function block

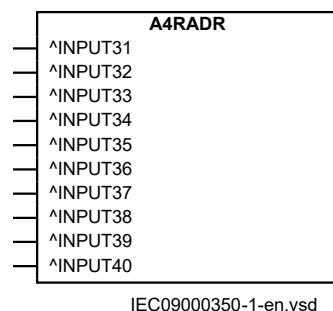


Figure 99: A4RADR function block, derived analog inputs



Channels 31-40 are not shown in LHMI. They are used for internally calculated analog signals.

12.4.4.3 Signals

Table 209: 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

12.4.4.4 Settings

Table 210: 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
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
FunType31	0 - 255	-	1	0	Function type for analog channel 31 (IEC-60870-5-103)
InfNo31	0 - 255	-	1	0	Information number for analog channel 31 (IEC-60870-5-103)
FunType32	0 - 255	-	1	0	Function type for analog channel 32 (IEC-60870-5-103)
InfNo32	0 - 255	-	1	0	Information number for analog channel 32 (IEC-60870-5-103)
FunType33	0 - 255	-	1	0	Function type for analog channel 33 (IEC-60870-5-103)
InfNo33	0 - 255	-	1	0	Information number for analog channel 33 (IEC-60870-5-103)
FunType34	0 - 255	-	1	0	Function type for analog channel 34 (IEC-60870-5-103)
InfNo34	0 - 255	-	1	0	Information number for analog channel 34 (IEC-60870-5-103)
FunType35	0 - 255	-	1	0	Function type for analog channel 35 (IEC-60870-5-103)
InfNo35	0 - 255	-	1	0	Information number for analog channel 35 (IEC-60870-5-103)
FunType36	0 - 255	-	1	0	Function type for analog channel 36 (IEC-60870-5-103)
InfNo36	0 - 255	-	1	0	Information number for analog channel 36 (IEC-60870-5-103)
FunType37	0 - 255	-	1	0	Function type for analog channel 37 (IEC-60870-5-103)

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
InfNo37	0 - 255	-	1	0	Information number for analog channel 37 (IEC-60870-5-103)
FunType38	0 - 255	-	1	0	Function type for analog channel 38 (IEC-60870-5-103)
InfNo38	0 - 255	-	1	0	Information number for analog channel 38 (IEC-60870-5-103)
FunType39	0 - 255	-	1	0	Function type for analog channel 39 (IEC-60870-5-103)
InfNo39	0 - 255	-	1	0	Information number for analog channel 39 (IEC-60870-5-103)
FunType40	0 - 255	-	1	0	Function type for analog channel 40 (IEC-60870-5-103)
InfNo40	0 - 255	-	1	0	Information number for analog channel 40 (IEC-60870-5-103)

Table 211: 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	Over trigger 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
UnderTrigOp40	Off On	-	-	Off	Use under level trigger for analog channel 40 (on) or not (off)
Table continues on next page					

Name	Values (Range)	Unit	Step	Default	Description
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

12.4.5 Binary input signals BxRBDR

12.4.5.1 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	-	-

12.4.5.2 Function block

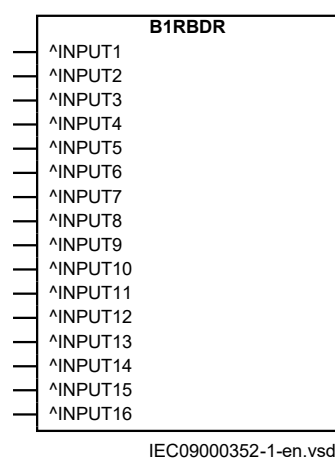


Figure 100: B1RBDR function block, binary inputs, example for B1RBDR - B6RBDR

12.4.5.3 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 212: 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

12.4.5.4 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 213: 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

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
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
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
Table continues on next page					

Name	Values (Range)	Unit	Step	Default	Description
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 channel 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
FunType1	0 - 255	-	1	0	Function type for binary channel 1 (IEC -60870-5-103)
InfNo1	0 - 255	-	1	0	Information number for binary channel 1 (IEC -60870-5-103)
FunType2	0 - 255	-	1	0	Function type for binary channel 2 (IEC -60870-5-103)
InfNo2	0 - 255	-	1	0	Information number for binary channel 2 (IEC -60870-5-103)
FunType3	0 - 255	-	1	0	Function type for binary channel 3 (IEC -60870-5-103)
InfNo3	0 - 255	-	1	0	Information number for binary channel 3 (IEC -60870-5-103)
FunType4	0 - 255	-	1	0	Function type for binary channel 4 (IEC -60870-5-103)
InfNo4	0 - 255	-	1	0	Information number for binary channel 4 (IEC -60870-5-103)
FunType5	0 - 255	-	1	0	Function type for binary channel 5 (IEC -60870-5-103)
InfNo5	0 - 255	-	1	0	Information number for binary channel 5 (IEC -60870-5-103)

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
FunType6	0 - 255	-	1	0	Function type for binary channel 6 (IEC -60870-5-103)
InfNo6	0 - 255	-	1	0	Information number for binary channel 6 (IEC -60870-5-103)
FunType7	0 - 255	-	1	0	Function type for binary channel 7 (IEC -60870-5-103)
InfNo7	0 - 255	-	1	0	Information number for binary channel 7 (IEC -60870-5-103)
FunType8	0 - 255	-	1	0	Function type for binary channel 8 (IEC -60870-5-103)
InfNo8	0 - 255	-	1	0	Information number for binary channel 8 (IEC -60870-5-103)
FunType9	0 - 255	-	1	0	Function type for binary channel 9 (IEC -60870-5-103)
InfNo9	0 - 255	-	1	0	Information number for binary channel 9 (IEC -60870-5-103)
FunType10	0 - 255	-	1	0	Function type for binary channel 10 (IEC -60870-5-103)
InfNo10	0 - 255	-	1	0	Information number for binary channel 10 (IEC -60870-5-103)
FunType11	0 - 255	-	1	0	Function type for binary channel 11 (IEC -60870-5-103)
InfNo11	0 - 255	-	1	0	Information number for binary channel 11 (IEC -60870-5-103)
FunType12	0 - 255	-	1	0	Function type for binary channel 12 (IEC -60870-5-103)
InfNo12	0 - 255	-	1	0	Information number for binary channel 12 (IEC -60870-5-103)
FunType13	0 - 255	-	1	0	Function type for binary channel 13 (IEC -60870-5-103)
InfNo13	0 - 255	-	1	0	Information number for binary channel 13 (IEC -60870-5-103)
FunType14	0 - 255	-	1	0	Function type for binary channel 14 (IEC -60870-5-103)
InfNo14	0 - 255	-	1	0	Information number for binary channel 14 (IEC -60870-5-103)
FunType15	0 - 255	-	1	0	Function type for binary channel 15 (IEC -60870-5-103)
InfNo15	0 - 255	-	1	0	Information number for binary channel 15 (IEC -60870-5-103)
FunType16	0 - 255	-	1	0	Function type for binary channel 16 (IEC -60870-5-103)
InfNo16	0 - 255	-	1	0	Information number for binary channel 16 (IEC -60870-5-103)

Table 214: 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
TrigLevel13	Trig on 0 Trig on 1	-	-	Trig on 1	Trigger on positive (1) or negative (0) slope for binary input 13
Table continues on next page					

Name	Values (Range)	Unit	Step	Default	Description
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

12.4.6 Operation principle

Disturbance report DRPRDRE is a common name for several functions to supply the operator, analysis engineer, and so on, with sufficient information about events in the system.

The functions included in the disturbance report are:

- Event list
- Indications
- Event recorder
- Trip value recorder
- Disturbance recorder

[Figure 101](#) 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 DRPRDRE acquires information from both AxRADR and BxRBDR.

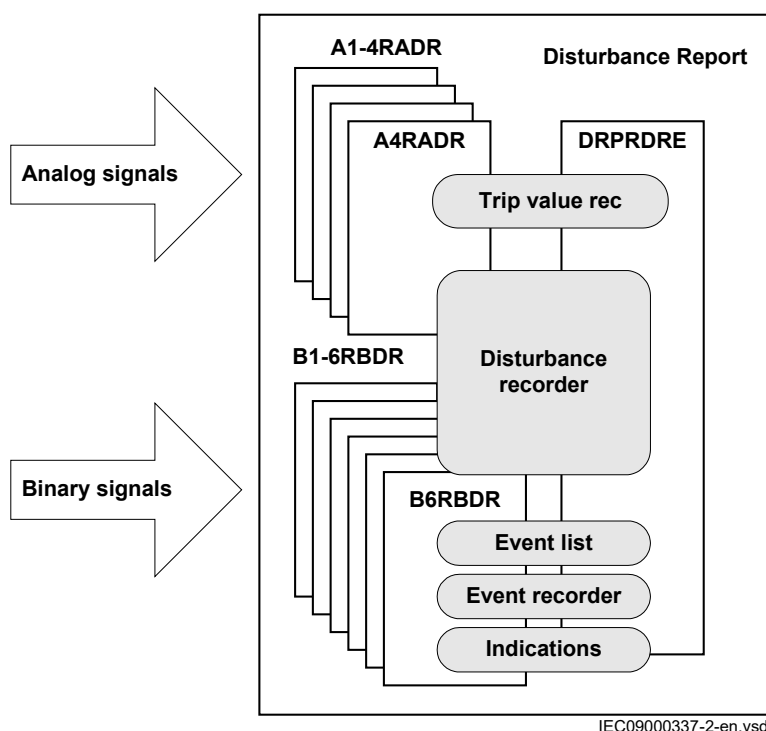


Figure 101: Disturbance report functions and related function blocks

The whole disturbance report can contain information for a number of recordings, each with the data coming from all the parts mentioned above. The event list function is working continuously, independent of disturbance triggering, recording time, and so on. All information in the disturbance report is stored in non-volatile flash memories. This implies that no information is lost in case of loss of auxiliary power. Each report will get an identification number in the interval from 0-999.

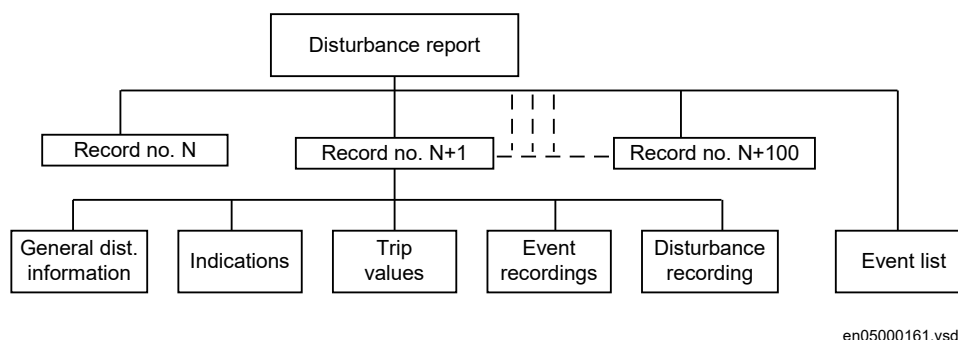


Figure 102: Disturbance report structure

Up to 200 disturbance reports can be stored. If a new disturbance is to be recorded when the memory is full, the oldest disturbance report is overwritten by the new one. The total recording capacity for the disturbance recorder depends on sampling frequency, number of analog and binary channels and recording time. In a 50 Hz system it is possible to record 200 where the maximum recording time is 0.7 seconds. The memory limit does not affect the rest of the disturbance report (Event list, Event recorder, Indications and Trip value recorder).



The maximum number of recordings depend on each recordings total recording time. Long recording time will reduce the number of recordings to less than 200.



The IED flash disk should NOT be used to store any user files. This might cause disturbance recordings to be deleted due to lack of disk space.

12.4.6.1 Disturbance information

Date and time of the disturbance, the indications, events, and the trip values are available on the local HMI. The complete disturbance report can be downloaded through PCM600 Disturbance handling tool, through a web browser using the WHMI, or via FTP or MMS (over IEC 61850) client. The PC can be connected to the IED front, rear or remotely via the station bus (Ethernet ports).

12.4.6.2 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.

12.4.6.3 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.

12.4.6.4 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.

12.4.6.5 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.

12.4.6.6 Disturbance recorder

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

12.4.6.7 Time tagging

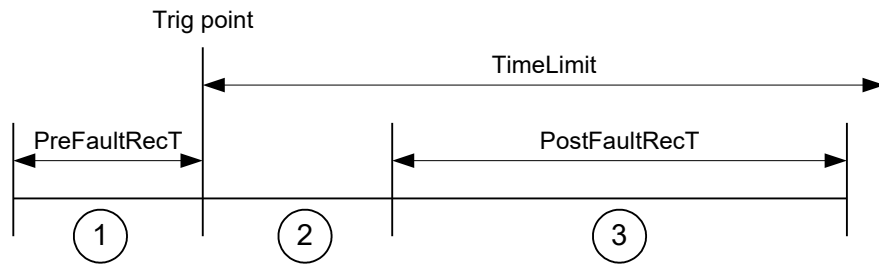
The IED has a built-in real-time calendar and clock. This function is used for all time tagging within the disturbance report

12.4.6.8 Recording times

Disturbance report DRPRDRE records information about a disturbance during a settable time frame. The recording times are valid for the whole disturbance report. Disturbance recorder, event recorder and indication function register disturbance data and events during $t_{\text{Recording}}$, the total recording time.

The total recording time, $t_{\text{Recording}}$, of a recorded disturbance is:

$$t_{\text{Recording}} = \begin{matrix} \text{PreFaultrecT} + t_{\text{Fault}} + \text{PostFaultrecT} \\ \text{or } \text{PreFaultrecT} + \text{TimeLimit}, \text{ depending on} \\ \text{which criterion stops the current disturbance recording} \end{matrix}$$



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Figure 103: 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 <i>PreFaultRecT</i> 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 <i>TimeLimit</i> the limit time).
PostFaultRecT, 3	Post fault recording time. The time the disturbance recording continues after all activated triggers are reset. Use the setting <i>PostFaultRecT</i> 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 <i>TimeLimit</i> to set this time.

12.4.6.9 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). The last 10 channels may be connected to internally calculated analog signals available as function block output signals (phase differential currents, bias currents and so on).

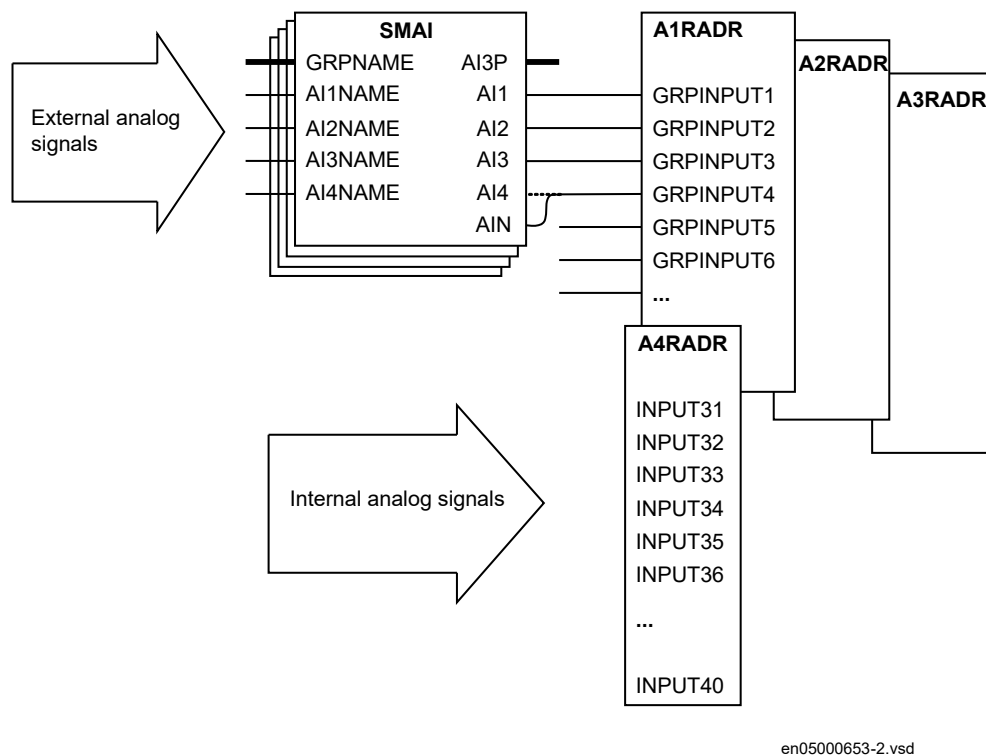


Figure 104: Analog input function blocks

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 (4000 and 4800 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 an input signal the corresponding information is available on the non-calculated output (AI4) on the SMAI function block. Connect the signals to the AxRADR accordingly.

For each of the analog signals, *Operation = On* means that it is recorded by the disturbance recorder. The trigger is independent of the setting of *Operation*, and triggers even if operation is set to *Off*. Both undervoltage and overvoltage can be used as trigger conditions. The same applies for the current signals.

If *Operation = Off*, no waveform (samples) will be recorded and reported in graph. However, Trip value, pre-fault and fault value will be recorded and reported. The input channel can still be used to trig the disturbance recorder.

If *Operation = On*, waveform (samples) will also be recorded and reported in graph.

The analog signals are presented only in the disturbance recording, but they affect the entire disturbance report when being used as triggers.

12.4.6.10 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 (*TrigDR* = "On"). 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*.

12.4.6.11 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 the local HMI and PCM600.

12.4.6.12 Post Retrigger

Disturbance report function does not automatically respond to any new trig condition during a recording, after all signals set as trigger signals have been reset. However, under certain circumstances the fault condition may reoccur during the post-fault recording, for instance by automatic reclosing to a still faulty power line.

In order to capture the new disturbance it is possible to allow retriggering (*PostRetrig = On*) during the post-fault time. In this case a new, complete recording will start and, during a period, run in parallel with the initial recording.

When the retrig parameter is disabled (*PostRetrig = Off*), a new recording will not start until the post-fault (*PostFaultrecT* or *TimeLimit*) period is terminated. If a new trig occurs during the post-fault period and lasts longer than the proceeding recording a new complete recording will be started.

Disturbance report function can handle maximum 3 simultaneous disturbance recordings.

12.4.7 Technical data

Table 215: DRPRDRE technical data

Function	Range or value	Accuracy
Current recording	-	$\pm 1,0\%$ of I_r at $I \leq I_r$ $\pm 1,0\%$ of I at $I > I_r$
Voltage recording	-	$\pm 1,0\%$ of U_r at $U \leq U_r$ $\pm 1,0\%$ 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	200, first in - first out	-
Time tagging resolution	0.25 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)	70 seconds (200 recordings) at 50 Hz, 50 seconds (200 recordings) at 60 Hz	-
Sampling rate	4.0 kHz at 50 Hz 4.8 kHz at 60 Hz	-
Recording bandwidth	(5–300) Hz	-

12.5 Indications

12.5.1 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 recorder function (triggered).

The Indication list function shows all selected binary input signals connected to the Disturbance recorder function that have changed status during a disturbance.

12.5.2 Function block

The Indications function has no function block of its own.

12.5.3 Signals

12.5.3.1 Input signals

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

12.5.4 Operation principle

The LED indications display this information:

Green LED:

Steady light	In Service
Flashing light	Starting up, or 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 indication 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 signal must be connected to binary input BxRBDR function block
- the DRPRDRE parameter *Operation* must be set *On*
- the DRPRDRE must be triggered (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 setting the binary inputs.

The name of the binary 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.

12.5.5 Technical data

Table 216: DRPRDRE technical data

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

12.6 Event recorder

12.6.1 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 recorder function. Each recording can contain up to 150 time-tagged events.

The event recorder information is available for the disturbances locally in the IED.

The event recording information is an integrated part of the disturbance record (Comtrade file).

12.6.2 Function block

The Event recorder has no function block of its own.

12.6.3 Signals

12.6.3.1 Input signals

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

12.6.4 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.



Events can not be read from the IED if more than one user is accessing the IED simultaneously.

12.6.5 Technical data

Table 217: DRPRDRE technical data

Function		Value
Buffer capacity	Maximum number of events in disturbance report	150
	Maximum number of disturbance reports	100
Resolution		0.25 ms
Accuracy		Depending on time synchronization

12.7 Event list

12.7.1 Functionality

Continuous event logging is useful for monitoring the system from an overview perspective and is a complement to specific disturbance recorder functions.

The event list logs every status change of all binary input signals connected to the Disturbance recorder function. The list may contain up to 1000 time-tagged events stored in a ring-buffer.

12.7.2 Function block

The Event list has no function block of its own.

12.7.3 Signals

12.7.3.1 Input signals

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

12.7.4 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 signal that appears in the event recording is the user-defined name assigned to the corresponding input of the BxRBDR function. 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.

12.7.5 Technical data

Table 218: DRPRDRE technical data

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

12.8 Trip value recorder

12.8.1 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 recorder function. The result is magnitude and phase angle before and during the fault for each analog input signal.

The trip value recorder information is available for the disturbances locally in the IED.

The trip value recorder information is an integrated part of the disturbance record (Comtrade file).

12.8.2 Function block

The Trip value recorder has no function block of its own.

12.8.3 Signals

12.8.3.1 Input signals

The trip value recorder function uses analog input signals connected to A1RADR to A3RADR (not A4RADR).

12.8.4 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* defines 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 signal that appears in the Trip value recorder function is the user-defined name assigned to the corresponding input of the AxRADR function. 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 can be viewed in PCM600 or via the local HMI.

12.8.5 Technical data

Table 219: DRPRDRE technical data

Function		Value
Buffer capacity	Maximum number of analog inputs	30
	Maximum number of disturbance reports	200

12.9 Disturbance recorder

12.9.1 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 selected analog and binary signals connected to the Disturbance recorder function (maximum 40 analog and 96 binary signals). The binary signals available are the same as for the event recorder function.

The function is characterized by great flexibility and is not dependent on the operation of protection functions. It can record disturbances not detected by protection functions. Up to 9,9 seconds of data before the trigger instant can be saved in the disturbance file.

The disturbance recorder information for up to 200 disturbances are saved in the IED and the local HMI is used to view the list of recordings.

12.9.2 Function block

The Disturbance recorder has no function block of its own.

12.9.3 Signals

See Disturbance report for input and output signals.

12.9.4 Settings

See Disturbance report for settings.

12.9.5 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) or digital Merging Units (MU) through the Signal Matrix Analog Input (SMAI) 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. Up to the last 200 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 triggered manually, by a 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.

12.9.5.1 Memory and storage



The maximum number of records depends on each record's total recording time. Long recording time will reduce the number of recordings to less than 200.



The IED flash disk should NOT be used to store any user files. This might cause disturbance recordings to be deleted due to lack of disk space.

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.



Saving a disturbance record to non-volatile memory may take up to 120 seconds. To prevent data loss, do not power off the IED within two minutes after the last recording.

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 uses this information to 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, for example, 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.

12.9.6 Technical data

Table 220: Disturbance report DRPRDRE technical data

Function	Range or value	Accuracy
Current recording	-	$\pm 1,0\%$ of I_r at $I \leq I_r$ $\pm 1,0\%$ of I at $I > I_r$
Voltage recording	-	$\pm 1,0\%$ of U_r at $U \leq U_r$ $\pm 1,0\%$ 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	200, first in - first out	-
Time tagging resolution	0.25 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)	70 seconds (200 recordings) at 50 Hz, 50 seconds (200 recordings) at 60 Hz	-
Sampling rate	4.0 kHz at 50 Hz 4.8 kHz at 60 Hz	-
Recording bandwidth	(5–300) Hz	-
Maximum time for saving new disturbance record	120 s	-

12.10 IEC 61850 generic communication I/O functions SPGGIO

12.10.1 Identification

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

12.10.2 Functionality

IEC61850 generic communication I/O functions SPGGIO is used to send one single logical signal to other systems or equipment in the substation.

12.10.3 Function block

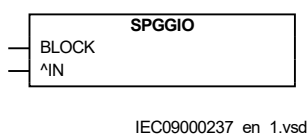


Figure 105: SPGGIO function block

12.10.4 Signals

Table 221: SPGGIO Input signals

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

12.10.5 Settings

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

12.10.6 Operation principle

Upon receiving a signal at its input, IEC61850 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 get the signal, PCM600 must be used to define which function block in which equipment or system should receive this information.

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

12.11.1 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	-	-

12.11.2 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.

12.11.3 Function block

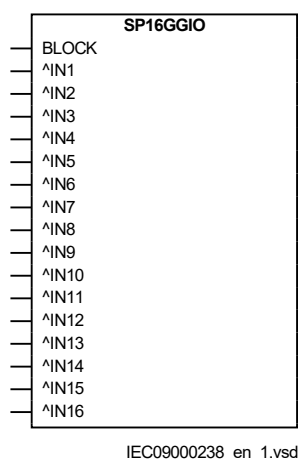


Figure 106: SP16GGIO function block

12.11.4 Signals

Table 222: 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

12.11.5 Settings

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

12.11.6 MonitoredData

Table 223: SP16GGIO Monitored data

Name	Type	Values (Range)	Unit	Description
OUT1	GROUP SIGNAL	-	-	Output 1 status
OUT2	GROUP SIGNAL	-	-	Output 2 status
OUT3	GROUP SIGNAL	-	-	Output 3 status
OUT4	GROUP SIGNAL	-	-	Output 4 status
OUT5	GROUP SIGNAL	-	-	Output 5 status
OUT6	GROUP SIGNAL	-	-	Output 6 status
OUT7	GROUP SIGNAL	-	-	Output 7 status
OUT8	GROUP SIGNAL	-	-	Output 8 status
OUT9	GROUP SIGNAL	-	-	Output 9 status
OUT10	GROUP SIGNAL	-	-	Output 10 status
OUT11	GROUP SIGNAL	-	-	Output 11 status
OUT12	GROUP SIGNAL	-	-	Output 12 status
OUT13	GROUP SIGNAL	-	-	Output 13 status
OUT14	GROUP SIGNAL	-	-	Output 14 status
OUT15	GROUP SIGNAL	-	-	Output 15 status
OUT16	GROUP SIGNAL	-	-	Output 16 status
OUTOR	GROUP SIGNAL	-	-	Output status logic OR gate for input 1 to 16

12.11.7 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.

12.12 IEC 61850 generic communication I/O functions MVGGIO

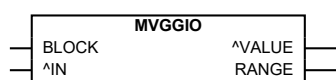
12.12.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
IEC61850 generic communication I/O functions	MVGGIO	-	-

12.12.2 Functionality

IEC61850 generic communication I/O functions (MVGGIO) function is used to send the instantaneous value of an analog signal 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.

12.12.3 Function block



IEC09000239-2-en.vsd

12.12.4 Signals

Table 224: MVGGIO Input signals

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

Table 225: MVGGIO Output signals

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

12.12.5 Settings

Table 226: MVGGIO Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
BasePrefix	micro milli unit kilo Mega Giga Tera	-	-	unit	Base prefix (multiplication factor)
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	xBase	0.01	900.00	High High limit multiplied with the base prefix (multiplication factor)
MV hLim	-5000.00 - 5000.00	xBase	0.01	800.00	High limit multiplied with the base prefix (multiplication factor)
MV lLim	-5000.00 - 5000.00	xBase	0.01	-800.00	Low limit multiplied with the base prefix (multiplication factor)
MV lLim	-5000.00 - 5000.00	xBase	0.01	-900.00	Low Low limit multiplied with the base prefix (multiplication factor)
MV min	-5000.00 - 5000.00	xBase	0.01	-1000.00	Minimum value multiplied with the base prefix (multiplication factor)
MV max	-5000.00 - 5000.00	xBase	0.01	1000.00	Maximum value multiplied with the base prefix (multiplication factor)
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)

12.12.6 Monitored data

Table 227: 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

12.12.7 Operation principle

Upon receiving an analog signal at its input, IEC61850 generic communication I/O functions (MVGGIO) will give the instantaneous value of the signal and the range, as output values. At the same time, it will send over IEC 61850-8-1 the value, to other IEC 61850 clients in the substation.

The principles of zero-point clamping, range supervision, and value reporting are explained in [Section 12.1.8.1](#). For MVGGIO, the measurement range is defined by the *MV min* and *MV max* settings.

12.13 Measured value expander block MVEXP

12.13.1 Identification

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

12.13.2 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 range supervision functionality. All measured values can be supervised with four settable limits: low-low limit, low limit, high limit and high-high limit. Similarly, the multilevel threshold alarm generation MONALM supervises measured or calculated analog values against the same kind of range thresholds.

The measured value expander block MVEXP translates the integer output signal from the measuring functions to one out of five binary signals: below low-low limit, below low limit, normal, above high limit or above high-high limit. The output signals can be used as conditions in the configurable logic or for alarming purpose.

12.13.3 Function block

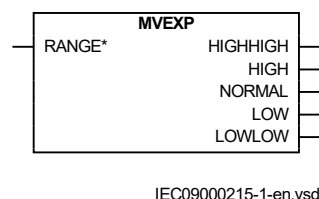


Figure 107: MVEXP function block

12.13.4 Signals

Table 228: MVEXP Input signals

Name	Type	Default	Description
RANGE	INTEGER	0	Measured value range

Table 229: 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

12.13.5 Settings

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

12.13.6 Operation principle

The input signal must be connected to a range output of MONALM or 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 230](#). Only one binary output can be active (1) at any time.

Table 230: Input integer value converted to binary output signals

Supervised value is	Input integer value	LOWLOW output	LOW output	NORMAL output	HIGH output	HIGHHIGH output
below low-low limit	4	1	0	0	0	0
between low-low and low limits	2	0	1	0	0	0
between low and high limits	0	0	0	1	0	0
between high-high and high limits	1	0	0	0	1	0
above high-high limit	3	0	0	0	0	1
(invalid)	>4	0	0	0	0	0

12.14 Monitoring event component for acknowledgeable alarms feature MONEVG

12.14.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Monitoring event component for acknowledgeable alarms feature	MONEVG	-	-

12.14.2 Functionality

MONEVG is used to generate alarm entries in a dedicated database that is separate from the disturbance recorder/event recorder. Alarms can be viewed and acknowledged in the Web interface.

12.14.3 Function block

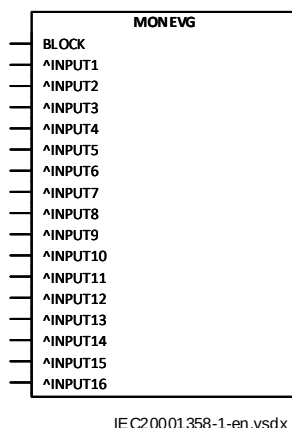


Figure 108: MONEVG function block

12.14.4 Signals

Table 231: MONEVG Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of function
INPUT1	BOOLEAN	0	Input 1
INPUT2	BOOLEAN	0	Input 2
INPUT3	BOOLEAN	0	Input 3
INPUT4	BOOLEAN	0	Input 4
INPUT5	BOOLEAN	0	Input 5
INPUT6	BOOLEAN	0	Input 6
INPUT7	BOOLEAN	0	Input 7
INPUT8	BOOLEAN	0	Input 8
INPUT9	BOOLEAN	0	Input 9
INPUT10	BOOLEAN	0	Input 10
INPUT11	BOOLEAN	0	Input 11
INPUT12	BOOLEAN	0	Input 12
INPUT13	BOOLEAN	0	Input 13
INPUT14	BOOLEAN	0	Input 14
INPUT15	BOOLEAN	0	Input 15
INPUT16	BOOLEAN	0	Input 16

12.14.5 Settings

Table 232: MONEVG Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
EventChMask	Off Channel 1-8 Channel 9-16 Channel 1-16	-	-	Off	Monitoring Event channel mask
Input1Group	0 - 20	-	1	0	Group selection for INPUT1
Input2Group	0 - 20	-	1	0	Group selection for INPUT2
Input3Group	0 - 20	-	1	0	Group selection for INPUT3
Input4Group	0 - 20	-	1	0	Group selection for INPUT4
Input5Group	0 - 20	-	1	0	Group selection for INPUT5
Input6Group	0 - 20	-	1	0	Group selection for INPUT6
Input7Group	0 - 20	-	1	0	Group selection for INPUT7
Input8Group	0 - 20	-	1	0	Group selection for INPUT8
Input9Group	0 - 20	-	1	0	Group selection for INPUT9
Input10Group	0 - 20	-	1	0	Group selection for INPUT10
Input11Group	0 - 20	-	1	0	Group selection for INPUT11
Input12Group	0 - 20	-	1	0	Group selection for INPUT12
Input13Group	0 - 20	-	1	0	Group selection for INPUT13
Input14Group	0 - 20	-	1	0	Group selection for INPUT14
Input15Group	0 - 20	-	1	0	Group selection for INPUT15
Input16Group	0 - 20	-	1	0	Group selection for INPUT16
MinReplntVal1	0 - 3600	s	1	1	Minimum reporting interval input 1
MinReplntVal2	0 - 3600	s	1	1	Minimum reporting interval input 2
MinReplntVal3	0 - 3600	s	1	1	Minimum reporting interval input 3
MinReplntVal4	0 - 3600	s	1	1	Minimum reporting interval input 4
MinReplntVal5	0 - 3600	s	1	1	Minimum reporting interval input 5
MinReplntVal6	0 - 3600	s	1	1	Minimum reporting interval input 6
MinReplntVal7	0 - 3600	s	1	1	Minimum reporting interval input 7
MinReplntVal8	0 - 3600	s	1	1	Minimum reporting interval input 8
MinReplntVal9	0 - 3600	s	1	1	Minimum reporting interval input 9
MinReplntVal10	0 - 3600	s	1	1	Minimum reporting interval input 10
MinReplntVal11	0 - 3600	s	1	1	Minimum reporting interval input 11
MinReplntVal12	0 - 3600	s	1	1	Minimum reporting interval input 12
MinReplntVal13	0 - 3600	s	1	1	Minimum reporting interval input 13
MinReplntVal14	0 - 3600	s	1	1	Minimum reporting interval input 14
MinReplntVal15	0 - 3600	s	1	1	Minimum reporting interval input 15
MinReplntVal16	0 - 3600	s	1	1	Minimum reporting interval input 16
Table continues on next page					

Name	Values (Range)	Unit	Step	Default	Description
EventPriority1	Not defined Note Sensor Error Warning Alarm Trip	-	-	Not defined	Priority of Event for input 1
EventPriority2	Not defined Note Sensor Error Warning Alarm Trip	-	-	Not defined	Priority of Event for input 2
EventPriority3	Not defined Note Sensor Error Warning Alarm Trip	-	-	Not defined	Priority of Event for input 3
EventPriority4	Not defined Note Sensor Error Warning Alarm Trip	-	-	Not defined	Priority of Event for input 4
EventPriority5	Not defined Note Sensor Error Warning Alarm Trip	-	-	Not defined	Priority of Event for input 5
EventPriority6	Not defined Note Sensor Error Warning Alarm Trip	-	-	Not defined	Priority of Event for input 6
EventPriority7	Not defined Note Sensor Error Warning Alarm Trip	-	-	Not defined	Priority of Event for input 7
EventPriority8	Not defined Note Sensor Error Warning Alarm Trip	-	-	Not defined	Priority of Event for input 8
EventPriority9	Not defined Note Sensor Error Warning Alarm Trip	-	-	Not defined	Priority of Event for input 9
EventPriority10	Not defined Note Sensor Error Warning Alarm Trip	-	-	Not defined	Priority of Event for input 10
Table continues on next page					

Name	Values (Range)	Unit	Step	Default	Description
EventPriority11	Not defined Note Sensor Error Warning Alarm Trip	-	-	Not defined	Priority of Event for input 11
EventPriority12	Not defined Note Sensor Error Warning Alarm Trip	-	-	Not defined	Priority of Event for input 12
EventPriority13	Not defined Note Sensor Error Warning Alarm Trip	-	-	Not defined	Priority of Event for input 13
EventPriority14	Not defined Note Sensor Error Warning Alarm Trip	-	-	Not defined	Priority of Event for input 14
EventPriority15	Not defined Note Sensor Error Warning Alarm Trip	-	-	Not defined	Priority of Event for input 15
EventPriority16	Not defined Note Sensor Error Warning Alarm Trip	-	-	Not defined	Priority of Event for input 16
MaxEventPerSec	3 - 30	Ev/s	1	15	Max event per second

12.14.6 Operation principle

IED has an internal database of alarm events that are saved to non-volatile memory every 60 minutes. Alarms can be viewed only in the Web HMI.

An alarm event is generated by activating (0 to 1 transition) an INPUTx input, provided the input number is included in the channel range specified by the *EventChMask* parameter.

When the BLOCK input is active, alarms are not generated. However, if an input is activated while BLOCK is active and remains active when BLOCK is deactivated, an alarm event is generated with the time stamp of the original input activation. Input pulses, that is, an activation followed by a deactivation, while BLOCK is active, are ignored.

Alarm generation for an individual input is inhibited if the associated *EventMask* parameter is set to *NoEvents*.

Each alarm event comprises the following information:

- **Date and time:** If the input signal carries an activation time stamp, the same is stored as event time. Otherwise, the system time when the function detected activation of that input is used.
- **Alarm name:** Copied from the name of the respective input. A user defined name should be assigned to each input used in the application.
- **Alarm type:** Copied from the associated *EventPriority* parameter. In the Web interface, the alarm type is displayed with a small icon.

Alarms cannot be cleared; they can only be acknowledged by the user in the Web interface. The username and the time stamp of acknowledgment are stored in the alarm event. If the corresponding input is still active, attempting to acknowledge an alarm will mark it as not acknowledged without storing the username and the time stamp.

Up to 5000 alarms can be stored in the IED. If this limit is exceeded, the oldest 1000 alarm events are deleted from the database.

The *InputGroup*, *MinRepIntVal*, and *MaxEventPerSec* parameters are for internal purposes and should have the default values.

12.15 Operation log

Operation log is a database for storing operational data related to a trigger event. It can be used, for example, for storing a set of monitored values associated with a switching operation of the circuit breaker or an alarm status activation, or for storing a set of values every few hours using a periodic trigger.

Stored operation records can be viewed on the LHMI or through WHMI. Furthermore, graphical summaries can be created in the Trend views of WHMI. This information can be used in the short term (for example, corrective actions) and in the long term (for example, functional analysis).

Two types of records are supported:

- Operation records for storing current data.
- Fingerprint records for storing initial data obtained during commissioning. These are intended as a reference for analysis of changes over time.

12.15.1 Operation log function OPERLOG

12.15.1.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Operation log	OPERLOG	-	-

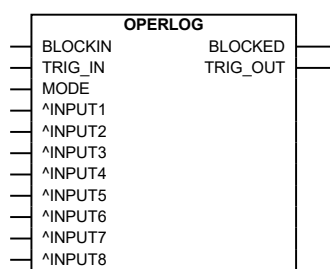
12.15.1.2 Functionality

OPERLOG initiates storing of an operation record in the IED upon activation of a binary trigger. The stored information includes time stamp, operation type, and mode associated with the trigger, along with up to eight connected real-value inputs. These inputs can be calculated values from another function or measured process data.

OPERLOG is designed primarily to record data pertinent to controlled switching operations or condition monitoring of power circuit breakers. Thus it supports classification of the recorded values according to process signal categories.

The number of operation records for each instance can be configured. Once the maximum number of records for an instance is exceeded, the oldest record is overwritten by the new record.

12.15.1.3 Function block



IEC12000035-1-en.vsd

Figure 109: OPERLOG function block

12.15.1.4 Signals

Table 233: OPERLOG Input signals

Name	Type	Default	Description
BLOCKIN	BOOLEAN	0	Block operation log data storage
TRIG_IN	BOOLEAN	0	Trigger input to log operation log data
MODE	INTEGER	0	Input for determining the operation log modes
INPUT1	REAL	0.0	Input signal 1
INPUT2	REAL	0.0	Input signal 2
INPUT3	REAL	0.0	Input signal 3
INPUT4	REAL	0.0	Input signal 4
INPUT5	REAL	0.0	Input signal 5
INPUT6	REAL	0.0	Input signal 6
INPUT7	REAL	0.0	Input signal 7
INPUT8	REAL	0.0	Input signal 8

Table 234: OPERLOG Output signals

Name	Type	Description
BLOCKED	BOOLEAN	Operation log blocked output
TRIG_OUT	BOOLEAN	Trigger output to connect operation log function in daisy chain

12.15.1.5 Settings

Table 235: OPERLOG Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Type	NA OC opening CB switching Drive starts 24h Drive runtime SF6 gas Cond temp	-	-	OC opening	Operation log instance type
TrgModOpn	Do not log Log without values Log with values	-	-	Log with values	Trigger option for logging data for open
TrgModCls	Do not log Log without values Log with values	-	-	Log with values	Trigger option for logging data for close
TsSrcSel	Signal Time System Time	-	-	Signal Time	For selecting the input which will be used for triggering the timestamp
Input1Group	NA Accuracy CB times CB switching Ambient Drive energy Additional Last open cur Elec error	-	-	Accuracy	Group selection for INPUT1
Input2Group	NA Accuracy CB times CB switching Ambient Drive energy Additional Last open cur Elec error	-	-	Accuracy	Group selection for INPUT2
Input3Group	NA Accuracy CB times CB switching Ambient Drive energy Additional Last open cur Elec error	-	-	Accuracy	Group selection for INPUT3
Input4Group	NA Accuracy CB times CB switching Ambient Drive energy Additional Last open cur Elec error	-	-	Accuracy	Group selection for INPUT4
Table continues on next page					

Name	Values (Range)	Unit	Step	Default	Description
Input5Group	NA Accuracy CB times CB switching Ambient Drive energy Additional Last open cur Elec error	-	-	Accuracy	Group selection for INPUT5
Input6Group	NA Accuracy CB times CB switching Ambient Drive energy Additional Last open cur Elec error	-	-	Accuracy	Group selection for INPUT6
Input7Group	NA Accuracy CB times CB switching Ambient Drive energy Additional Last open cur Elec error	-	-	Accuracy	Group selection for INPUT7
Input8Group	NA Accuracy CB times CB switching Ambient Drive energy Additional Last open cur Elec error	-	-	Accuracy	Group selection for INPUT8

Table 236: OPERLOG Non group settings (advanced)

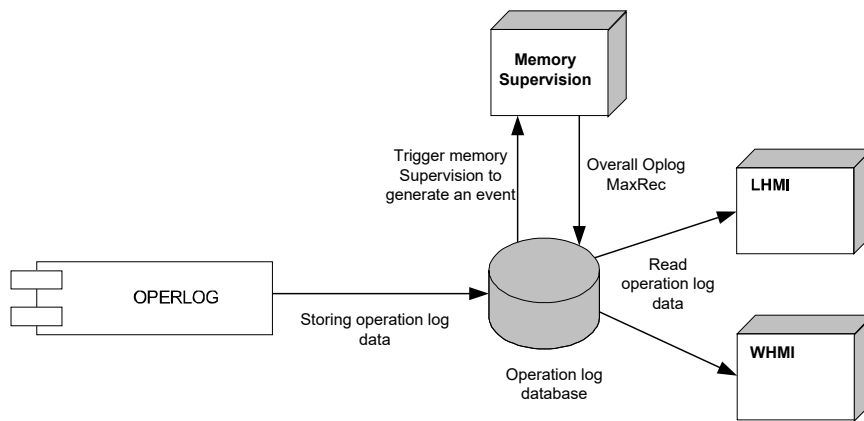
Name	Values (Range)	Unit	Step	Default	Description
MaxRecords	100 - 20000	-	100	100	Maximum number of records



It is recommended not to increase *MaxRecords* beyond the default value in the pre-configuration of Switchsync PWC600, otherwise performance of the user interface may be affected.

12.15.1.6 Operation principle

OPERLOG function performs a trigger based data transfer to the operation log database for the connected inputs. [Figure 110](#) shows the operation log module.



IEC12000036-1-en.vsd

Figure 110: Operation log system overview

- This function saves records of input values to a persistent memory (flash) based on a trigger. The connected input values can be calculated data from different functions or measured process data.
- The records that are logged by the operation log component can be viewed in LHMI and WHMI as common data or phase segregated data. If the signal connected has an associated unit, it will also be displayed.
- The memory supervision component MONMEMSUP monitors the overall memory consumed by all operation log components instantiated in the IED. Even though there is a provision for setting maximum records for every instance of operation log, it is the memory supervision which finally checks the IED capacity. If the size of the database exceeds the available memory of 40MB, the newest record will overwrite the oldest one. One record created by one instance of OPLOG will consume approximately 80 Byte of data, irrespective of the number of input channels connected to that component.
- By a specific triggering option, a stored operation record can be marked as “fingerprint record”. Fingerprint records are retained during normal clearing of the operation log database, neither will they be overwritten in case of memory overrun. The number of fingerprint records is limited to 50 (settable); storing another fingerprint record after reaching this limit will overwrite the oldest fingerprint record.



A mechanism for limiting the number of write operations per time period is implemented in the IED, to prevent the flash memory from wearing out. As a consequence, it may take up an hour to save new operation records permanently in the database. If the auxiliary power is interrupted before new data are saved, these data are lost. The time of flash saving is neither indicated on the IED nor can it be influenced by the user.

Triggering

Storing of an operation record is triggered by the input signal TRIG_IN going high. TRIG_IN is primarily a binary signal. Depending on the application, it may be augmented by additional data to form a composite signal.

If the application is to store operation data of the circuit breaker along with the time stamp and operation type, a composite trigger signal should be applied comprising the following information.

- Time stamp provided by the application, for example, the time when a command has been received
- Circuit breaker operation type (Close or Open)
- Whether the data should be stored as fingerprint record

In the Switchsync PWC600 pre-configuration, the OPLOGTRIG output of SSCPOW provides such a composite trigger signal. *TsSrcSel* should be set to “Signal Time” to assure correct storing of the application generated time stamp.

In an application for periodic process monitoring (for example, maximum temperature attained in a day), where measured data are stored immediately on triggering, a simple binary (Boolean) signal can be used to trigger OPERLOG. In this case, *TsSrcSel* should be set to “System Time”, to generate the time stamp from the IED’s system time when TRIG_IN was activated. In this case, the CB operation type (Close or Open) will be stored as “not applicable”.

Processing of trigger signals can be further controlled by the *TrgModOpn* (for open operation) and *TrgModCls* (for close operation) parameters. The options are:

- Do not log: A trigger signal for the respective operation (Close or Open) will not store an operation record.
- Log without values: Operation record will include only the operation type (Close or Open) and the time stamp.
- Log with values: Operation record will include operation type (Close or Open), time stamp, and the values at the connected inputs.

Grouping and categorizing operation data

To enable grouped and categorized presentation of logged data in LHMI or WHMI, two settings and one input are provided. One instance of OPERLOG allows to connect maximum eight real-value inputs; if more than eight values are to be logged with the same trigger signal, additional function block instances are required. To logically group these instances together in the database, Type should be set to the same value.

If, within one Type of OPERLOG, a client such as trend graph page in WHMI is configured to show the values of selected inputs only, the *InputxGroup* settings allow this segregation. They should be set according to the class of monitored process data, for example, “Accuracy” (of controlled switching operations) or “Ambient” (temperature).

The input signal MODE, which is stored together with the other input data, provides dynamic categorization (at runtime). It is intended to give a status evaluation of each switching operation at a glance. This mode information is further explained in [Section](#).

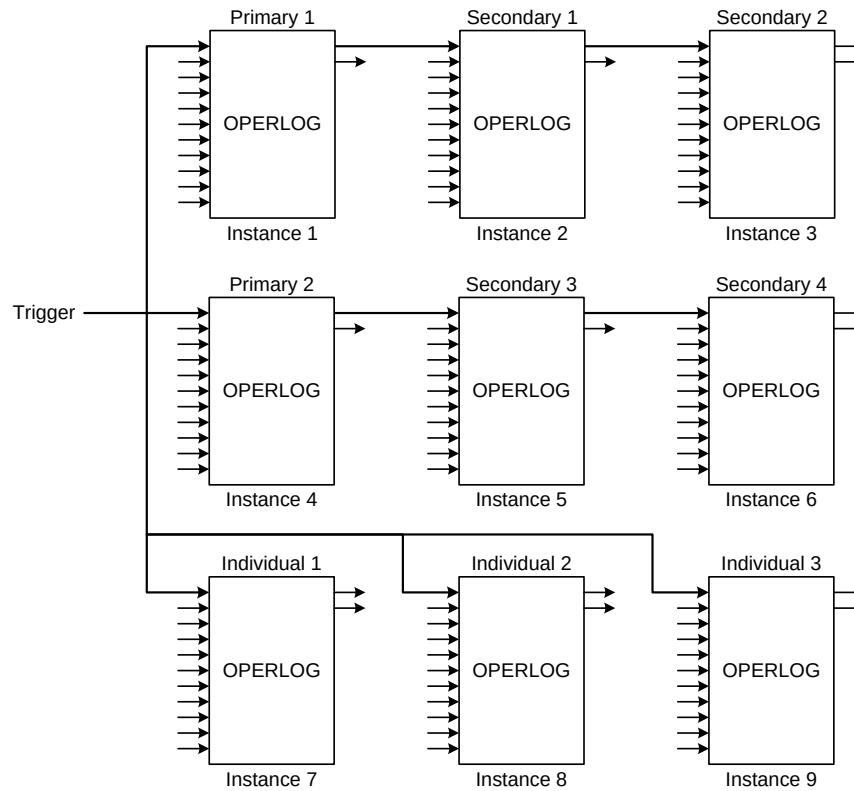
Configuring instances in ACT

Operation log instances can be configured to store phase segregated values such as operation times of the three circuit breaker poles, or phase independent values such as ambient temperature.



Do not connect more than three components in a daisy chain.

For phase independent signals, configure OPERLOG as individual instance(s). An example of possible trigger connections is shown in [Figure 111](#).



IEC12000047-1-EN.vsd

Figure 111: Trigger connections for operation log instances

Configure the instances in ACT such that

- Individual instances do not have any input or output daisy chain connection to any other operation log component.
- Primary instances have only output daisy chain connection to the secondary operation log component.
- Secondary instances have input daisy chain connection to a primary or secondary operation log component and possibly an output daisy chain connection to another secondary instance.



With one or more operation records already stored in the database, changes in OPERLOG related ACT configuration or in OPERLOG parameters may lead to wrong reporting on LHMI or WHMI.

To prevent wrong reporting after configuration changes, the following procedure should be observed:

1. Download the operation log database through WHMI.
2. Write configuration changes to the IED.
3. Clear all operation records and fingerprint records in the IED.

12.15.2 Clear operation log data CLROPLOG

12.15.2.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Clear operation log data	CLROPLOG	-	-

12.15.2.2 Functionality

The CLROPLOG function enables deletion of either operation records or fingerprint records from the operation log database.

Two separate binary inputs for initiating deletion of records are provided. Activating one of these inputs will clear all records of the corresponding type from the database.

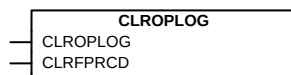


Clearing records cannot be undone.



Permanent storage of the emptied database is subject to the same flash memory write cycle as storing new records, see above.

12.15.2.3 Function block



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Figure 112: Function block

12.15.2.4 Signals

Table 237: CLROPLOG Input signals

Name	Type	Default	Description
CLROPLOG	BOOLEAN	0	Input for clearing the operation log data
CLRFRCD	BOOLEAN	0	Input for clearing the finger print records

12.15.2.5 Settings

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

12.16 Compensation of circuit breaker switching times CBCOMP

12.16.1 Identification

Function description	IEC 61850 identification
Compensation of circuit breaker switching times	CBCOMP

12.16.2 Functionality

To achieve accurate controlled switching, a point-on-wave controller needs to take into account the estimated operating times of the circuit breaker. Depending on the design, mechanical closing and opening times may be affected by variations in external conditions such as:

- Control voltage
- Temperature
- Drive energy
- Idle time (which is the time elapsed since last circuit breaker operation)

Each quantity that is measured can be converted into a compensation value (that is, deviation in milliseconds from the nominal operating time) – in PWC600 this is done by the ANSCAL function.

The compensation of circuit breaker switching times (CBCOMP) function provides combined compensation by adding up all available individual compensation values for each CB pole. The resulting total compensation values (one per pole) take into account the quantity and health status of sensors and the CB operation type (closing or opening). In controlled switching, this is used to optimize prediction of the circuit breaker operating times for precise switching instants. CBCOMP has pre-defined inputs for the compensation values of the external parameters listed above. Furthermore, it provides two groups of spare inputs, which may be used to compensate additional measured quantities.

12.16.3 Function block

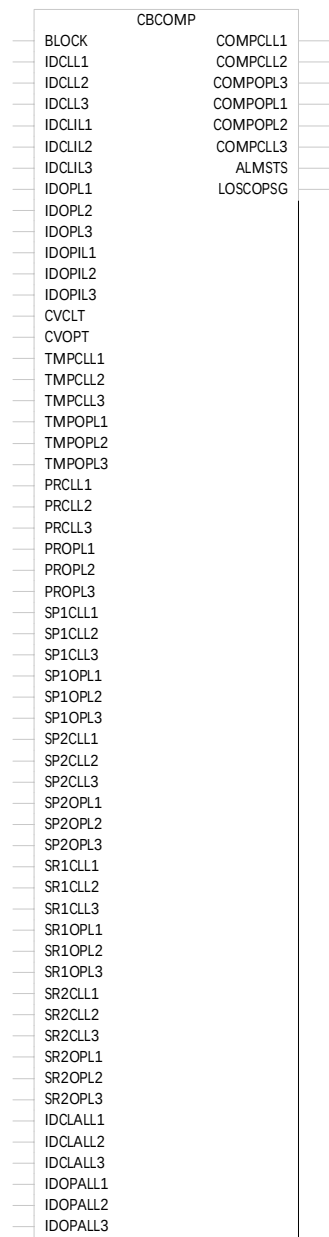


Figure 113: CBCOMP Function block

12.16.4 Signals

Table 238: CBCOMP Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block binary outputs
IDCLL1	GROUP SIGNAL	-	Idle time (mechanical status based) compensation value for closing CB pole L1
IDCLL2	GROUP SIGNAL	-	Idle time (mechanical status based) compensation value for closing CB pole L2
IDCLL3	GROUP SIGNAL	-	Idle time (mechanical status based) compensation value for closing CB pole L3
IDCLIL1	GROUP SIGNAL	-	Idle time (current based) compensation value for closing CB pole L1
IDCLIL2	GROUP SIGNAL	-	Idle time (current based) compensation value for closing CB pole L2
IDCLIL3	GROUP SIGNAL	-	Idle time (current based) compensation value for closing CB pole L3
IDOPL1	GROUP SIGNAL	-	Idle time (mechanical status based) compensation value for opening CB pole L1
IDOPL2	GROUP SIGNAL	-	Idle time (mechanical status based) compensation value for opening CB pole L2
IDOPL3	GROUP SIGNAL	-	Idle time (mechanical status based) compensation value for opening CB pole L3
IDOPIL1	GROUP SIGNAL	-	Idle time (current based) compensation value for opening CB pole L1
IDOPIL2	GROUP SIGNAL	-	Idle time (current based) compensation value for opening CB pole L2
IDOPIL3	GROUP SIGNAL	-	Idle time (current based) compensation value for opening CB pole L3
CVCLT	GROUP SIGNAL	-	Control voltage compensation value for close
CVOPT	GROUP SIGNAL	-	Control voltage compensation value for open
TMPCLL1	GROUP SIGNAL	-	Temperature compensation value for closing CB pole L1
TMPCLL2	GROUP SIGNAL	-	Temperature compensation value for closing CB pole L2
TMPCLL3	GROUP SIGNAL	-	Temperature compensation value for closing CB pole L3
TMPOPL1	GROUP SIGNAL	-	Temperature compensation value for opening CB pole L1
TMPOPL2	GROUP SIGNAL	-	Temperature compensation value for opening CB pole L2
TMPOPL3	GROUP SIGNAL	-	Temperature compensation value for opening CB pole L3
PRCLL1	GROUP SIGNAL	-	Drive pressure compensation value for closing CB pole L1
PRCLL2	GROUP SIGNAL	-	Drive pressure compensation value for closing CB pole L2
PRCLL3	GROUP SIGNAL	-	Drive pressure compensation value for closing CB pole L3

Table continues on next page

Name	Type	Default	Description
PROPL1	GROUP SIGNAL	-	Drive pressure compensation value for opening CB pole L1
PROPL2	GROUP SIGNAL	-	Drive pressure compensation value for opening CB pole L2
PROPL3	GROUP SIGNAL	-	Drive pressure compensation value for opening CB pole L3
SP1CLL1	GROUP SIGNAL	-	Spring charge (analog input) compensation value for closing CB pole L1
SP1CLL2	GROUP SIGNAL	-	Spring charge (analog input) compensation value for closing CB pole L2
SP1CLL3	GROUP SIGNAL	-	Spring charge (analog input) compensation value for closing CB pole L3
SP1OPL1	GROUP SIGNAL	-	Spring charge (analog input) compensation value for opening CB pole L1
SP1OPL2	GROUP SIGNAL	-	Spring charge (analog input) compensation value for opening CB pole L2
SP1OPL3	GROUP SIGNAL	-	Spring charge (analog input) compensation value for opening CB pole L3
SP2CLL1	GROUP SIGNAL	-	Spring charge (binary inputs) compensation value for closing CB pole L1
SP2CLL2	GROUP SIGNAL	-	Spring charge (binary inputs) compensation value for closing CB pole L2
SP2CLL3	GROUP SIGNAL	-	Spring charge (binary inputs) compensation value for closing CB pole L3
SP2OPL1	GROUP SIGNAL	-	Spring charge (binary inputs) compensation value for opening CB pole L1
SP2OPL2	GROUP SIGNAL	-	Spring charge (binary inputs) compensation value for opening CB pole L2
SP2OPL3	GROUP SIGNAL	-	Spring charge (binary inputs) compensation value for opening CB pole L3
SR1CLL1	GROUP SIGNAL	-	Spare 1 compensation value for closing CB pole L1
SR1CLL2	GROUP SIGNAL	-	Spare 1 compensation value for closing CB pole L2
SR1CLL3	GROUP SIGNAL	-	Spare 1 compensation value for closing CB pole L3
SR1OPL1	GROUP SIGNAL	-	Spare 1 compensation value for opening CB pole L1
SR1OPL2	GROUP SIGNAL	-	Spare 1 compensation value for opening CB pole L2
SR1OPL3	GROUP SIGNAL	-	Spare 1 compensation value for opening CB pole L3
SR2CLL1	GROUP SIGNAL	-	Spare 2 compensation value for closing CB pole L1
SR2CLL2	GROUP SIGNAL	-	Spare 2 compensation value for closing CB pole L2
SR2CLL3	GROUP SIGNAL	-	Spare 2 compensation value for closing CB pole L3
SR2OPL1	GROUP SIGNAL	-	Spare 2 compensation value for opening CB pole L1
SR2OPL2	GROUP SIGNAL	-	Spare 2 compensation value for opening CB pole L2
Table continues on next page			

Name	Type	Default	Description
SR2OPL3	GROUP SIGNAL	-	Spare 2 compensation value for opening CB pole L3
IDCLALL1	BOOLEAN	0	Idle time (mechanical status) compensation alarm for closing CB pole L1
IDCLALL2	BOOLEAN	0	Idle time (mechanical status) compensation alarm for closing CB pole L2
IDCLALL3	BOOLEAN	0	Idle time (mechanical status) compensation alarm for closing CB pole L3
IDOPALL1	BOOLEAN	0	Idle time (mechanical status) compensation alarm for opening CB pole L1
IDOPALL2	BOOLEAN	0	Idle time (mechanical status) compensation alarm for opening CB pole L1
IDOPALL3	BOOLEAN	0	Idle time (mechanical status) compensation alarm for opening CB pole L1

Table 239: Breakdown of input group signals

Name	Type	Description
OPSIGNAL	REAL	Closing/Opening time correction value
ALARM	BOOLEAN	Sensor value out of supervision range, or faulty sensor. See ANSCAL for more details.
SENSTSOUT	BOOLEAN	Sensor is faulty, or communication lost. This signal is used for IEC 61850 purpose only.

Table 240: CBCOMP Output signals

Name	Type	Description
COMPCLL1	REAL	Compensation delay for closing CB pole L1
COMPCLL2	REAL	Compensation delay for closing CB pole L2
COMPOPL3	REAL	Compensation delay for closing CB pole L3
COMPOPL1	REAL	Compensation delay for opening CB pole L1
COMPOPL2	REAL	Compensation delay for opening CB pole L2
COMPCLL3	REAL	Compensation delay for opening CB pole L3
ALMSTS	INTEGER	Alarm status of compensation input(s)
LOSCOPSG	BOOLEAN	Loss of enabled compensation signal

The alarm conditions from the individual input channels are bit packed in ALMSTS as follows:

Bit 0	Bit 1	Bit 2	Bit 3	Bit 4	Bit 5	Bit 6	Bit 7
Idle time	Control voltage	Temperature	Drive pressure	Spring charge 1 (analog)	Spring charge 2 (binary)	Spare 1	Spare 2

12.16.5 Settings

Table 241: CBCOMP Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	On	Operation Off / On
IdleTimeErrInpOpt	All Healthy Max. one faulty Min. one healthy	-	-	All Healthy	Idle time compensation requirement on input health status
TempErrInpOpt	All Healthy Max. one faulty Min. one healthy	-	-	All Healthy	Temperature compensation requirement on input health status
PresErrInpOpt	All Healthy Max. one faulty Min. one healthy	-	-	All Healthy	Drive pressure compensation requirement on input health status
Spr1ErrInpOpt	All Healthy Max. one faulty Min. one healthy	-	-	All Healthy	Spring charge (analog) compensation requirement on input health status
Spr2ErrInpOpt	All Healthy Max. one faulty Min. one healthy	-	-	All Healthy	Spring charge (binary) compensation requirement on input health status
Spare1ErrInpOpt	All Healthy Max. one faulty Min. one healthy	-	-	All Healthy	Spare1 compensation requirement on input health status
Spare2ErrInpOpt	All Healthy Max. one faulty Min. one healthy	-	-	All Healthy	Spare2 compensation requirement on input health status

Table 242: CBCOMP Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
IdleTimeInpSel	Electrical Mechanical	-	-	Mechanical	Idle time input selection - primary current/voltage (electrical) or CB auxiliary contacts (mechanical)
IdleCompModeSel	None O&C, 3 sensors O&C, 1 sensor C only, 3 sensors C only, 1 sensor O only, 3 sensors O only, 1 sensor	-	-	None	Idle time compensation input mode selection
CntrlVoltCompModeSel	None O&C, 1 sensor C only, 1 sensor O only, 1 sensor	-	-	None	Control voltage compensation input mode
TempCompModeSel	None O&C, 3 sensors O&C, 1 sensor C only, 3 sensors C only, 1 sensor O only, 3 sensors O only, 1 sensor	-	-	None	Temperature compensation input mode

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
PresCompModeSel	None O&C, 3 sensors O&C, 1 sensor C only, 3 sensors C only, 1 sensor O only, 3 sensors O only, 1 sensor	-	-	None	Drive pressure compensation input mode
Spr1CompModeSel	None O&C, 3 sensors O&C, 1 sensor C only, 3 sensors C only, 1 sensor O only, 3 sensors O only, 1 sensor	-	-	None	Spring charge (analog) compensation input mode
Spr2CompModeSel	None O&C, 3 sensors O&C, 1 sensor C only, 3 sensors C only, 1 sensor O only, 3 sensors O only, 1 sensor	-	-	None	Spring charge (binary) compensation input mode
Spare1CompModeSel	None O&C, 3 sensors O&C, 1 sensor C only, 3 sensors C only, 1 sensor O only, 3 sensors O only, 1 sensor	-	-	None	Spare1 compensation input mode
Spare2CompModeSel	None O&C, 3 sensors O&C, 1 sensor C only, 3 sensors C only, 1 sensor O only, 3 sensors O only, 1 sensor	-	-	None	Spare2 compensation input mode

12.16.6 Monitored data

Table 243: CBCOMP Monitored data

Name	Type	Values (Range)	Unit	Description
COMPCLL1	REAL	-	ms	Compensation delay for closing CB pole L1
COMPCLL2	REAL	-	ms	Compensation delay for closing CB pole L2
COMPOPL3	REAL	-	ms	Compensation delay for closing CB pole L3
COMPOPL1	REAL	-	ms	Compensation delay for opening CB pole L1
COMPOPL2	REAL	-	ms	Compensation delay for opening CB pole L2
COMPCLL3	REAL	-	ms	Compensation delay for opening CB pole L3
ALMSTS	INTEGER	-	-	Alarm status of compensation input(s)
LOSCOPSG	BOOLEAN	-	-	Loss of enabled compensation signal

12.16.7 Operation principle

In order to optimize the predicted circuit breaker switching times, analog parameters such as idle time, control voltage, ambient temperature, drive pressure, and spring charge can be monitored periodically through appropriate sensors. In a typical application, ANSCAL converts each sensor signal to a compensation value (that is, time deviation from nominal operating time), which is then supplied to CBCOMP. All associated compensation values are added up to yield six total compensation values COMPCLLx and COMPOPLx, two per phase. See [Figure 114](#).

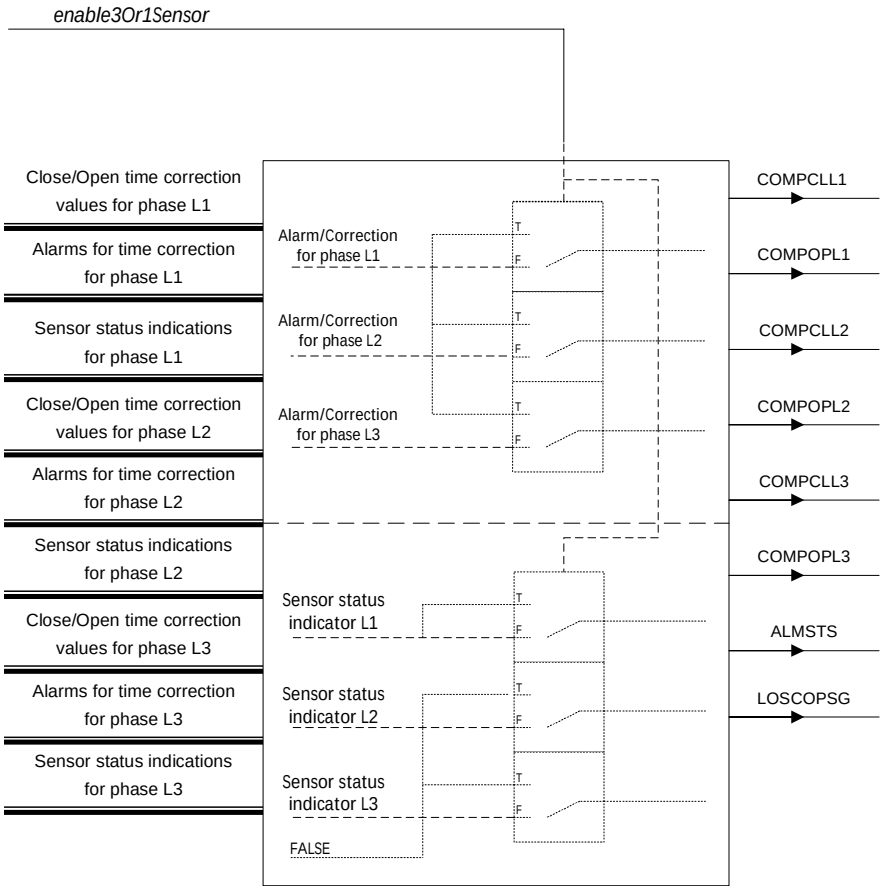


Figure 114: CBCOMP internal data processing

The number of available sensors and their respective health status are taken into account for the calculations. Each compensation scheme can be configured to provide compensation for Open operations, Close operations, or both. For each parameter to be compensated, CBCOMP features a dedicated group of compensation values inputs, as explained in [Table 244](#).

Table 244: Compensation signal inputs for measured parameters

Measured parameter	Quantity of inputs for closing time and opening time compensation	Remarks
Idle time, based on mechanical status	3 + 3	Mechanical status is derived from CB auxiliary contacts
Idle time, based on primary current or load voltage signals	3 + 3	CB status is detected as closed if current is flowing ($I > I_{Dead}$) or load voltage is present ($U_L > U_{Dead}$), and open otherwise
Control voltage	1 + 1	Control voltage is measured from IED's power supply input
Temperature	3 + 3	Requires external acquisition device, supplying measured values via IEC 61850 GOOSE messages
Drive pressure	3 + 3	Requires external acquisition device, supplying measured values via IEC 61850 GOOSE messages
Spring charge, analog measurement	3 + 3	Requires external acquisition device, supplying measured values via IEC 61850 GOOSE messages
Spring charge, based on binary range indication signals	3 + 3	For example, obtained from spring limit switches indicating OCO-block or CO-block conditions
Spare 1	3 + 3	For user defined sensor signals. Requires external acquisition device, supplying measured values via IEC 61850 GOOSE messages. Alternatively, internally calculated analog signals can be used.
Spare 2	3 + 3	For user defined sensor signals. Requires external acquisition device, supplying measured values via IEC 61850 GOOSE messages. Alternatively, internally calculated analog signals can be used.

Only one of the idle time compensation channels, viz. status based or current based, is used for calculating the final compensation value. The selection is made by the *IdleTimeInpSel* setting.

12.16.7.1 Compensation mode

Depending on the number of sensors available for a given parameter, and on the circuit breaker operations to be controlled (or compensation characteristics available), the respective value for *CompModeSel* defines the compensation mode applied to that parameter. See [Table 245](#). In Switchsync PWC600, this selection can be made automatically by SST.

Table 245: Compensation mode for each parameter

Number of sensors	Compensate closing times	Compensate opening times	CompModeSel setting
0	-	-	Disable O&C
(Any)	No	No	Disable O&C
1	Yes	No	Enable C1Sensor
1	No	Yes	Enable O1Sensor
1	Yes	Yes	EnableO&C1Sensor
3 (one per CB pole)	Yes	No	Enable C3Sensor
3 (one per CB pole)	No	Yes	Enable O3Sensor
3 (one per CB pole)	Yes	Yes	EnableO&C3Sensor

With three sensors enabled, individual compensation values are processed for each CB pole. With only a single sensor input enabled, the compensation value on the input for breaker pole L1 is used for all three poles.

12.16.7.2 Sensor status

Only accurate measured values from the sensors are useful in optimizing controlled switching performance. In case of a faulty sensor, wrong output values may even deteriorate the result. As part of the input group signals, CBCOMP accepts health status information of each sensor, where logical 1 indicates a missing or faulty sensor. Any 'unhealthy' condition indication on an enabled sensor input activates the LOSCOPSG output. Unacceptable numbers of faulty sensors, which do not meet the criterion defined by the *ErrInpOpt* setting, activate the ALMSTS output. Furthermore, the sensor failure information can be used for selecting a fallback strategy. This assumes that operating conditions for three adjacent circuit breaker poles would generally be similar. The strategies also depend on the *ErrInpOpt* setting for each measured parameter, see [Table 246](#).

Table 246: Processing of compensation values in dependence on sensor status

CompModeSel setting	ErrInpOpt setting	Number of faulty sensors	Compensation value processed in phases with healthy sensor	Compensation value processed in phases with faulty sensor	ALMSTS bit for the channel
...1 Sensor	(Any)	0	Input value	-	0
		1	0.0	0.0	1
...3 Sensor	(Any)	0	Input value	-	0
	All healthy	1, 2 or 3	0.0	0.0	1
	Only one faulty	1	Input value	Average of input values in phases with healthy sensor	0
		2 or 3	0.0	0.0	1
	Atleast one healthy	1	Input value	Average of input values in phases with healthy sensor	0
		2	Input value	Input value in phase with healthy sensor	0
		3	0.0	0.0	1

12.17 Multilevel threshold alarm generation MONALM

12.17.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Multilevel threshold alarm generation	MONALM	-	-

12.17.2 Functionality

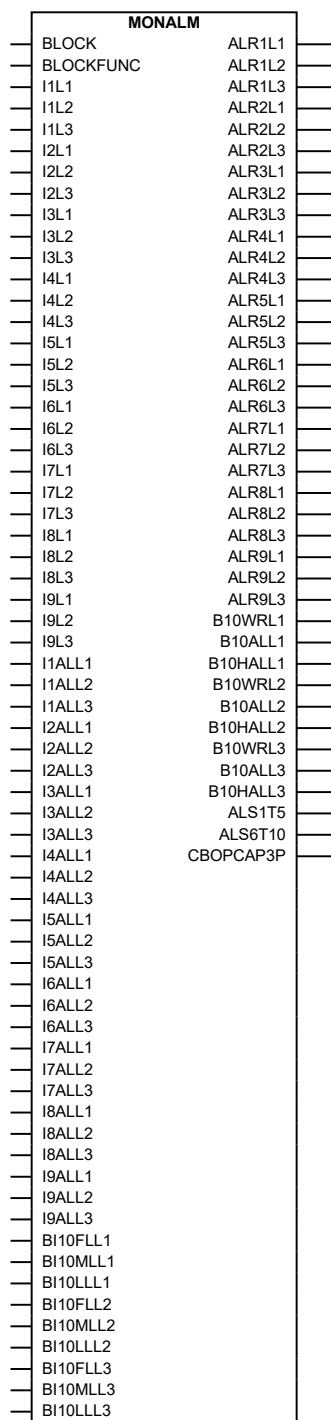
MONALM is used to monitor up to 9 groups of measured or calculated analog values, to ascertain whether they are within a defined "normal" range as per the process requirements. The function compares each input value against 1...4 threshold levels and indicates the range in which it is currently residing. Values outside the normal range are indicated by a warning or alarm.

The numerical range information can be decoded into binary status signals by other functions such as MVEXP, for example, to control a LED or binary output or to generate an event.

Furthermore, MONALM monitors one group of binary inputs, which represent alarm levels, and replicates the input values to corresponding output signals. These signals are also used to indicate the operational capability of the circuit breaker.

A quick indication of the overall status can be obtained from two alarm status outputs, which summarize the conditions of 5 input groups each.

12.17.3 Function block



IEC12000039_1_vsd

Figure 115: MONALM function block

12.17.4 Signals

Table 247: MONALM Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of binary outputs
BLOCKFUNC	BOOLEAN	0	Block functionality to block execution of this function and populate outputs with default values
I1L1	REAL	0.0	Analog input 1 L1
I1L2	REAL	0.0	Analog input 1 L2
I1L3	REAL	0.0	Analog input 1 L3
I2L1	REAL	0.0	Analog input 2 L1
I2L2	REAL	0.0	Analog input 2 L2
I2L3	REAL	0.0	Analog input 2 L3
I3L1	REAL	0.0	Analog input 3 L1
I3L2	REAL	0.0	Analog input 3 L2
I3L3	REAL	0.0	Analog input 3 L3
I4L1	REAL	0.0	Analog input 4 L1
I4L2	REAL	0.0	Analog input 4 L2
I4L3	REAL	0.0	Analog input 4 L3
I5L1	REAL	0.0	Analog input 5 L1
I5L2	REAL	0.0	Analog input 5 L2
I5L3	REAL	0.0	Analog input 5 L3
I6L1	REAL	0.0	Analog input 6 L1
I6L2	REAL	0.0	Analog input 6 L2
I6L3	REAL	0.0	Analog input 6 L3
I7L1	REAL	0.0	Analog input 7 L1
I7L2	REAL	0.0	Analog input 7 L2
I7L3	REAL	0.0	Analog input 7 L3
I8L1	REAL	0.0	Analog input 8 L1
I8L2	REAL	0.0	Analog input 8 L2
I8L3	REAL	0.0	Analog input 8 L3
I9L1	REAL	0.0	Analog input 9 L1
I9L2	REAL	0.0	Analog input 9 L2
I9L3	REAL	0.0	Analog input 9 L3
I1ALL1	BOOLEAN	0	Alarm input signal showing input 1 L1's state of health
I1ALL2	BOOLEAN	0	Alarm input signal showing input 1 L2's state of health
I1ALL3	BOOLEAN	0	Alarm input signal showing input 1 L3's state of health
I2ALL1	BOOLEAN	0	Alarm input signal showing input 2 L1's state of health
I2ALL2	BOOLEAN	0	Alarm input signal showing input 2 L2's state of health
I2ALL3	BOOLEAN	0	Alarm input signal showing input 2 L3's state of health
I3ALL1	BOOLEAN	0	Alarm input signal showing input 3 L1's state of health
I3ALL2	BOOLEAN	0	Alarm input signal showing input 3 L2's state of health
Table continues on next page			

Name	Type	Default	Description
I3ALL3	BOOLEAN	0	Alarm input signal showing input 3 L3's state of health
I4ALL1	BOOLEAN	0	Alarm input signal showing input 4 L1's state of health
I4ALL2	BOOLEAN	0	Alarm input signal showing input 4 L2's state of health
I4ALL3	BOOLEAN	0	Alarm input signal showing input 4 L3's state of health
I5ALL1	BOOLEAN	0	Alarm input signal showing input 5 L1's state of health
I5ALL2	BOOLEAN	0	Alarm input signal showing input 5 L2's state of health
I5ALL3	BOOLEAN	0	Alarm input signal showing input 5 L3's state of health
I6ALL1	BOOLEAN	0	Alarm input signal showing input 6 L1's state of health
I6ALL2	BOOLEAN	0	Alarm input signal showing input 6 L2's state of health
I6ALL3	BOOLEAN	0	Alarm input signal showing input 6 L3's state of health
I7ALL1	BOOLEAN	0	Alarm input signal showing input 7 L1's state of health
I7ALL2	BOOLEAN	0	Alarm input signal showing input 7 L2's state of health
I7ALL3	BOOLEAN	0	Alarm input signal showing input 7 L3's state of health
I8ALL1	BOOLEAN	0	Alarm input signal showing input 8 L1's state of health
I8ALL2	BOOLEAN	0	Alarm input signal showing input 8 L2's state of health
I8ALL3	BOOLEAN	0	Alarm input signal showing input 8 L3's state of health
I9ALL1	BOOLEAN	0	Alarm input signal showing input 9 L1's state of health
I9ALL2	BOOLEAN	0	Alarm input signal showing input 9 L2's state of health
I9ALL3	BOOLEAN	0	Alarm input signal showing input 9 L3's state of health
BI10FLL1	BOOLEAN	0	Binary input 10 full level signal for phase L1
BI10MLL1	BOOLEAN	0	Binary input 10 medium level signal for phase L1
BI10LLL1	BOOLEAN	0	Binary input 10 low level signal for phase L1
BI10FLL2	BOOLEAN	0	Binary input 10 full level signal for phase L2
BI10MLL2	BOOLEAN	0	Binary input 10 medium level signal for phase L2
BI10LLL2	BOOLEAN	0	Binary input 10 low level signal for phase L2
BI10FLL3	BOOLEAN	0	Binary input 10 full level signal for phase L3
BI10MLL3	BOOLEAN	0	Binary input 10 medium level signal for phase L3
BI10LLL3	BOOLEAN	0	Binary input 10 low level signal for phase L3

Table 248: MONALM Output signals

Name	Type	Description
ALR1L1	INTEGER	Alarm range integer value for signal 1 L1
ALR1L2	INTEGER	Alarm range integer value for signal 1 L2
ALR1L3	INTEGER	Alarm range integer value for signal 1 L3
ALR2L1	INTEGER	Alarm range integer value for signal 2 L1
ALR2L2	INTEGER	Alarm range integer value for signal 2 L2
ALR2L3	INTEGER	Alarm range integer value for signal 2 L3
ALR3L1	INTEGER	Alarm range integer value for signal 3 L1
ALR3L2	INTEGER	Alarm range integer value for signal 3 L2
ALR3L3	INTEGER	Alarm range integer value for signal 3 L3
ALR4L1	INTEGER	Alarm range integer value for signal 4 L1

Table continues on next page

Name	Type	Description
ALR4L2	INTEGER	Alarm range integer value for signal 4 L2
ALR4L3	INTEGER	Alarm range integer value for signal 4 L3
ALR5L1	INTEGER	Alarm range integer value for signal 5 L1
ALR5L2	INTEGER	Alarm range integer value for signal 5 L2
ALR5L3	INTEGER	Alarm range integer value for signal 5 L3
ALR6L1	INTEGER	Alarm range integer value for signal 6 L1
ALR6L2	INTEGER	Alarm range integer value for signal 6 L2
ALR6L3	INTEGER	Alarm range integer value for signal 6 L3
ALR7L1	INTEGER	Alarm range integer value for signal 7 L1
ALR7L2	INTEGER	Alarm range integer value for signal 7 L2
ALR7L3	INTEGER	Alarm range integer value for signal 7 L3
ALR8L1	INTEGER	Alarm range integer value for signal 8 L1
ALR8L2	INTEGER	Alarm range integer value for signal 8 L2
ALR8L3	INTEGER	Alarm range integer value for signal 8 L3
ALR9L1	INTEGER	Alarm range integer value for signal 9 L1
ALR9L2	INTEGER	Alarm range integer value for signal 9 L2
ALR9L3	INTEGER	Alarm range integer value for signal 9 L3
B10WRL1	BOOLEAN	Output warning signal for binary input 10 L1
B10ALL1	BOOLEAN	Output alarm signal for binary input 10 L1
B10HALL1	BOOLEAN	Output high alarm signal for binary input 10 L1
B10WRL2	BOOLEAN	Output warning signal for binary input 10 L2
B10ALL2	BOOLEAN	Output alarm signal for binary input 10 L2
B10HALL2	BOOLEAN	Output high alarm signal for binary input 10 L2
B10WRL3	BOOLEAN	Output warning signal for binary input 10 L3
B10ALL3	BOOLEAN	Output alarm signal for binary input 10 L3
B10HALL3	BOOLEAN	Output high alarm signal for binary input 10 L3
ALS1T5	INTEGER	Alarm status integer for inputs 1 to 5
ALS6T10	INTEGER	Alarm status integer for inputs 6 to 10
CBOPCAP3P	INTEGER	CB operation capability signal having packed information for three phases

12.17.5 Settings

Table 249: MONALM Non group settings (basic)

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

Table 250: MONALM Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Inp1LimitSelect	Disabled Hi, HiHi, Lo, LoLo Hi, Hi-Hi Lo, Lo-Lo Hi, Lo Hi-Hi, Lo-Lo Hi Hi-Hi Lo Lo-Lo	-	-	Disabled	Selection of monitored limits for input 1
Inp1HystAbsolute	0.0 - 99999.9	-	0.1	10.0	Absolute Hysteresis value for input 1
Inp1HiHiLimit	-99999.9 - 99999.9	-	0.1	100.0	High alarm value limit above which an upper limit alarm would be issued for input 1.
Inp1HiLimit	-99999.9 - 99999.9	-	0.1	100.0	High warning value limit above which an upper limit warning would be issued for input 1.
Inp1LoLimit	-99999.9 - 99999.9	-	0.1	0.0	Low value limit below which a lower limit warning would be issued for input 1.
Inp1LoLoLimit	-99999.9 - 99999.9	-	0.1	0.0	Lower value limit below which a lower limit alarm would be issued for input 1.
Inp1SensorMode	1 sensor mode 3 sensor mode	-	-	1 sensor mode	Selection of one or three sensors for input 1.
Inp2LimitSelect	Disabled Hi, HiHi, Lo, LoLo Hi, Hi-Hi Lo, Lo-Lo Hi, Lo Hi-Hi, Lo-Lo Hi Hi-Hi Lo Lo-Lo	-	-	Disabled	Selection of monitored limits for input 2.
Inp2HystAbsolute	0.0 - 99999.9	-	0.1	10.0	Absolute Hysteresis value for input 2
Inp2HiHiLimit	-99999.9 - 99999.9	-	0.1	100.0	High alarm value limit above which an upper limit alarm would be issued for input 2.
Inp2HiLimit	-99999.9 - 99999.9	-	0.1	100.0	High warning value limit above which an upper limit warning would be issued for input 2.
Inp2LoLimit	-99999.9 - 99999.9	-	0.1	0.0	Low value limit below which a lower limit warning would be issued for input 2.
Inp2LoLoLimit	-99999.9 - 99999.9	-	0.1	0.0	Lower value limit below which a lower limit alarm would be issued for input 2.
Inp2SensorMode	1 sensor mode 3 sensor mode	-	-	1 sensor mode	Selection of one or three sensors for input 2.
Inp3LimitSelect	Disabled Hi, HiHi, Lo, LoLo Hi, Hi-Hi Lo, Lo-Lo Hi, Lo Hi Hi-Hi Lo Lo-Lo	-	-	Disabled	Selection of monitored limits for input 3.
Inp3HystAbsolute	0.0 - 99999.9	-	0.1	10.0	Absolute Hysteresis value for input 3
Table continues on next page					

Name	Values (Range)	Unit	Step	Default	Description
Inp3HiHiLimit	-99999.9 - 99999.9	-	0.1	100.0	High alarm value limit above which an upper limit alarm would be issued for input 3.
Inp3HiLimit	-99999.9 - 99999.9	-	0.1	100.0	High warning value limit above which an upper limit warning would be issued for input 3.
Inp3LoLimit	-99999.9 - 99999.9	-	0.1	0.0	Low value limit below which a lower limit warning would be issued for input 3.
Inp3LoLoLimit	-99999.9 - 99999.9	-	0.1	0.0	Lower value limit below which a lower limit alarm would be issued for input 3.
Inp3SensorMode	1 sensor mode 3 sensor mode	-	-	1 sensor mode	Selection of one or three sensors for input 3.
Inp4LimitSelect	Disabled Hi, HiHi, Lo, LoLo Hi, Hi-Hi Lo, Lo-Lo Hi, Lo Hi-Hi, Lo-Lo Hi Lo Lo-Lo	-	-	Disabled	Selection of monitored limits for input 4
Inp4HystAbsolute	0.0 - 99999.9	-	0.1	10.0	Absolute Hysteresis value for input 4
Inp4HiHiLimit	-99999.9 - 99999.9	-	0.1	100.0	High alarm value limit above which an upper limit alarm would be issued for input 4.
Inp4HiLimit	-99999.9 - 99999.9	-	0.1	100.0	High warning value limit above which an upper limit warning would be issued for input 4.
Inp4LoLimit	-99999.9 - 99999.9	-	0.1	0.0	Low value limit below which a lower limit warning would be issued for input 4.
Inp4LoLoLimit	-99999.9 - 99999.9	-	0.1	0.0	Lower value limit below which a lower limit alarm would be issued for input 4.
Inp4SensorMode	1 sensor mode 3 sensor mode	-	-	1 sensor mode	Selection of one or three sensors for input 4.
Inp5LimitSelect	Disabled Hi, HiHi, Lo, LoLo Hi, Hi-Hi Lo, Lo-Lo Hi, Lo Hi-Hi, Lo-Lo Hi Hi-Hi Lo Lo-Lo	-	-	Disabled	Selection of monitored limits for input 5
Inp5HystAbsolute	0.0 - 99999.9	-	0.1	10.0	Absolute Hysteresis value for input 5
Inp5HiHiLimit	-99999.9 - 99999.9	-	0.1	100.0	High alarm value limit above which an upper limit alarm would be issued for input 5.
Inp5HiLimit	-99999.9 - 99999.9	-	0.1	100.0	High warning value limit above which an upper limit warning would be issued for input 5.
Inp5LoLimit	-99999.9 - 99999.9	-	0.1	0.0	Low value limit below which a lower limit warning would be issued for input 5.
Inp5LoLoLimit	-99999.9 - 99999.9	-	0.1	0.0	Lower value limit below which a lower limit alarm would be issued for input 5.
Table continues on next page					

Name	Values (Range)	Unit	Step	Default	Description
Inp5SensorMode	1 sensor mode 3 sensor mode	-	-	1 sensor mode	Selection of one or three sensors for input 5.
Inp6LimitSelect	Disabled Hi, HiHi, Lo, LoLo Hi, Hi-Hi Lo, Lo-Lo Hi, Lo Hi-Hi, Lo-Lo Hi Hi-Hi Lo Lo-Lo	-	-	Disabled	Selection of monitored limits for input 6
Inp6HystAbsolute	0.0 - 99999.9	-	0.1	10.0	Absolute Hysteresis value for input 6
Inp6HiHiLimit	-99999.9 - 99999.9	-	0.1	100.0	High alarm value limit above which an upper limit alarm would be issued for input 6.
Inp6HiLimit	-99999.9 - 99999.9	-	0.1	100.0	High warning value limit above which an upper limit warning would be issued for input 6.
Inp6LoLimit	-99999.9 - 99999.9	-	0.1	0.0	Low value limit below which a lower limit warning would be issued for input 6
Inp6LoLoLimit	-99999.9 - 99999.9	-	0.1	0.0	Lower value limit below which a lower limit alarm would be issued for input 6.
Inp6SensorMode	1 sensor mode 3 sensor mode	-	-	1 sensor mode	Selection of one or three sensors for input 6.
Inp7LimitSelect	Disabled Hi, HiHi, Lo, LoLo Hi, Hi-Hi Lo, Lo-Lo Hi, Lo Hi-Hi, Lo-Lo Hi Hi-Hi Lo Lo-Lo	-	-	Disabled	Selection of monitored limits for input 7
Inp7HystAbsolute	0.0 - 99999.9	-	0.1	10.0	Absolute Hysteresis value for input 7
Inp7HiHiLimit	-99999.9 - 99999.9	-	0.1	100.0	High alarm value limit above which an upper limit alarm would be issued for input 7.
Inp7HiLimit	-99999.9 - 99999.9	-	0.1	100.0	High warning value limit above which an upper limit warning would be issued for input 7.
Inp7LoLimit	-99999.9 - 99999.9	-	0.1	0.0	Low value limit below which a lower limit warning would be issued for input 7.
Inp7LoLoLimit	-99999.9 - 99999.9	-	0.1	0.0	Lower value limit below which a lower limit alarm would be issued for input 7.
Inp7SensorMode	1 sensor mode 3 sensor mode	-	-	1 sensor mode	Selection of one or three sensors for input 7.
Inp8LimitSelect	Disabled Hi, HiHi, Lo, LoLo Hi, Hi-Hi Lo, Lo-Lo Hi, Lo Hi-Hi, Lo-Lo Hi Hi-Hi Lo Lo-Lo	-	-	Disabled	Selection of monitored limits for input 8

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
Inp8HystAbsolute	0.0 - 99999.9	-	0.1	10.0	Absolute Hysteresis value for input 8
Inp8HiHiLimit	-99999.9 - 99999.9	-	0.1	100.0	High alarm value limit above which an upper limit alarm would be issued for input 8
Inp8HiLimit	-99999.9 - 99999.9	-	0.1	100.0	High warning value limit above which an upper limit warning would be issued for input 8.
Inp8LoLimit	-99999.9 - 99999.9	-	0.1	0.0	Low value limit below which a lower limit warning would be issued for input 8.
Inp8LoLoLimit	-99999.9 - 99999.9	-	0.1	0.0	Lower value limit below which a lower limit alarm would be issued for input 8.
Inp8SensorMode	1 sensor mode 3 sensor mode	-	-	1 sensor mode	Selection of one or three sensors for input 8.
Inp9LimitSelect	Disabled Hi, HiHi, Lo, LoLo Hi, Hi-Hi Lo, Lo-Lo Hi, Lo Hi-Hi, Lo-Lo Hi Hi-Hi Lo Lo-Lo	-	-	Disabled	Selection of monitored limits for input 9
Inp9HystAbsolute	0.0 - 99999.9	-	0.1	10.0	Absolute Hysteresis value for input 9
Inp9HiHiLimit	-99999.9 - 99999.9	-	0.1	100.0	High alarm value limit above which an upper limit alarm would be issued for input 9.
Inp9HiLimit	-99999.9 - 99999.9	-	0.1	100.0	High warning value limit above which an upper limit warning would be issued for input 9.
Inp9LoLimit	-99999.9 - 99999.9	-	0.1	0.0	Low value limit below which a lower limit warning would be issued for input 9.
Inp9LoLoLimit	-99999.9 - 99999.9	-	0.1	0.0	Lower value limit below which a lower limit alarm would be issued for input 9.
Inp9SensorMode	1 sensor mode 3 sensor mode	-	-	1 sensor mode	Selection of one or three sensors for input 9.
BinInp10AlarmMode	Disable all Enab only Wrn Enab only Alarm Enab only Hi Alarm Enab Wrn & Alarm Enab Al & Hi Al Enab Wrn Al & HiAl	-	-	Disable all	Selection of alarm mode for binary input 10
BinInp10SensorMode	1 sensor mode 3 sensor mode	-	-	1 sensor mode	Selection of one or three sensors for binary input 10.

12.17.6 Monitored data

Table 251: MONALM Monitored data

Name	Type	Values (Range)	Unit	Description
ALR1L1	INTEGER	0=Normal 1=High Warning 2=Low Warning 3=High Alarm 4=Low Alarm	-	Alarm range integer value for signal 1 L1
ALR1L2	INTEGER	0=Normal 1=High Warning 2=Low Warning 3=High Alarm 4=Low Alarm	-	Alarm range integer value for signal 1 L2
ALR1L3	INTEGER	0=Normal 1=High Warning 2=Low Warning 3=High Alarm 4=Low Alarm	-	Alarm range integer value for signal 1 L3
ALR2L1	INTEGER	0=Normal 1=High Warning 2=Low Warning 3=High Alarm 4=Low Alarm	-	Alarm range integer value for signal 2 L1
ALR2L2	INTEGER	0=Normal 1=High Warning 2=Low Warning 3=High Alarm 4=Low Alarm	-	Alarm range integer value for signal 2 L2
ALR2L3	INTEGER	0=Normal 1=High Warning 2=Low Warning 3=High Alarm 4=Low Alarm	-	Alarm range integer value for signal 2 L3
ALR3L1	INTEGER	0=Normal 1=High Warning 2=Low Warning 3=High Alarm 4=Low Alarm	-	Alarm range integer value for signal 3 L1
ALR3L2	INTEGER	0=Normal 1=High Warning 2=Low Warning 3=High Alarm 4=Low Alarm	-	Alarm range integer value for signal 3 L2
ALR3L3	INTEGER	0=Normal 1=High Warning 2=Low Warning 3=High Alarm 4=Low Alarm	-	Alarm range integer value for signal 3 L3
ALR4L1	INTEGER	0=Normal 1=High Warning 2=Low Warning 3=High Alarm 4=Low Alarm	-	Alarm range integer value for signal 4 L1
ALR4L2	INTEGER	0=Normal 1=High Warning 2=Low Warning 3=High Alarm 4=Low Alarm	-	Alarm range integer value for signal 4 L2
Table continues on next page				

Name	Type	Values (Range)	Unit	Description
ALR4L3	INTEGER	0=Normal 1=High Warning 2=Low Warning 3=High Alarm 4=Low Alarm	-	Alarm range integer value for signal 4 L3
ALR5L1	INTEGER	0=Normal 1=High Warning 2=Low Warning 3=High Alarm 4=Low Alarm	-	Alarm range integer value for signal 5 L1
ALR5L2	INTEGER	0=Normal 1=High Warning 2=Low Warning 3=High Alarm 4=Low Alarm	-	Alarm range integer value for signal 5 L2
ALR5L3	INTEGER	0=Normal 1=High Warning 2=Low Warning 3=High Alarm 4=Low Alarm	-	Alarm range integer value for signal 5 L3
ALR6L1	INTEGER	0=Normal 1=High Warning 2=Low Warning 3=High Alarm 4=Low Alarm	-	Alarm range integer value for signal 6 L1
ALR6L2	INTEGER	0=Normal 1=High Warning 2=Low Warning 3=High Alarm 4=Low Alarm	-	Alarm range integer value for signal 6 L2
ALR6L3	INTEGER	0=Normal 1=High Warning 2=Low Warning 3=High Alarm 4=Low Alarm	-	Alarm range integer value for signal 6 L3
ALR7L1	INTEGER	0=Normal 1=High Warning 2=Low Warning 3=High Alarm 4=Low Alarm	-	Alarm range integer value for signal 7 L1
ALR7L2	INTEGER	0=Normal 1=High Warning 2=Low Warning 3=High Alarm 4=Low Alarm	-	Alarm range integer value for signal 7 L2
ALR7L3	INTEGER	0=Normal 1=High Warning 2=Low Warning 3=High Alarm 4=Low Alarm	-	Alarm range integer value for signal 7 L3
ALR8L1	INTEGER	0=Normal 1=High Warning 2=Low Warning 3=High Alarm 4=Low Alarm	-	Alarm range integer value for signal 8 L1
ALR8L2	INTEGER	0=Normal 1=High Warning 2=Low Warning 3=High Alarm 4=Low Alarm	-	Alarm range integer value for signal 8 L2
Table continues on next page				

Name	Type	Values (Range)	Unit	Description
ALR8L3	INTEGER	0=Normal 1=High Warning 2=Low Warning 3=High Alarm 4=Low Alarm	-	Alarm range integer value for signal 8 L3
ALR9L1	INTEGER	0=Normal 1=High Warning 2=Low Warning 3=High Alarm 4=Low Alarm	-	Alarm range integer value for signal 9 L1
ALR9L2	INTEGER	0=Normal 1=High Warning 2=Low Warning 3=High Alarm 4=Low Alarm	-	Alarm range integer value for signal 9 L2
ALR9L3	INTEGER	0=Normal 1=High Warning 2=Low Warning 3=High Alarm 4=Low Alarm	-	Alarm range integer value for signal 9 L3

12.17.7 Operation principle

The Multilevel threshold alarm generation MONALM function triggers an alarm when an analog quantity is not in a normal range.

MONALM works on the principle of comparing the analog quantity against a set of thresholds in two directions at two different levels on either side. Nine analog quantities, for example, control voltage, temperature, drive pressure, spring pressure and so on can be monitored such that when they exceed the threshold values, alarms are generated. The binary signals are the supervising levels of an analog signal, whose status level (for example, gas pressure, spring charge status and so on) indicates when the analog signal falls below the threshold.

Use the setting *InpxSensorMode* to select the number of signals to supervise in a channel: Select "1 Sensor Mode" if a single sensor signal is connected to the corresponding IxL1 input, else select "3 Sensor Mode" for three sensor signals (one per phase).

Up to nine analog input signals can be supervised. For each signal, one or two supervision thresholds can be configured in each direction, or supervision can be disabled altogether in any direction.

The binary input level alarm can be configured to indicate *Warning*, *Alarm* and/or *High Alarm*.

- If the full level binary signal is high, no warning or alarm is generated, regardless of the status of the other binary signals.
- If the full level binary signal is low and the medium level signal is high, *Warning* goes high.
- If only the low level signal is high, *Alarm* goes high.
- If all binary inputs are low, *High Alarm* goes high.

For analog quantities, exceeding the thresholds can trigger one of the four alarms. The output ALRxLn can have different values according to the conditions defined below:

- 0 (*normal range*) indicates, the input signal is in normal range, that is, between low and high warning limits, or the alarm input IxALn is high
- 1 (*high warning*) indicates, the signal has risen to or above *InpxHiLimit*
- 2 (*low warning*) indicates, the signal has dropped to or below *InpxLoLimit*
- 3 (*high alarm*) indicates, the signal has risen to or above *InpxHiHiLimit*
- 4 (*low alarm*) indicates, the signal has dropped to or below *InpxLoLoLimit*

where x indicates the analog input and n indicates the phase.



The input value 1.175494E-38, which is the smallest possible real value, is not evaluated for determining the range and is always treated as in Normal range, regardless of the set limits. The purpose is to prevent raising of alarms on quantities that have no defined value, for example, a switching time if the circuit breaker has not been operated yet.

Activating any IxALn input forces the corresponding output value to 0 (normal range). This can be used to suppress alarms under non-applicable conditions.

MONALM also generates a general alarm (gives information) when any one of the alarming condition is present or when a signal connected to IxALn goes high. Loss of the sensor signal of the monitored analog signals can be connected to this.

12.17.7.1 Alarm status logic

The status of the supervision alarm is indicated by an alarm status functionality which is designed to bit pack the alarm status of all ten input groups into two integer signals. The sequential bits carry the status information of each analog input group for all the three phases independently. The phase information for every input is described using two bits, where the least significant bit (LSB) indicates warning and the most significant bit (MSB) indicates alarm or high alarm.

The alarm status information for phase L1,

- If the signal is in low or high warning range, the LSB is set high.
- If the signal is in low or high alarm range, the MSB is set high.
- If alarm input signal IxALL1 is high, both MSB and LSB are set high (this indicates the status of signal's health).
- In all other conditions both MSB and LSB are set low.

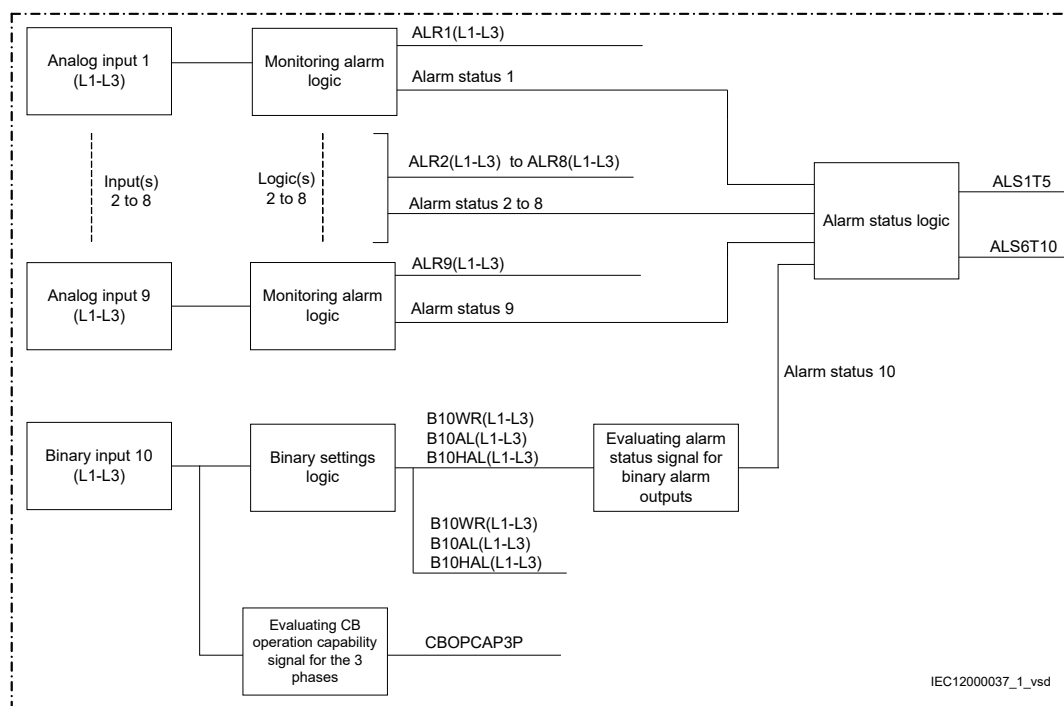


Figure 116: MONALM logic diagram

Figure 116 shows the alarm status processing of the analog inputs and a single binary input in the three phases. It also evaluates the alarm status logic and generates the outputs.

Similarly, for phase L2 and phase L3, the alarm status are set. The information for all the ten inputs in three-phases are divided into two 32 bit outputs. Here, output 1 is designated as ALS1T5 and output 2 is designated as ALS6T10. The last two bits in both outputs are unused.

Calculating alarm status bits for analog input signals

Example for alarm status calculation for analog input signals 1-9:

Consider for any input x for phase n, if *Warning (Low Warning/High Warning)* information is set, then:

$[6 \cdot (x-1) + 2 \cdot (n-1)]^{\text{th}}$ bit position in alarm status output goes high.

If *Alarm (Low Alarm/High Alarm)* information needs to be set, then:

$[6 \cdot (x-1) + 2 \cdot (n-1) + 1]^{\text{th}}$ bit position in alarm status output goes high.

The *Alarm* and *Warning* information for selected examples is shown in [Table 252](#).

Table 252: Alarm and Warning information for analog input signals

Input	phase	Assumed alarm range	Bit position
1	L1	High Warning	$6 \cdot (1-1) + 2 \cdot (1-1) = 0$ 0 th bit set high
1	L2	Low Alarm	$6 \cdot (1-1) + 2 \cdot (2-1) + 1 = 3$ 3 rd bit set high
1	L3	Low Warning	$6 \cdot (1-1) + 2 \cdot (3-1) = 4$ 4 th bit set high
2	L1	Low Warning	$6 \cdot (2-1) + 2 \cdot (1-1) = 6$ 6 th bit set high
2	L2	High Alarm	$6 \cdot (2-1) + 2 \cdot (2-1) + 1 = 9$ 9 th bit set high
2	L3	Low Alarm	$6 \cdot (2-1) + 2 \cdot (3-1) + 1 = 11$ 11 th bit set high
3	L1	Normal	both 12 th and 13 th bit set low
3	L2	High Warning	$6 \cdot (3-1) + 2 \cdot (2-1) = 14$ 14 th bit set high
3	L3	Alarm Input is high	both 16 th and 17 th bit set high
4	L1	Normal	both 18 th and 19 th bit set low
4	L2	Low Alarm	$6 \cdot (4-1) + 2 \cdot (2-1) + 1 = 21$ 21 st bit set high
4	L3	Low Warning	$6 \cdot (4-1) + 2 \cdot (3-1) = 22$ 22 nd bit set high
5	L1	Low Warning	$6 \cdot (5-1) + 2 \cdot (1-1) = 24$ 24 th bit set high
5	L2	High Warning	$6 \cdot (5-1) + 2 \cdot (2-1) = 26$ 26 th bit set high
5	L3	Alarm Input is high	both 28 th and 29 th bit set high

ALS1T5 becomes 00110101011000110100101001011001 in binary, that is 895699545 in decimal.

During the bit packing, the 30th and 31st bits are not used (set as zero).

Similar procedure is carried out for ALS6T10

Calculating alarm status bits for binary input signals

Example for alarm status calculation for binary input 10:

Table 253: Alarm status bits for binary input signals

Input in phase	Alarm range	Alarm status
L1	Warning	is set to 01
L2	Alarm	is set to 1000
L3	High Alarm	is set to 100000

Hence the alarm status for binary input 10 is 101001. This gets bit packed in ALS6T10 (in 24th to 29th bit position).

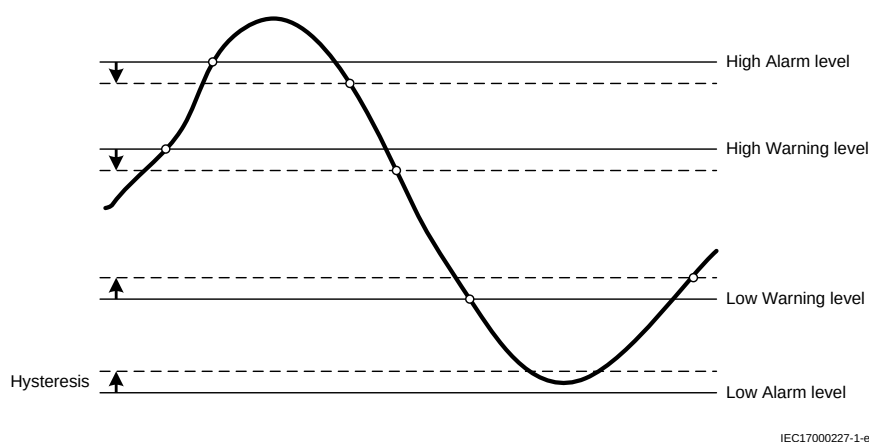
If none of these conditions are met (that is no warning or alarm), the bits are set to 0.

12.17.7.2 Hysteresis

Hysteresis is applied to prevent frequent toggling of alarms if the input signal oscillates around the threshold by a small amount. The extent of the hysteresis zone is defined by *InpxHystAbsolute* for each of the analog input signals x. This setting applies equally to all enabled thresholds for that signal group.

- If the signal rises above one of the upper thresholds, the output will indicate this condition until the signal drops below the level threshold minus hysteresis.
- If the signal drops below one of the lower thresholds, the output will indicate this condition until the signal rises above the level threshold plus hysteresis.

This is demonstrated in [Figure 117](#), showing an analog signal passing from Normal range through High Warning, High Alarm, High Warning, Normal, Low Warning, and back to Normal ranges. Hysteresis is indicated by arrows, and small circles mark the points of output status change.



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Figure 117: Example of analog signal passing through warning and alarm levels with hysteresis

12.17.7.3 Circuit breaker operation capability

The operation capability of the circuit breaker can be determined by the binary input signal levels for the three phases.

For any phase,

- When the input signal is full level, the breaker can operate a full cycle of open-close-open operation.
- When the input signal is medium level, the breaker can operate only a close followed by an open operation.
- When the input signal is low level, the breaker operation is restricted to a single open operation.
- When the input signal is absent, there cannot be a possible breaker operation.

Example, consider full level binary input signal (representing stored energy in the drive) for phase L1, medium level signal for phase L2 and low level signal for phase L3.

- Phase L1 has full level binary input signal. It implies that full spring charge is available and the breaker can operate a complete cycle of open-close-open operation.
- For phase L2, the full level binary signal is absent and only the medium level binary input signal is high, it implies that sufficient spring charge is unavailable for a full cycle operation. Hence the breaker can operate only a close followed by an open operation.
- For phase L3, the spring charge is low, the breaker can operate only open operation.

In this case, the integer value of CBOPCAP3P is 131844 as defined in [Table 254](#)

[Table 254](#) shows all possible combinations of circuit breaker operation for the three phases with the corresponding output integer values.

Table 254: Operation capability of the circuit breaker

Combination			Integer
L1	L2	L3	CBOPCAP3P
None	None	None	65793
None	None	Open	131329
None	None	Close-Open	196865
None	None	Open-Close-Open	262401
None	Open	None	66049
None	Open	Open	131585
None	Open	Close-Open	197121
None	Open	Open-Close-Open	262657
None	Close-Open	None	66305
None	Close-Open	Open	131841
None	Close-Open	Close-Open	197377
None	Close-Open	Open-Close-Open	262913
None	Open-Close-Open	None	66561
None	Open-Close-Open	Open	132097
None	Open-Close-Open	Close-Open	197633
None	Open-Close-Open	Open-Close-Open	263169
Open	None	None	65794
Open	None	Open	131330
Open	None	Close-Open	196866
Open	None	Open-Close-Open	262402
Open	Open	None	66050
Open	Open	Open	131586
Open	Open	Close-Open	197122
Open	Open	Open-Close-Open	262658

Table continues on next page

Combination			Integer
L1	L2	L3	CBOPCAP3P
Open	Close-Open	None	66306
Open	Close-Open	Open	131842
Open	Close-Open	Close-Open	197378
Open	Close-Open	Open-Close-Open	262914
Open	Open-Close-Open	None	66562
Open	Open-Close-Open	Open	132098
Open	Open-Close-Open	Close-Open	197634
Open	Open-Close-Open	Open-Close-Open	263170
Close-Open	None	None	65795
Close-Open	None	Open	131331
Close-Open	None	Close-Open	196867
Close-Open	None	Open-Close-Open	262403
Close-Open	Open	None	66051
Close-Open	Open	Open	131587
Close-Open	Open	Close-Open	197123
Close-Open	Open	Open-Close-Open	262659
Close-Open	Close-Open	None	66307
Close-Open	Close-Open	Open	131843
Close-Open	Close-Open	Close-Open	197379
Close-Open	Close-Open	Open-Close-Open	262915
Close-Open	Open-Close-Open	None	66563
Close-Open	Open-Close-Open	Open	132099
Close-Open	Open-Close-Open	Close-Open	197635
Close-Open	Open-Close-Open	Open-Close-Open	263171
Open-Close-Open	None	None	65796
Open-Close-Open	None	Open	131332
Open-Close-Open	None	Close-Open	196868
Open-Close-Open	None	Open-Close-Open	262404
Open-Close-Open	Open	None	66052
Open-Close-Open	Open	Open	131588
Open-Close-Open	Open	Close-Open	197124
Open-Close-Open	Open	Open-Close-Open	262660
Open-Close-Open	Close-Open	None	66308
Open-Close-Open	Close-Open	Open	131844
Open-Close-Open	Close-Open	Close-Open	197380
Open-Close-Open	Close-Open	Open-Close-Open	262916
Open-Close-Open	Open-Close-Open	None	66564
Open-Close-Open	Open-Close-Open	Open	132100
Open-Close-Open	Open-Close-Open	Close-Open	197636
Open-Close-Open	Open-Close-Open	Open-Close-Open	263172



In the default configuration, connecting no signals to the hardware binary inputs for spring charge levels results in CBOPCAP3P permanently indicating full for all three phases (integer value 263172).

12.18 Advanced circuit breaker operations monitoring ACBMSCBR

12.18.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Advanced circuit breaker operations monitoring	ACBMSCBR	-	-

12.18.2 Functionality

The ACBMSCBR function is designed to provide the monitoring functionality of circuit breakers (CB). The monitoring functionality is evaluated based on certain feedback inputs which can either be electrical or mechanical in nature.

The electrical feedbacks can be:

- Breaker Current
- Load Voltage

Mechanical feedback is taken from CB auxiliary contacts:

- NO (Normally Open (52a)) only
- NC (Normally Closed (52b)) only
- NO and NC (52a and 52b)

Based on the available feedback signals, the function evaluates multiple electrical and mechanical parameters which are made available as outputs of the function.

- Based on the electrical feedbacks, the evaluated or detected electrical parameters are:
 - Arcing time and electrical interruption time (time from breaker trip command till arc extinction)
 - Pre-strike angle and electrical making time (time from breaker close command till breaker current inception)
 - Electrical status of circuit breaker (conducting or isolating)
 - Electrical status of load
 - Re-strike/re-ignition and the respective count over operations
 - Re-strike/re-ignition correction
 - Electrical adaptation based on previous closing operation error
 - Breaker electrical and mechanical scatter correction
 - Instantaneous, peak and RMS (Root Mean Square) currents at the instant of current interruption
 - Overcurrent detection
 - Inrush current peak during energization
 - Interrupter wear (contact ablation) for open operations
 - Phase shift between the reference source and feedback load voltage
- Similarly, based on the mechanical feedbacks, the evaluated or detected mechanical parameters are:
 - Mechanical status of circuit breaker
 - Mechanical opening time which includes,

- Initial mechanical delay (time from breaker trip command to status change of NO)
 - Operating time (time from command to primary contact separation)
 - Mechanical closing time which includes,
 - Initial mechanical delay (time from breaker close command to status change of NC)
 - Operating time (time from breaker close command to primary contact touch)
 - Movement time (time interval between status changes of NC and NO)
 - Circuit breaker unstable operating times
3. Apart from monitoring of electrical or mechanical parameters, the function also monitors, evaluates, or detects parameters which consider both electrical and mechanical feedbacks. These parameters are:
- Detection and monitoring of external operation (circuit breaker status change not initiated by this IED)
 - Contradicting electrical and mechanical status
 - Operation count (Close-Open cycles)
 - Count of point-on-wave controlled Close and Open operations
 - Consolidated CB status

12.18.3 Function block

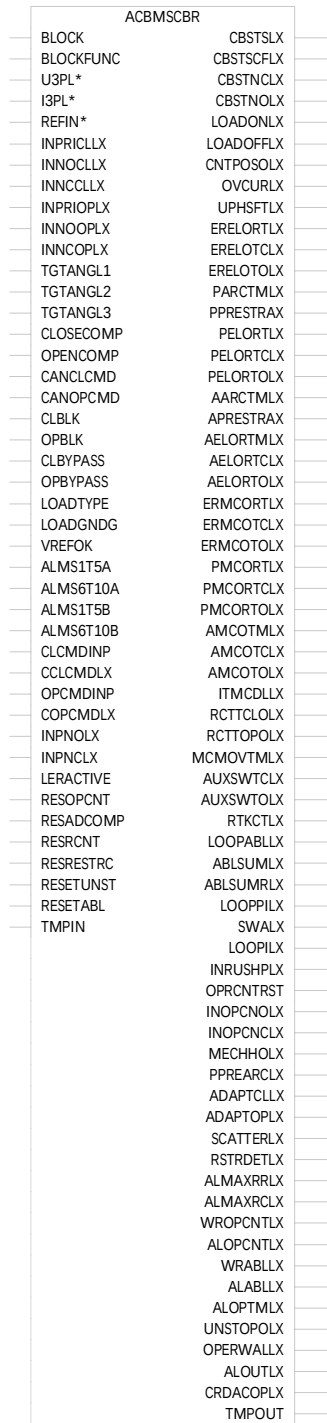


Figure 118: Function Block Diagram

* mandatory input connections.

12.18.4 Signals

Table 255: ACBMSCBR Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Force all binary outputs to 0
BLOCKFUNC	BOOLEAN	0	Block execution of this function and populate outputs with default values
U3PL	GROUP SIGNAL	-	Three phase load voltage
I3PL	GROUP SIGNAL	-	Three phase load current
REFIN	GROUP SIGNAL	-	Three phase preprocessed reference signal
INPRICLLX	REAL	0.0	Nominal time from Close command till primary contact closing in this phase
INNOCLLX	REAL	0.0	Nominal time from Close command till NO contact closing in this phase
INNCCLLX	REAL	0.0	Nominal time from Close command till NC contact opening in this phase
INPRIOP LX	REAL	0.0	Nominal time from Open command till primary contact opening in this phase
INNOOP LX	REAL	0.0	Nominal time from Open command till NO contact opening in this phase
INNCOPLX	REAL	0.0	Nominal time from Open command till NC contact closing in this phase
TGTANGL1	REAL	0.0	Target switching angle for phase L1
TGTANGL2	REAL	0.0	Target switching angle for phase L2
TGTANGL3	REAL	0.0	Target switching angle for phase L3
CLOSECOMP	REAL	0.0	Mechanical compensation offset for closing instant in this phase
OPENCOMP	REAL	0.0	Mechanical compensation offset for opening instant in this phase
CANCLCMD	BOOLEAN	0	Closing operation canceled
CANOPCMD	BOOLEAN	0	Opening operation canceled
CLBLK	BOOLEAN	0	Closing operation blocked
OPBLK	BOOLEAN	0	Opening operation blocked
CLBYPASS	BOOLEAN	0	Closing operation bypassed
OPBYPASS	BOOLEAN	0	Opening operation bypassed
LOADTYPE	INTEGER	1	Type of switched load
LOADGNDG	INTEGER	0	Type of grounding of switched load
VREFOK	BOOLEAN	0	Source voltage signal is suitable as reference
ALMS1T5A	INTEGER	0	Alarm status integer for input 1 to 5 from MONALMa
ALMS6T10A	INTEGER	0	Alarm status integer for input 6 to 10 from MONALMa
ALMS1T5B	INTEGER	0	Alarm status integer for input 1 to 5 from MONALMb
ALMS6T10B	INTEGER	0	Alarm status integer for input 6 to 10 from MONALMb
CLCMDINP	BOOLEAN	0	Input close command
CCLCMDLX	BOOLEAN	0	Time stamped controlled closing command for this phase
OPCMDINP	BOOLEAN	0	Input open command
Table continues on next page			

Name	Type	Default	Description
COPCMDLX	BOOLEAN	0	Time stamped controlled opening command for this phase
INPNOLX	BOOLEAN	0	Status of NO (52a) auxiliary contact in this phase
INPNCLX	BOOLEAN	0	Status of NC (52b) auxiliary contact in this phase
LERACTIVE	BOOLEAN	0	CB timing test mode active
RESOPCNT	BOOLEAN	0	Reset operation count
RESADCOMP	BOOLEAN	0	Reset adaptive correction
RESRCNT	BOOLEAN	0	Reset re-strike/re-ignition count
RESRESTRC	BOOLEAN	0	Reset re-strike/re-ignition correction for opening operations
RESETUNST	BOOLEAN	0	Reset CB unstable state
RESETABL	BOOLEAN	0	Reset ablation sum and relative ablation sum outputs
TMPIN	REAL	0.0	Temperature input

Table 256: ACBMSCBR Output signals

Name	Type	Description
CBSTSLX	INTEGER	CB position derived from mechanical and electrical status for this phase
CBSTSCFLX	INTEGER	CB position confirmation to SSCPOW for this phase
CBSTNCLX	BOOLEAN	CB open status derived from auxiliary contacts and primary feedback signal for this phase
CBSTNOLX	BOOLEAN	CB closed status derived from auxiliary contacts and primary feedback signal for this phase
LOADONLX	BOOLEAN	RMS of selected feedback signal is above OpenCThreshold
LOADOFFLX	BOOLEAN	RMS of selected feedback signal is below OpenFThreshold
CNTPOSOLX	BOOLEAN	Contradicting electrical and mechanical breaker position detected for this phase
OVCURLX	BOOLEAN	Overcurrent detected in this phase
UPHSFTLX	REAL	Phase shift between the connected source and load voltage in this phase
ERELORTLX	REAL	Difference between actual and predicted electrical operation time for this phase
ERELOTCLX	REAL	Difference between actual and predicted electrical making times for this phase
ERELOTOLX	REAL	Difference between actual and predicted electrical interrupting times for this phase
PARCTMLX	REAL	Predicted arcing time for this phase
PPRESTRAX	REAL	Predicted pre-strike angle for this phase
PELORTLX	REAL	Predicted electrical operation time for this phase
PELORTLX	REAL	Predicted electrical closing (making) time for this phase
PELORTLX	REAL	Predicted electrical opening (interrupting) time for this phase
AARCTMLX	REAL	Actual arcing time for this phase
APRESTRAX	REAL	Actual pre-strike angle for this phase
AELORTMLX	REAL	Actual electrical operation time for this phase
AELORTCLX	REAL	Actual electrical closing (making) time for this phase
AELORTOLX	REAL	Actual electrical opening (interrupting) time for this phase
Table continues on next page		

Name	Type	Description
ERMORTLX	REAL	Difference between actual and predicted mechanical operation time for this phase
ERMOTCLX	REAL	Difference between actual and predicted mechanical closing times for this phase
ERMOTOLX	REAL	Difference between actual and predicted mechanical opening times for this phase
PMORTLX	REAL	Predicted mechanical operation time for this phase
PMOTCLX	REAL	Predicted mechanical closing time for this phase
PMOTOLX	REAL	Predicted mechanical opening time for this phase
AMOTMLX	REAL	Actual mechanical operation time for this phase
AMOTCLX	REAL	Actual mechanical closing time for this phase
AMOTOLX	REAL	Actual mechanical opening time for this phase
ITMDLLX	REAL	Initial mechanical movement delay in this phase
RCTTCLOLX	REAL	Reaction time (initial mechanical delay) of the breaker for closing of this phase
RCTTOPOLX	REAL	Reaction time (initial mechanical delay) of the breaker for opening of this phase
MCMOVTMLX	REAL	Mechanical movement time between changeover of NO and NC auxiliary contacts in this phase
AUXSWTCLX	REAL	Time gap between NC and NO auxiliary contacts changeover for closing of this phase
AUXSWTOLX	REAL	Time gap between NO and NC auxiliary contacts changeover for opening of this phase
RTKCTLX	REAL	Re-strike/re-ignition count for this phase
LOOPALLX	REAL	Last open operation ablation calculated for breaker contacts in this phase
ABLSUMLX	REAL	Cumulated sum of calculated ablation for this phase
ABLSUMLX	REAL	Ablation sum in this phase relative to set alarm level
LOOPILX	REAL	Peak current interrupted during last open operation in this phase
SWALX	REAL	RMS current detected before last open operation in this phase
LOOPILX	REAL	Instantaneous current interrupted during last open operation in this phase
INRUSHPLX	REAL	Inrush current peak for this phase
OPRCNTRST	INTEGER	Resettable counter of CB operations in this phase
INOPCNOLX	INTEGER	Total number of in-sync opening operations for this phase
INOPCNCLX	INTEGER	Total number of in-sync closing operations for this phase
MECHHOLX	INTEGER	Mechanical health indication based on status of auxiliary contacts at conclusion of CB operation
PPREARCLX	REAL	Predicted pre-arcing time for closing of this phase
ADAPTCLLX	REAL	Adaptive correction offset for closing of this phase
ADAPTOPLX	REAL	Adaptive extension of target arcing time for opening of this phase
SCATTERLX	REAL	Switching target offset for handling mechanical and electrical scatter in this phase
RSTRDETLX	BOOLEAN	Re-ignition/re-strike detected for this phase
ALMAXRRLX	BOOLEAN	Alarm: re-ignition/re-strike count exceeding limit for this phase
ALMAXRCLX	BOOLEAN	Alarm: maximum restrike correction limit reached in this phase
Table continues on next page		

Name	Type	Description
WROPNTLX	BOOLEAN	Warning: number of operations exceeding set level for this phase
ALOPNTLX	BOOLEAN	Alarm: number of operations exceeding set level for this phase
WRABLLX	BOOLEAN	Warning: contact ablation exceeding threshold for this phase
ALABLLX	BOOLEAN	Alarm: contact ablation exceeding threshold for this phase
ALOPTMLX	BOOLEAN	Alarm: CB operating time exceeding threshold for this phase
UNSTOPOLX	BOOLEAN	Unstable mechanical operating times detected for this phase
OPERWALLX	BOOLEAN	Too many consecutive operations with monitored value outside warning limit for this phase
ALOUTLX	BOOLEAN	General monitoring alarm for this phase
CRDACOPLX	INTEGER	Coordination output from ACBMSCBR to OPLOG for this phase
TMPOUT	REAL	Temperature output

12.18.5 Settings and parameters

Table 257: ACBMSCBR Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	On	Operation mode Off / On
PhaseIdentifier	L1 L2 L3	-	-	L1	Phase identification of this function instance
ScatterMechCl	0.00 - 3.00	ms	0.05	1.00	Mechanical closing time scatter of CB
Ablation	Disable Enable	-	-	Disable	Enable / Disable ablation calculation
InitialOpCnt	0 - 20000	-	1	0	Initial mechanical operation count
GlobalBaseSel	1 - 6	-	1	1	Selection of global base values group

Table 258: ACBMSCBR Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
FeedbackSigC	Current Load voltage None	-	-	Current	Feedback signal for detecting actual switching instants for a close operation
FeedbackSigO	Current Load voltage None	-	-	Current	Feedback signal for detecting actual switching instants for an open operation
BetaAdjustElec	0.0 - 1.0	-	0.1	0.5	Adaptive correction factor applied to electrical target error
BetaAdjustMech	0.0 - 1.0	-	0.1	0.2	Adaptive correction factor applied to mechanical target error
MechMonitor	Disable Enable	-	-	Disable	Enable / Disable monitoring of mechanical parameters
AuxPosAvailable	None NO NC NO and NC	-	-	None	Availability of NO / NC auxiliary contact status
InitArcTime	0.0 - 20.0	ms	0.1	5.0	Initial arcing time for re-ignition free de-energization

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
MaxArcTime	0.0 - 20.0	ms	0.1	8.0	Maximum arcing time for re-ignition free de-energization
ScatterRDDS	0.0 - 25.0	%	0.1	15.0	Spread of nominal RDDS
ArcTimeTrafo	0.0 - 10.0	ms	0.1	0.5	Expected arcing time for transformer de-energization
OvercurrentThresh	110 - 10000	%IB	10	200	Threshold level for detection of overcurrent
OperWithAlm	Disable Enable	-	-	Disable	Enable / Disable alarm for monitored outputs exceeding warning threshold
OutAlm	Disable Enable	-	-	Disable	Enable / Disable general alarm output
AblationAlm	Disable Enable	-	-	Disable	Enable / Disable alarm for ablation
ContradPosAlm	Disable Enable	-	-	Disable	Enable / Disable indication of contradicting electrical and mechanical CB position
OpCntAlm	Disab warn & alarm Enab warn Enab alarm Enab warn & alarm	-	-	Disab warn & alarm	Enable / Disable alarm for operation count
OpTmAlm	Disable Enable	-	-	Disable	Enable / Disable alarm for operation time
UnstOpChrAlm	Disable Enable	-	-	Disable	Enable / Disable indication of CB unstable operating times
MaxReStrCorrAlm	Disable Enable	-	-	Disable	Enable / Disable alarm for maximum re-strike correction limit reached
RestrReigAlm	Disable Enable	-	-	Disable	Enable / Disable alarm for restrike / re-ignition detection

Table 259: ACBMSCBR Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
AblationAlarmLevel	0.0 - 99999.9	-	1.0	20000.0	Ablation threshold for alarm state
CumCurrPower	0.05 - 5.00	-	0.05	2.00	Current exponent setting for cumulative calculation
InitialCumAbl	0.000 - 99999.999	-	0.001	0.000	Initial cumulated ablation
AblationCoeff0	-99999.99999 - 99999.99999	-	0.00001	0.00000	Coefficient 0 in ablation calculation formula
AblationCoeff1	-99999.99999 - 99999.99999	-	0.00001	0.12500	Coefficient 1 in ablation calculation formula
AblationCoeff2	-99999.99999 - 99999.99999	-	0.00001	0.00000	Coefficient 2 in ablation calculation formula
AblationCoeff3	-99999.99999 - 99999.99999	-	0.00001	0.00000	Coefficient 3 in ablation calculation formula
AblationCoeff4	-99999.99999 - 99999.99999	-	0.00001	0.00000	Coefficient 4 in ablation calculation formula
PowerCoeff1	0.0000 - 10.0000	-	0.0001	1.0000	Power coefficient 1 in ablation calculation formula
PowerCoeff2	0.0000 - 10.0000	-	0.0001	1.0000	Power coefficient 2 in ablation calculation formula
PowerCoeff3	0.0000 - 10.0000	-	0.0001	1.0000	Power coefficient 3 in ablation calculation formula

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
PowerCoeff4	0.0000 - 10.0000	-	0.0001	1.0000	Power coefficient 4 in ablation calculation formula
AblationWarnLevel	0.0 - 99999.9	-	1.0	15000.0	Ablation threshold for warning state
MinCurrentLimit	0 - 99999	A	1	1000	Minimum current limit for ablation calculation
OverCurrentLimit	0 - 999999	A	1	15000	Beyond this current limit, ablation value of setting AblatCalShEst will be applied
AblatCalShEst	0.0 - 99999.9	-	1.0	5000.0	Ablation for current exceeding higher threshold
OperationsMon	1 - 10	-	1	3	Number of error operations to trigger warning operation alarm
MaxReStrikeCorr	0 - 3	ms	1	1	Highest allowed correction value for arcing time

Table 260: ACBMSCBR Group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
CloseCThreshold	1 - 100	%	1	10	Coarse threshold for detecting appearance of selected feedback signal
CloseFThreshold	1.0 - 100.0	%	0.1	3.0	Fine threshold for precise detection of start of selected feedback signal
OpenCThreshold	1 - 100	%	1	20	Coarse threshold for detecting disappearance of selected feedback signal
OpenFThreshold	1.0 - 100.0	%	0.1	3.0	Fine threshold for precise detection of interruption of selected feedback signal
ScaleFactorV	0.000 - 100.000	-	0.001	1.000	Scaling factor for UBase in load voltage signal evaluation
RDDS	5.0 - 999.0	kV/ms	1.0	100.0	Nominal circuit breaker RDDS for phase LX
GapVoltage	0.00 - 10.00	pu	0.01	1.00	Expected gap voltage peak across breaker contacts, prior to current inception
InrushCurRef	1 - 100	%	1	80	Reference level for magnetic inrush current peak evaluation in percent of maximum RMS value

12.18.6 Monitored data

Table 261: ACBMSCBR Monitored data

Name	Type	Values (Range)	Unit	Description
CBSTSLX	INTEGER	0=EI inv mec inv 1=EI inv mec open 2=EI inv mec close 3=EI inv mec faulty 4=EI open mec inv 5=EI open mec open 6=EI open mec close 7=EI open mec faulty 8=EI close mec inv 9=EI close mec open 10=EI close mec close 11=EI close mec faulty	-	CB position derived from mechanical and electrical status for this phase
CBSTSCFLX	INTEGER	0=Unknown 1=Open 2=Closed	-	CB position confirmation to SSCPOW for this phase
CBSTNCLX	BOOLEAN	-	-	CB open status derived from auxiliary contacts and primary feedback signal for this phase
CBSTNOLX	BOOLEAN	-	-	CB closed status derived from auxiliary contacts and primary feedback signal for this phase
LOADONLX	BOOLEAN	-	-	RMS of selected feedback signal is above OpenCThreshold
LOADOFFLX	BOOLEAN	-	-	RMS of selected feedback signal is below OpenFThreshold
OVCURLX	BOOLEAN	-	-	Overcurrent detected in this phase
UPHSFTLX	REAL	-	deg	Phase shift between the connected source and load voltage in this phase
ERELORTLX	REAL	-	ms	Difference between actual and predicted electrical operation time for this phase
ERELOTCLX	REAL	-	ms	Difference between actual and predicted electrical making times for this phase
ERELOTOLX	REAL	-	ms	Difference between actual and predicted electrical interrupting times for this phase
PARCTMLX	REAL	-	ms	Predicted arcing time for this phase
PPRESTRAX	REAL	-	deg	Predicted pre-strike angle for this phase
PELORTLX	REAL	-	ms	Predicted electrical operation time for this phase
PELORTCLX	REAL	-	ms	Predicted electrical closing (making) time for this phase

Table continues on next page

Name	Type	Values (Range)	Unit	Description
PELORTOLX	REAL	-	ms	Predicted electrical opening (interrupting) time for this phase
AARCTMLX	REAL	-	ms	Actual arcing time for this phase
APRESTRAX	REAL	-	deg	Actual pre-strike angle for this phase
AELORTMLX	REAL	-	ms	Actual electrical operation time for this phase
AELORTCLX	REAL	-	ms	Actual electrical closing (making) time for this phase
AELORTOLX	REAL	-	ms	Actual electrical opening (interrupting) time for this phase
ERMORTLX	REAL	-	ms	Difference between actual and predicted mechanical operation time for this phase
ERMORTCLX	REAL	-	ms	Difference between actual and predicted mechanical closing times for this phase
ERMORTOLX	REAL	-	ms	Difference between actual and predicted mechanical opening times for this phase
PMORTLX	REAL	-	ms	Predicted mechanical operation time for this phase
PMORTCLX	REAL	-	ms	Predicted mechanical closing time for this phase
PMORTOLX	REAL	-	ms	Predicted mechanical opening time for this phase
AMCOTMLX	REAL	-	ms	Actual mechanical operation time for this phase
AMCOTCLX	REAL	-	ms	Actual mechanical closing time for this phase
AMCOTOLX	REAL	-	ms	Actual mechanical opening time for this phase
ITMCDLLX	REAL	-	ms	Initial mechanical movement delay in this phase
RCTTCLOLX	REAL	-	ms	Reaction time (initial mechanical delay) of the breaker for closing of this phase
RCTTOPOLX	REAL	-	ms	Reaction time (initial mechanical delay) of the breaker for opening of this phase
MCMOVTMLX	REAL	-	ms	Mechanical movement time between changeover of NO and NC auxiliary contacts in this phase
AUXSWTCLX	REAL	-	ms	Time gap between NC and NO auxiliary contacts changeover for closing of this phase
AUXSWTOLX	REAL	-	ms	Time gap between NO and NC auxiliary contacts changeover for opening of this phase
ABLSUMLX	REAL	-	-	Cumulated sum of calculated ablation for this phase
ABLSUMRLX	REAL	-	-	Ablation sum in this phase relative to set alarm level
LOOPILX	REAL	-	A	Peak current interrupted during last open operation in this phase
SWALX	REAL	-	A	RMS current detected before last open operation in this phase
Table continues on next page				

Name	Type	Values (Range)	Unit	Description
LOOPILX	REAL	-	A	Instantaneous current interrupted during last open operation in this phase
INRUSHPLX	REAL	-	A	Inrush current peak for this phase
MECHHOLX	INTEGER	1=Ok 2=Warning 3=Alarm	-	Mechanical health indication based on status of auxiliary contacts at conclusion of CB operation
PPREARCLX	REAL	-	ms	Predicted pre-arcing time for closing of this phase
ADAPTCLLX	REAL	-	ms	Adaptive correction offset for closing of this phase
ADAPTOPLX	REAL	-	ms	Adaptive extension of target arcing time for opening of this phase
SCATTERLX	REAL	-	ms	Switching target offset for handling mechanical and electrical scatter in this phase
TMPOUT	REAL	-	deg	Temperature output

12.18.7 Operation principle

The ACBMSCBR function is active whenever *Operation* is set to "On" and the BLOCKFUNC input is 0 (or unconnected).

[Figure 119](#) displays the overall functionality of ACBMSCBR. The different sub-functions are described below.

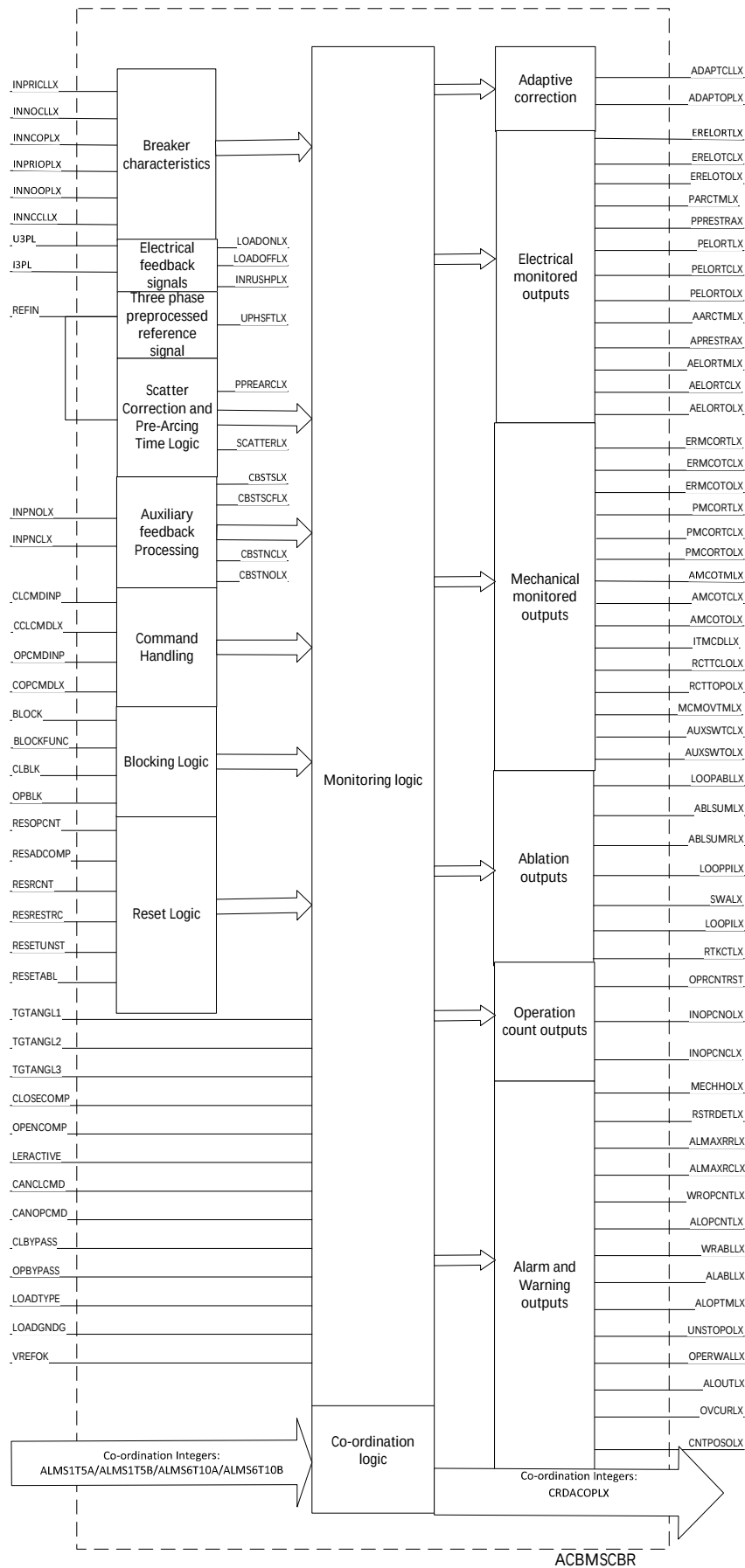


Figure 119: Block diagram of ACBMSCBR functionality

12.18.7.1 Coordination logic

The coordination logic is the interface between ACBMSCBR and other application functions. Its inputs and outputs carry different information from one function to the other.

Some functionalities in ACBMSCBR are influenced by the bit-encoded data on its coordination inputs. These comprise the following 32-bit integer signals.

Table 262: Coordination inputs

Input name	Source function in PWC600 IED	Information received
ALMS1T5A	MONALM	Three-phase alarm indication for: - Mechanical operating time - Initial mechanical delay - Mechanical movement time
ALMS6T10A	MONALM	
ALMS1T5B	MONALM	Three-phase alarm indication for maximum re-strike/re-ignition.
ALMS6T10B	MONALM	Three-phase alarm indication for: Operation count

Similarly, the coordination logic's 32-bit integer outputs from ACBMSCBR are:

Table 263: Coordination outputs

Output name	Receiver function in PWC600 IED	Information transmitted
CRDACOPLX	OPLOGTRIG	- Operation blocked, bypassed, or canceled - Unstable breaker operating times - Intermediate position of breaker - Operation failed - Operation command redundant or in learning mode - Absence of electrical and mechanical feedback signals - External open or close operations - Voltage reference fail - Predicted and actual open operations - Predicted and actual close operations

12.18.7.2 Breaker pole specific operating times

For the individual breaker pole, the nominal mechanical closing and opening times are the most relevant characteristics. These are obtained from the following input signals.

Table 264: Inputs for breaker pole specific operating times

Input Name	Information received
INPRICLX	Average time (in milliseconds) from close command to main contact touch.
INNOCLLX	Average time (in milliseconds) from close command to NO (52a) auxiliary contact close.
INNCLLX	Average time (in milliseconds) from close command to NC (52b) auxiliary contact open.
Table continues on next page	

Input Name	Information received
INPRIOPX	Average time (in milliseconds) from trip command to main contact separation.
INNOOPLX	Average time (in milliseconds) from trip command to NO (52a) auxiliary contact open.
INNCOPX	Average time (in milliseconds) from trip command to NC (52b) auxiliary contact close.

All these data are provided to the other subfunctions of ACBMSCBR as needed.

12.18.7.3 Electrical signal processing

The electrical three-phase signals to be considered as inputs for the functionality are:

Table 265: Three-phase electrical primary signal

Input Name	Information received
U3PL	RMS and signal samples of three-phase load voltage
I3PL	RMS and signal samples of three-phase load current

The *PhaseIdentifier* setting determines which of the phases in the three-phase group signals is actually evaluated in each function instance. The electrical primary signal to be used for monitoring of CB Close and Open operations is selected by the setting *FeedbackSigC* and *FeedbackSigO* respectively. The corresponding global base value is fetched from a specified GBASVAL instance, see [Table 266](#).

Table 266: Selection of feedback signal and base value

Setting	Description
<i>FeedbackSigC</i>	Selected electrical feedback signal (CB current or load voltage) for close operations.
<i>FeedbackSigO</i>	Selected electrical feedback signal (CB current or load voltage) for open operations.
<i>GlobalBaseSel</i>	Selection of GBASVAL function instance from which <i>UBase</i> and <i>IBase</i> are taken.
<i>ScaleFactorV</i>	Scaling factor for <i>UBase</i> in load voltage signal evaluation.

For the selected electrical feedback signal (I3P or U3PL), the RMS value is compared with a threshold value deduced from the settings *CloseCThreshold* and *OpenCThreshold*, as detailed in [Table 267](#). The signal is considered healthy if the RMS of the signal in this phase is greater than both the *CloseCThreshold* and *OpenCThreshold* thresholds. Healthy feedback signal is further interpreted as the breaker being electrically closed.

Table 267: Dead value settings

Setting	Description
<i>CloseCThreshold</i>	Threshold level for the selected electrical feedback signal, in percent of global base value and scaling factor of <i>UBase</i> , to eliminate unwanted signals during breaker closing. For example, <i>FeedbackSigC</i> ="Voltage" <i>CloseCThreshold</i> = 5% $CloseCThreshold(absolutevalue) = 5\% \text{ of } UBase * ScaleFactorV$
<i>OpenCThreshold</i>	Threshold level for the selected electrical feedback signal, in percent of global base value and scaling factor of <i>UBase</i> , to eliminate unwanted signals during breaker opening. For example, <i>FeedbackSig</i> ="Current" <i>OpenCThreshold</i> = 5% $OpenCThreshold(absolutevalue) = 5\% \text{ of } IBase$

Apart from the electrical feedback signals, the function also receives zero crossing time stamps, average half cycle times and voltage peaks from ANSGPROC function. The processed reference signal (source voltage) is received at the REFIN input and the healthiness evaluation at the VREFOK input.

The healthiness of electrical feedback signals (CB current or load voltage) are evaluated inside ACBMSCBR function. From a healthy load voltage signal, ACBMSCBR evaluates the zero crossings by comparing the polarity of consecutive samples. If two consecutive samples have opposite polarity, a zero crossing must be located between them. This is shown in Figure 120 where two zero crossings ZC1 and ZC2 have been detected. Using linear interpolation, the time stamp of a zero-crossing point is calculated between the two samples of opposite polarity.

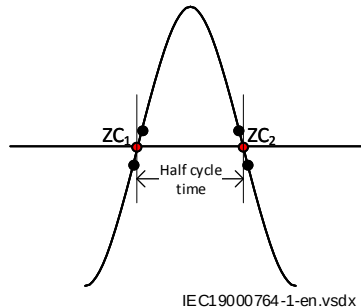


Figure 120: Interpolation of zero-crossings from adjacent samples

If "Load voltage" or "None" is selected either in *FeedbackSigC* or *FeedbackSigO* and both source voltage and load voltage are considered healthy, the phase shift between the two signals is calculated from the time stamps of the zero crossings and provided on the UPHSFTLX output.

12.18.7.4 Scatter correction and pre-arcing time evaluation for CB closing

As suggested by CIGRE WG 13.07, the controlled energizing angles can be optimized based on the position of the angle on the gap voltage across breaker contacts. The value of the gap voltage can vary based on the load configuration. For example, in case of a star grounded load without stored energy, the magnitude of the gap voltage is equal to the connected source voltage whereas in case of ungrounded load, the total gap voltage across the first two simultaneous closing phases together is equal to the phase-phase voltage.

Conceptually, every breaker closes onto the gap voltage. To optimize the controlled switching performance in the system, the function statistically optimizes the switching angle considering the breaker characteristics.

It is generally assumed that the mechanical switching times and the dynamic dielectric withstand properties of a circuit breaker, as a mechanical device, are not perfectly constant but normally distributed around the mean value. The breaker data comes with a specification of $\pm 3\sigma$ scatter value and a mean value of μ . The scatter value of $\pm 3\sigma$ defines the maximum (99.7%) deviation from the mean value that can be expected under realistic conditions.

For mechanical closing time of the CB, the mean value is obtained from the input INPPRICLLX and its scatter from the setting *ScatterMechCl*. Thus, the final mechanical operating time for any specific closing operation is expected to lie between the limits: $(\text{INPPRICLLX} - \text{ScatterMechCl})$ and $(\text{INPPRICLLX} + \text{ScatterMechCl})$.

Similarly, for the rate of decrease of dielectric strength (RDDS) of the CB, the mean value is obtained from the setting *RDDS* and the scatter from *ScatterRDDS*. Thus, the final RDDS for any specific closing operation is expected to lie between the limits:

$$RDDS_{\min} = RDDS \left(1 - \frac{\text{ScatterRDDS}}{100} \right)$$

and

$$RDDS_{\max} = RDDS \left(1 + \frac{ScatterRDDS}{100} \right)$$

as *ScatterRDDS* is specified in percent of nominal RDDS.

The settings that determine the optimized energizing angle are listed in [Table 268](#).

Table 268: Scatter based settings of ACBMSCBR

Setting	Description
<i>RDDS</i>	Rate of decay of dielectric strength of the breaker. It is negative in nature and the dielectric strength reduces as the contacts approach each other. It is the statistical average of several measured RDDS values.
<i>ScatterMechCl</i>	Standard deviation of mechanical closing time scatter.
<i>ScatterRDDS</i>	Percentage difference between the nominal and observed minimum/maximum RDDS values.
<i>GapVoltage</i>	Expected gap voltage across the corresponding phase circuit breaker just prior to the target making instant.

The following subsections explain how ACBMSCBR optimizes the mechanical closing target for different application scenarios.

Closing at gap voltage zero

The objective of considering breaker scatter for gap voltage zero target is to minimize the pre-striking voltage.

Aiming for current making precisely at gap voltage zero may actually result in high switching overvoltages. [Figure 121\(a\)](#) displays the behavior of the breaker when the minimum RDDS (as defined above) is lower than the maximum system voltage gradient. [Figure 122\(a\)](#) displays the behavior of the breaker when the minimum RDDS of the CB is greater/equal to the maximum system voltage gradient.

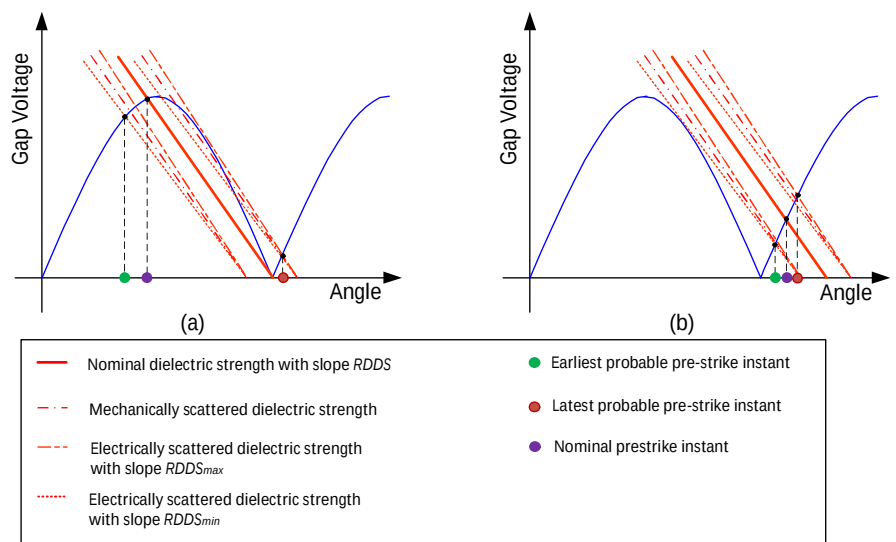
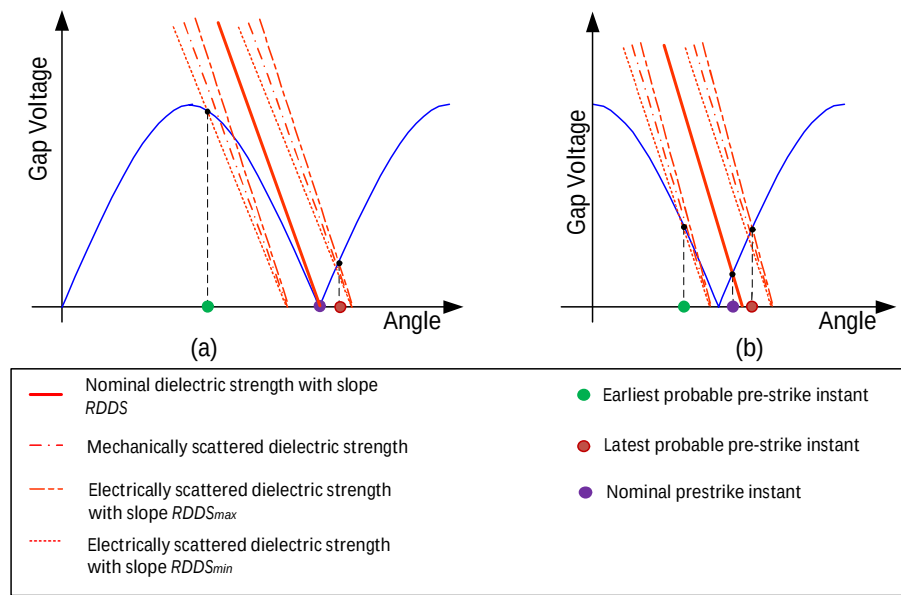


Figure 121: Voltage zero closing with low-RDDS circuit breaker: (a) closing target at gap voltage zero. (b) shifted closing target for minimum pre-strike voltage.



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Figure 122: Voltage zero closing with high-RDDS circuit breaker: (a) closing target at gap voltage zero. (b) shifted closing target for minimum pre-strike voltage.

As shown in [Figure 121\(a\)](#) and [Figure 122\(a\)](#), the actual instants at which the current is established in the circuit can vary from 'earliest probable pre-strike instant' to 'latest probable pre-strike instant'. This variation depends on the electrical and mechanical scatter of the breaker. The magnitude of the transient increases as the pre-strike instant moves away from intended gap voltage zero target. Thus, for given mechanical and dielectric scatter, it is desirable to obtain a combination of 'earliest probable pre-strike instant' and 'latest probable pre-strike instant' for which the highest expected pre-strike voltage is minimal.

The solution approach depends on the circuit breaker properties:

- If the minimum RDDS is lower than the maximum system voltage gradient (1 pu) the optimal target energization instant is obtained by avoiding the previous half cycle of gap voltage. This is achieved by shifting the energizing target to the right until the 'earliest probable pre-strike instant' is no more located in, but still close to, the previous half cycle of gap voltage. See [Figure 121\(b\)](#).
- If the minimum RDDS is greater/equal to the maximum system voltage gradient (1pu) the optimal target energization instant is obtained by minimizing the probable pre-strike voltage on both half cycles adjacent to the zero crossing. This is achieved by shifting the energizing target to the right until the 'earliest probable pre-strike instant' and 'latest probable pre-strike instant' are both at the same distance from the gap voltage zero target. See [Figure 122 \(b\)](#).

ACBMSCBR performs the scatter correction as explained above and evaluates the expected pre-arcing time in the shifted optimized energizing target. The shift of the optimized energizing angle from the ideal target angle (TGTANGLX) is given at the SCATTERLX output and the expected pre-arcing time in the shifted optimized energizing target is given at the PPREARCLX output as shown in [Figure 123](#).

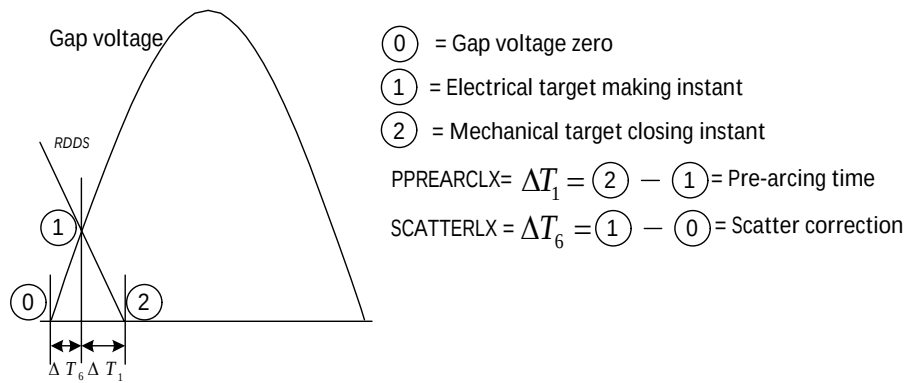


Figure 123: Pre-arcing time and scatter correction during gap voltage zero closing

The value of PPREARCLX (in milliseconds) is calculated as.

$$PPREARCLX = \frac{\text{Voltage at optimized energizing angle (Figure above)}}{RDDS}$$

Closing at gap voltage peak

The objective of considering breaker scatter for gap voltage peak application is to maximize the pre-striking voltage.

Aiming for current making precisely at gap voltage peak may actually result in fairly low pre-strike voltage. Figure 124(a) displays the behavior of the breaker when the maximum RDDS (as defined above) is lower than the maximum system voltage gradient. Figure 125(a) displays the behavior of the breaker when the maximum RDDS (as defined above) is greater/equal the maximum system voltage gradient.

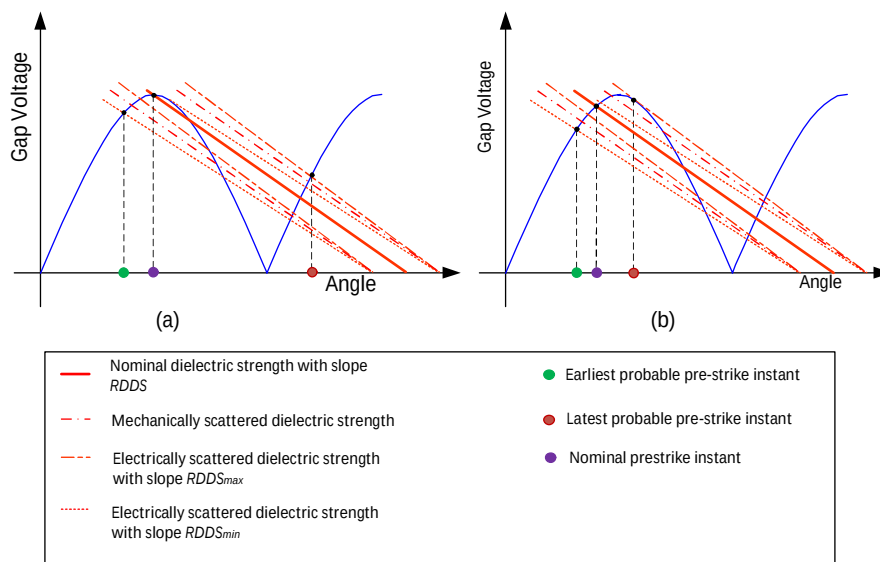


Figure 124: Voltage peak closing with low-RDDS circuit breaker : (a) Closing target at gap voltage peak. (b) Shifted closing target for maximum pre-strike voltage.

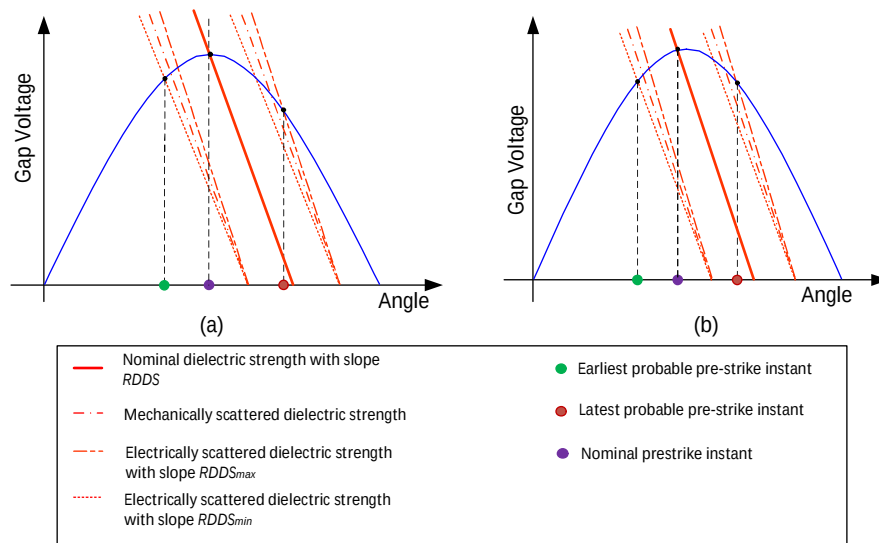


Figure 125: Voltage peak closing with high-RDDS circuit breaker: (a) Closing target at gap voltage peak. (b) Shifted closing target for maximum pre-strike voltage.

As shown in [Figure 124\(a\)](#) and [Figure 125\(a\)](#), the actual instants at which the current is established in the circuit can vary from 'earliest probable pre-strike instant' to 'latest probable pre-strike instant'. This variation depends on the electrical and mechanical scatter of the breaker. The magnitude of the inrush current asymmetry increases as the pre-strike instant moves away from intended gap voltage peak target. Thus, for given mechanical and dielectric scatter, it is desirable to obtain a combination of 'earliest probable pre-strike instant' and 'latest probable pre-strike instant' for which the highest expected inrush current asymmetry is minimal.

The solution approach depends on the circuit breaker properties:

- If the maximum RDDS is lower than the maximum system voltage gradient (1 pu) the optimal target energization instant is obtained by avoiding the next half cycle of gap voltage. This is achieved by shifting the energizing target to the left until the 'latest probable pre-strike instant' is no more located in the next half cycle of gap voltage. See [Figure 124\(b\)](#).
- If the maximum RDDS is greater/equal to the maximum system voltage gradient (1pu) the optimal target energization instant is obtained by maximizing the probable pre-strike voltage on both sides of the gap voltage peak. This is achieved by shifting the energizing target to the left until the 'earliest probable pre-strike instant' and 'latest probable pre-strike instant' are both at the same distance from the gap voltage peak. See [Figure 125\(b\)](#).

ACBMSCBR performs the scatter correction as explained above and evaluates the expected pre-arcing time in the shifted optimized energizing target. The shift of the optimized energizing angle from the ideal target angle (TGTANGLX) is given at the SCATTERLX output and the expected pre-arcing time in the shifted optimized energizing target is given at the PPREARCLX output as shown in [Figure 126](#).

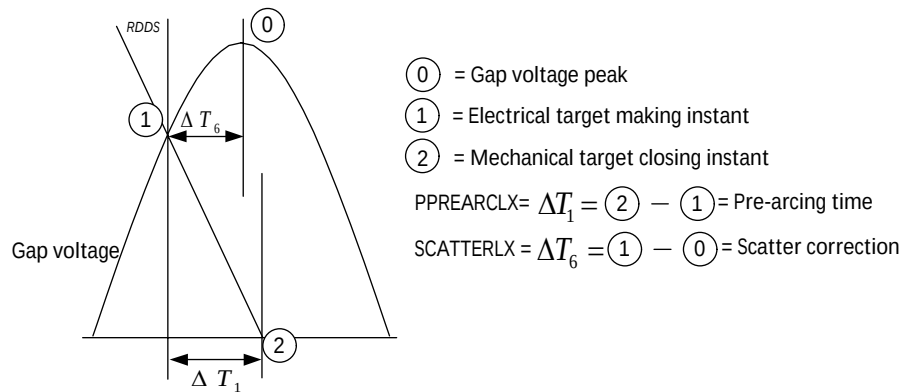


Figure 126: Pre-arcing time and scatter correction during gap voltage peak energizing

The value of PPREARCLX (in milliseconds) is calculated as.

$$PPREARCLX = \frac{\text{Voltage at optimized energizing angle (Figure above)}}{RDDS}$$

Closing at gap voltage angles other than zero and peak

Current making targets other than gap voltage zero or peak are naturally located on an increasing or decreasing slope of the sine wave. So, this target cannot be optimized considering the breaker scatter characteristics. Nevertheless, to ensure minimum deviation from the specified target, it is beneficial to keep the energizing angle within the limits of voltage zero target and voltage peak target computed for the specific circuit breaker. The lowest achievable energizing angle is obtained by assuming gap voltage zero closing application ([Section 12.18.7.4.1](#)) and the highest achievable energizing angle is obtained by assuming gap voltage peak closing application ([Section 12.18.7.4.2](#)).

If the target angle is within the highest and lowest achievable energizing angle, the scatter correction is not applied. In this case, as there is no shift from the intended switching angle, SCATTERLX is assigned a value of zero and PPREARCLX denotes the pre-arcing time at the intended switching target (TGTANGLX).

For a capacitive load type (capacitor, line, cable), if the target angle is beyond the highest and the lowest achievable energizing angle the lowest achievable energizing angle (optimized target for voltage zero closing) is used as the optimized energizing angle.

For an inductive load type (reactor, transformer), if the target angle is beyond the highest and the lowest achievable energizing angle the highest achievable energizing angle (optimized target for voltage peak closing) is used as the target energizing angle.

In this case, the shift of the optimized energizing angle from the intended switching target (TGTANGLX) is given at the SCATTERLX output. Also, the pre-arcing time in the shifted optimized energizing target is given at the PPREARCLX output.

12.18.7.5 Circuit breaker status

In protection and control systems, the mechanical status (closed or open) of a circuit breaker is typically obtained from its 52a (NO) and 52b (NC) auxiliary contacts. [Table 269](#) provides the typical condition of NO and NC during different breaker states.

Table 269: NO and NC status during different breaker states

NC status	NO status	Breaker state
0	0	Invalid / intermediate
1	0	Open
0	1	Closed
1	1	Faulty

Furthermore, ACBMSCBR derives the electrical status of the circuit breaker from the selected feedback signal ([Section 12.18.7.3](#)). If the feedback signal is "healthy" the CB is assumed electrically closed (conducting); otherwise it is assumed electrically open (isolating).

From the electrical and mechanical feedback signals, the outputs CBSTSLX, CBSTSCFLX, CBSTNOLX and CBSTNCLX are deduced according to [Table 271](#), using the case numbers from [Table 270](#).

Table 270: Determination of case number for different feedback signals and load types

FeedbackSigO	FeedbackSigC	Capacitor/Reactor / Coupled Capacitor	Transformer/Transmission Line/Coupled Transformer
		Case No	Case No
Current	Current	1	0
Current	Load voltage	2	1
Load voltage	Current	2	1
Load voltage	Load voltage	1	1
Current	None	1	0
Load voltage	None	1	1
None	Current	1	0
None	Load voltage	1	1
None	None	0	0

Case No = 0- electrical status of the breaker is not evaluated

Case No = 1- electrical status of the breaker is evaluated based on either voltage or current signal

Case No = 2- electrical status of the breaker is evaluated based on both voltage and current signals

Table 271: Circuit breaker status deduced from feedback signals, using case numbers from [Table 270](#)

AuxPosAvail able	Electrical feedback signal open Status	Electrical feedback signal open Status	INPNOLX	INPNCLX	CBSTSLX	CBSTNLLX	CBSTNCLX	CBSTSCFLX
Case No 1								
None	Not Healthy	Not Healthy	X	X	El open mec inv (4)	0	1	Open (1)
	Not Healthy	Healthy	X	X	El inv mec inv (0)	0	0	Unknown (0)
	Healthy	Not Healthy	X	X	El inv mec inv (0)	0	0	Unknown (0)
	Healthy	Healthy	X	X	El close mec inv (8)	1	0	Closed (2)
Table continues on next page								

AuxPosAvailable	Electrical feedback signal open Status	Electrical feedback signal open Status	INPNOLX	INPNCLX	CBSTSLX	CBSTNLLX	CBSTNCLX	CBSTSCFLX
NO	Not Healthy	Not Healthy	0	X	El open mec open (5)	0	1	Open (1)
			1	X	El open mec close (6)	1	0	Unknown (0)
	Not Healthy	Healthy	0	X	El inv mec open (1)	0	1	Unknown (0)
			1	X	El inv mec close (2)	1	0	Unknown (0)
	Healthy	Not Healthy	0	X	El inv mec open (1)	0	1	Unknown (0)
			1	X	El inv mec close (2)	1	0	Unknown (0)
	Healthy	Healthy	0	X	El close mec open (9)	0	1	Unknown (0)
			1	X	El close mec close (10)	1	0	Closed (2)
NC	Not Healthy	Not Healthy	X	0	El open mec close (6)	1	0	Unknown (0)
			X	1	El open mec open (5)	0	1	Open (1)
	Not Healthy	Healthy	X	0	El inv mec close (2)	1	0	Unknown (0)
			X	1	El inv mec open (1)	0	1	Unknown (0)
	Healthy	Not Healthy	X	0	El inv mec close (2)	1	0	Unknown (0)
			X	1	El inv mec open (1)	0	1	Unknown (0)
	Healthy	Healthy	X	0	El close mec close (10)	1	0	Closed (2)
			X	1	El close mec open (9)	0	1	Unknown (0)
Table continues on next page								

AuxPosAvailable	Electrical feedback signal open Status	Electrical feedback signal open Status	INPNOLX	INPNCLX	CBSTSLX	CBSTNLLX	CBSTNCLX	CBSTSCFLX
NO and NC	Not Healthy	Not Healthy	0	0	El open mec inv (4)	0	0	Unknown (0)
			0	1	El open mec open (5)	0	1	Open (1)
			1	0	El open mec close (6)	1	0	Unknown (0)
			1	1	El open mec faulty (7)	1	1	Unknown (0)
	Not Healthy	Healthy	0	0	El inv mec inv (0)	0	0	Unknown (0)
			0	1	El inv mec open (1)	0	1	Unknown (0)
			1	0	El inv mec close (2)	1	0	Unknown (0)
			1	1	El inv mec faulty (3)	1	1	Unknown (0)
	Healthy	Not Healthy	0	0	El inv mec inv (0)	0	0	Unknown (0)
			0	1	El inv mec open (1)	0	1	Unknown (0)
			1	0	El inv mec close (2)	1	0	Unknown (0)
			1	1	El inv mec faulty (3)	1	1	Unknown (0)
	Healthy	Healthy	0	0	El close mec inv (8)	0	0	Unknown (0)
			0	1	El close mec open (9)	0	1	Unknown (0)
			1	0	El close mec close (10)	1	0	Closed (2)
			1	1	El close mec faulty (11)	1	1	Unknown (0)
Case No 2								
None	Not Healthy	Not Healthy	X	X	El open mec inv (4)	0	1	Open (1)
	Healthy	Healthy	X	X	El close mec inv (8)	1	0	Closed (2)
NO	Not Healthy	Not Healthy	0	X	El open mec open (5)	0	1	Open (1)
			1	X	El open mec close (6)	1	0	Unknown (0)
	Healthy	Healthy	0	X	El close mec open (9)	0	1	Unknown (0)
			1	X	El close mec close (10)	1	0	Closed (2)
Table continues on next page								

<i>AuxPosAvailable</i>	Electrical feedback signal open Status	Electrical feedback signal open Status	INPNOLX	INPNCLX	CBSTSLX	CBSTNLLX	CBSTNCLX	CBSTSCFLX
NC	Not Healthy	Not Healthy	X	0	El open mec close (6)	1	0	Unknown (0)
			X	1	El open mec open (5)	0	1	Open (1)
	Healthy	Healthy	X	0	El close mec close (10)	1	0	Closed (2)
			X	1	El close mec open (9)	0	1	Unknown (0)
NO and NC	Not Healthy	Not Healthy	0	0	El open mec inv (4)	0	1	Unknown (0)
			0	1	El open mec open (5)	0	1	Open (1)
			1	0	El open mec close (6)	1	0	Unknown (0)
			1	1	El open mec faulty (7)	1	1	Unknown (0)
	Healthy	Healthy	0	0	El close mec inv (8)	1	0	Unknown (0)
			0	1	El close mec open (9)	0	1	Unknown (0)
			1	0	El close mec close (10)	1	0	Closed (2)
			1	1	El close mec faulty (11)	1	1	Unknown (0)
Case No 3								
None	X	X	X	X	El inv mec inv (0)	0	0	Unknown (0)
NO	X	X	0	X	El inv mec open (1)	0	1	Open (1)
	X	X	1	X	El inv mec close (2)	1	0	Closed (2)
NC	X	X	X	0	El inv mec close (2)	1	0	Closed (2)
	X	X	X	1	El inv mec open (1)	0	1	Open (1)
NO and NC	X	X	0	0	El inv mec inv (0)	0	0	Unknown (0)
	X	X	0	1	El inv mec open (1)	0	1	Open (1)
	X	X	1	0	El inv mec close (2)	1	0	Closed (2)
	X	X	1	1	El inv mec faulty (3)	1	1	Unknown (0)

CBSTSCFLX represents a consolidated CB status, derived from available electrical and mechanical feedback signals.

CBSTNOLX and CBSTNCLX represent virtual NO and NC auxiliary contacts, the status of which is derived from available electrical and mechanical feedback signals.

12.18.7.6 Command handling

ACBMSCBR receives the trip or close command (OPCMDINP / CLCMDINP) issued by the user and the point-on-wave controlled trip or close command (COPCMDLX / CCLCMDLX) from SSCPOW. The time stamps of these signals are used as a reference for numerous electrical and mechanical monitored values as explained in [Section 12.18.7.10](#).

After a switching command has been issued to the circuit breaker, the expectation is for the status of the electrical and mechanical feedback signals to change within a certain time period. If no status change is observed within this time period, the operation is considered to be failed.

If the function does not receive a trip/close command but the electrical or auxiliary feedback signal changes, then the operation is considered as an external operation (not initiated by this IED). Only few monitoring evaluations are performed on external operations.

12.18.7.7 Blocking logic

Operation of ACBMSCBR can be blocked by the inputs BLOCK and BLOCKFUNC. Activating the BLOCK input forces the Boolean (binary) outputs of the function to 0. Activating the BLOCKFUNC input blocks the complete function, forcing all outputs to default values.

Evaluation of CB Open and Close operations can also be blocked by the inputs OPBLK and CLBLK respectively. Activating the OPBLK input along with OPCMDINP forces all electrical and mechanical parameters to their default values. Similarly, activating the CLBLK input along with CLCMDINP forces all electrical and mechanical parameters to their default values.

12.18.7.8 Cancel logic

Evaluation of CB Open and Close operations can be cancelled by the inputs CANOPCMD and CANCLCMD respectively. If the CANOPCMD input comes within certain period of time after the input OPCMDINP then it forces all electrical and mechanical parameters to its default values. Similarly, if the CANCLCMD input comes within certain period of time after the input CLCMDINP then it forces all electrical and mechanical parameters to its default values.

12.18.7.9 Bypass logic

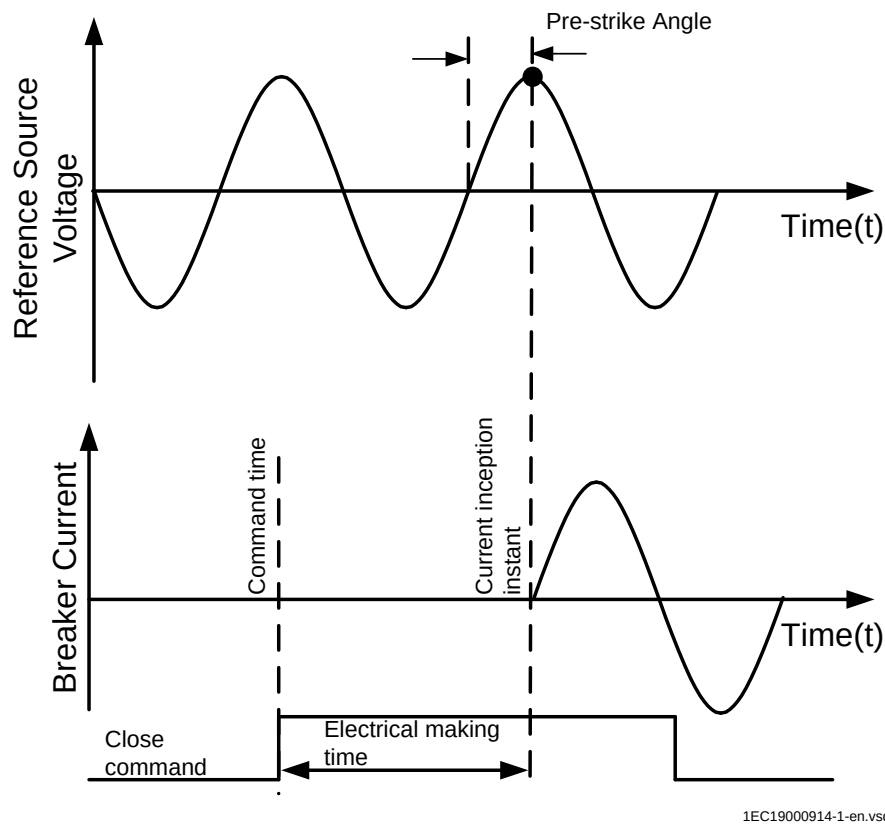
Whenever OPBYPASS / CLBYPASS inputs are activated along with OPCMDINP / CLCMDINP command inputs, ACBMSCBR publishes all predicted and actual electrical monitoring parameters to its default values, whereas all predicted and actual mechanical monitoring parameters are still evaluated.

12.18.7.10 Switching operations monitoring logic

This subfunction evaluates switching operations for deducing information on the circuit breaker.

Close operation electrical monitoring

This feature detects the instant of current inception, from which it derives the actual making time and pre-strike angle, as shown in [Figure 127](#).



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Figure 127: Electrical monitoring of CB closing, shown for current feedback

The monitored quantities are evaluated from the electrical feedback signal selected by *FeedbackSigC*. Based on the detected instant of inception, the electrical making time is evaluated as the time difference between the instant of controlled close command (CCLCMDLX) and the current inception instant as shown in Figure 127.

Similarly, the actual pre-strike angle is evaluated as summation of the predicted pre-strike angle and difference of actual and predicted electrical making times.

The inception instant is determined based on the settings *CloseCThreshold* and *CloseFThreshold*. Both settings are defined in percent of global base values (Section 12.18.7.3).

Using the absolute values of *CloseCThreshold* and *CloseFThreshold*, the inception instant is detected as shown in Figure 128 and Figure 129.

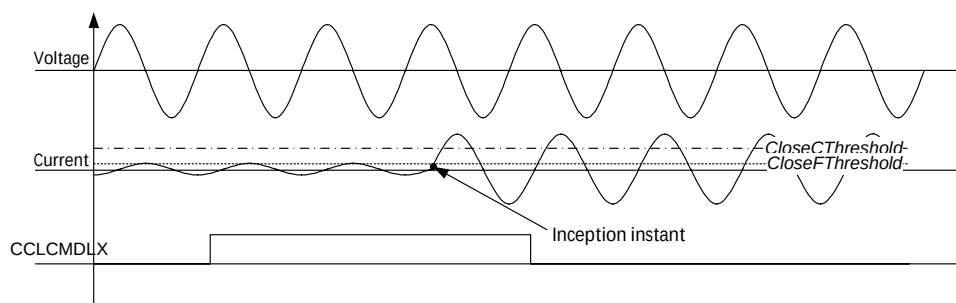


Figure 128: Detection of current inception instant

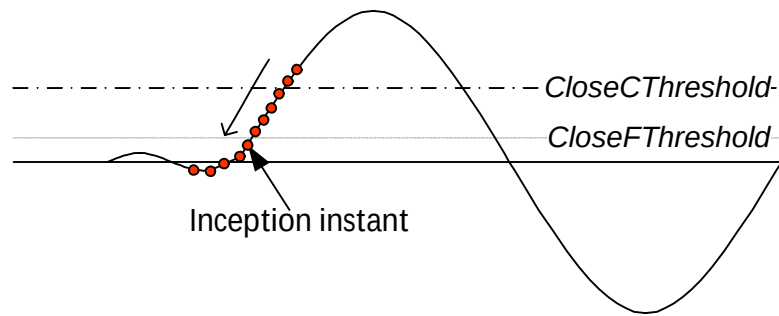


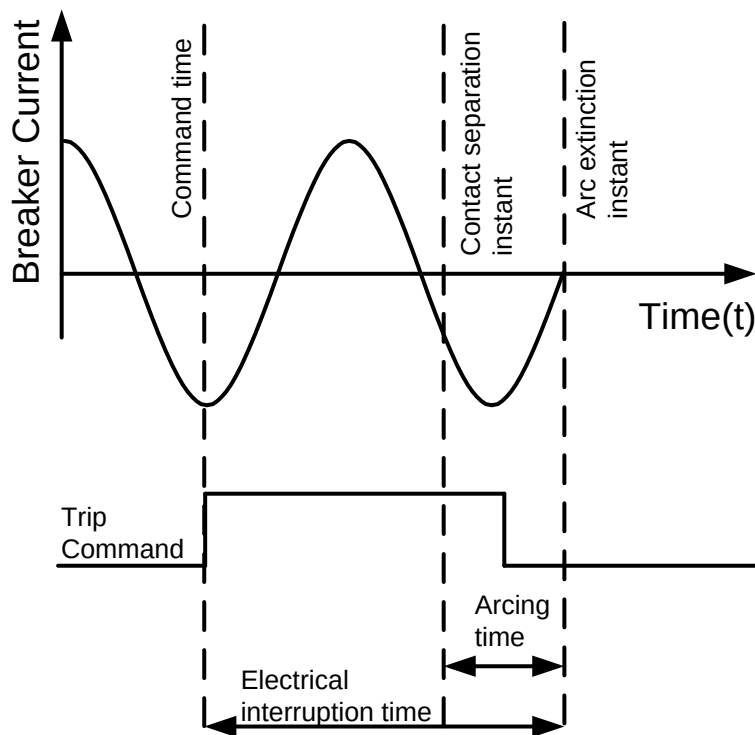
Figure 129: Detection of precise current inception instant

The function initially detects the breaker state change from the RMS value of the electrical feedback signal: The breaker is assumed closed as soon as the RMS value rises above the absolute *CloseCThreshold* value. From the instant of closed state detection, the function backtracks the samples until the absolute value is less than or equal to *CloseFThreshold*. This sample with corresponding timestamp is considered the inception instant.

In addition to the actual values, ACBMSCBR also provides the predicted pre-strike angle and predicted making time for the operation, as detailed in [Section 12.18.7.11.1](#). The predicted values are published on receiving the closing command CLCMDINP, and the actual values are published as soon as the inception is detected.

Open operation electrical monitoring

This feature detects the instant of current interruption (arc extinction), from which it derives the interruption time and arcing time, as shown in [Figure 130](#).



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Figure 130: Electrical monitoring of CB opening, shown for current feedback

The monitored quantities are evaluated from the electrical feedback selected by *FeedbackSigO*. Based on the detected instant of interruption, the electrical interruption time is evaluated as the time difference between the instant of controlled trip command (COPCMDLX) and the interruption instant as shown in [Figure 130](#). Similarly, the arcing time is evaluated as the time difference between estimated instant of breaker contact separation and the interruption instant.

The interruption instant is determined based on the settings *OpenCThreshold* and *OpenFThreshold*. Both settings are defined in percent of global base values. So, based on the configured *FeedbackSigO* (Current or load voltage), the global base value of the current or voltage is used to convert *OpenCThreshold* and *OpenFThreshold* into absolute values, same as for closing (described above).

For detecting the interruption instant, two different algorithms are applied depending on selected feedback signal and load type.

When using current feedback with capacitor or reactor or transmission line load, or voltage feedback with reactor or transformer load, the interruption instant is detected as shown in [Figure 131](#) and [Figure 132](#), using the absolute values of *OpenCThreshold* and *OpenFThreshold*.

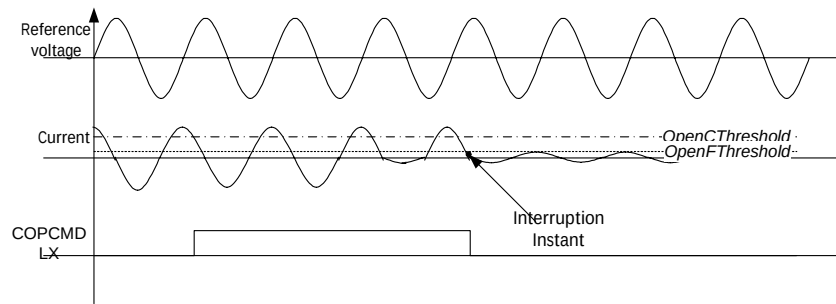


Figure 131: Detection of current interruption instant

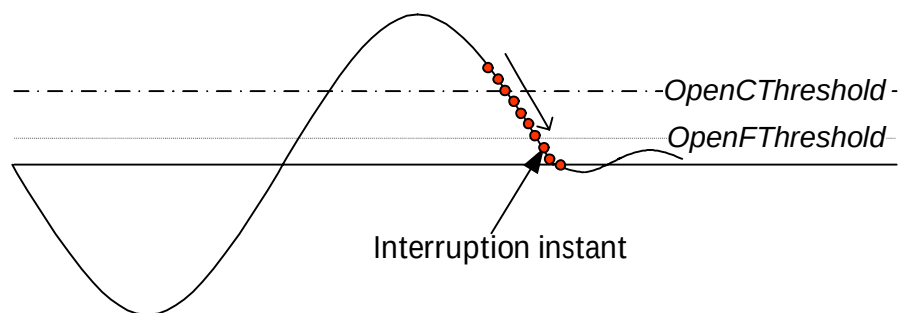


Figure 132: Detection of precise current interruption instant

The function initially detects the breaker state change from the RMS value of the electrical feedback signal: The breaker is assumed open as soon as the RMS value drops below the absolute *OpenCThreshold* value. From the point where the feedback signal was last seen above the threshold, the function forward-tracks the samples until the absolute value is less than or equal to *OpenFThreshold*. This sample with corresponding timestamp is considered the interruption instant.

When using voltage feedback with capacitor or uncompensated line/cable load, the interruption instant is detected as shown in [Figure 133](#) and [Figure 134](#).

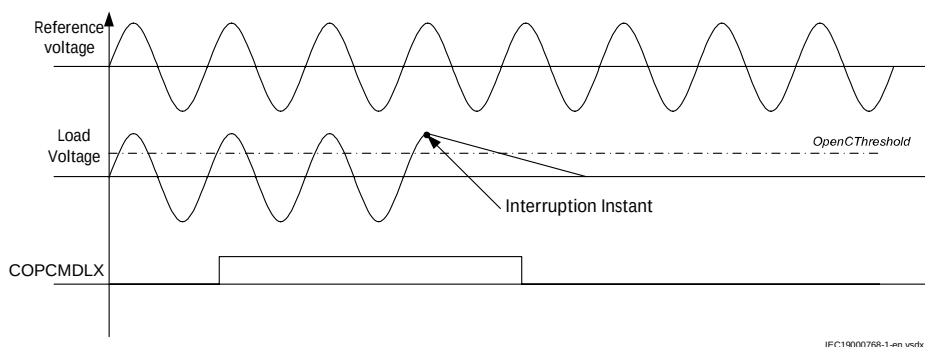


Figure 133: Detection of load voltage interruption instant for capacitive load

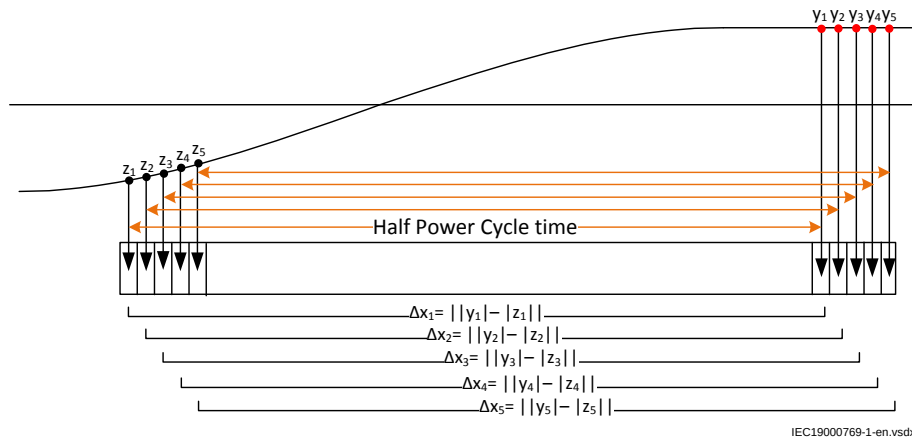


Figure 134: Detection of precise load voltage interruption instant for capacitive load

The function initially detects the breaker state change from the RMS value of the load voltage feedback signal: The breaker is assumed open as soon as the RMS value drops below the absolute *OpenCThreshold* value. (A capacitive load will usually retain a trapped DC charge after current interruption. Still, the measured voltage will decay to zero quickly because the primary VT and the input VT on the TRM cannot transmit DC voltage.) From the instant of open state detection, the function backtracks the voltage samples from the last 5 power cycles.

Specifically, it evaluates the difference between absolute values of each sample and the sample exactly nominal half power cycle back (Δx as shown in [Figure 134](#)). If the average of five consecutive differences is greater than or equal to *OpenFThreshold*, the earliest of the five samples with its corresponding timestamp is considered the interruption instant.

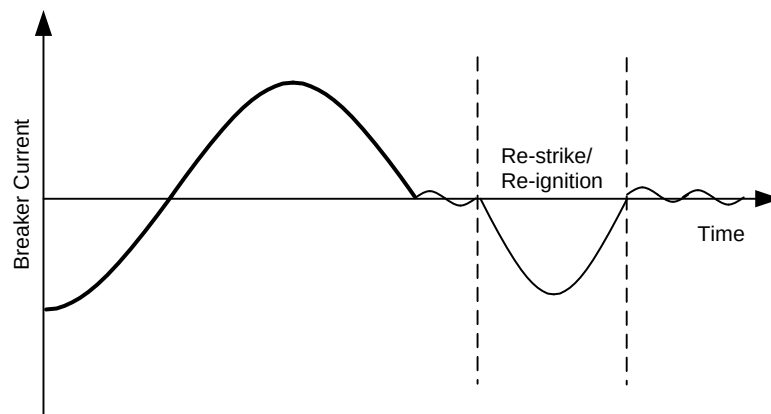
In addition to the actual values, ACBMSCBR also provides the predicted interruption time and predicted arcing time for the operation, as detailed in [Section 12.18.7.11.2](#). The predicted values are given on receiving the trip command OPCMDINP, and the actual values are given as soon as the interruption is detected.

ACBMSCBR also evaluates the instantaneous, peak and RMS of the interrupted current at the instant of current interruption and publishes them at its outputs LOOPILX, LOOPPILX and SWALX respectively, until the next switching operation.

At the detected instant of current interruption, ACBMSCBR stores the instantaneous value and publishes it at LOOPILX. Similarly, ACBMSCBR scans through the current samples from the controlled trip command COPCMDLX till the detected instant of current interruption to determine the instantaneous peak value of the interrupted current (LOOPPILX). Based on the monitored peak value as described above, the RMS value of interrupted current (SWALX) is evaluated assuming a sinusoidal waveform.

Re-strike/Re-ignition detection

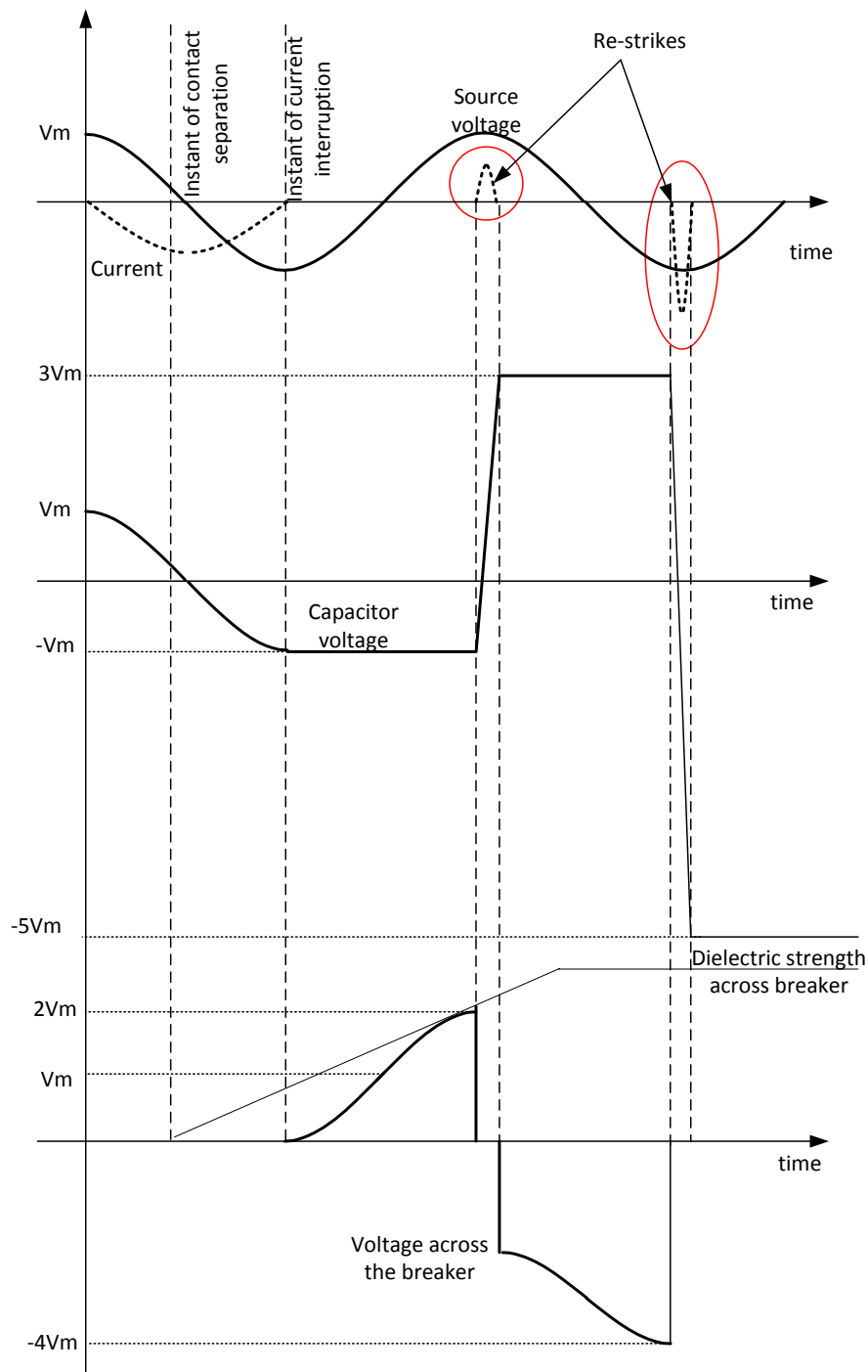
A circuit breaker is said to re-ignite or re-strike if, during an opening operation, current is initially interrupted but starts flowing again shortly thereafter, as shown in [Figure 135](#).



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Figure 135: Re-strike/re-ignition of breaker

During CB tripping, after the primary contact of the breaker separates, the current continues through an electrical arc until natural current zero. During that time period, the potential dielectric strength of the contact gap gradually increases while the CB is still conducting. After initial interruption, the CB will re-ignite/re-strike if the TRV (voltage across breaker contacts after current interruption) exceeds the actual dielectric strength, which in turn depends on the time since contact separation and correspondingly arcing time. For example, in case of capacitive load, re-strikes may occur due to trapped voltage on the load as shown in [Figure 136](#).



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Figure 136: Re-strikes on a capacitive load

When de-energizing a reactive load, re-ignitions occur essentially because of current chopping, which refers to interruption of the current prior to its natural current zero. This is due to the small inductive currents, which are interrupted by a high-power circuit breaker. The steep current gradient of chopping initiates high-amplitude and high-frequency voltage oscillations between reactor inductance and stray capacitances. Thus, the TRV (voltage across the interrupter gap) rises very quickly, as shown in [Figure 137](#).

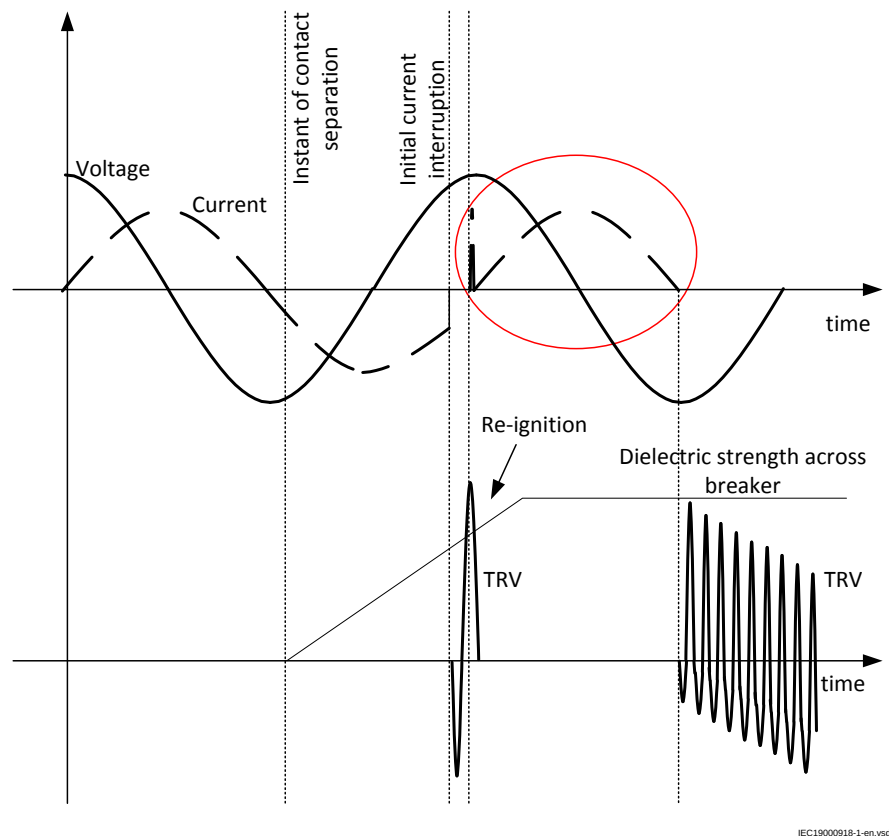
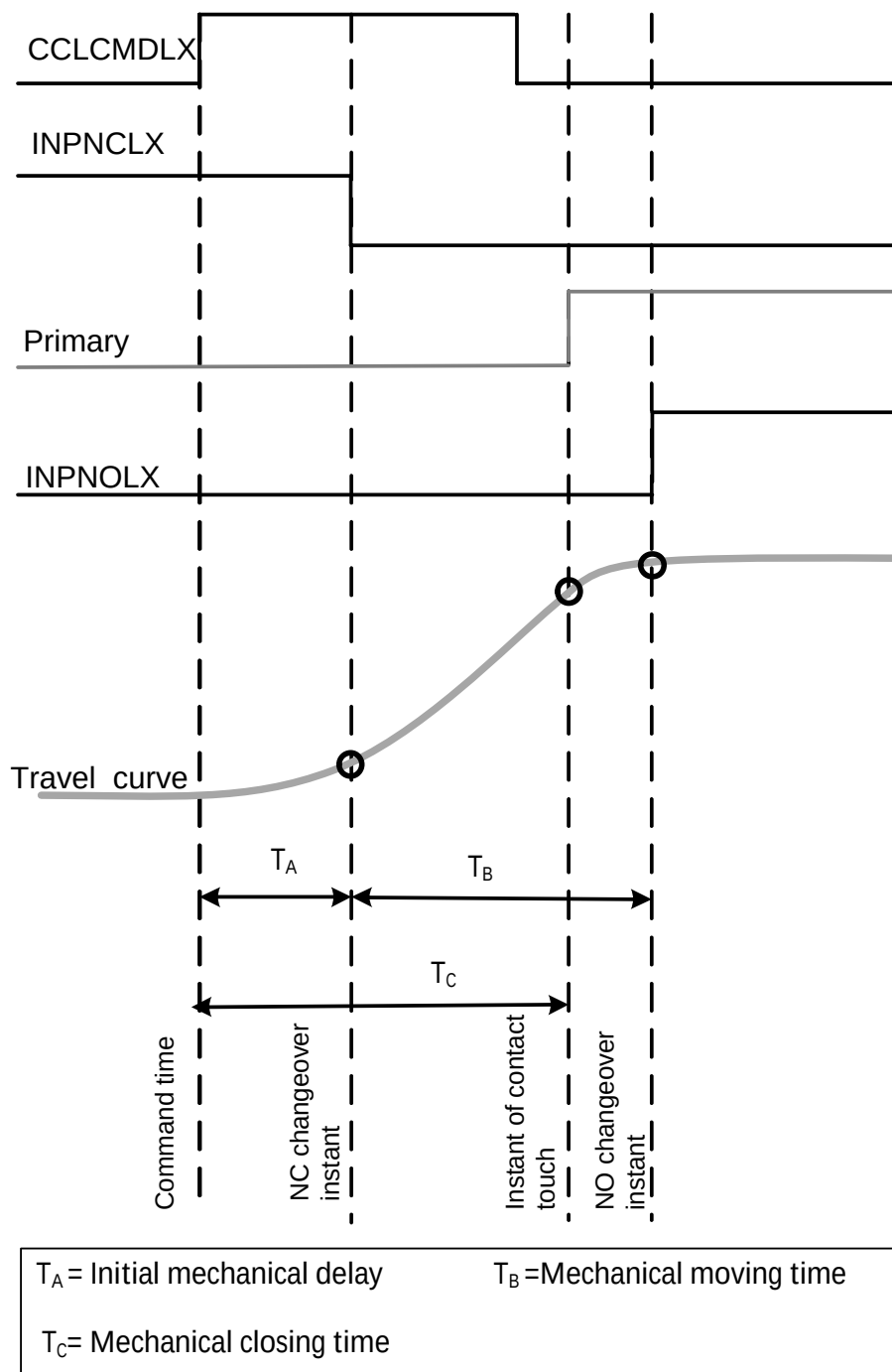


Figure 137: Re-ignition on an inductive load

Re-ignitions or re-strikes may damage the interrupter. Hence, detecting these events is useful for adapting the controlled switching operation, so as to minimize deterioration of the interrupter. The detection algorithm is described in [Section 12.18.7.11.3](#).

Close operation mechanical monitoring

As per the physical design of the breaker, every closing operation is associated with a changeover pattern of the 52a (NO) and 52b (NC) auxiliary contacts, as shown in [Figure 138](#). Assuming that changeover of the auxiliary contacts always occurs on the same point of the travel curve, this allows a simple monitoring of the mechanical closing operations of the CB.



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Figure 138: Events during CB closing operation

The mechanical closing time, initial mechanical delay, and mechanical moving time are evaluated based on the selected auxiliary feedback signal determined via *AuxPosAvailable* and enabled *MechMonitor*.

The mechanical closing time is the time gap between the instant of received close command and instant of primary contact touch as shown in Figure 138. As the instant of primary contact touch is not directly accessible, it is interpolated from the NO and NC changeover timestamps. Subsequent to the interpolated primary contact touch instant, the mechanical closing time is evaluated as given in Table 272.

Table 272: Derivation of the mechanical closing time from NO and NC changeover timestamps

auxPosAvailable	Estimated mechanical closing time
None	0.0
NO only	$T_{main} = T_{main0} + (T_{NO} - T_{NO0})$
NC only	$T_{main} = T_{main0} + (T_{NC} - T_{NC0})$
NO and NC	$T_{main} = T_{NC} + \left((T_{main0} - T_{NC0}) \cdot \frac{T_{NO} - T_{NC}}{T_{NO0} - T_{NC0}} \right)$

where,

T_{main} = Estimated mechanical operating time

T_{NO} = Actual time gap between NO changeover time and CCLCMDLX activation

T_{NC} = Actual time gap between NC changeover time and CCLCMDLX activation

T_{main0} = nominal mechanical closing time, as received on the INPRICLLX input

T_{NO0} = nominal changeover time of NO auxiliary contact, as received on the INNOCLLX input

T_{NC0} = nominal changeover time of NC auxiliary contact, as received on the INNCCLLX input

In addition to the actual (estimated) value, ACBMSCBR also provides the predicted mechanical CB closing time for the operation. The predicted value is given on receiving the close command (CLCMDINP), and the actual value is given 300 ms after receiving the CCLCMDLX command.

Based on the changeover of NC contact, the initial mechanical delay is evaluated as the time gap between the instant of received close command and instant of NC changeover as shown in [Table 273](#).

Table 273: Derivation of the initial mechanical closing delay from NO and NC changeover timestamps

auxPosAvailable	Initial mechanical delay
None	0.0
NO only	0.0
NC only	$t_{imd} = t_{NC} - \text{CCLCMDLX (timestamp)}$
NO and NC	$t_{imd} = t_{NC} - \text{CCLCMDLX (timestamp)}$

where,

t_{imd} = Measured initial mechanical delay

t_{NC} = Actual NC changeover time

Similarly, based on the changeover of NO and NC contacts, the mechanical moving time is evaluated as the time gap between the instant of NO changeover and the instant of NC changeover as shown in [Table 274](#).

Table 274: Derivation of the mechanical moving time for closing from NO and NC changeover timestamps

auxPosAvailable	Mechanical moving time
None	0.0
NO only	0.0
NC only	0.0
NO and NC	$MMT = t_{NO} - t_{NC}$

where,

MMT= Measured mechanical moving time

t_{NC} = Actual NC changeover time

t_{NO} = Actual NO changeover time

Open operation mechanical monitoring

As per the physical design of the breaker, every opening operation is associated with a changeover pattern of the 52a (NO) and 52b (NC) auxiliary contacts, as shown in [Figure 139](#). Assuming that changeover of the auxiliary contacts always occurs on the same point of the travel curve, this allows a simple monitoring of the mechanical opening operations of the CB.

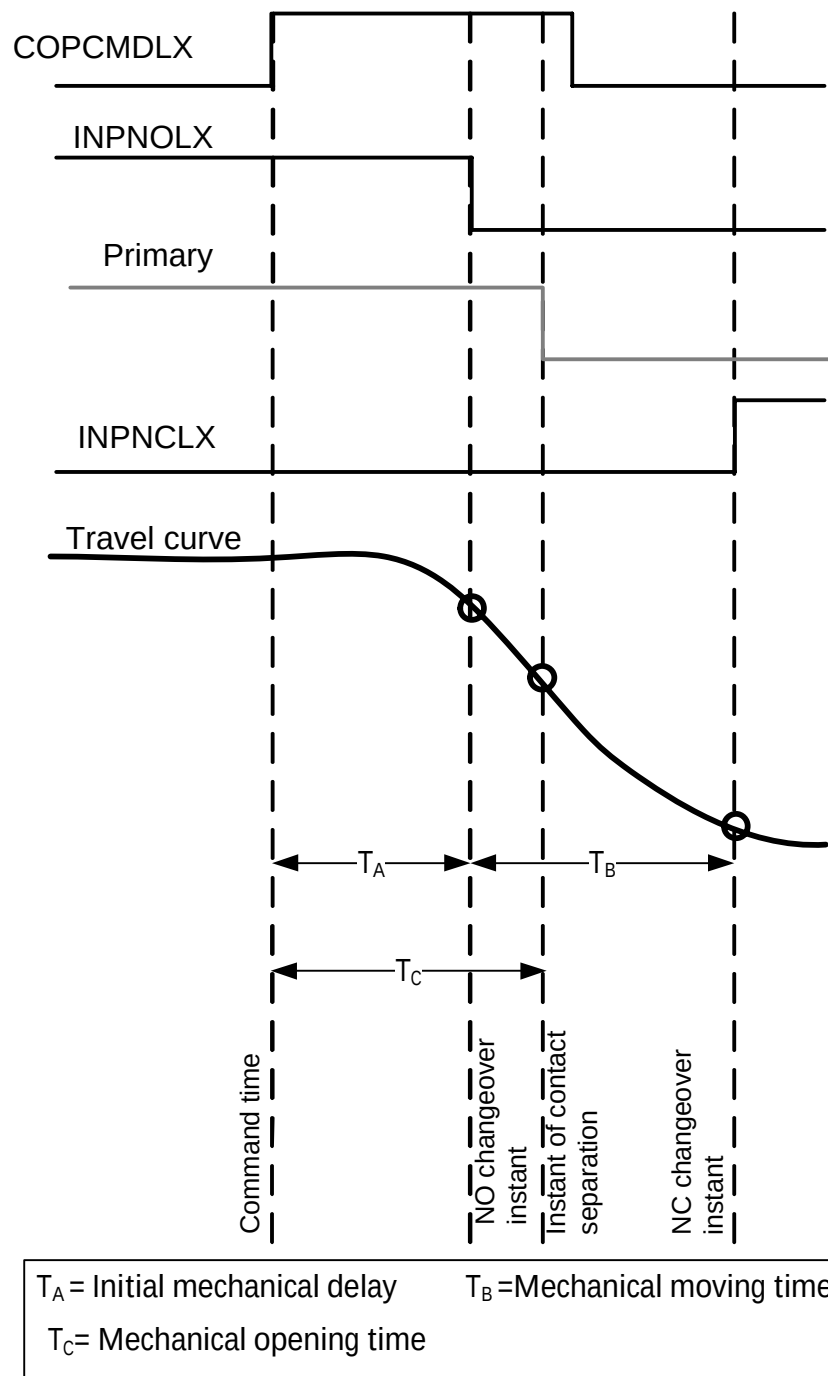


Figure 139: Events during CB opening operation

The mechanical opening time, initial mechanical delay, and mechanical moving time are evaluated based on the selected auxiliary feedback signal determined via *AuxPosAvailable* and enabled *MechMonitor*.

The mechanical opening time is the time gap between the instant of received open command and instant of primary contact separation as shown in [Figure 139](#). As the instant of primary contact separation is not directly accessible, it is interpolated from the NO and NC changeover timestamps. Subsequent to the interpolated primary contact separation instant, the mechanical opening time is evaluated as given in [Table 275](#).

Table 275: Derivation of mechanical opening time from NO and NC changeover timestamps

auxPosAvailable	Estimated mechanical opening time
None	0.0
NO only	$T_{main} = T_{main0} + (T_{NO} - T_{NO0})$
NC only	$T_{main} = T_{main0} + (T_{NC} - T_{NC0})$
NO and NC	$T_{main} = T_{NO} + \left((T_{main0} - T_{NO0}) \cdot \frac{T_{NC} - T_{NO}}{T_{NC0} - T_{NO0}} \right)$

where,

T_{main} = Estimated mechanical operating time

T_{NO} = Actual time gap between NO changeover time and COPCMDLX activation

T_{NC} = Actual time gap between NC changeover time and COPCMDLX activation

T_{main0} = nominal mechanical opening time, as received on the INPRIOPLX input

T_{NO0} = nominal changeover time of NO auxiliary contact, as received on the INNOOPLX input

T_{NC0} = nominal changeover time of NC auxiliary contact, as received on the INNCOPLX input

In addition to the actual (estimated) value, ACBMSCBR also provides the predicted mechanical CB opening time for the operation. The predicted value is given on receiving the trip command (OPCMDINP), and the actual value is given 300 ms after receiving the COPCMDLX command.

Based on the changeover of NO contact, the initial mechanical delay is evaluated as the time gap between the instant of received close command and instant of NO changeover as shown in [Table 276](#).

Table 276: Derivation of the initial mechanical opening delay from NO and NC changeover timestamps

auxPosAvailable	Initial mechanical delay
None	0.0
NO only	$t_{imd} = t_{NO} - \text{COPCMDLX (timestamp)}$
NC only	0.0
NO and NC	$t_{imd} = t_{NO} - \text{COPCMDLX (timestamp)}$

where,

T_{imd} = Measured initial mechanical delay

t_{NO} = Actual NO changeover time

Similarly, based on the changeover of NO and NC contacts, the mechanical moving time is evaluated as the time gap between the instant of NC changeover and the instant of NO changeover as shown in [Table 277](#).

Table 277: Derivation of the mechanical moving time for opening from NO and NC changeover timestamps

auxPosAvailable	Mechanical moving time
None	0.0
NO only	0.0
NC only	0.0
NO and NC	$MMT = t_{NC} - t_{NO}$

where,

MMT= Measured mechanical moving time

t_{NC} = Actual NC changeover time

t_{NO} = Actual NO changeover time

12.18.7.11 Electrical monitoring

Based on the detection of electrical current interruption and inception, the ACBMSCBR function provides the following electrical monitoring values at its outputs.

- Pre-strike angle and electrical making time
- Arcing time and electrical interruption time
- Re-strike/re-ignition detection and its count over operations.

Pre-strike angle and electrical making time (CB closing)

ACBMSCBR provides two sets of values each for pre-strike angle and electrical making time during any close operation, namely the predicted and actual values of the operation. The predicted values are published as soon as the close command is received on the CLCMDINP input, and the actual values are published as soon as the inception instant is detected. The predicted values are given at the outputs PPRESTRAX, PELORTLX and PELORTCLX. The actual values are given at the outputs APRESTRAX, AELORTMLX and AELORTCLX.

The predicted pre-strike angle PPRESTRAX (in degrees) is defined as:

$$PPRESTRAX = TGTANGLx + SCATTERLX$$

where SCATTERLX is the optimized offset from ideal target making instant. Refer [Section 12.18.7.4](#).

The predicted electrical making time PELORTCLX (in milliseconds) is defined as:

$$PELORTCLX = INPRICLLX - PPRESTRAX + CLOSECOMP + ADAPTCLLX$$

where PPRESTRAX is the expected pre-arcing time, CLOSECOMP is the total compensation value for the mechanical closing time and ADAPTCLLX is the adaptive correction value for closing.

The same value is also given at the output PELORTLX for closing operations.

Refer [Section 12.18.7.4](#) and [Section 12.18.7.13.1](#).

The actual electrical making time AELORTCLX (in milliseconds) is defined as:

$$AELORTCLX = \text{Electrical Making Time}$$

Refer [Section 12.18.7.10.1](#).

The same value is also given at the output AELORTMLX for closing operations.

The actual pre-strike angle APRESTRAX (in degrees) is defined as:

$$\text{APRESTRAX} = \text{PPRESTRAX} + \text{AELORTCLX} - \text{PELORTCLX}$$

Refer to [Section 12.18.7.10.1](#).

ACBMSCBR also evaluates error target value ERELOTCLX (in milliseconds) for close operations as difference between AELORTCLX and PELORTCLX,

$$\text{ERELOTCLX} = \text{AELORTCLX} - \text{PELORTCLX}$$

The same value is also given at the output ERELORTLX for closing operations.

Arcing time and electrical interruption time (CB opening)

ACBMSCBR provides two sets of values each for arcing time and electrical interruption time during any trip operation, namely the predicted and actual values of the operation. The predicted values are published as soon as the trip command is received on the OPCMDINP input, and the actual values are published as soon as the interruption instant is detected. The predicted values are given at the outputs PARCTMLX, PELORTLX and PELORTOLX. The actual values are given at the outputs AARCTMLX, AELORTMLX and AELORTOLX.

Knowledge of the following design characteristics of the circuit breaker is essential for monitoring. These characteristics are provided to the function through the following settings.

Table 278: Breaker specific settings for open operations

Setting	Description
<i>InitArcTime</i>	Initial target arcing time for load de-energization without unwanted re-ignitions / re-strikes
<i>MaxArcTime</i>	Maximum arcing time of the re-ignition free window, as obtained from type tests of inductive switching
<i>ArcTimeTrafoLX</i>	Target arcing time for interruption of transformer charging current

The predicted arcing time PARCTMLX (in milliseconds) is defined as:

$$\text{PARCTMLX} = \text{InitArcTime} + \text{ADAPTOPLX}$$

where ADAPTOPLX is the adaptive correction value for opening. Refer [Section 12.18.7.13.2](#).

The definition of predicted electrical interruption time PELORTOLX (in milliseconds) depends on the selected load type. For transformer loads,

$$\text{PELORTOLX} = \text{INPRIOPLX} + \text{ArcTimeTrafoLX} + \text{ADAPTOPLX} + \text{OPENCOMP}$$

For all other load types,

$$\text{PELORTOLX} = \text{INPRIOPLX} + \text{InitArcTime} + \text{ADAPTOPLX} + \text{OPENCOMP}$$

where OPENCOMP is the total compensation value for the mechanical opening time.

The same value is also given at the output PELORTLX for opening operations.

The actual electrical interruption time AELORTOLX (in milliseconds) is defined as:

$$\text{AELORTOLX} = \text{Electrical Interruption time (detailed in [Section 12.18.7.10.2](#))}$$

The same value is also given at the output AELORTMLX for opening operations.

The actual arcing time AARCTMLX (in milliseconds) is defined as:

AARCTMLX = Electrical Interruption time – INPRIOPLX

Refer [Section 12.18.7.10.2](#).

ACBMSCBR also evaluates error target value ERELOTOLX (in milliseconds) for open operations as difference between AELORTOLX and PELORTOLX,

ERELOTOLX = AELORTOLX – PELORTOLX

The same value is also given at the output ERELORTLX for opening operations.

Re-strike/re-ignition detection and count

In every controlled opening operation, ACBMSCBR checks the primary current signal selected by *FeedbackSigO* for re-ignition/re-strike (see [Section 12.18.7.10.3](#)) and indicates this event by activating the RSTRDETLX output. Specifically, a re-ignition or re-strike is declared when final current interruption is detected later than 1/8 power cycle after the predicted interruption instant,

$AELORTOLX - PELORTOLX > T/8$.

Every re-ignition/re-strike increments an internal counter. The counter value is published at the RTKCTLX output. It can be reset to zero by activating the RESRCNT input.

12.18.7.12 Mechanical monitoring

Based on the detection of auxiliary contact changeover, ACBMSCBR provides the following mechanical monitoring values at its outputs.

- Mechanical operating time
- Initial mechanical delay
- Mechanical movement time

Mechanical operating time

ACBMSCBR provides two values during any open/close operation, namely the predicted and the actual (estimated) mechanical operating time. The predicted value is published as soon as a Close or Trip command is received on the CLCMDINP or OPCMDINP input and the actual value is published 300 ms after receiving the CCLCMDLX or COPCMDLX command.

The predicted mechanical opening time PMCORTOLX (in milliseconds) is defined as:

$PMCORTOLX = INPRIOPLX + OPENCOMP$

where OPENCOMP is the total compensation value for the mechanical opening time.

The same value is also given at the output PMCORTLX for opening operations..

The predicted mechanical closing time PMCORTCLX (in milliseconds) is defined as:

$PMCORTCLX = INPRICLLX + CLOSECOMP + ADAPTCLLX$

where CLOSECOMP is the total compensation value for the mechanical closing time.

The same value is also given at the output PMCORTLX for closing operations.

The actual mechanical opening time AMCOTOLX (in milliseconds) is defined as:

$AMCOTOLX = \text{Mechanical opening time}$

Refer [Section 12.18.7.10.5](#).

The same value is also given at the output AMCOTMLX for opening operations.

The actual mechanical closing time $AMCOTCLX$ (in milliseconds) is defined as:

$AMCOTCLX = \text{Mechanical closing time}$

Refer [Section 12.18.7.10.4](#).

The same value is also given at the output $AMCOTMLX$ for closing operations.

Initial mechanical delay

As explained in [Section 12.18.7.10.5](#) and [Section 12.18.7.10.4](#), ACBMSCBR evaluates and gives the initial mechanical delay at its outputs $ITMCDLLX$. The individual value for open and close operation is given at the $RCTTOPOLX$ and $RCTTCLOLX$ outputs, respectively.

Mechanical moving time

As explained in [Section 12.18.7.10.5](#) and [Section 12.18.7.10.4](#), ACBMSCBR evaluates and gives the mechanical movement time at its $MCMOVTMLX$ output. The individual value for open and close operation is given at the $AUXSWTOLX$ and $AUXSWTCLX$ outputs, respectively.

12.18.7.13 Adaptive correction

Adaptive correction for closing

After some time in service, the properties of the circuit breaker may change. Adaptive correction is the technique of tracking changes in actual operating times and automatically adjusting the controlled switching parameters accordingly. ACBMSCBR does this by evaluating the electrical and mechanical target errors monitored in the last controlled closing operation.

For adaptive correction of electrical making time, the function evaluates the electrical target error (ϵ_{elec}) as the difference between the predicted and actual making times.

$\epsilon_{elec} = \text{Actual elec. making time} - \text{Predicted elec. making time}$

Similarly, the function evaluates the mechanical target error as the difference between the predicted and actual mechanical closing times.

$\epsilon_{mech} = \text{Actual mech. closing time} - \text{Predicted mech. closing time}$

This evaluated error is utilized for adjusting the CB release instant in the next controlled closing operation. For example, the electrical error is compensated in a proportionate way for the subsequent close operation as shown in [Figure 140](#).

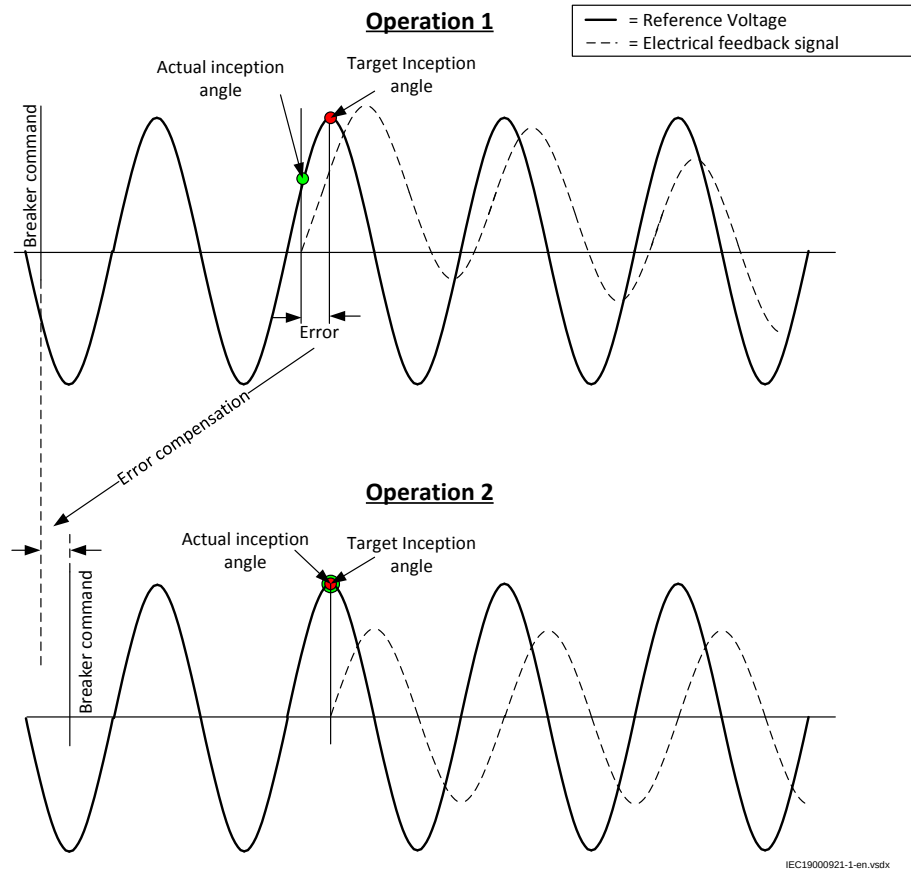


Figure 140: Adaptive correction of electrical making time

It is recommended to apply only a fraction ("beta factor") of the target error as correction value. Individual beta factors for electrical and mechanical errors are provided and the total correction value is calculated as:

$$\text{ADAPTCLLX}_{\text{new}} = \text{BetaAdjustElec} \cdot \varepsilon_{\text{elec}} + \text{BetaAdjustMech} \cdot \varepsilon_{\text{mech}}$$

where,

BetaAdjustElec = Adaptive correction factor (setting) for electrical error

BetaAdjustMech = Adaptive correction factor (setting) for mechanical error

Usually, no more than one of these beta factors should be greater than zero.

The evaluated **ADAPTCLLX** is added to the summation of previous correction values and that result is used for next controlled closing operation. It is given as an output of the function and also added to the predicted electrical and mechanical operating time in the next controlled closing operation.

Adaptive correction for opening

For a high voltage circuit breaker, the actual instant of main contact separation cannot be seen as the primary current is usually interrupted at a natural zero crossing. Hence, adaptive correction for opening is based on the detection of re-ignitions or re-strikes, assuming that further such events can be prevented by targeting longer arcing time.

Whenever a re-ignition or re-strike is detected (see [Section 12.18.7.11.3](#)), an internal extension value is increased by 1 ms (fixed increment). For the next controlled opening operation, this extension value is added to the target arcing time.

The arcing time extension is limited by *MaxReStrikeCorr* or *MaxArcTime* whichever is reached first.

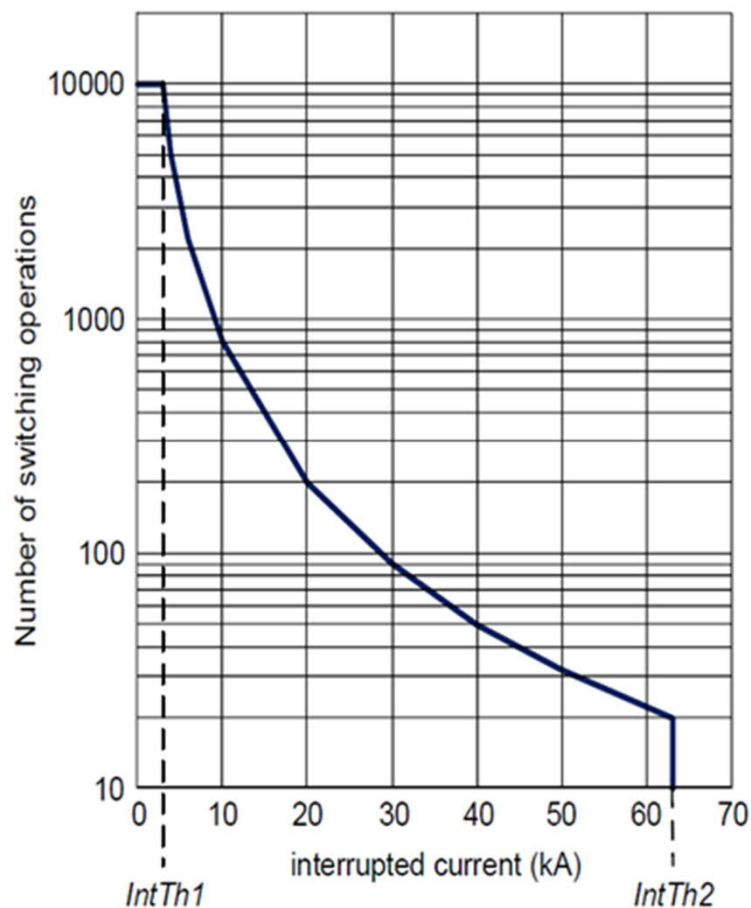
The extension value for the target arcing time is given as output ADAPTOPLX and also added to the predicted electrical operating time and predicted arcing time in the next controlled opening operation.

12.18.7.14 Ablation monitoring

During CB opening, plasma from switching arcs in the circuit breaker will erode both the metallic contacts and the teflon nozzles of the interrupter. This process is called interrupter wear or contact ablation in the document.

[Figure 141](#) shows a typical electrical life curve of a circuit breaker rated to interrupt maximum 63 kA and to endure 10000 mechanical operation cycles. For every value of interrupted current, the graph tells how many operations at that current the CB can perform before the interrupter needs overhaul. It is divided into three parts:

- Interruptions of low currents below *IntTh1* are considered mechanical operations.
- Interruption of higher currents (between *IntTh1* and *IntTh2*) causes non-negligible ablation, which reduces the number of remaining operations till end of life.
- Currents beyond the *IntTh2* limit should never occur in service, as they exceed the equipment rating and may lead to CB failure.



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Figure 141: Example of electrical life curve of a circuit breaker

ACBMSCBR calculates contact ablation as the number of equivalent mechanical operations lost during a CB opening operation, according to the model explained above. All ablation related calculations are performed only when *Ablation* is set to "Enable". For calculating the contact ablation in the last CB opening operation, the interrupted current is integrated over the arcing time, $\int I^n dt$. In the function, this integration is performed numerically on the arcing current samples (samples after mechanical contact separation till final current interruption); the integrated arcing current is calculated as:

$$\sum I(\text{integrated}) = \frac{|i_1|^n + |i_2|^n + |i_3|^n + \dots + |i_k|^n}{k}$$

where $i_1, i_2, i_3, \dots, i_k$ are the arcing current samples, and n is the breaker type specific exponent given by *CumCurrPower*.

From that, ablation is calculated according to the range of integrated current, as shown in [Table 279](#). The lower range boundary *IntTh1* is taken from the setting *MinCurrentLimit*, the upper boundary *IntTh2* from *OverCurrentLimit*. The resulting ablation value is given at the *LOOPABLLX* output as equivalent mechanical operations lost during the last CB opening.

Table 279: Ablation value estimation

Range	LOOPABLLX
$0 < \sum I < \text{IntTh1}^n$	1
$\text{IntTh1}^n \leq \sum I \leq \text{IntTh2}^n$	$C_0 + C_1 \cdot (\sum I)^{P_1} + C_2 \cdot (\sum I)^{P_2} + C_3 \cdot (\sum I)^{P_3} + C_4 \cdot (\sum I)^{P_4}$
$\sum I > \text{IntTh2}^n$	<i>AblatCalShEst</i>

where,

$C_0 = \text{AblationCoeff0}$

$C_1 = \text{AblationCoeff1}$

$C_2 = \text{AblationCoeff2}$

$C_3 = \text{AblationCoeff3}$

$C_4 = \text{AblationCoeff4}$

$P_1 = \text{PowerCoeff1}$

$P_2 = \text{PowerCoeff2}$

$P_3 = \text{PowerCoeff3}$

$P_4 = \text{PowerCoeff4}$

The ablation value for the last operation is added to a cumulated ablation estimate (*ABLSUMLX*) to keep track of the total contact ablation. *ABLSUMLX* retains the value during power loss.

Moreover, the function sets *ABLSUMLX* in relation to a maximum value given by *AblationAlarmLevel*. The ratio is given at the *ABLSUMLX* output and can be used for displaying or threshold checking of the relative interrupter wear:

$$ABLSUMRLX = \frac{ABLSUMLX}{AblationAlarmLevel}$$

Activating the RESETABL input will set ABLSUM to the initial value *InitialCumAbt*; ABLSUMRLX will be updated accordingly.

12.18.7.15 Inrush current peak evaluation

Starting from activation of the Close command input CLCMDINP, ACBMSCBR searches for the current sample (from I3PL input) having the highest absolute value within 15 power cycles. To filter out high-frequency transients, only sets of four consecutive samples exceeding the threshold level defined by *InrushCurRef* are considered. The signed sample value is published as inrush current peak at the INRUSHPLX output.

This evaluation is done only for transformer loads.

12.18.7.16 Electrical status of load

As soon as the load voltage or current RMS received by the function (through I3PL or U3PL) crosses a pre-defined open coarse threshold value (absolute value of *OpenCThreshold*), then binary output LOADONLX gets activated and remains active as long as it satisfies the condition.

Similarly, as soon as the load voltage or current RMS received by the function (through I3PL or U3PL) falls below a pre-defined open fine threshold value (absolute value of *OpenFThreshold*), then binary output LOADOFFLX gets activated and remains active as long as it satisfies the condition.

The above-mentioned points for different scenarios are summarized in [Table 280](#).

Table 280: Activation of LOADONLX and LOADOFFLX outputs

Feedback SigO	Iload(RMS) ≥ <i>OpenCThreshold</i> * <i>IBase</i>	Iload(RMS) ≥ <i>OpenFThreshold</i> * <i>IBase</i>	Uload(RMS) ≥ <i>OpenCThreshold</i> * <i>UBase</i> * <i>ScaleFactorV</i>	Uload(RMS) ≥ <i>OpenFThreshold</i> * <i>UBase</i> * <i>ScaleFactorV</i>	LOADON LX	LOADOF FLX
None	X	X	N	N	0	1
None	X	X	N	Y	0	0
None	X	X	Y	X	1	0
Load voltage	X	X	N	N	0	1
Load voltage	X	X	N	Y	0	0
Load voltage	X	X	Y	X	1	0
Current	N	N	X	X	0	1
Current	N	Y	X	X	0	0
Current	Y	X	X	X	1	0

12.18.7.17 Operation count monitoring

With the monitoring of actual operations, the function also counts the number of CB operations. For that purpose, a cycle of CB closing and CB opening is considered as one operation. The function presents output(OPRCNTRST) to accommodate the count of Close and Open cycles operations.

The function also counts the controlled switching operations in response to SSCPOW issued trip/close (COPCMDLX/CCLCMDLX) commands. These are given via the outputs INOPCNCLX for controlled closing operations and INOPCNOLX for controlled opening operations, respectively.

All the above mentioned three operation counters will retain their values even during powercycle.

12.18.7.18 Alarm and warning

ACBMSCBR can raise a warning or alarm on certain pre-defined conditions and monitored values.

The different alarms raised by the function are:

- CB Operations count Alarm and Warning
- Maximum Re-strike/Re-ignition count Alarm
- Mechanical operating time Alarm
- Unstable breaker Alarm
- Re-ignition/re-strike detected Alarm
- Fault detection Alarm
- Maximum Re-strike/Re-ignition Correction Alarm
- Mechanical Heath Alarm
- Contradicting CB positions Alarm
- Ablation Alarm and Warning
- Out-of-limit operations count Alarm
- General Alarm

CB Operations count alarm and warning

The counter of CB operations cycles OPRCNTRST can be compared against warning and alarm thresholds outside ACBMSCBR (see MONALM function). The comparison result is fed back to ACBMSCBR through the coordination input ALMS6T10B. If enabled by the *OpCntAlm* setting, counter values above the threshold will raise a warning or alarm on the WROPCNTLX or ALOPCNTLX output, respectively. These outputs are activated for only one task cycle.

ALMS6T10B comprises alarm and warning status for all three phases. Depending on the system phase to which an ACBMSCBR instance is assigned, it extracts the relevant information for that phase only. [Table 281](#) lists the bit combinations that indicate an operation count warning or alarm for the respective phase and the resulting output values.

Table 281: CB Operations count Alarm and Warning

Phase Instance	ALMS6T10B							opCntAlm	WROPCNTLX	ALOPCNTLX
	Bit0	Bit1	Bit2	Bit3	Bit4	Bit5	Bit6-Bit31			
L1	1	0	X	X	X	X	X	Enab warn/ Enab warn & alarm	1	0
	0	1	X	X	X	X	X	Enab alarm/ Enab warn & alarm	0	1
L2	X	X	1	0	X	X	X	Enab warn/ Enab warn & alarm	1	0
	X	X	0	1	X	X	X	Enab alarm/ Enab warn & alarm	0	1
L3	X	X	X	X	1	0	X	Enab warn/ Enab warn & alarm	1	0
	X	X	X	X	0	1	X	Enab alarm/ Enab warn & alarm	0	1
X	X	X	X	X	X	X	X	Disab warn & alarm	0	0

Maximum re-strike/re-ignition count alarm

The counter of re-ignitions or restrikes RTKCTLX can be compared against an alarm threshold outside ACBMSCBR (see MONALM function). The comparison result is fed back to ACBMSCBR through the coordination input ALMS1T5B. If enabled by the *RestrReigAlm* setting, counter values above the threshold will raise an alarm on the ALMAXRRLX output. This output is activated for only one task cycle.

ALMS1T5B comprises alarm status for all three phases. Depending on the system phase to which an ACBMSCBR instance is assigned, it extracts the relevant information for that phase only. [Table 282](#) lists the bit combinations that indicate a re-strike/re-ignition count alarm for the respective phase and the resulting output values.

Table 282: Maximum re-strike/re-ignition count alarm

Phase Instance	ALMS1T5B							RestrReigAlm	ALMAXRRLX
	Bit1	Bit2	Bit3	Bit4	Bit5	Bit6	Bit7-Bit31		
L1	1	0	X	X	X	X	X	Enable	1
L2	X	X	1	0	X	X	X	Enable	1
L3	X	X	X	X	1	0	X	Enable	1
X	X	X	X	X	X	X	X	Disable	0

Mechanical operating time alarm

The estimated mechanical operating time *AMCOTMLX* can be compared against alarm thresholds outside *ACBMSCBR* (see *MONALM* function), separately for closing time and opening time. The comparison results are fed back to *ACBMSCBR* through the coordination input *ALMS1T5A*. If enabled by the *OpTmAlm* setting, operating times outside the limits will raise an alarm on the *ALOPTMLX* output. This output is activated for only one task cycle.

ALMS1T5A comprises alarm status for all three phases. Depending on the system phase to which an *ACBMSCBR* instance is assigned, it extracts the relevant information for that phase only. [Table 283](#) lists the bit combinations that indicate a mechanical operating time alarm for the respective phase and the resulting output values.

Table 283: Mechanical operating time alarm

Phase Instance	ALMS1T5A													opTmAlm	ALOPTMLX
	Bit0	Bit1	Bit2	Bit3	Bit4	Bit5	Bit6	Bit7	Bit8	Bit9	Bit10	Bit11	Bit12-31		
L1	1	0	X	X	X	X	X	X	X	X	X	X	X	Enable	1
	X	X	X	X	X	X	0	1	X	X	X	X	X	Enable	1
L2	X	X	1	0	X	X	X	X	X	X	X	X	X	Enable	1
	X	X	X	X	X	X	X	X	0	1	X	X	X	Enable	1
L3	X	X	X	X	1	0	X	X	X	X	X	X	X	Enable	1
	X	X	X	X	X	X	X	X	X	X	0	1	X	Enable	1
X	X	X	X	X	X	X	X	X	X	X	X	X	X	Disable	0

Unstable breaker alarm

If both *MechMonitor* and *UnstOpChrAlm* are set to "Enable", *ACBMSCBR* checks for consistency of the actual mechanical operating times. Specifically, it evaluates the difference between the last three operations of the same type (Close or Open). If the actual mechanical operating time of the second operation is 10% deviated from the actual mechanical operating time of the first operation and the actual mechanical operating time of the third operation is 10% deviated from the actual mechanical operating time of the second operation, the breaker is declared unstable. This is indicated by activating the **UNSTOPOLX** output. The output remains high till the alarm is manually cleared.

Re-ignition/re-strike detected alarm

If *RestrReigAlm* is set to "Enable" and a re-ignition or re-strike has been detected (see [Section 12.18.7.11.3](#)), the *RSTRDETLX* output is activated for one task cycle.

Overcurrent detection Alarm

If "Current" is selected for either *FeedbackSigC* or *FeedbackSigO*, *ACBMSCBR* continuously compares the primary current RMS to the overcurrent threshold, which is calculated as $OvercurrentThresh \cdot IBase / 100$. If the current exceeds the threshold, the *OVCURLX* output is activated; it remains active as long as till the current RMS is higher than the overcurrent threshold.

Maximum re-strike/re-ignition correction alarm

As explained in [Section 12.18.7.13.2](#), *ACBMSCBR* adapts to re-strikes/re-ignitions till the correction limit is reached. Upon encountering the maximum correction limit with an enabled *MaxReStrCorrAlm* setting, the *ALMAXRCLX* output is activated. This output remains high till the re-strike/re-ignition correction is manually cleared.

Mechanical health alarm

After completion of every switching operation, ACBMSCBR checks the final status of the connected auxiliary contacts against the switching operation type (Close or Open). The result is given at the MECHHOLX output. [Table 284](#) presents the logic table for assessing the circuit breaker's mechanical health.

Table 284: Circuit breaker mechanical health derived from status of auxiliary contacts after operation

Operation type	AuxPosAvailable	MechMonitor	INPNOLX	INPNCLX	MECHHOLX
Close	NO and NC/ NC only	Enable	0	1	Alarm
Close	NO and NC/ NO only	Enable	1	0	OK
Close	NO and NC	Enable	0	0	Warning
Close	NO and NC	Enable	1	1	Alarm
Open	NO and NC/ NO only	Enable	1	0	Alarm
Open	NO and NC/ NC only	Enable	0	1	OK
Open	NO and NC	Enable	0	0	Warning
Open	NO and NC	Enable	1	1	Alarm
X	X	Disable	X	X	OK
X	None	X	X	X	OK

Contradicting CB positions alarm

ACBMSCBR detects a contradictory position whenever the circuit breaker appears electrically conducting although it is mechanically open. This is evaluated from the selected electrical feedback signal and available auxiliary contacts, as per [Table 271](#). If *ContradPosAlm* is set to "Enable" and *CBSTSLX* = "EI close mec open" for more than 100 ms, the *CNTPOSOLX* output is activated; it remains active as long as this contradicting condition persists.

Ablation alarm and warning

ACBMSCBR compares the cumulated contact ablation (*ABLSUMLX*, see [Section 12.18.7.14](#)) with different thresholds to raise alarms and warnings.

An ablation-based alarm is raised by activating the *ALABLLX* output whenever *AblationAlm* is enabled and

$ABLSUMLX > AblationAlarmLevel$

Similarly, an ablation-based warning is raised by activating the *WRABLLX* output whenever *AblationAlm* is enabled and

$ABLSUMLX > AblationWarnLevel$

The alarm and warning outputs remain high till the cumulated ablation is manually reset or the limits are increased above the cumulated ablation value.

Out-of-limit operation count alarm

A CB switching operation is declared out-of-limit if one of the monitored values exceeds an alarm threshold. This information is taken from the *ALMS1T5A*, *ALMS6T10A*, and *ALMS6T10B* coordination inputs.

The coordination inputs comprise alarm status for all three phases. Depending on the system phase to which an ACBMSCBR instance is assigned, it extracts the relevant information for that phase only. [Table 285](#) lists the bit combinations that are interpreted as out-of-limit operation for the respective phase.

Table 285: Coordination signal values interpreted as out-of-limit operation

Input	'Out-of-limit' L1		'Out-of-limit' L2		'Out-of-limit' L3	
	Bit Number	Value	Bit Number	Value	Bit Number	Value
ALMS1T5A	Bit 0	1	Bit 2	1	Bit 4	1
	Bit 1	0	Bit 3	0	Bit 5	0
	OR		OR		OR	
	Bit 6	1	Bit 8	1	Bit 10	1
	Bit 7	0	Bit 9	0	Bit 11	0
	OR		OR		OR	
	Bit 12	1	Bit 14	1	Bit 16	1
	Bit 13	0	Bit 15	0	Bit 17	0
	OR		OR		OR	
	Bit 18	1	Bit 20	1	Bit 22	1
	Bit 19	0	Bit 21	0	Bit 23	0
	OR		OR		OR	
	Bit 24	1	Bit 26	1	Bit 28	1
	Bit 25	0	Bit 27	0	Bit 29	0
	OR		OR		OR	
ALMS6T10A	Bit 0	1	Bit 2	1	Bit 4	1
	Bit 1	0	Bit 3	0	Bit 5	0

Each out-of-limit operation increments an internal counter. If the counter value exceeds the *OperationsMon* threshold and *OperWithAlm* is "Enabled", the function will raise an alarm on the OPERWALLX output. This output is activated for only one task cycle.

General alarm

This functionality raises a general alarm ALOUTLX whenever either ALMAXRRLX, ALOPTMLX, ALABLLX or ALOPCNTLX is activated and the setting *OutAlm* is enabled.

12.18.7.19 Reset logic

For many monitoring functions, ACBMSCBR can reset the internal status by clearing the old values and re-starting the respective algorithm.

If the operating environments change, for example the circuit breaker has undergone maintenance or the IED is used to switch a different breaker, it is recommended to reset the internal values of accumulated parameters to avoid erroneous calculations. The clear or resetting options can be accessed through LHMI or WHMI by navigating to **Clear/Clear CB cond. indicators**.

The function provides the following reset features:

- Reset adaptive closing time correction
- Reset ablation
- Reset operation count
- Reset re-strike/re-ignition count
- Reset re-strike/re-ignition correction
- Reset unstable detection

Reset adaptive closing time correction

This function allows the user to flush the older correction values and restart the close adaptive corrections freshly. Upon receiving the positive edge of binary input **RESADCOMP (RESADCOMP**

binary input status changes from 0 to 1), the function resets the adaptive correction to zero. The result can also be observed on the output ADAPTCLX which gives a value of zero.

The adaptive closing time correction can be cleared through LHMI or WHMI by navigating to **Main menu /Clear / Clear CB cond. indicators /Clear adaptive comp .**

Reset ablation

The function allows the user to clear the old accumulated values of monitored ablation and restart the ablation calculation. The function resets the accumulated ablation, and assigns the value of *InitialCumAbl*, when function receives the positive edge of binary input **RESETABL** (**RESETABL** binary input status changes from 0 to 1). The result can also be observed on the output ABLSUMLX which gives the value of *InitialCumAbl*.

The resetting of ablation values can also be accessed through LHMI or WHMI by navigating to **Main menu /Clear / Clear CB cond. indicators /Clear CB wear .**

Reset operation count

The function allows the user to clear the old operation counts and restart the operation count freshly. The function resets the open-close operation count (OPRCNTRST) and assigns the value of *InitialOpCnt*, accumulated in-sync operation count for open (INOPCNOLX) and accumulated in-sync operation count for close (INOPCNCLX) setting the value to zero, when function receives the positive edge of binary input **RESETOPCNT** (**RESETOPCNT** binary input status changes from 0 to 1).

The operation count can also be cleared through LHMI or WHMI by navigating to **Main menu /Clear/ Clear CB cond. indicators /Clear operation count.**

Reset re-strike/re-ignition count

The function allows the user to clear the old detected operation counts of re-strike/re-ignition and restart the count. The function resets the accumulated operation counts of re-strike or re-ignition (**RTKCTLX**) to zero, when **RESRCNT** is activated.

The re-strike or re-ignition count can also be cleared through LHMI or WHMI by navigating to **Main menu /Clear/ Clear CB cond. indicators /Clear restrike count .**

Reset re-strike/re-ignition correction

This function allows the user to remove the older correction values and restart the adaptive correction for CB open operations. The function resets the re-strike or re-ignition correction to zero when function receives the positive edge of binary input **RESRESTR** (**RESRESTR** binary input status changes from 0 to 1).

The result can also be observed on the output ADAPTOPLX which gives a value of zero.

The re-strike/re-ignition correction can also be cleared through LHMI or WHMI by navigating to **Main menu /Clear / Clear CB cond. indicators /Clear restrike correction .**

Reset unstable detection

The function allows the user to clear the unstable detection of the breaker. The function resets the internal counter of inconsistent switching operations of the breaker when **RESETUNST** is activated. After resetting the CB instability, the output **UNSTOPOLX** is deactivated.

The unstable detection can also be cleared through LHMI or WHMI by navigating to **Main menu / Clear/ Clear CB cond. indicators /Clear unstable mode.**

12.18.7.20 Temperature handling logic

ACBMSCBR doesn't directly measure the temperature or evaluate any information related to temperature. It only includes an internal connection between the dedicated temperature input and output: The analog value of temperature received on the **TMPIN** input is directly forwarded to the **TMPOUT** output.

12.18.7.21 Learning active mode

ACBMSCBR enters "Learning active mode" when the binary input channel LERACTIVE is activated. This indicates the CB Learning commissioning mode for acquiring the mechanical operating times of the circuit breaker (see CBLEARN function). In this mode, most functionalities of ACBMSCBR are disabled and none of the input commands (CLCMDINP / CCLCMDLX / OPCMDINP / COPCMDLX) are considered. The disabled functionalities during the breaker learning mode are:

- Overcurrent detection (OVCURLX)
- Unstable operation detection (UNSTOPOLX)
- Re-strike detection, restrike count and maximum Re-strike/Re-ignition correction Alarm (RSTRDETLX, RTKCTLX)
- Ablation calculation (LOOPABLLX) with its alarm and warning
- Mechanical operating time Alarm (ALOPTMLX)
- General Alarm (ALOUTLX)
- Mechanical moving time (MCMOVTMLX, AUXSWTOLX and AUXSWTCLX)
- Arcing time (PARCTMLX, AARCTMLX)
- Electrical operating time (PELORTLX, PELORTCLX, PELORTOLX, AELORTMLX, AELORTCLX, AELORTOLX) and pre-strike angle (PPRESTRAX, APRESTRAX)
- Mechanical operating time (PMCORTLX, PMCORTCLX, PMCORTOLX, AMCOTMLX, AMCOTCLX and AMCOTOLX)
- Initial mechanical delay (ITMCDLLX, RCTTOPOLX, and RCTTCLOLX)
- Instantaneous value (LOOPILX), peak value (LOOPPILX) and RMS value (SWALX) of the interrupted current
- Inrush current peak evaluation (INRUSHPLX)

12.19 Operation log trigger generator OPLOGTRIG

12.19.1 Identification

Function description	IEC 61850 identification
Operation log trigger generator	OPLOGTRIG

12.19.2 Functionality (Application summary)

OPLOGTRIG function was specifically designed for application in point-on-wave controllers (PWC600). Its purpose is to trigger an operation record for every switching operation, to store relevant data pertaining to that operation. At the same time, it generates an "operation mode", which is a combined assessment of the circumstances and result of the switching operation in the three phases. Initial operations that are assessed as "Actual" are also stored as "fingerprint records". Finally, OPLOGTRIG provides interfaces for clearing operation records and fingerprint records.

12.19.3 Function block

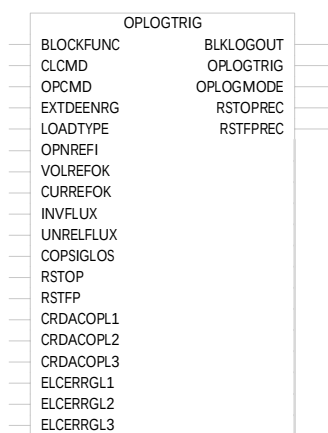


Figure 142: Function block diagram

12.19.4 Signals

12.19.5 Settings and parameters

12.19.6 Operation principle

OPLOGTRIG function can be enabled or disabled by the *Operation* setting.

The overall functionality of the OPLOGTRIG function is shown in [Figure 143](#).

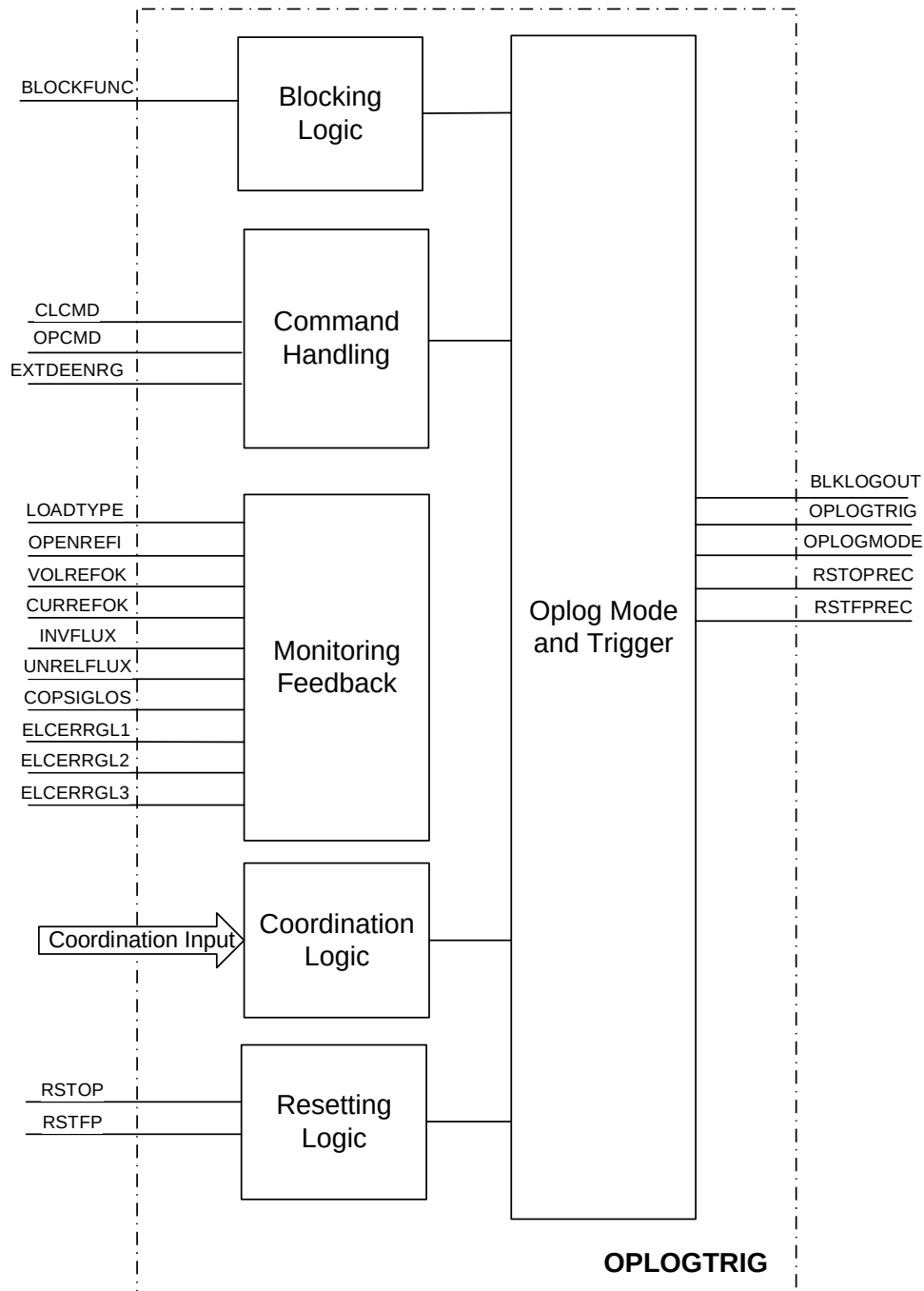


Figure 143: Overall block diagram of OPLOGTRIG

This function operates on the sub-functional aspects as described below.

12.19.6.1 Operation log trigger

After completion of a CB switching operation, OPLOGTRIG generates a trigger signal to OPERLOG by activating the OPLOGTRIG output for one task time. The conditions for trigger generation are summarized below.

- CLCMD or OPCMD input status change from 0 to 1 or coordination information of "External" operation received at any one CRDACOPLx input.
- Coordination information of "monitoring is completed for CB switching operation" is received for all three CRDACOPLx inputs. If this coordination information is not received for all three

CRDACOPLx inputs within 200 ms after it has been received for any one CRDACOPLx input, then oplog will be published from coordination information CRDACOPLx received for one or two phases.

- For open operation with Power transformer and Coupled transformer load types, oplog will be triggered after 1200 ms after receiving open command to ensure residual flux calculation is completed.

The CB operation type (Close or Open) and the operation time stamp are integrated in the OPLOGTRIG output signal for use by OPERLOG function.

12.19.6.2 Operation modes

Based on the feedback received from other functions, OPLOGTRIG generates a single operation mode and provides the same on its OPLOGMODE output. The oplog modes generated by the function are described in [Table 286](#). If multiple conditions are applicable, the mode with lowest number in the Order column is declared as Operation Log Mode.

Table 286: Operation modes

Order	Mode	Mode number	Description of conditions
1	Invalid Flux	1671	• Calculated residual fluxes are outside their expected range. • Invalid Flux is monitored using INVFLUX binary input.
2	Unreliable Flux	1672	• It is not possible to calculate a stable residual flux value due to non-negligible transformer limb voltage after de-energization. • Unreliable Flux is monitored using UNRELFUX binary input.
3	External deenergization without trip cmd	1666	• The load is deenergized by the operation of an upstream breaker, that is, load current or load voltage was switched off, but mechanical status is not changed for local circuit breaker. • External deenergization without trip cmd is detected when EXTDEENRG binary input is activated and external operation is detected via co-ordination input CRDACOPLx.
4	External Operation	1444	• When a CB operation is detected to be initiated externally, that is, the command is not issued from PWC600 but mechanical and/or electrical circuit breaker status change has been detected. • External operation is detected via co-ordination input CRDACOPLx.
5	Cancelled Operation	1446	• If there are time synchronizing issues, the PIO card may reject to operate the output commands at the specified release times and indicates this condition by Cancel signals. Please refer to the section on Time synchronization. • Cancel commands are monitored using the co-ordination input CRDACOPLx.
6	Operation Blocked	1451	• A controlled switching command was not executed due to blocking conditions. • Blocked operation command is monitored by co-ordination input CRDACOPLx.
7	Reference signal missing	1448	• When the command is received, the amplitude of the selected reference signal is too low. (Reference for close operation is always voltage and for open operations, this can be voltage or current) • Reference signal status is monitored using VOLREFOK, CURREFOK, OPNREFI binary inputs.

Table continues on next page

Order	Mode	Mode number	Description of conditions
8	N/A	1457	- When electrical status cannot be used (that is the applicable setting <i>FeedbackSigC</i> or <i>FeedbackSigO</i> in ACBMSCBR is selected as "None") and mechanical feedback is unavailable (either mechanical feedback is disabled OR mechanical feedback is enabled with no auxiliary contacts available). - This information is received via co-ordination input CRDACOPLx.
9	Redundant Operation	1473	- If a close command is received when the circuit breaker is already monitored in closed condition OR - If an open command is received when the circuit breaker is already monitored in open condition - The circuit breaker position is evaluated in the ACBMSCBR function and the indication of redundant operation is received by the OPLOGTRIG function via co-ordination input CRDACOPLx.
10	Failed Operation	1474	- When a command is issued and no feedback of mechanical or electrical status change is detected within 300ms (irrespective of the system frequency) from the time the output command is issued by the IED. - A failed operation is monitored by the function via co-ordination input CRDACOPLx.
11	CB in Intermediate Position with Alarm	1456	When the mode 1450 has electrical target error* alarms detected above the specified limits.
12	CB in Intermediate Position	1450	- When any operation is performed and after that electrical CB status and mechanical CB status are opposite to each other. - A CB intermediate position is monitored via co-ordination input CRDACOPLx.
13	CB Unstable with Alarm	1455	When the mode 1449 has electrical target error* alarms detected above the specified limits.
14	CB Unstable	1449	- When the mechanical operating times are inconsistent (varying by 10% over previous operating time) for two consecutive operations. - Close operations are compared to close operations only, and likewise for open operations. - This mode may be declared for several operations till the CBUnstable condition is reset. - A CB's unstable condition is monitored via co-ordination input CRDACOPLx.
15	Bypassed Operation	1443	- When the controlled switching commands to the CB are emitted without point-on-wave synchronization, all three phases simultaneously. - A bypassed operation is monitored via co-ordination input CRDACOPLx.
16	Re-ignition	1673	- When the difference between actual arcing time and predicted arcing time is more than 2 ms. - Reignition is monitored by the function via co-ordination input CRDACOPLx.
17	Reduced Accuracy Operation with Alarm	1453	When the mode 1442 has electrical target error* alarms detected above the specified limits.
Table continues on next page			

Order	Mode	Mode number	Description of conditions
18	Reduced Accuracy Operation	1442	- When any compensation is enabled but its sensor status is faulty. - Reduced accuracy operation is monitored by the COPSIGLOS input.
19	Actual Operation with Alarm	1452	When the mode 1441 has electrical target error* alarms detected above the specified limits.
20	Actual operation	1441	- When a controlled switching operation is monitored to have taken place as expected. An operation is actual when the circuit breaker is either electrically or mechanically monitored to have operated within 300 ms after the controlled commands are issued. - The operation is declared actual when none of the above conditions prevail.

* Electrical target error is defined as the difference between actual and predicted electrical operating times. OPLOGTRIG receives the target error ranges, resulting from comparing these errors against threshold values, at its ELCERRGLx inputs. If at least one of the error ranges has a value of 3 (hi-hi) or 4 (lo-lo), an operation mode with alarm is declared.

12.19.6.3 Fingerprint records trigger

Fingerprint records are records of initial "actual" switching operations, which are retained even if the maximum number of operation records has been exceeded and the oldest records are overwritten. The total number of fingerprint records is defined by *FPRecords*. The setting *FPRecMode* defines the number of fingerprint records by operation type (Close or Open): If "CombinedTotalRcrds" is selected, any number of C or O operations will be stored. With "EqualOpnClsRcrds", half of the database is reserved for closing operations and the other half for opening operations.

After first start-up of the IED, or after database clearing, each switching operation with "Actual" mode will be added until the limit of *FPRecords* has been reached. These initial records are stored both in the database for regular operations and in the one for fingerprint records. This is a background process and requires no further configuration.

12.19.6.4 Clearing operation records and fingerprint records

For clearing the database of operation records, the RSTOPREC output shall be connected to the CLROPLOG input of CLROPLOG function. This output is activated by activating the RSTOP input or through **Clear operation records** in the **Clear** menu of LHMI or WHMI.

For clearing the database of fingerprint records, the RSTFPREC output shall be connected to the CLRFPRCD input of CLROPLOG function. This output is activated by activating the RSTFP input or through **Clear fingerprint records** in the **Clear** menu of LHMI or WHMI.

The clearing outputs remain active as long as the corresponding binary inputs are active.

12.19.6.5 Function blocking

Activation of binary input BLOCKFUNC will block processing of any received information in OPLOGTRIG: No operation record or fingerprint records is triggered, and no operation mode is generated. This condition is indicated by output BLKLOGOUT, which remains active for the same time as BLOCKFUNC input.

12.20 Transformer residual flux evaluation TRAFOSWT

12.20.1 Identification

Function description	IEC 61850 identification
Transformer residual flux evaluation	TRAFOSWT

12.20.2 Functionality

To mitigate inrush currents, a power transformer is ideally energized at a phase angle where the dynamic flux (from the source voltage) matches the residual flux in the core. TRAFOSWT estimates the residual fluxes in the core(s) of a three-phase power transformer by integrating the voltage on the windings during de-energization. Based on the estimated residual fluxes and other parameters of the transformer and the power system, it provides optimal target making angles, for the next energization to the receiver functions.

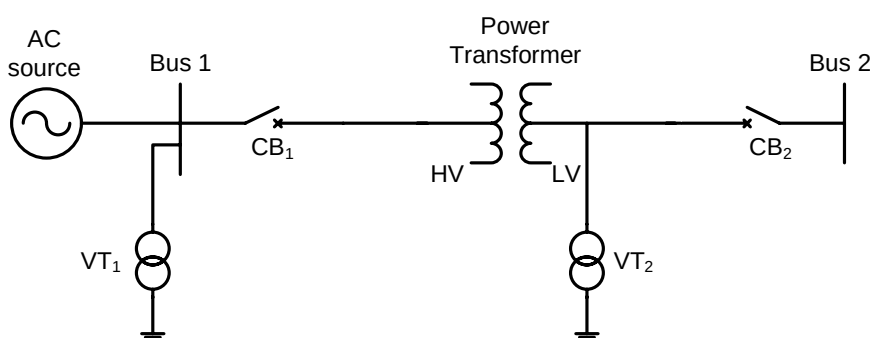


Figure 144: Example- single-line diagram of controlled switching system for power transformer

As an example, [Figure 144](#) shows a simple single-line diagram of a power system. A three-phase power transformer can be connected to the high voltage grid (represented by a three-phase AC source) through circuit breaker CB_1 . The source voltage is measured using VT_1 whereas VT_2 measures the load side voltage or the transformer LV side voltage. For controlled switching of the transformer, CB_2 is assumed open, that is, the LV side of the transformer is in no-load condition. When CB_1 is opened a certain residual magnetic flux will remain in each core of the transformer. Using the output signal of VT_2 , TRAFOSWT estimates the residual fluxes by numerical integration of the limb voltages. Based on these residual fluxes, the TRAFOSWT function provides switching angles for the next controlled closing operation.

12.20.3 Function block

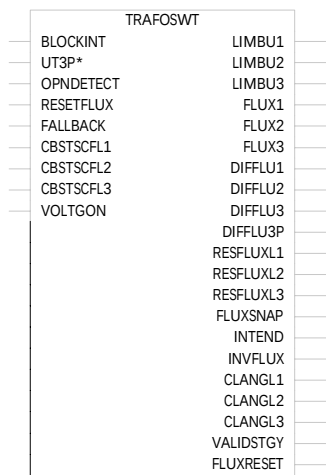


Figure 145: Function block diagram

* Denotes grouped input connections.

12.20.4 Signals

12.20.5 Settings and parameters

12.20.6 Monitored data

12.20.7 Operation principle

The TRAFOSWT function is active when the *Operation* setting is "On" and the BLOCKINT input is 0.

A block diagram of the TRAFOSWT function is shown in [Figure 146](#). The individual sub-functions are described below.

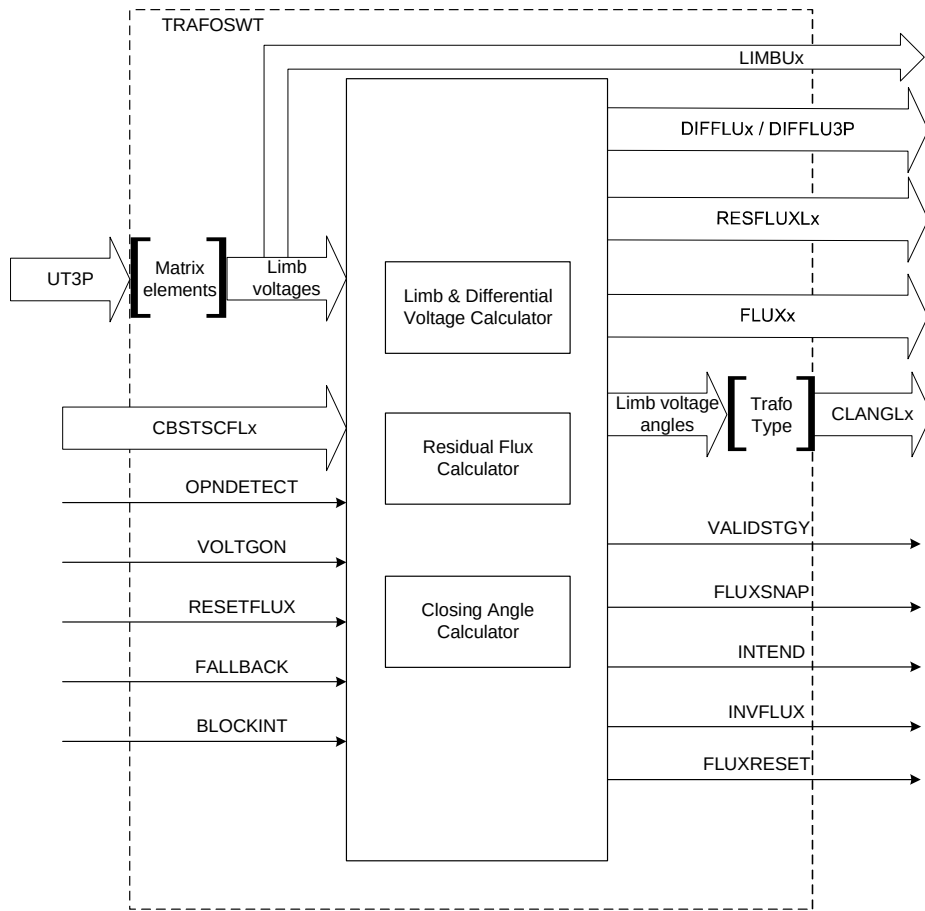


Figure 146: Overall block diagram of TRAFOSWT functionality

TRAFOSWT continuously reads the three-phase transformer load voltage samples from its UT3P input (usually received from SMAI, possibly through 3PHSELECT) and multiplies them by a conversion matrix (the matrix elements are usually obtained from SST) to obtain the respective limb voltages (elaborated in [Section 12.20.7.1](#)). The three calculated limb voltages are directly published for visualization (DREC) and combined into a group signal for accurate detection of making instants (ACBMSCBR). Upon activation of the CB opening indication, the function integrates the limb voltages to obtain the magnetic fluxes in the respective transformer core; the integrated voltage samples are also made available on analog outputs. The final integration values, taken after a specified integration time, are considered the residual fluxes. This integration method is elaborated in [Section 12.20.7.2](#). The function further evaluates target making or closing angles using the estimated residual fluxes as explained in [Section 12.20.7.3](#).

The next subsections describe the functionality of TRAFOSWT in detail.

12.20.7.1 Limb Voltage Conversion

The load voltages received at the UT3P input are grouped into vectors **UT** of three-phase concurrent samples. Each vector is multiplied by a conversion matrix **LimbVConv** to obtain the respective limb voltages,

$$\text{LIMBU} = \text{UT} \cdot \text{LimbVConv}$$

The coefficients of **LimbVConv** are taken from the *LimbVConvXY* settings; these values are derived considering the following parameters:

- transformer core type
- electrical configuration and grounding (vector group) of the transformer
- to which winding the load VT is connected
- electrical configuration of the load VT

The required calculations for most common transformer configurations are described in the PWC600 User Manual and are implemented in the Switchsync Setting Tool (SST).

The resulting streams of limb voltage samples are published at the outputs LIMBU1, LIMBU2, and LIMBU3. Internally, these limb voltages are normalized to p.u. using *UBase* setting (selected by *GlobalBaseSel*), for calculating the residual fluxes in the next step.

Most power transformers have coupling between the phases, either through a delta winding (electrical coupling) or through a three-limb core (magnetic coupling). Due to this inter-phase coupling, energization of the first phase causes voltage to appear also in the other phase(s) although the respective CB poles are still not closed. This makes it difficult to detect the actual making instant in the later phase(s) to close. However, as the three voltages sum up to zero it is possible to detect the later making instants from a suitable algebraic combination of limb voltages. In TRAFOSWT, the *TrafoType* setting determines the appropriate combination as listed in [Table 287](#).

Table 287: Differential limb voltage signal outputs

Switch Case	Description	Differential voltage outputs		
		DIFFLU1	DIFFLU2	DIFFLU3
1	Yn, non-coupled	LIMBU1	LIMBU2	LIMBU3
2	Yn, coupled	$(\text{LIMBU1} - \text{LIMBU2})/\sqrt{3}$	$(\text{LIMBU3} - \text{LIMBU1})/\sqrt{3}$	$(\text{LIMBU2} - \text{LIMBU3})/\sqrt{3}$
3	Y, coupled/non-coupled	LIMBU1	LIMBU2	LIMBU3
4	D, 30° (D1)	$(\text{LIMBU2} - \text{LIMBU3})/\sqrt{3}$	$(\text{LIMBU1} - \text{LIMBU2})/\sqrt{3}$	$(\text{LIMBU3} - \text{LIMBU1})/\sqrt{3}$
5	D, 330° (D11)	$(\text{LIMBU1} - \text{LIMBU2})/\sqrt{3}$	$(\text{LIMBU2} - \text{LIMBU3})/\sqrt{3}$	$(\text{LIMBU3} - \text{LIMBU1})/\sqrt{3}$
6	D, 210° (D7)	$(\text{LIMBU2} - \text{LIMBU3})/\sqrt{3}$	$(\text{LIMBU1} - \text{LIMBU2})/\sqrt{3}$	$(\text{LIMBU3} - \text{LIMBU1})/\sqrt{3}$
7	D, 150° (D5)	$(\text{LIMBU1} - \text{LIMBU2})/\sqrt{3}$	$(\text{LIMBU2} - \text{LIMBU3})/\sqrt{3}$	$(\text{LIMBU3} - \text{LIMBU1})/\sqrt{3}$
8	Z, 30° (Z1)	LIMBU1	LIMBU3	LIMBU2
9	Z, 330° (Z11)	LIMBU1	LIMBU2	LIMBU3

The differential limb voltages are provided at the outputs DIFFLU1, DIFFLU2 and DIFFLU3. The three-phase grouped signal for the same is the DIFFLU3P output.

12.20.7.2 Residual Flux Calculator

Estimation of residual fluxes (integration over fixed window)

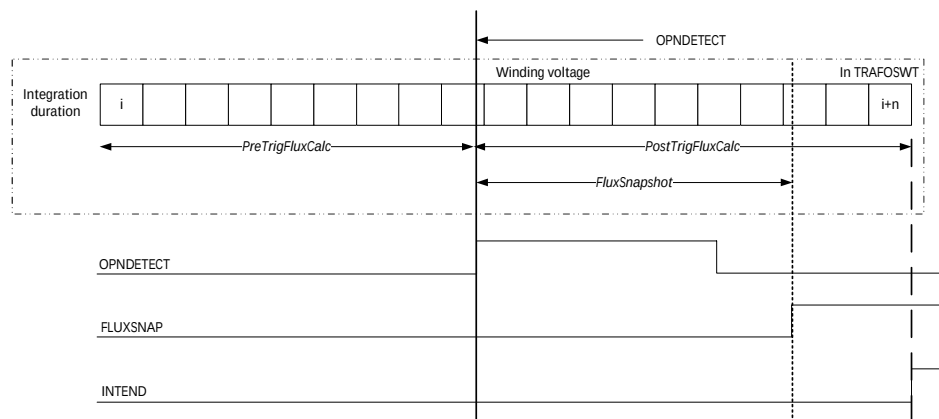


Figure 147: Residual Flux Estimation Cycle

TRAFOSWT continuously keeps the latest limb voltage samples in a buffer of size *PreTrigFluxCalc*. Upon activation of the OPNDETECT input the function identifies the amplitude and the first suitable voltage peak in each phase, starting from the oldest samples in the buffer. From there, it numerically integrates the limb voltage samples (in p.u.), for a settable duration determined by *PreTrigFluxCalc* + *PostTrigFluxCalc*. During that time, status changes of OPNDETECT are ignored.

The resulting limb fluxes are published at the FLUX1, FLUX2, FLUX3 outputs, which can be connected to an analog disturbance recorder. As the integration runs synchronous to the acquisition of new samples, the FLUX1/2/3 outputs appear delayed by *PreTrigFluxCalc* with respect to the real-time primary voltage and current signals.

The setting *PreTrigFluxCalc* defines the number of cycles to be considered for integration prior to activation of OPNDETECT, whereas *PostTrigFluxCalc* defines the number of cycles to be considered for integration post OPNDETECT activation.

The function then takes a snapshot of the estimated fluxes at the *FluxSnapshot* timestamp. This setting defines the instant at which the flux values are to be averaged and sent out for further calculation or analysis, from the point at which OPNDETECT input is detected as shown in [Figure 147](#).

The estimated flux values of the final power cycle (at *FluxSnapshot* timestamp) are provided at the outputs RESFLUXL1, RESFLUXL2 and RESFLUXL3 (individually calculated for each phase). These residual fluxes are stored inside the function in non-volatile memory for making them available even if the IED reboots.

At *FluxSnapshot* time after OPNDETECT activation, the function activates the binary output FLUXSNAP for a duration of *PreTrigFluxCalc*. When the function reaches the end of this *PostTrigFluxCalc* duration, binary output INTEND is activated and remains active for *PreTrigFluxCalc* duration.



Activating BLOCKINT input results in a different behavior of the function. This has been elaborated in [Section 12.20.7.7](#).



If there is a chance that the original source of the load voltage signal may change in service (for example, through 3PHSELECT), the application should ensure that no integration is triggered during the transition period. In the mentioned example, this can be achieved by feeding the BLOCKOUT signal of 3PHSELECT to the BLOCKINT input of TRAFOSWT. If any integration is ongoing, it will be completed before BLOCKINT takes effect. Refer to [Section 12.20.7.7](#) for more details.

Validity of Estimated Residual Fluxes

After taking the snapshot, TRAFOSWT performs a plausibility check on the estimated residual fluxes. The calculated flux after de-energization (taken at the *FluxSnapshot* setting) should not exceed the peak of the flux before de-energization. If this condition gets violated in any phase, a binary output INVFLUX is activated. If the condition doesn't get violated, a binary output VALIDSTGY is activated. The calculated residual flux values are still published in such a condition.

In case of the activation of VOLTGON binary input, the function retains the previous state of INVFLUX output whereas the output VALIDSTGY is reset to 0.

Table 288: Activation of VALIDSTGY and INVFLUX

$I_{RESFLUX} > \Phi_{peak}$	VOLTGON	FALLBACK	VALIDSTGY	INVFLUX
Y	0	0	1	0
N	0	0	0	1
X	X	1	0	Previous state
X	1	X	0	Previous state

where, Φ_{peak} is the peak of the dynamic flux in the individual phase.

These outputs remain active until the next activation of OPNDETECT. Before the first transformer de-energization evaluated by this function and with no retained values, both binary outputs are 0. Also, when the transformer is energized, that is, VOLTGON = 1, INVFLUX retains its previous state, whereas VALIDSTGY is reset to 0.

12.20.7.3 Closing Angle Calculator

Based on the residual fluxes estimated in [Section 12.20.7.2.1](#), TRAFOSWT calculates the ideal target making angles for controlled energization of the transformer. Since the residual fluxes estimated in the mentioned section are based on the limb voltages, the function first needs to map these fluxes from the limb voltages onto the source voltages based on which the switching angles are defined. The necessary calculations are predefined in the function for each specific winding configuration, which is selected through the *TrafoType* setting as per [Table 289](#). The making angles for each phase are obtained by performing a sine inverse on the respective estimated residual fluxes.

Table 289: Transformer types

<i>TrafoType</i>	Switched Winding Type with neutral grounding	Electrically or magnetically coupled?	Phase Angle
Yn non-coupled	Star with grounded neutral	No	-
Yn coupled	Star with grounded neutral	Yes	-
Y	Star with ungrounded neutral	No	-
D1	Delta	Yes	+30° (D1)
D11	Delta	Yes	-30° (D11)
D7	Delta	Yes	-150° (D7)
Table continues on next page			

<i>TrafoType</i>	Switched Winding Type with neutral grounding	Electrically or magnetically coupled?	Phase Angle
D5	Delta	Yes	+150° (D5)
Z1	Zig-zag with grounded neutral	-	+30°
Z11	Zig-zag with grounded neutral	-	-30°

The CLANGL1, CLANGL2 and CLANGL3 outputs provide the target making angles as per the closing targets definition of SSCPOW. Target angles will be re-calculated in case of IED reboot, when any of the residual flux values changes (including actual de-energization, manual reset), or upon change of *TrafoType*.

The default switching sequence is L1-L3-L2. In order to maintain this sequence in case of coupled phases, an additional delay is applied to the target making instant of the non-prestriking phase. The minimum delay is specified by the *NoPrestrikeDelay* setting.

12.20.7.4 Delayed Closing Strategy

After energizing the first limb of a coupled transformer, any residual flux in the remaining limbs will usually decay to negligible values ("equalize") within 1-2 cycles. This can be utilized in controlled switching by delaying the later energizing phases accordingly, which simplifies the making strategy. In TRAFOSWT, the *ClosingStrategy* setting determines whether to employ the "Delayed" closing strategy as explained above, or whether the three phases are energized with minimum delay from first to last phase ("Rapid" closing strategy). In case of "Delayed" strategy, the *HCycleDelay* setting specifies the minimum number of half cycles for delaying the later switching phase(s); it needs to be set to ensure flux equalization at the time of energizing these phases.

12.20.7.5 Fallback Strategy

The fallback strategy is a default switching strategy that is not based on the estimated residual fluxes. TRAFOSWT requests application of the fallback closing strategy, by clearing its VALIDSTGY output, when any of the following conditions is true.

1. Binary input FALLBACK is activated.
2. CBSTSCFL1 = CBSTSCFL2 = CBSTSCFL3 = 2 (the breaker is already in a closed position).
3. Binary output INVFLUX is activated.
4. Binary input BLOCKINT is activated.

If the function meets any one of the above-mentioned conditions, the closing angles calculated earlier are retained but VALIDSTGY output is cleared to indicate that the angles may not be valid.

12.20.7.6 Resetting Estimated Residual Flux

In case where the estimated residual fluxes are considered invalid, TRAFOSWT includes a provision to reset the residual fluxes to initial values. Upon activating the RESETFLUX input, the function performs the following updates:

1. RESFLUXL1/FLUX1 = *ResidualFluxLimb1*
2. RESFLUXL2/FLUX2 = *ResidualFluxLimb2*
3. RESFLUXL3/FLUX3 = *ResidualFluxLimb3*

A binary output FLUXRESET is activated whenever the flux is reset, for as long as the binary input RESETFLUX is active. This binary input (RESETFLUX) is also linked to the Clear menu (**Clear residual fluxes**) in LHMI and WHMI.

The residual fluxes stored during the previous open operation are reset to 0 when a positive edge of the binary input VOLTGON is detected by the function (VOLTGON binary input status changes from

0 to 1), indicating that the breaker is closed. Activation of VOLTGON clears the calculated residual fluxes, independent of BLOCKINT.

Once the residual fluxes are reset to the user defined values, the closing angles are recalculated and updated at the corresponding outputs. The binary output VALIDSTGY is also reset to 1 and INVFLUX is reset to 0 in this case.

12.20.7.7 Blocking the TRAFOSWT Function

The operation of TRAFOSWT function can be blocked by activating a binary input BLOCKINT. The purpose of this input is to block all the outputs of the function (both analog and binary). The priority of BLOCKINT in relation to other related functionalities can be seen from the list below, wherein the first item has highest priority.

1. De-energization is in progress, that is, the function is in the process of calculating residual fluxes and closing angles. This process is executed completely before responding to BLOCKINT input.
2. BLOCKINT input is activated. The residual fluxes, VALIDSTGY, INVFLUX and closing angles are retained when this input is activated. All the remaining outputs are set to their default values as a long as this input is active.
3. RESETFLUX is activated.

12.21 General function to map to GDE GFGDE

12.21.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
General function to map to GDE	GFGDE	-	-

12.21.2 Functionality

GFGDE is a general interface function for mapping the signals to measurand, breaker and isolator position, which indicates the symbol in the Graphical Display Editor (GDE) of PCM600 and displays it in LHMI. This function also supports the real-to-integer and integer-to-real conversion.

12.21.3 Function block

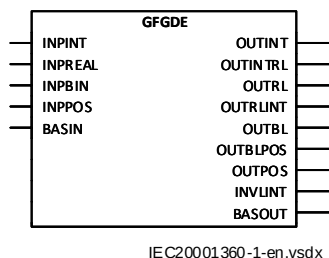


Figure 148: GFGDE function block

12.21.4 Signals

Table 290: GFGDE Input signals

Name	Type	Default	Description
INPINT	INTEGER	0	Integer input
INPREAL	REAL	0.0	Real input
INPBIN	BOOLEAN	0	Binary input
INPPPOS	INTEGER	0	Switch position input
BASIN	BOOLEAN	0	Input for loop connection with BAS_OUT

Table 291: GFGDE Output signals

Name	Type	Description
OUTINT	INTEGER	Integer output value derived from INPINT to map to measurand in GDE
OUTINTRL	REAL	Real output value derived from INPINT
OUTRL	REAL	Real output value derived from INPREAL to map to measurand in GDE
OUTRLINT	INTEGER	Integer output value derived from INPREAL
OUTBL	BOOLEAN	Boolean output value derived from INPBIN
OUTBLPOS	INTEGER	Position output value derived from INPBIN to map to breaker indication in GDE
OUTPOS	INTEGER	Position output derived from INPPPOS to map to breaker indication in GDE
INVLINT	BOOLEAN	Invalid OUTRLINT input value
BASOUT	BOOLEAN	Output for loop connection with BAS_IN

12.21.5 Settings

Table 292: GFGDE Non group settings (basic)

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

12.21.6 Operation principle

Output	Derived from input	GDE symbols supported	Application
OUTINT	INPINT	Measurand	Shows the integer values, for example, operation count in LHMI.
OUTINTRL		None	None
OUTRL	INPREAL	Measurand	Shows the real values, for example, breaker operation time, control voltage, and temperature in LHMI.
OUTRLINT		None	None

Table continues on next page

Output	Derived from input	GDE symbols supported	Application
OUTBL	INPBIN	None	None
OUTBLPOS		Breaker Indication only, Breaker2 Indication only	Shows the breaker or isolator position in LHMI when only NO/52a feedback is available. To use NC/52b for this purpose, invert it using the INVERTER function and connect to this input.
OUTPOS	INPPOS	Isolator Indication only, Isolator2 Indication only	Shows the breaker or isolator position in LHMI if the position information is directly available from other functions.

INVLINT is high if INPREAL is greater or lower than the integer value, which is handled by the function. Under such condition, OUTRLINT retains the maximum (4294967295) or the minimum (-4294967295) integer.

BASIN must be connected to BASOUT for proper operation of the function.

12.22 Circuit breaker operation time learning CBLEARN

12.22.1 Identification

Table 293: Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Circuit breaker contact operation time learning	CBLEARN	—	—

12.22.2 Functionality

This function provides semi-automatic learning of the mechanical closing and opening times of a circuit breaker's primary contacts and, optionally, auxiliary contacts. In addition, logical wiring errors are detected and reported during the learning process. This function learns the timing information of three phases of a circuit breaker independently, each of which may have its individual drive. When a switching command is received, it generates a request to SSCPOW function for sending the commands to the circuit breaker poles, and acquires the changeover times of the connected contacts accurately through precision binary inputs. The user has an option to accept or reject the results of each operation. Accepted results are averaged and made available for use in the controlled switching application.

For performing controlled switching and monitoring, the knowledge of the mechanical operating times, that is time from command until main contact touch/separation, of the circuit breaker is of prime importance. This information is required for determining the CB release instant in each phase from the target switching instant. While monitoring live switching operations, the timing information of auxiliary contacts (NO/52a and NC/52b) is used for estimation of primary contact timing. This function has the option to provide the other functions with either the default setting values or the learnt values (if learning has been performed at least once) at its output interfaces.

12.22.3 Function block

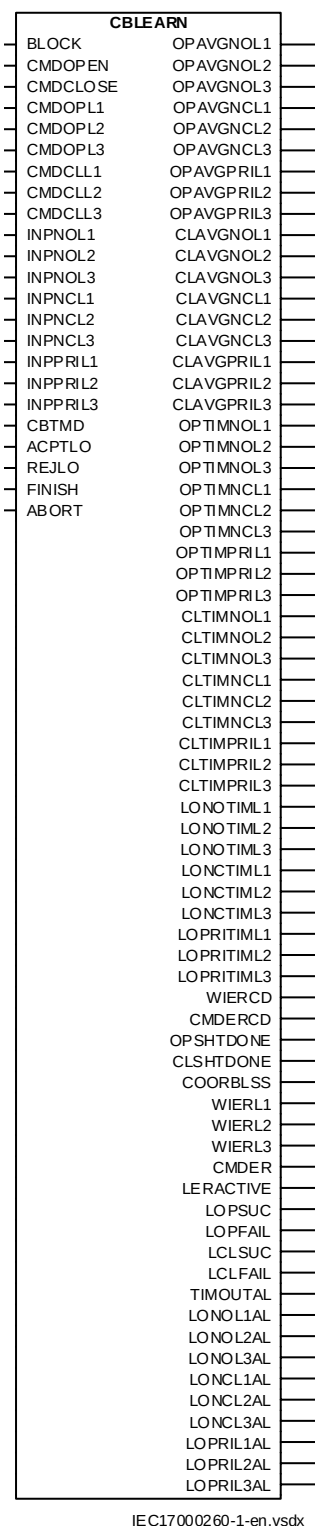


Figure 149: Function block

12.22.4 Signals

Table 294: CBLEARN Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of the function
CMDOPEN	BOOLEAN	0	Open command issued by user
CMDCLOSE	BOOLEAN	0	Close command issued by user
CMDOPL1	BOOLEAN	0	Open command input from SSCPOW for phaseL1
CMDOPL2	BOOLEAN	0	Open command input from SSCPOW for phaseL2
CMDOPL3	BOOLEAN	0	Open command input from SSCPOW for phaseL3
CMDCLL1	BOOLEAN	0	Close command input from SSCPOW for phaseL1
CMDCLL2	BOOLEAN	0	Close command input from SSCPOW for phaseL2
CMDCLL3	BOOLEAN	0	Close command input from SSCPOW for phaseL3
INPNOL1	BOOLEAN	0	NO contact feedback from circuit breaker phaseL1
INPNOL2	BOOLEAN	0	NO contact feedback from circuit breaker phaseL2
INPNOL3	BOOLEAN	0	NO contact feedback from circuit breaker phaseL3
INPNCL1	BOOLEAN	0	NC contact feedback from circuit breaker phaseL1
INPNCL2	BOOLEAN	0	NC contact feedback from circuit breaker phaseL2
INPNCL3	BOOLEAN	0	NC contact feedback from circuit breaker phaseL3
INPPRIL1	BOOLEAN	0	Primary contact feedback from circuit breaker phaseL1
INPPRIL2	BOOLEAN	0	Primary contact feedback from circuit breaker phaseL2
INPPRIL3	BOOLEAN	0	Primary contact feedback from circuit breaker phaseL3
CBTMD	BOOLEAN	0	Command input for activating CB test mode
ACPTLO	BOOLEAN	0	Accept the last operation and corresponding calculations
REJLO	BOOLEAN	0	Reject the last operation and corresponding calculations
FINISH	BOOLEAN	0	Finish the CB test mode and accept learnt values as final values
ABORT	BOOLEAN	0	Finish the CB test mode and reject learnt values

Table 295: CBLEARN Output signals

Name	Type	Description
OPAVGNOL1	REAL	Average value of NO contact operating time till the last accepted open operation for phaseL1
OPAVGNOL2	REAL	Average value of NO contact operating time till the last accepted open operation for phaseL2
OPAVGNOL3	REAL	Average value of NO contact operating time till the last accepted open operation for phaseL3
OPAVGNCL1	REAL	Average value of NC contact operating time till the last accepted open operation for phaseL1
OPAVGNCL2	REAL	Average value of NC contact operating time till the last accepted open operation for phaseL2
OPAVGNCL3	REAL	Average value of NC contact operating time till the last accepted open operation for phaseL3
OPAVGPRIL1	REAL	Average value of primary contact operating time till the last accepted open operation for phaseL1
Table continues on next page		

Name	Type	Description
OPAVGPRIL2	REAL	Average value of primary contact operating time till the last accepted open operation for phaseL2
OPAVGPRIL3	REAL	Average value of primary contact operating time till the last accepted open operation for phaseL3
CLAVGNOL1	REAL	Average value of NO contact operating time till the last accepted close operation for phaseL1
CLAVGNOL2	REAL	Average value of NO contact operating time till the last accepted close operation for phaseL2
CLAVGNOL3	REAL	Average value of NO contact operating time till the last accepted close operation for phaseL3
CLAVGNCL1	REAL	Average value of NC contact operating time till the last accepted close operation for phaseL1
CLAVGNCL2	REAL	Average value of NC contact operating time till the last accepted close operation for phaseL2
CLAVGNCL3	REAL	Average value of NC contact operating time till the last accepted close operation for phaseL3
CLAVGPRIL1	REAL	Average value of primary contact operating time till the last accepted close operation for phaseL1
CLAVGPRIL2	REAL	Average value of primary contact operating time till the last accepted close operation for phaseL2
CLAVGPRIL3	REAL	Average value of primary contact operating time till the last accepted close operation for phaseL3
OPTIMNOL1	REAL	Final average value of NO contact operating time for open operations for phaseL1
OPTIMNOL2	REAL	Final average value of NO contact operating time for open operations for phaseL2
OPTIMNOL3	REAL	Final average value of NO contact operating time for open operations for phaseL3
OPTIMNCL1	REAL	Final average value of NC contact operating time for open operations for phaseL1
OPTIMNCL2	REAL	Final average value of NC contact operating time for open operations for phaseL2
OPTIMNCL3	REAL	Final average value of NC contact operating time for open operations for phaseL3
OPTIMPRIL1	REAL	Final average value of primary contact operating time for open operations for phaseL1
OPTIMPRIL2	REAL	Final average value of primary contact operating time for open operations for phaseL2
OPTIMPRIL3	REAL	Final average value of primary contact operating time for open operations for phaseL3
CLTIMNOL1	REAL	Final average value of NO contact operating time for close operations for phaseL1
CLTIMNOL2	REAL	Final average value of NO contact operating time for close operations for phaseL2
CLTIMNOL3	REAL	Final average value of NO contact operating time for close operations for phaseL3
CLTIMNCL1	REAL	Final average value of NC contact operating time for close operations for phaseL1
CLTIMNCL2	REAL	Final average value of NC contact operating time for close operations for phaseL1
CLTIMNCL3	REAL	Final average value of NC contact operating time for close operations for phaseL3
Table continues on next page		

Name	Type	Description
CLTIMPRIL1	REAL	Final average value of primary contact operating time for close operations for phaseL1
CLTIMPRIL2	REAL	Final average value of primary contact operating time for close operations for phaseL2
CLTIMPRIL3	REAL	Final average value of primary contact operating time for close operations for phaseL3
LONOTIML1	REAL	NO contact operating time for last operation for phaseL1
LONOTIML2	REAL	NO contact operating time for last operation for phaseL2
LONOTIML3	REAL	NO contact operating time for last operation for phaseL3
LONCTIML1	REAL	NC contact operating time for last operation for phaseL1
LONCTIML2	REAL	NC contact operating time for last operation for phaseL2
LONCTIML3	REAL	NC contact operating time for last operation for phaseL3
LOPRITIML1	REAL	Primary contact operating time for last operation for phaseL1
LOPRITIML2	REAL	Primary contact operating time for last operation for phaseL2
LOPRITIML3	REAL	Primary contact operating time for last operation for phaseL3
WIERCD	INTEGER	Integer for indicating type of wiring error
CMDERCD	INTEGER	Integer for indicating type of command error
OPSHTDONE	INTEGER	Number of successful open shots performed
CLSHTDONE	INTEGER	Number of successful close shots performed
COORBLSS	INTEGER	Co-ordination output to SSCPOW to indicate the command
WIERL1	BOOLEAN	Indication for wiring error in phaseL1
WIERL2	BOOLEAN	Indication for wiring error in phaseL2
WIERL3	BOOLEAN	Indication for wiring error in phaseL3
CMDER	BOOLEAN	Indication for command error
LERACTIVE	BOOLEAN	Indication for CB test mode is active
LOPSUC	BOOLEAN	Indication for successful last open operation
LOPFAIL	BOOLEAN	Indication for unsuccessful last open operation
LCLSUC	BOOLEAN	Indication for successful last close operation
LCLFAIL	BOOLEAN	Indication for unsuccessful last close operation
TIMOUTAL	BOOLEAN	Signal time out for not receiving auxiliary contact or primary contact feedback
LONOL1AL	BOOLEAN	Alarm if NO contact operating time last operation for phaseL1 is not in the tolerance limit
LONOL2AL	BOOLEAN	Alarm if NO contact operating time last operation for phaseL2 is not in the tolerance limit
LONOL3AL	BOOLEAN	Alarm if NO contact operating time last operation for phaseL3 is not in the tolerance limit
LONCL1AL	BOOLEAN	Alarm if NC contact operating time last operation for phaseL1 is not in the tolerance limit
LONCL2AL	BOOLEAN	Alarm if NC contact operating time last operation for phaseL2 is not in the tolerance limit
LONCL3AL	BOOLEAN	Alarm if NC contact operating time last operation for phaseL3 is not in the tolerance limit

Table continues on next page

Name	Type	Description
LOPRIL1AL	BOOLEAN	Alarm if Primary contact operating time last operation for phaseL1 is not in the tolerance limit
LOPRIL2AL	BOOLEAN	Alarm if Primary contact operating time last operation for phaseL2 is not in the tolerance limit
LOPRIL3AL	BOOLEAN	Alarm if Primary contact operating time last operation for phaseL3 is not in the tolerance limit

12.22.5 Settings

Table 296: CBLEARN Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
DefaultNOOpTimeL1	1.0 - 200.0	ms	0.1	10.0	Default operating time of NO contact for open command for phaseL1
DefaultNOOpTimeL2	1.0 - 200.0	ms	0.1	10.0	Default operating time of NO contact for open command for phaseL2
DefaultNOOpTimeL3	1.0 - 200.0	ms	0.1	10.0	Default operating time of NO contact for open command for phaseL3
DefaultNCOpTimeL1	1.0 - 200.0	ms	0.1	10.0	Default operating time of NC contact for open operation for phase L1
DefaultNCOpTimeL2	1.0 - 200.0	ms	0.1	10.0	Default operating time of NC contact for open operation for phase L2
DefaultNCOpTimeL3	1.0 - 200.0	ms	0.1	10.0	Default operating time of NC contact for open operation for phase L3
DefaultPriOpTimeL1	1.0 - 200.0	ms	0.1	10.0	Default operating time of primary contact for open operation for phase L1
DefaultPriOpTimeL2	1.0 - 200.0	ms	0.1	10.0	Default operating time of primary contact for open operation for phase L2
DefaultPriOpTimeL3	1.0 - 200.0	ms	0.1	10.0	Default operating time of primary contact for open operation for phase L3
DefaultNOCITimeL1	1.0 - 200.0	ms	0.1	10.0	Default operating time of NO contact for Close operation for phaseL1
DefaultNOCITimeL2	1.0 - 200.0	ms	0.1	10.0	Default operating time of NO contact for Close operation for phaseL2
DefaultNOCITimeL3	1.0 - 200.0	ms	0.1	10.0	Default operating time of NO contact for Close operation for phaseL3
DefaultNCCITimeL1	1.0 - 200.0	ms	0.1	10.0	Default operating time of NC contact for Close operation for phaseL1
DefaultNCCITimeL2	1.0 - 200.0	ms	0.1	10.0	Default operating time of NC contact for Close operation for phaseL2
DefaultNCCITimeL3	1.0 - 200.0	ms	0.1	10.0	Default operating time of NC contact for Close operation for phaseL3
DefaultPriCITimeL1	1.0 - 200.0	ms	0.1	10.0	Default operating time of primary contact for close operation for phase L1
DefaultPriCITimeL2	1.0 - 200.0	ms	0.1	10.0	Default operating time of primary contact for open operation for phase L2
DefaultPriCITimeL3	1.0 - 200.0	ms	0.1	10.0	Default operating time of primary contact for open operation for phase L3
TimeOutAlarmDelay	1.0 - 1500.0	ms	1.0	500.0	Maximum time delay for status change of auxiliary & primary contacts after receiving input command

Table continues on next page

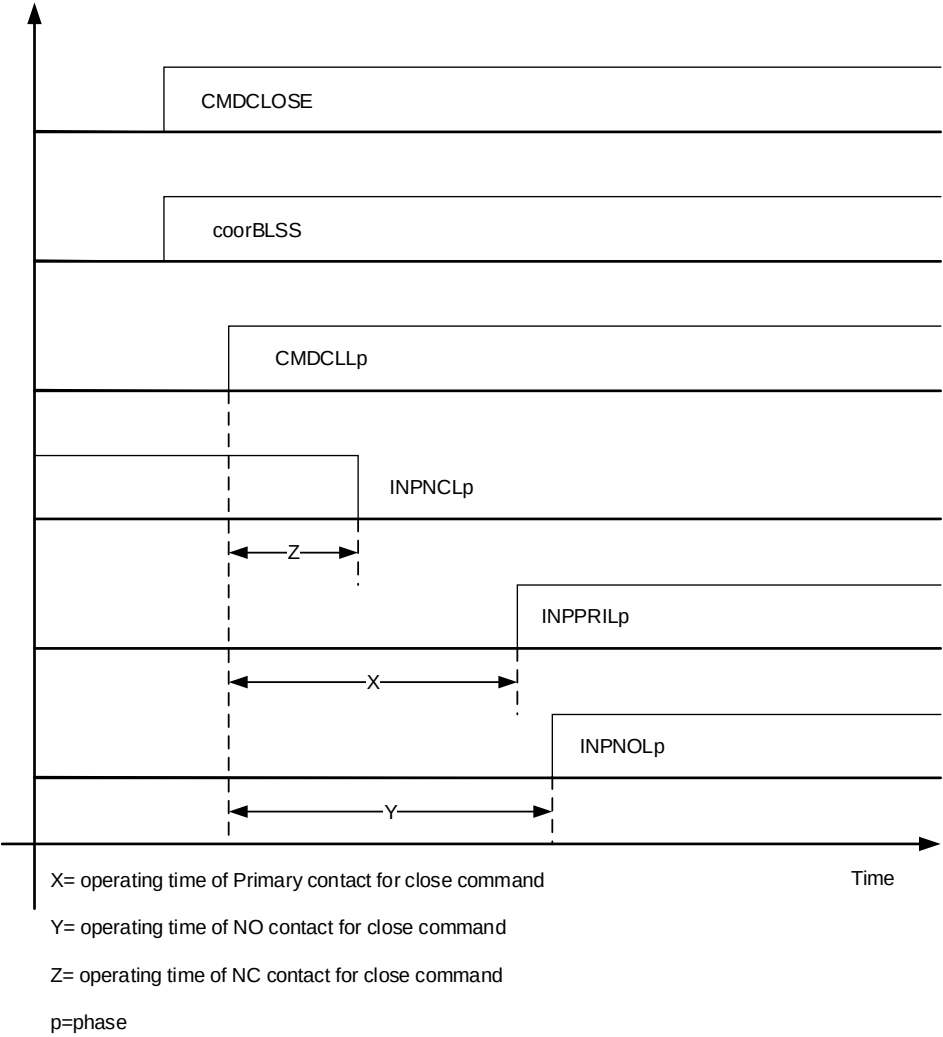
Name	Values (Range)	Unit	Step	Default	Description
Mode	Open Close Open & Close	-	-	Open & Close	Operation type selection (open/close/open and close)
BreakerType	SPO breaker TPO breaker	-	-	SPO breaker	Type of circuit breaker(single pole operated or single drive)
LearnNONC	MainOnly NO&Main NC&Main NO&NC&Main	-	-	MainOnly	Option for learning the auxiliary contacts operating time
AvgSetSel	setOPisCalcAvgValues setOPisDefaultValues	-	-	setOPisCalcAvgValues	Selection for final average outputs either learnt values or default set values

Table 297: CBLEARN Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
AlmTolRange	0.0 - 100.0	%	0.1	10.0	Tolerance for generating the last operation time alarms
AlmTolSetSel	AlmTolOnDefVal AlmTolOnAvgCalVal	-	-	AlmTolOnDefVal	Relative tol selection for last oper time alarms based on default set or calculated average values

12.22.6 Operation principle

This function is used to acquire the primary contacts' and optionally the auxiliary contacts' (NO/52a and NC/52b) timing information during CB test mode. CBLEARN receives the switching commands on its binary inputs and releases time staggered commands to the individual poles of the circuit breaker through SSCPOW function block. From the status changeover instants of primary and auxiliary contacts, CBLEARN calculates the switching times and detects command errors and wiring errors. Typical expected sequences of contact changeover, in each CB pole, are shown in [Figure 150](#) and [Figure 151](#).



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Figure 150: Expected sequence of contact status changes for closing one circuit breaker pole

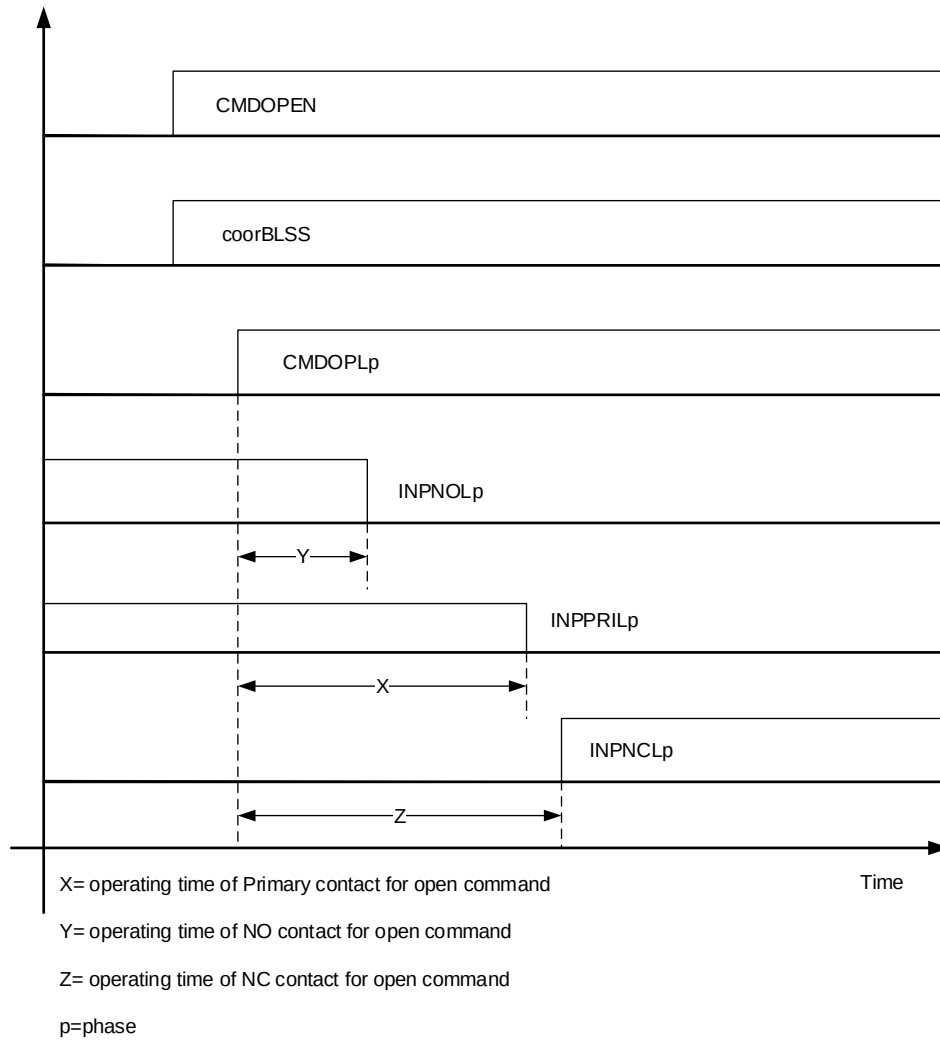


Figure 151: Expected sequence of contact status changes for opening one circuit breaker pole

CBLEARN can be activated from LHMI menu or by activating the CBTMD input. Once this trigger goes high, CBLEARN enters the learning mode (the LERACTIVE output becomes high) and it remains in this mode until FINISH or ABORT inputs are activated. In learning mode, CBLEARN interacts closely with the SSCPOW function block, as shown in [Figure 152](#).

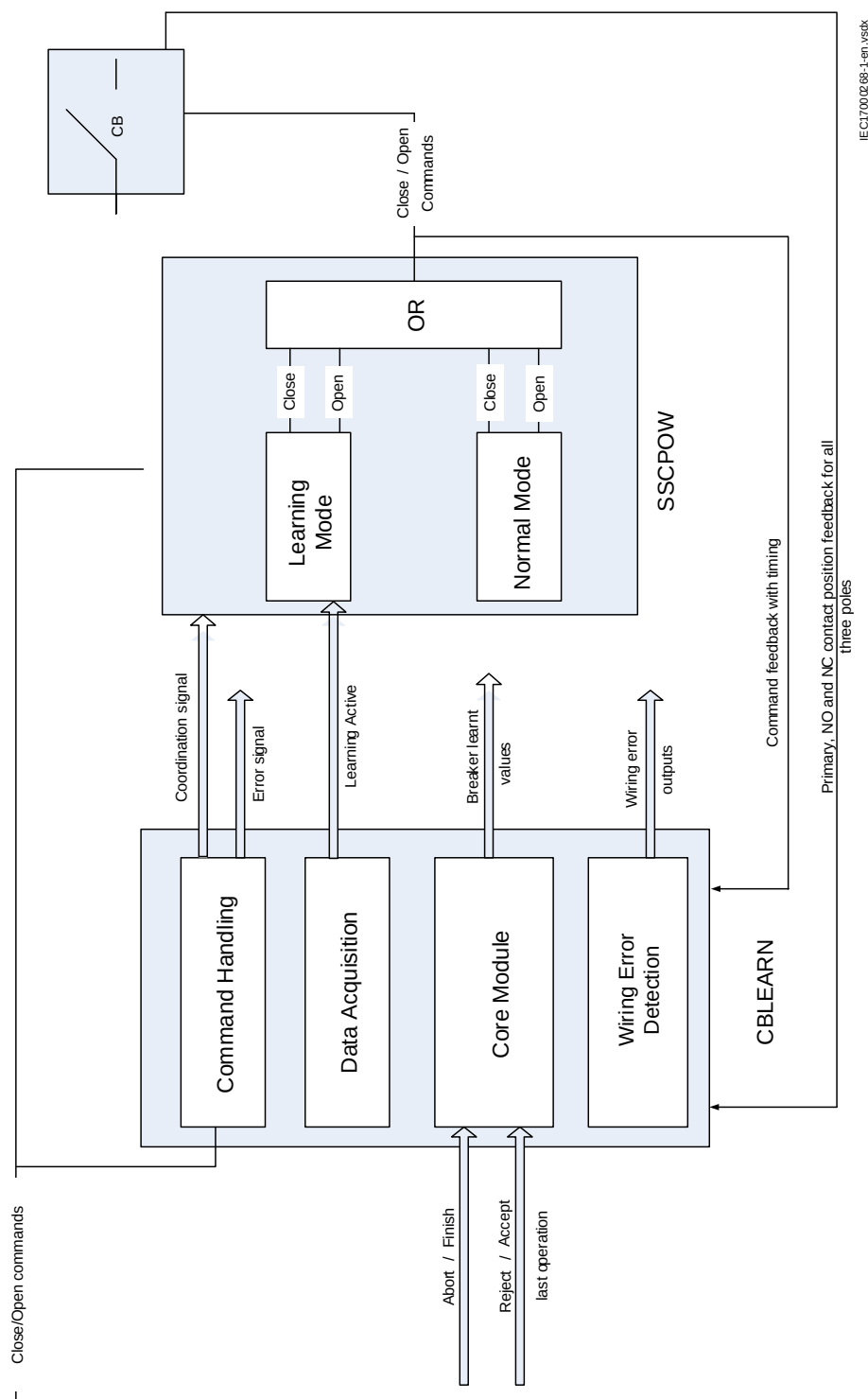


Figure 152: Signal flow diagram

12.22.6.1 Command handling logic

CBLEARN receives CB Close and Open and releases separate commands through SSCPOW function block to the three poles of the circuit breaker, as shown in [Figure 152](#). Circuit breaker pole

L1 is operated first, then L2, and finally L3. The time delay between poles is defined by the *TimeOutAlarmDelay* setting. It ensures that any cross cable interference or wiring mix up between phases can be reliably detected.

The function also detects static wiring errors, dynamic wiring errors and errors in command execution. These are described below.

Static wiring errors

When static wiring errors are detected, operation of the circuit breaker is not permitted until they are rectified. A static wiring error is detected if at least one of the following expectations is violated.

1. All 3 poles are either not open or closed simultaneously. If two poles are open and one pole is closed, the pole that is closed will be declared to have an error as it is not in agreement with the other two poles being open. The same applies vice versa if two poles are closed and one pole is open.
2. For any phase, if the primary contact is open it expects NO/52a to be open and NC/52b to be closed.
3. For any phase, if the primary contact is closed it expects NO/52a to be closed and NC/52b to be open.

CBLEARN checks the position of the breaker from the primary and auxiliary contacts. If the CB position of any phase has errors, the wiringError (WIERLX) signal of the corresponding phase is activated. The observed wiring errors and the corresponding error codes are shown in [Table 298](#).

Table 298: Wiring errors and corresponding error codes

Static wiring error in phase			Error Code for WIERCD	Numeric code of WIERCD
WIERL1	WIERL2	WIERL3		
0	0	0	NoWiringErr	0
1	0	0	WirErrL1	1
0	1	0	WirErrL2	2
0	0	1	WirErrL3	3
1	1	0	WirErrL1&L2	4
1	0	1	WirErrL1&L3	5
0	1	1	WirErrL2&L3	6
1	1	1	WirErrL1&L2&L3	7
Command issued to phase L1 or phase L2 or phase L3 but status changeovers are not received			WirErrStatChngeNR	Refer the table below
Command issued to one phase but status changeovers are observed in different phase(s)			WirErrStChOtherPh	

The indications for static wiring errors will remain active for as long as the unexpected status combination persists.

Dynamic wiring errors

Dynamic wiring errors are detected during the execution of the Open/Close commands. For example: If the command is released to phase L1, CBLEARN expects status changes of the primary and auxiliary contacts of phase L1 only. If no status changeover is observed within a set period, it declares a time-out alarm and dynamic wiring error in phase L1. The same is applied to detect wiring errors in phases L2 and L3. If an Open or Close command is issued to one phase but status changeovers are detected in another phase, CBLEARN issues a wiring error. Error codes for different types of wiring errors are explained in [Table 299](#).

Table 299: Wiring error codes

Command issued to phase	Status changeover observed			Description	WIERCD	wiringErrorStatus		
	L1	L2	L3			WIERL1	WIERL2	WIERL3
L1	No	No	No	Command issued to phase L1 but status changeovers are not received	8	1	0	0
L2	No	No	No	Command issued to phase L2 but status changeovers are not received	8	0	1	0
L3	No	No	No	Command issued to phase L3 but status changeovers are not received	8	0	0	1
L1	No	Yes	No	Command issued to phase L1 but status changeovers are observed in phase L2	9	1	1	0
L1	No	No	Yes	Command issued to phase L1 but status changeovers are observed in phase L3	9	1	0	1
L1	No	Yes	Yes	Command issued to phase L1 but status changeovers are observed in phases L3 and L2	9	1	1	1
L1	Yes	Yes	No	Command issued to phase L1 but status changeovers are observed in phases L1 and L2	9	1	1	0
L1	Yes	No	Yes	Command issued to phase L1 but status changeovers are observed in phases L1 and L3	9	1	0	1
L1	Yes	Yes	Yes	Command issued to phase L1 but status changeovers are observed in all three phases	9	1	1	1
L2	No	No	Yes	Command issued to phase L2 but status changeovers are observed in phase L3	9	0	1	1
L2	No	Yes	Yes	Command issued to phase L2 but status changeovers are observed in phases L2 and L3	9	0	1	1

The indications for dynamic wiring errors will remain active for one task time only.

Command Errors

Whenever CBLEARN receives an invalid command, CMDER is set high. The identified error is indicated on the CMDERCD output, see [Table 300](#).

Table 300: Command Error codes

Present state	Command received	Error code for CMDERCD	Description for CMDERCD
Breaker is Open	Open command	<i>CmdErrOpen</i>	Function received OPEN command from the user when CB is in open position
Breaker is Closed	Close command	<i>CmdErrClose</i>	Function received CLOSE command from the user when CB is in closed position
Close operation is in progress	Open command	<i>CmdErrOpenProg</i>	Function received OPEN command from the user when close operation of CB is still in progress
Table continues on next page			

Present state	Command received	Error code for CMDERCD	Description for CMDERCD
Open operation is in progress	Close command	<i>CmdErrCloseProg</i>	Function received CLOSE command from the user when open operation of CB is still in progress
Open operation is in progress	Open command	<i>NoCmdErr</i>	Command is ignored
Close operation is in progress	Close command	<i>NoCmdErr</i>	Command is ignored

The indications for command errors will remain active for one task time only.



During execution of a command in CB Test Mode, if for any phase, errors are detected, learning for the current operation is stopped and an emergency trip (instantaneous trip command to all three poles simultaneously) is issued. Identified errors are expected to be corrected before proceeding.

Commands are accepted until CB test mode is exited by activating ABORT or FINISH inputs.

12.22.6.2 Data acquisition logic

After the command request has been sent to SSCPOW, this block receives the actual command information sent to the circuit breaker from SSCPOW and waits for the update of main and auxiliary contact information. Upon receiving this information, the operating times can be evaluated.

12.22.6.3 Core logic

Core module is executed when data acquisition is successful following an open or close command from SSCPOW. Once the appropriate timing information has been evaluated for primary and auxiliary contacts, the core logic derives the actual switching times from command to NO/52a, NC/52b and Primary contact changeover, and makes them available on the outputs LONOTIMLX, LONCTIMLX, LOPRITIMLX (where LX is L1, L2 L3). At the same time the function increments the counter of operations performed.

If the acquired values are considered not to be correct, they can be discarded by activating the REJLO input. Once the REJLO command is received, CBLEARN discards the calculated temporary time values that correspond to the last operation and decrements the number of operations performed counter.

The calculated switching times from the last operation are accepted implicitly, by issuing a new switching command, or explicitly, by activating the ACPTLO input. Once a new switching command or the ACPTLO signal is received, the accepted values acquired thus far are averaged and presented at the outputs OPAVGNOLX, OPAVGNCLX, OPAVGPRILX and CLAVGNOLX, CLAVGNCLX, CLAVGPRILX for open and close respectively (where LX is L1, L2, or L3). If the average values are found satisfactory, CB test mode can be completed and exited by activating the FINISH input. Once FINISH is activated, CBLEARN exits CB test mode. Only when *AvgSetSel* has been set to "setOpsCalcAvgValues", the average values are presented at the outputs OPTIMNOLx, OPTIMNCLx, OPTIMPRILx and CLTIMNOLx, CLTIMNCLx, CLTIMPRILx for opening and closing respectively (where Lx is L1, L2, or L3).



Change *AvgSetSel* to "setOpsCalcAvgValues" only when CB test mode has been completed successfully!



To avoid loss of the calculated average values, make sure to keep the IED powered up for minimum 1 hour after completing CB test mode.

CB test mode can be aborted at any stage of learning by activating the ABORT input if the learning cannot be continued or the results are not satisfactory. In such a case the function discards the currently calculated average values and retains the set average outputs to either the previously learnt values (if available) or user-set values, depending on *AvgSetSel* setting.

Depending on the *Mode* selection, the function calculates the operating times of the auxiliary and primary contacts for the open command or close command or both. For example, if *Mode* is set to "Open only", only the operating times corresponding to the open command are evaluated and are updated at the corresponding average outputs. The average outputs for the close command follow the previously learnt values if available or user-set values otherwise.

Table 301: Selection of operating time values based on *Mode*

Mode	Open set average outputs OPTIMNOLX, OPTIMNCLX, OPTIMPRILX	Close set average outputs CLTIMNOLX, CLTIMNCLX, CLTIMPRILX
Open & Close	Learnt values	Learnt values
Open	Learnt values	Set values
Close	Set Values	Learnt values

Depending on the availability of auxiliary contacts, *LearnNONC* should be set to define the scope of learning as follows:

Table 302: Selection of auxiliary contacts for learning purpose

LearnNONC setting	Learn primary contacts	Learn NO (52a) auxiliary contacts	Learn NC (52b) auxiliary contacts
MainOnly	yes	no	no
NO&Main	yes	yes	no
NC&Main	yes	no	yes
NO&NC&Main	yes	yes	yes

Successful and unsuccessful operations

An operation is declared successful if status changes of auxiliary and primary contacts are detected for all the phase commands within a set time of *TimeOutAlarmDelay* after CMDOPX (for open operation) or CMDCLX (for close operation) information has been received from SSCPOW. Otherwise the operation is declared as failed. This is indicated externally on the LOPSUC, LCLSUC and LOPFAIL, LCLFAIL outputs, respectively, as shown in [Table 303](#) and [Table 304](#).

Table 303: Last opening operation type

Last opening operation type	LOPFAIL	LOPSUC
No open operation	0	0
Successful open operation	0	1
Unsuccessful open operation	1	0

Table 304: Last closing operation type

Last closing operation type	LCLFAIL	LCLSUC
No close operation	0	0
Successful close operation	0	1
Unsuccessful close operation	1	0

Last operation time alarms

The operation times of the last operation are compared against their expected values, which are either set values or calculated average values, depending on the *AlmTo/SetSel* setting. Refer [Table 305](#) for detailed description.

Table 305: Reference values for checking actual switching times ($X = L1 / L2 / L3$)

<i>AlmTo/SetSel</i> setting	Primary contact closing time	Primary contact opening time	NO (52a) closing time	NO (52a) opening time	NC (52b) closing time	NC (52b) opening time
<i>AlmToOnDefVal</i>	<i>DefaultPriCITimeX</i> setting	<i>DefaultPriOpTimeX</i> setting	<i>DefaultNOCITimeX</i> setting	<i>DefaultNOOpTimeX</i> setting	<i>DefaultNCCITimeX</i> setting	<i>DefaultNCOPTimeX</i> setting
<i>AlmToOnAvgCalVal</i>	CLAVGPRIX	OPAVGPRIX	CLAVGNOX	OPAVGNOX	CLAVGNCX	OPAVGNCX

Any deviation of more than *AlmTo/Range* from the expected value will raise an alarm. The only exception is the first operation when comparison to calculated average values (*AlmToOnAvgCalVal*) is selected:

Here, an alarm will be raised if the difference between phases exceeds the *AlmTo/Range* setting.

Section 13 Station communication

13.1 IEC 61850-8-1 communication protocol

13.1.1 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	-	-

13.1.2 Functionality

The IED supports the communication protocol IEC 61850-8-1. All operational information and controls are available through this protocol.

The IED is equipped with optical Ethernet rear port(s) for the substation communication standard IEC 61850-8-1. IEC 61850-8-1 protocol allows intelligent electrical devices (IEDs) from different vendors to exchange information and simplifies system engineering. Peer-to-peer communication according to GOOSE is part of the standard. Disturbance files downloading is provided.

Disturbance files (waveform files in Switchsync PWC600 terminology) are accessed using the IEC 61850-8-1 protocol. Disturbance files are also available to any Ethernet based application via FTP in the standard Comtrade format. Further, the IED can send and receive binary values, double point values and measured values (for example from MMXU functions), together with their quality bit, 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 and systems, and simultaneously reports events to five different clients on the IEC 61850 station bus.

The Denial of Service functions DOSLAN1 and DOSFRNT are included to limit the inbound network traffic. The communication can thus never compromise the primary functionality of the IED.

The event system has a rate limiter to reduce CPU load. The event channel has a quota of 10 events/second after the initial 30 events/second. If the quota is exceeded the event channel transmission is blocked until the event changes is below the quota, no event is lost.

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(s) (100BASE-FX).

The IED supports SNTP and IRIG-B time synchronization methods with a time-stamping accuracy of ± 1 ms.

- Ethernet based: SNTP
- With time synchronization wiring: IRIG-B

13.1.3 Communication interfaces and protocols

Table 306: Supported station communication interfaces and protocols

Protocol	Ethernet
	100BASE-FX LC
IEC 61850-8-1	•
HTTPS	•
• = Supported	

13.1.4 Settings

Table 307: IEC61850-8-1 Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off/On
PortSelGOOSE	Front LAN1	-	-	LAN1	Port selection for GOOSE communication
PortSelMMS	Front LAN1 Front+LAN1	-	-	LAN1	Port selection for MMS communication

13.1.5 Technical data

Table 308: Communication protocol

Function	Value
Protocol	TCP/IP (Ethernet)
Communication speed for the IEDs	100 Mbit/s
Protocol	IEC 61850-8-1
Communication speed for the IEDs	100BASE-FX

13.2 GOOSE binary receive GOOSEBINRCV

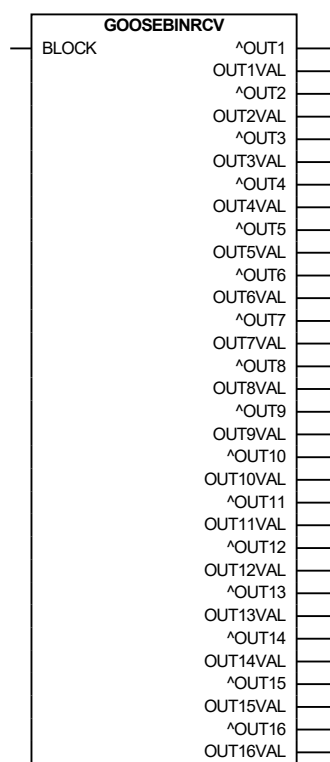
13.2.1 Identification

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

13.2.2 Functionality

GOOSEBINRCV is used to receive 16 binary values via IEC 61850 GOOSE messages.

13.2.3 Function block



IEC09000236_en.vsd

Figure 153: GOOSEBINRCV function block

13.2.4 Signals

Table 309: GOOSEBINRCV Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of output signals

Table 310: 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
OUT5	BOOLEAN	Binary output 5
OUT5VAL	BOOLEAN	Valid data on binary output 5

Table continues on next page

Name	Type	Description
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

13.2.5 Settings

Table 311: GOOSEBINRCV Non group settings (basic)

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

13.2.6 Operation principle

The OUTxVAL output will be 1 (high) if the incoming message contains valid data for channel x. In case of invalid data the OUTx output will be forced to 0 (low). In case of communication error the OUTx output will retain the last valid value.

13.3 GOOSE function block to receive a double point value GOOSEDPRCV

13.3.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
GOOSE function block to receive a double point value	GOOSEDPRCV	-	-

13.3.2 Functionality

GOOSEDPRCV is used to receive a double point value using IEC 61850 protocol via GOOSE.

13.3.3 Function block

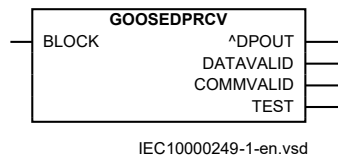


Figure 154: GOOSEDPRCV function block

13.3.4 Signals

Table 312: GOOSEDPRCV Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of function

Table 313: GOOSEDPRCV Output signals

Name	Type	Description
DPOUT	INTEGER	Double point output
DATAVALID	BOOLEAN	Data valid for double point output
COMMVALID	BOOLEAN	Communication valid for double point output
TEST	BOOLEAN	Test output

13.3.5 Settings

Table 314: GOOSEDPRCV Non group settings (basic)

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

13.3.6 Operation principle

DPOUT represents the double-point status (transmitted via IEC 61850 GOOSE message) of a switching element according to the following table.

DPOUT (integer value)	DPOUT (binary value)	Status
0	00	intermediate / unknown
1	01	off / open
2	10	on / closed
3	11	faulty

The DATAVALID output will be 1 (high) as long as the incoming message contains valid data. In case of invalid data DPOUT will be forced to 0.

The COMMVALID output will become 0 (low) when the subscribed GOOSE messages are not received as expected. In this case DPOUT will retain the last valid value.

The TEST output will be 1 (high) when the sending IED is in test mode.



The input of this GOOSE block must be linked in SMT to receive the double point values.



The implementation for IEC 61850 quality data handling is restricted to a simple level. If quality data validity is GOOD then the DATAVALID output will be HIGH. If quality data validity is INVALID, QUESTIONABLE, OVERFLOW, FAILURE or OLD DATA then the DATAVALID output will be LOW.

13.4 GOOSE function block to receive an integer value GOOSEINTRCV

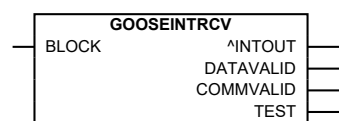
13.4.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
GOOSE function block to receive an integer value	GOOSEINTRCV	-	-

13.4.2 Functionality

GOOSEINTRCV is used to receive an integer value using IEC 61850 protocol via GOOSE.

13.4.3 Function block



IEC10000250-1-en.vsd

Figure 155: GOOSEINTRCV function block

13.4.4 Signals

Table 315: GOOSEINTRCV Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of function

Table 316: GOOSEINTRCV Output signals

Name	Type	Description
INTOUT	INTEGER	Integer output
DATAVALID	BOOLEAN	Data valid for integer output
COMMVALID	BOOLEAN	Communication valid for integer output
TEST	BOOLEAN	Test output

13.4.5 Settings

Table 317: GOOSEINTRCV Non group settings (basic)

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

13.4.6 Operation principle

The DATAVALID output will be 1 (high) as long as the incoming message contains valid data. In case of invalid data INTOUT will be forced to 0.

The COMMVALID output will become 0 (low) when the subscribed GOOSE messages are not received as expected. In this case INTOUT will retain the last valid value.

The TEST output will go HIGH if the sending IED is in test mode.



The input of this GOOSE block must be linked in SMT to receive the integer values.



The implementation for IEC 61850 quality data handling is restricted to a simple level. If quality data validity is GOOD then the DATAVALID output will be HIGH. If quality data validity is INVALID, QUESTIONABLE, OVERFLOW, FAILURE or OLD DATA then the DATAVALID output will be LOW.

13.5 GOOSE function block to receive a measurand value GOOSEMVRVCV

13.5.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
GOOSE function block to receive a measurand value	GOOSEMVRVCV	-	-

13.5.2 Functionality

GOOSEMVRVCV is used to receive a measured (analog) value using IEC 61850 protocol via GOOSE.

13.5.3 Function block

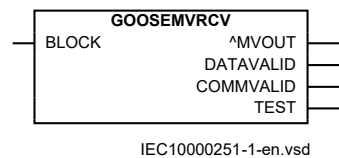


Figure 156: GOOSEMVRVCV function block

13.5.4 Signals

Table 318: GOOSEMVRVCV Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of function

Table 319: GOOSEMVRVCV Output signals

Name	Type	Description
MVOUT	REAL	Measurand value output
DATAVALID	BOOLEAN	Data valid for measurand value output
COMMVALID	BOOLEAN	Communication valid for measurand value output
TEST	BOOLEAN	Test output

13.5.5 Settings

Table 320: GOOSEMVRVCV Non group settings (basic)

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

13.5.6 Operation principle

The DATAVALID output will be 1 (high) as long as the incoming message contains valid data. In case of invalid data MVOOUT will be forced to 0.

The COMMVALID output will become 0 (low) when the subscribed GOOSE messages are not received as expected. In this case MVOOUT will retain the last valid value.

The TEST output will go HIGH if the sending IED is in test mode.



The input of this GOOSE block must be linked in SMT to receive the measurand values.



The implementation for IEC 61850 quality data handling is restricted to a simple level. If quality data validity is GOOD then the DATAVALID output will be HIGH. If quality data validity is INVALID, QUESTIONABLE, OVERFLOW, FAILURE or OLD DATA then the DATAVALID output will be LOW

13.6 GOOSE function block to receive a single point value GOOSESPRCV

13.6.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
GOOSE function block to receive a single point value	GOOSESPRCV	-	-

13.6.2 Functionality

GOOSESPRCV is used to receive a single point value using IEC 61850 protocol via GOOSE.

13.6.3 Function block

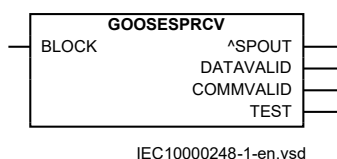


Figure 157: GOOSESPRCV function block

13.6.4 Signals

Table 321: GOOSESPRCV Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of function

Table 322: GOOSESPRCV Output signals

Name	Type	Description
SPOUT	BOOLEAN	Single point output
DATAVALID	BOOLEAN	Data valid for single point output
COMMVALID	BOOLEAN	Communication valid for single point output
TEST	BOOLEAN	Test output

13.6.5 Settings

Table 323: GOOSESPRCV Non group settings (basic)

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

13.6.6 Operation principle

The DATAVALID output will be 1 (high) as long as the incoming message contains valid data. In case of invalid data SPOUT will be forced to 0.

The COMMVALID output will become 0 (low) when the subscribed GOOSE messages are not received as expected. In this case SPOUT will retain the last valid value.

The TEST output will go HIGH if the sending IED is in test mode.



The input of this GOOSE block must be linked in SMT to receive the binary single point values.



The implementation for IEC 61850 quality data handling is restricted to a simple level. If quality data validity is GOOD then the DATAVALID output will be HIGH. If quality data validity is INVALID, QUESTIONABLE, OVERFLOW, FAILURE or OLD DATA then the DATAVALID output will be LOW

13.7 IEC 61850-9-2(LE) merging unit

13.7.1 Introduction

The IEC 61850-9-2 standard defines a process bus for transmitting sampled values of primary voltage and current signals over Ethernet. "LE" (Light Edition) is a commonly agreed implementation guideline, which defines a practical subset of IEC 61850-9-2 to allow straightforward implementation and application.

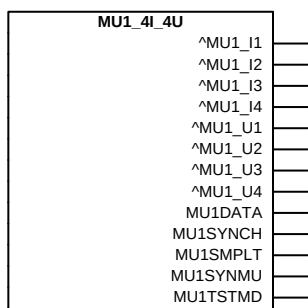
IEC 61850-9-2(LE) defines a logical device Merging Unit (MU). A MU collects up to four individual current and four voltage signals and merges them into a single data stream.

In the Switchsync PWC600 IED, sampled values streams from up to four MUs are received on the LAN2 A port of the communication interface module COM03. The application can access them as outputs of the MUX_4I_4U function blocks ($x = 1 \dots 4$) and use them in the same manner as analog inputs on a TRM or AIM card.

13.7.2 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
IEC 61850-9-2(LE) merging unit	MU1_4I_4U MU2_4I_4U MU3_4I_4U MU4_4I_4U	-	-

13.7.3 Function block



IEC17000228-1-en.vsd

13.7.4 Signals

Table 324: MU1_4I_4U Output signals

Name	Type	Description
MU1_I1	STRING	Analogue input I1
MU1_I2	STRING	Analogue input I2
MU1_I3	STRING	Analogue input I3
MU1_I4	STRING	Analogue input I4
MU1_U1	STRING	Analogue input U1
MU1_U2	STRING	Analogue input U2
MU1_U3	STRING	Analogue input U3
MU1_U4	STRING	Analogue input U4
MU1DATA	BOOLEAN	Fatal error, serious data loss
MU1SYNCH	BOOLEAN	MU clock not synchronized to same clock as IED
MU1SMPLT	BOOLEAN	Sample lost
MU1SYNMU	BOOLEAN	Synchronization lost in MU
MU1TSTMD	BOOLEAN	MU in test mode

13.7.5 Settings

Table 325: MU1_4I_4U Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
SVId	0 - 35	-	1	ABB_MU0101	MU identifier
SmplGrp	0 - 65535	-	1	0	Sampling group
CTStarPoint1	FromObject ToObject	-	-	ToObject	ToObject= towards protected object, FromObject= the opposite
CTStarPoint2	FromObject ToObject	-	-	ToObject	ToObject= towards protected object, FromObject= the opposite
CTStarPoint3	FromObject ToObject	-	-	ToObject	ToObject= towards protected object, FromObject= the opposite
CTStarPoint4	FromObject ToObject	-	-	ToObject	ToObject= towards protected object, FromObject= the opposite

Table 326: MU1_4I_4U Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
SynchMode	NoSynch Init Operation	-	-	Operation	Synchronization mode



MU2_4I_4U, MU3_4I_4U and MU4_4I_4U have the same settings as MU1_4I_4U.

13.7.6 Operation principle

A merging unit (MU) gathers sampled values of primary current and voltage signals from instrument transformers, electronic transducers, or both. The gathered data are transmitted to subscribers over the process bus, utilizing a process bus according to the IEC 61850-9-2(LE) specification.

The IED communicates with the MUs over the process bus via the LAN2 A port (X3) of the communication interface module. Only data streams sampled at 80 samples/cycle are accepted. In ACT, the MU appears as a function block (unlike an analog input module).

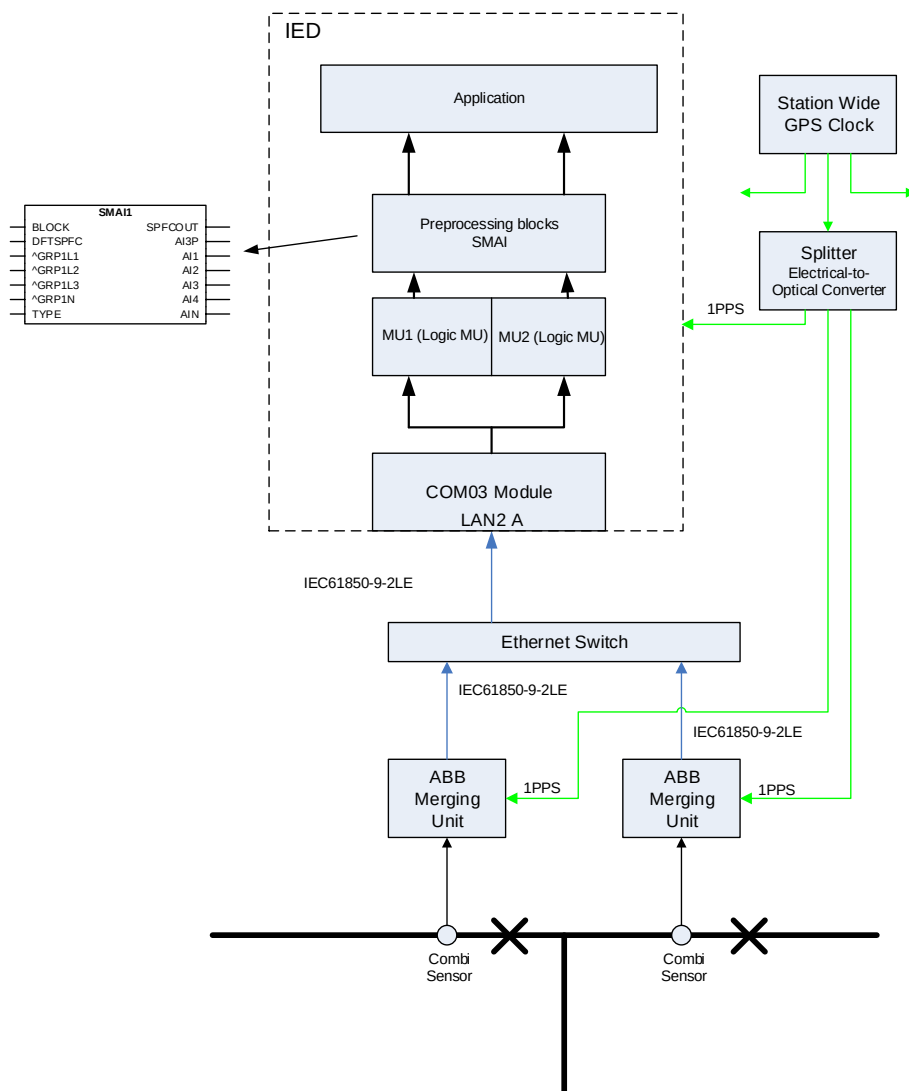


Figure 158: Example of signal path for sampled analog values from merging units via process bus IEC 61850-9-2LE with PPS synchronization

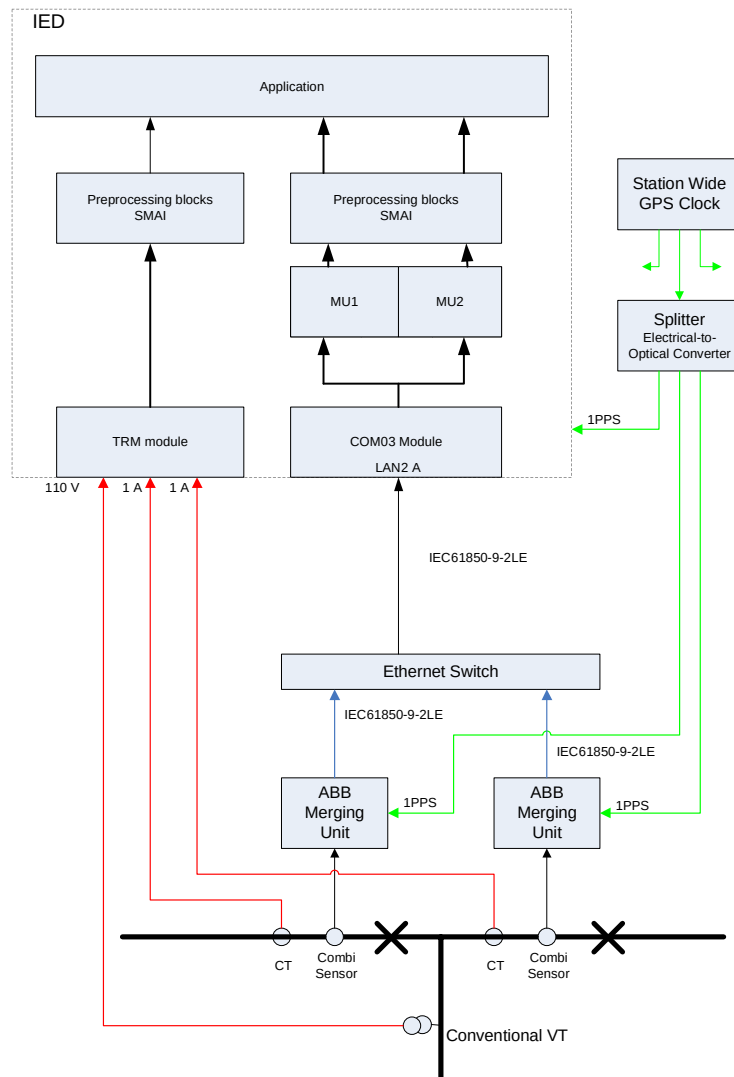


Figure 159: Example of signal path for sampled analog values from MU and conventional CT/VT

13.7.6.1 Signal identification

Up to four logical MUs can be connected to an IED on a single physical interface. The data streams from individual MUs are distinguished by the *SVId* (Sampled Values Identification) setting, which must be set identical to the *MsvId* data attribute of MSVCB01 in the MU.

The IEC 61850-9-2(LE) guideline specifies that the value of *SVId* shall comprise 10 characters and follow the convention "xxxxMUnn01". The portions "xxxx" and "nn" can be substituted by user-defined

strings, whereas “MU” and “01” are fixed and should not be changed. However, the MUX_4I_4U function blocks will work correctly also with less restrictive values of *SVId*.

The *SmpGrp* parameter is not used in the PWC600 implementation, keep it at default value 0.

Within a MU1_4I_4U function block, the assignment of sampled values streams (4 currents, 4 voltages) is fixed, as provided by the MU.

13.7.6.2 Time synchronization

Sampled values received over the process bus are time stamped. For synchronizing the signal processing in the IED to the incoming data stream, an external 1PPS signal shall be provided on the PPS Rx port (X10) of the communication interface module. Accuracy shall be class T4 ($\pm 4 \mu\text{s}$) or better.

Preferably, a GPS based clock source is used as master for generating a station-wide 1PPS clock for all merging units and receiving IEDs. This is particularly important when an IED may receive sampled values from more than one MU. Only if any IED is connected to just one MU then the MU may be used as clock master for the receiving IED(s).

The *SynchMode* parameter determines handling of the synchronization information in the datastream:

- When set to "NoSynch" it will not check the SmpSynch flag.
- When set to "Operation" it will always check the SmpSynch flag.
- "Init" should not be used.

See TIMESYNCHGEN for further information on time synchronization.

13.7.6.3 Alarm signals

Each MU function block has five binary alarm signal outputs.

- MUDATA: Indicates when sample sequence needs to be realigned, that is, the application needs to be restarted soon. The signal is raised for 2 seconds before the application is restarted.
- SYNCH: Indicates that the internal time synchronization quality is out of the set value from parameter TIMESYNCHGEN.*syncAccLevel* ("1 μs ", "4 μs " or "unspecified") and the parameter TIMESYNCHGEN.*AppSynch* is set to "Synch". If TIMESYNCHGEN.*AppSynch* is set to "NoSynch", the SYNCH output never goes high.
- SMPLT: Indicates that more than one sample has been lost or marked as invalid, overflowed or failed and the sample has thereafter been substituted.
- SYNMU: Indicates that the MU connected is not synchronized. Received from SmpSynch flag in datastream. No IED setting affects this signal.
- TSTMD: Indicates that the MU connected is in "Test Mode". Received from Test flag in datastream. No IED setting affects this signal.



In case of communication problems, all analog outputs will be forced to 0.0.



Connect the binary output signals, except for TSTMD, to the BLKSYNSW input of the SSCPOW function, for blocking controlled switching operations in case of communication problems. See the section on Controlled Switching & Monitoring.

13.7.6.4 Accuracy of power measurement functions

The power measurement functions (CVMMXN, CMMXU, VMMXU and VNMMXU) contain correction factors to account for the nonlinearity in the input circuits, mainly in the input transformers, when using direct analog connection to the IED.

The IED uses the same correction factors when feeding the IED with analog signals over IEC 61850-9-2(LE). Since the signals via IEC 61850-9-2(LE) are not subjected to the same nonlinearity errors, this causes an inaccuracy in the measured values.

For voltage signals, the correction factors are less than 0.05% of the measured value and no angle compensation, hence the impact on the reported value can be ignored.

For current signals, the correction factors cause a significant impact on the reported values at low currents. The correction factors are +2.4% and -3.6 degrees at signal levels below 5% of the set base current, +0.6% and -1.12 degrees at signal level 30% of the set base current and 0% and -0.44 degrees at signal levels above 100% of the set base current. Between the calibration points 5%, 30% and 100% of the set base current, linear interpolation is used.

13.7.7 Technical data

Table 327: IEC 61850-9-2LE communication protocol

Function	Value
Protocol	IEC 61850-9-2LE
Communication speed for the IEDs	100BASE-FX

13.8 Redundant station bus communication

13.8.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
System component for parallel redundancy protocol	PRPSTATUS	-	-

13.8.2 Functionality

Redundant station bus communication according to IEC 62439-3 Edition 2 is available as option in the IED. It uses both ports LAN1A and LAN1B on the COM03 module to connect to two redundant networks using Parallel Redundancy Protocol (PRP).

13.8.3 Function block

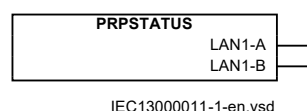


Figure 160: PRPSTATUS function block

13.8.4 Signals

Table 328: PRPSTATUS Output signals

Name	Type	Description
LAN1-A	BOOLEAN	LAN1 channel A status
LAN1-B	BOOLEAN	LAN1 channel B status

13.8.5 Setting parameters

The PRPSTATUS function has no user settings.

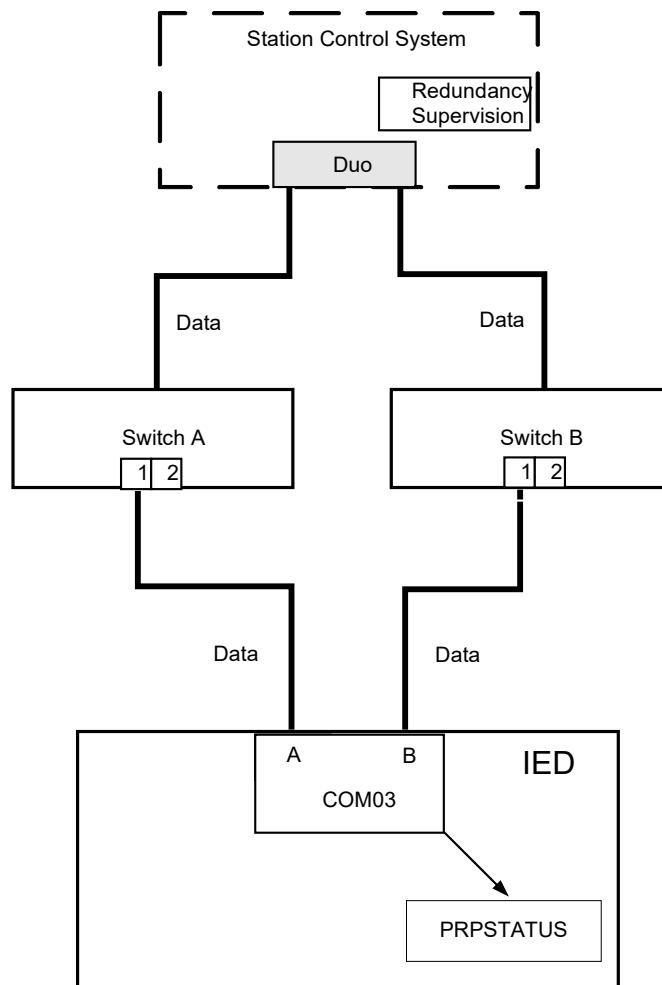
Redundant station bus communication is configured in the LHMI under **Main menu /Configuration/Communication /TCP-IP configuration/ETHLAN1_AB** where *Operation mode*, *IPAddress* and *IPMask* can be entered.

13.8.6 Operation principle

The redundant station bus communication is configured using the local HMI, **Main Menu / Configuration/Communication /TCP-IP configuration/ETHLAN1_AB** . The settings are also visible in PST in PCM600.

Redundant communication runs in parallel, meaning that the same data package is transmitted on both channels simultaneously. The received package identity from one channel is compared with the data package identity from the other channel. If the identity is the same, the last package is discarded.

PRPSTATUS supervises redundant communication on the two channels. If no data package has been received on one or both channels within the last 10 s, the output LAN1-A and/or LAN1-B are set to indicate error.



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Figure 161: Redundant station bus

13.9 Activity logging parameters ACTIVLOG

13.9.1 Activity logging ACTIVLOG

ACTIVLOG contains all settings for activity logging.

Up to 6 external log servers can be defined as receivers for system events. Each server is defined by IP address, IP port number and protocol format. The format can be either syslog (RFC 3164) or Common Event Format (CEF) from ArcSight.

13.9.2 Settings

Table 329: ACTIVLOG Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
ExtLogSrv1Type	Off SYSLOG UDP/IP SYSLOG TCP/IP CEF TCP/IP	-	-	Off	External log server 1 type
ExtLogSrv1Port	1 - 65535	-	1	514	External log server 1 port number
ExtLogSrv1IP	0 - 18	IP Address	1	127.0.0.1	External log server 1 IP-address
ExtLogSrv2Type	Off SYSLOG UDP/IP SYSLOG TCP/IP CEF TCP/IP	-	-	Off	External log server 2 type
ExtLogSrv2Port	1 - 65535	-	1	514	External log server 2 port number
ExtLogSrv2IP	0 - 18	IP Address	1	127.0.0.1	External log server 2 IP-address
ExtLogSrv3Type	Off SYSLOG UDP/IP SYSLOG TCP/IP CEF TCP/IP	-	-	Off	External log server 3 type
ExtLogSrv3Port	1 - 65535	-	1	514	External log server 3 port number
ExtLogSrv3IP	0 - 18	IP Address	1	127.0.0.1	External log server 3 IP-address
ExtLogSrv4Type	Off SYSLOG UDP/IP SYSLOG TCP/IP CEF TCP/IP	-	-	Off	External log server 4 type
ExtLogSrv4Port	1 - 65535	-	1	514	External log server 4 port number
ExtLogSrv4IP	0 - 18	IP Address	1	127.0.0.1	External log server 4 IP-address
ExtLogSrv5Type	Off SYSLOG UDP/IP SYSLOG TCP/IP CEF TCP/IP	-	-	Off	External log server 5 type
ExtLogSrv5Port	1 - 65535	-	1	514	External log server 5 port number
ExtLogSrv5IP	0 - 18	IP Address	1	127.0.0.1	External log server 5 IP-address
ExtLogSrv6Type	Off SYSLOG UDP/IP SYSLOG TCP/IP CEF TCP/IP	-	-	Off	External log server 6 type
ExtLogSrv6Port	1 - 65535	-	1	514	External log server 6 port number
ExtLogSrv6IP	0 - 18	IP Address	1	127.0.0.1	External log server 6 IP-address

13.10 Generic security application component AGSAL

13.10.1 Generic security application AGSAL

As a logical node AGSAL is used for monitoring security violation regarding authorization, access control and inactive association including authorization failure. Therefore, all the information in AGSAL can be configured to report to 61850 client.

Section 14 Basic IED functions

14.1 Self supervision with internal event list

14.1.1 Functionality

The Self supervision with internal event list INTERRSIG and SELFSUPEVLST function reacts to internal system events generated by the different built-in self-supervision elements. The internal events are saved in an internal event list presented on LHMI, WHMI, and in PCM600 event viewer tool.

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

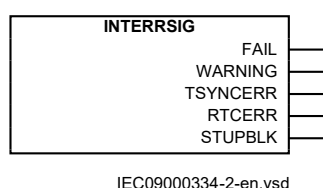


Figure 162: INTERRSIG function block

14.1.2.3 Signals

Table 330: INTERRSIG Output signals

Name	Type	Description
FAIL	BOOLEAN	Internal fail
WARNING	BOOLEAN	Internal warning
TSYCERR	BOOLEAN	Time synchronization error
RTCERR	BOOLEAN	Real time clock error
STUPBLK	BOOLEAN	Application startup block

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	SELSUPEVLST	-	-

14.1.3.2 Settings

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

14.1.4 Operation principle

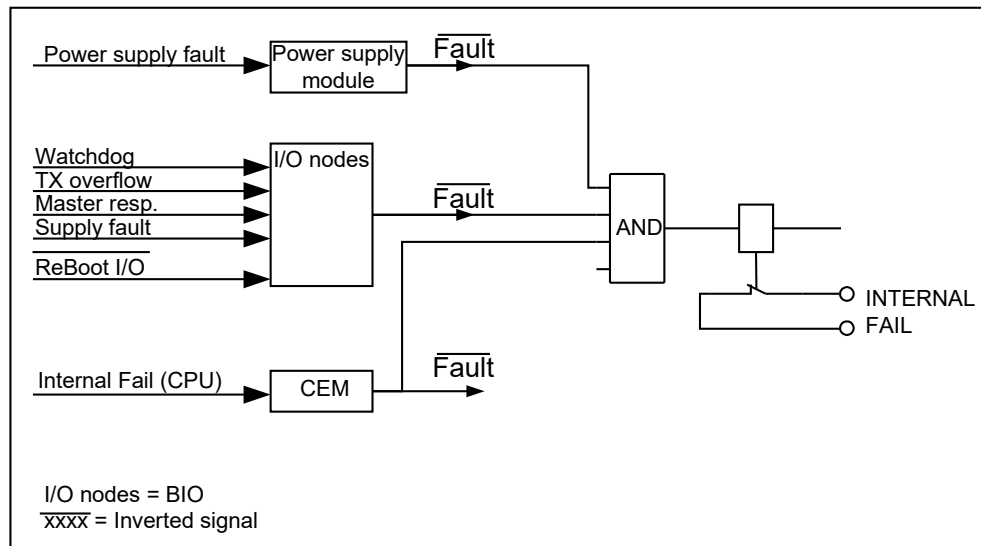
The self-supervision operates continuously and includes:

- 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, from the Event Viewer in PCM600 or from a SMS/SCS system.

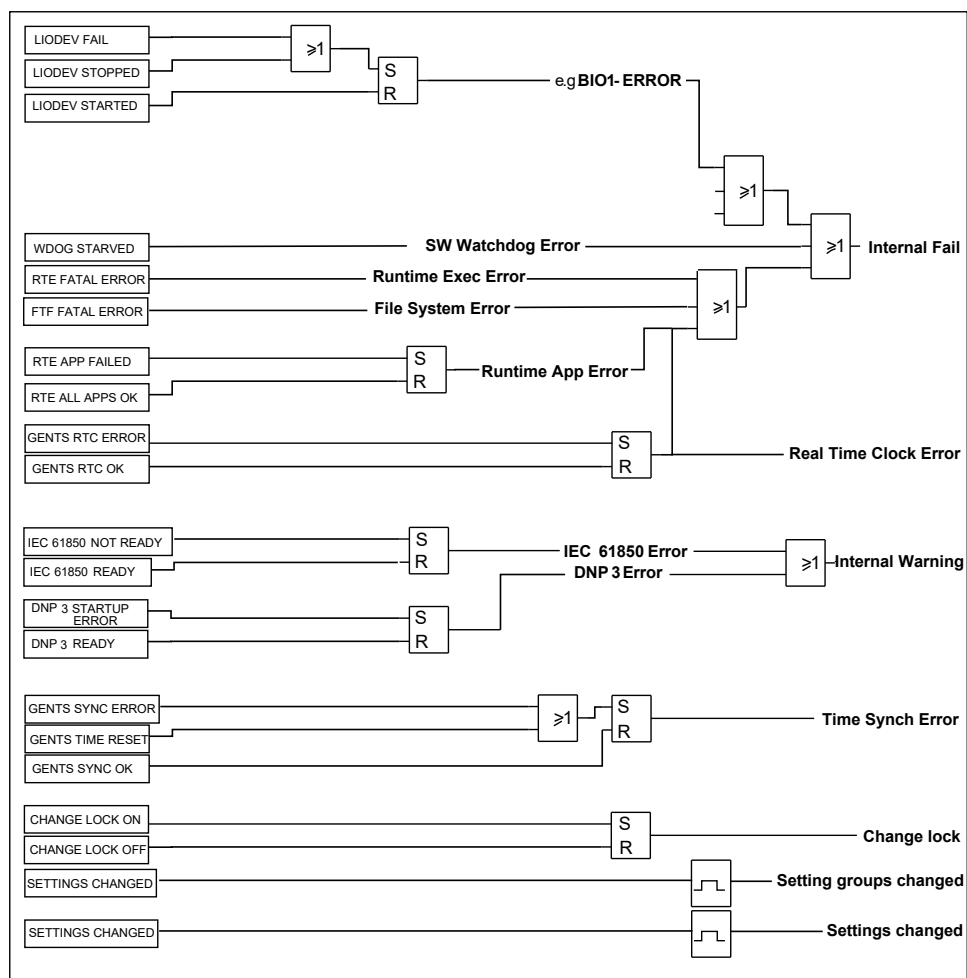
Under the Diagnostics menu in the local HMI the present information from the self-supervision function can be reviewed. The information can be found under **Main menu/Diagnostics/Internal events** or **Main menu/Diagnostics/IED status/General**. The information from the self-supervision function is also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

A self-supervision summary can be obtained by means of the potential free change-over alarm contact IRF (Internal Fail) located on the power supply module. This output contact is activated (where there is no fault) and deactivated (where there is a fault) by the Internal Fail signal, see [Figure 163](#). The software watchdog timeout and the undervoltage detection of the PSM will deactivate the contact as well.



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Figure 163: Hardware self-supervision, potential-free contact



IEC09000381-2-en.vsd

Figure 164: 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 INTERRSIG.

14.1.4.1 Internal signals

SELSUPEVLST 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.

- Standard signals are always presented in the IED, see [Table 331](#).
- Hardware dependent internal signals are collected depending on the hardware configuration, see [Table 332](#).

Explanations of internal signals are listed in [Table 333](#).

Table 331: SELSUPEVLST 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
Setting(s) Changed	Setting(s) changed
Setting Group(s) Changed	Setting group(s) changed
Change Lock	Change lock status
File System Error	Fault tolerant file system status

Table 332: Self-supervision's hardware dependent internal signals

Card	Name of signal	Description
PSM	PSM-Error	Power supply module error status
TRM	TRM-Error	Transformer module error status
COM	COM-Error	Communication module error status
BIO	BIO-Error	Binary input/output module error status
PIO	PIO-Error	Precision binary input/output module error status

Table 333: 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.
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 IEC 61850 stack did not succeed in some actions like reading IEC 61850 configuration, startup, for example.
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, for example.
Setting(s) Changed	This signal will generate an internal event to the internal event list if any setting(s) is changed.
Setting Group(s) Changed	This signal will generate an internal event to the Internal Event List if any setting group(s) is 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.

14.1.4.2 Run-time model

The analog signals to the A/D converter are internally distributed into two different converters, one with low amplification and one with high amplification, see [Figure 165](#).

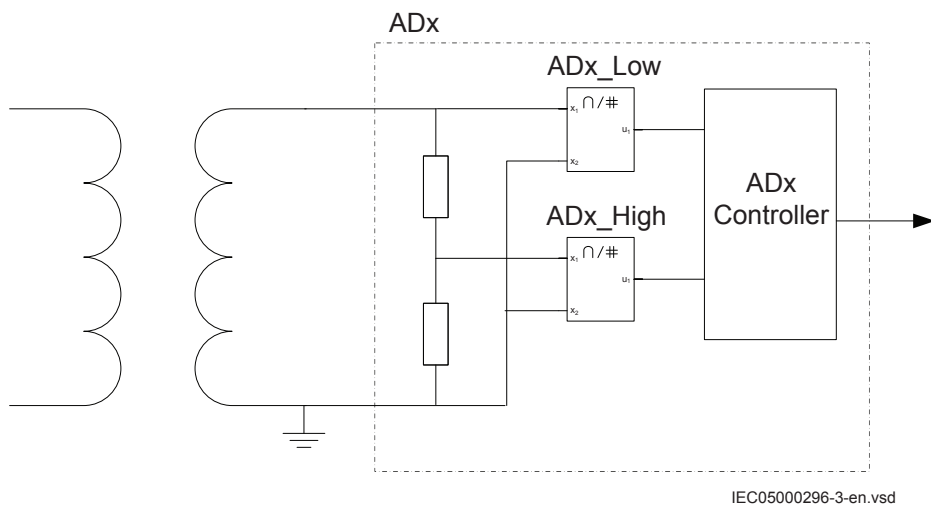


Figure 165: Simplified drawing of A/D converter for the IED.

The technique to split the analog input signal into two A/D converter(s) with different amplification makes it possible to supervise the A/D converters under normal conditions where the signals from the two A/D 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. The ADx_Controller function is included in all IEDs equipped with an analog input module. 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 shall be sent to the CPU, that is the signal that has the most suitable signal 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 A/D converter channels can be performed. If the validation fails, the CPU will be informed and an alarm will be given for A/D converter failure.

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

14.1.5 Technical data

Table 334: Self supervision with internal event list

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

14.2 Time system

14.2.1 Functionality

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



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 335: TIMESYNCHGEN Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
CoarseSyncSrc	Off SNTP	-	-	Off	Coarse time synchronization source
FineSyncSource	Off SNTP IRIG-B	-	-	Off	Fine time synchronization source
SyncMaster	Off SNTP-Server	-	-	Off	Activate IEDas synchronization master
HWSyncSrc	Off IRIG-B PPS	-	-	Off	Hardware time synchronization source
AppSynch	NoSynch Synch	-	-	NoSynch	Time synchronization mode for application
SyncAccLevel	Class T5 (1us) Class T4 (4us) Unspecified	-	-	Unspecified	Wanted time synchronization accuracy

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 336: 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 DSTBEGIN

14.2.4.1 Identification

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

14.2.4.2 Settings

Table 337: DSTBEGIN Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
MonthInYear	January February March April May June July August September October November December	-	-	March	Month in year when daylight time starts
DayInWeek	Sunday Monday Tuesday Wednesday Thursday Friday Saturday	-	-	Sunday	Day in week when daylight time starts
WeekInMonth	Last First Second Third Fourth	-	-	Last	Week in month when daylight time starts
UTCTimeOfDay	00:00 00:30 1:00 1:30 ... 48:00	-	-	1:00	UTC Time of day in hours when daylight time starts

14.2.5 Time system, summer time ends DSTEND

14.2.5.1 Identification

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

14.2.5.2 Settings

Table 338: DSTEND Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
MonthInYear	January February March April May June July August September October November December	-	-	October	Month in year when daylight time ends
DayInWeek	Sunday Monday Tuesday Wednesday Thursday Friday Saturday	-	-	Sunday	Day in week when daylight time ends
WeekInMonth	Last First Second Third Fourth	-	-	Last	Week in month when daylight time ends
UTCTimeOfDay	00:00 00:30 1:00 1:30 ... 48:00	-	-	1:00	UTC Time of day in hours 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 339: 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 340: 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

Encoding

This type of encoding consists of the following options:

- IRIG-B. This encoding is based on the legacy (pre-2004) IRIG-B standard which is without any time zone information. IRIG-B uses the timecoding available in IRIG-B 00x and IRIG-B 12x, where x = 0-7. When x is set in the range from 4- 7, the year information is provided along with year and time data.
- 1344. This encoding is based on the current (2004) IRIG-B standard. IED uses the time zone information from TIMEZONE:1. The setting 1344 refers to the Annex F in IEEE1344, which adds information regarding quality of the time using the control bits in the IRIG-B message. This annex also contains the year information with the variable x that ranges from 4-7 in the 2004 version of IRIG-B.
- 1344TZ. This encoding is based on the current (2004) IRIG-B standard. The time zone information from IRIG-B overrides the TIMEZONE:1 settings.

TimeZoneAs1344

This type of encoding consists of the following options:

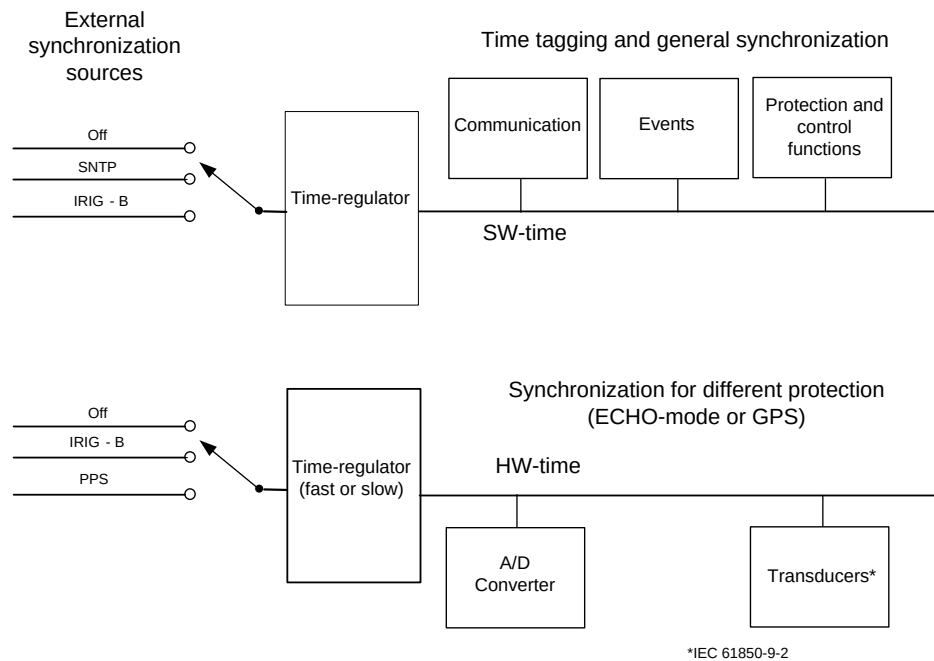
- MinusTZ. Encoded IRIG time minus time zone offset equals UTC at all times.
- PlusTZ. Encoded IRIG time plus time zone offset equals UTC at all times.

14.2.8 Operation principle

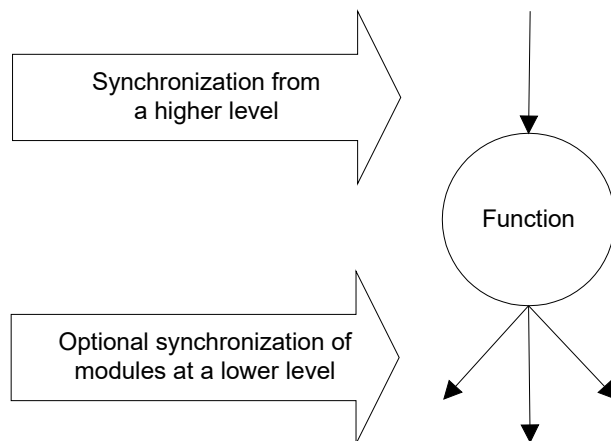
14.2.8.1 General concepts

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. Clock accuracy indicates the increase in error, that is, the time gained or lost by the clock. A disciplined clock knows its own faults and tries to compensate for them.

Design of the time system (clock synchronization)*Figure 166: Design of time system (clock synchronization)***Synchronization principle**

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



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Figure 167: 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. This gives 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

At IED startup, the internal time is free running. If the RTC is still alive since the last up time, the time in the IED will be accurate (may drift 35 ppm), but if the RTC power has been lost during power off (will happen after 5 days), the IED time will start at 1970-01-01.

Time synchronization startup procedure

Coarse time synchronization is used to set the time on the very first message and if any message has an offset of more than ten seconds. If no FineSyncSource is given, the CoarseSyncSource is used to synchronize the time.

Fine time synchronization is used to set the time on the first message after a time reset or if the source may always set the fine time, and the source gives a large offset towards the IED time. After this, the time is used to synchronize the time after a spike filter, that is, if the source glitches momentarily or there is a momentary error, this is neglected. FineSyncSource that may always set the time is only IRIG-B.

It is not recommended to use SNTP as both fine and coarse synchronization source, as some clocks sometimes send out a bad message. For example, Arbiter clocks sometimes send out a "zero-time message", which if SNTP is set as coarse synchronization source (with or without SNTP as fine synchronization source) leads to a jump to "2036-02-07 06:28" and back. In all cases, except for demonstration, it is recommended to use SNTP as FineSynchSource only.

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 options

Two main options 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 via IEC 61850 station bus. For SNTP to operate properly, there must be an SNTP server present, preferably in the same station. The SNTP synchronization provides an accuracy that gives +/- 1 ms accuracy for binary inputs. The IED itself can be set as an SNTP-time server.

SNTP provides complete time-information and can be used as both fine and coarse time synch source. However shall SNTP normally be used as fine synch only. The only reason to use SNTP as

coarse synch is in combination with PPS as fine source. The combination SNTP as both fine and coarse source shall not be used.

SNTP server requirements

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

Synchronization via IRIG-B

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-B module. In this case, send also the local time in the messages.

Synchronization via process bus IEC 61850-9-2LE

An optical PPS signal can be used for the time synchronisation of the process bus communication (IEC 61850-9-2LE protocol). This signal should emanate either from the external GPS clock or from the merging unit.

14.2.9 Technical data

Table 341: Time synchronization, time tagging

Function	Value
Time tagging resolution, events	1 ms
Time tagging resolution, waveform records	0.25 ms (50 Hz) / 0.208 ms (60 Hz)
Time tagging error with SNTP synchronization	±1.0 ms max.
Time tagging error with IRIG-B synchronization	±0.1 ms max.

14.3 Parameter setting group handling

14.3.1 Functionality

Use the four different groups of settings to optimize the IED operation for different power system conditions. 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 be applied to a variety of power 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 342: 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

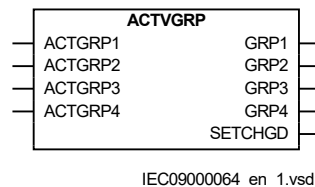


Figure 168: ACTVGRP function block

14.3.3.3 Signals

Table 343: 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 344: 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

The parameter *MaxNoSetGrp* defines the maximum number of setting groups in use to switch between. Switching can only be done within that number of groups. The number of setting groups selected to be used will be filtered so only the setting groups used will be shown on the Parameter Setting Tool.

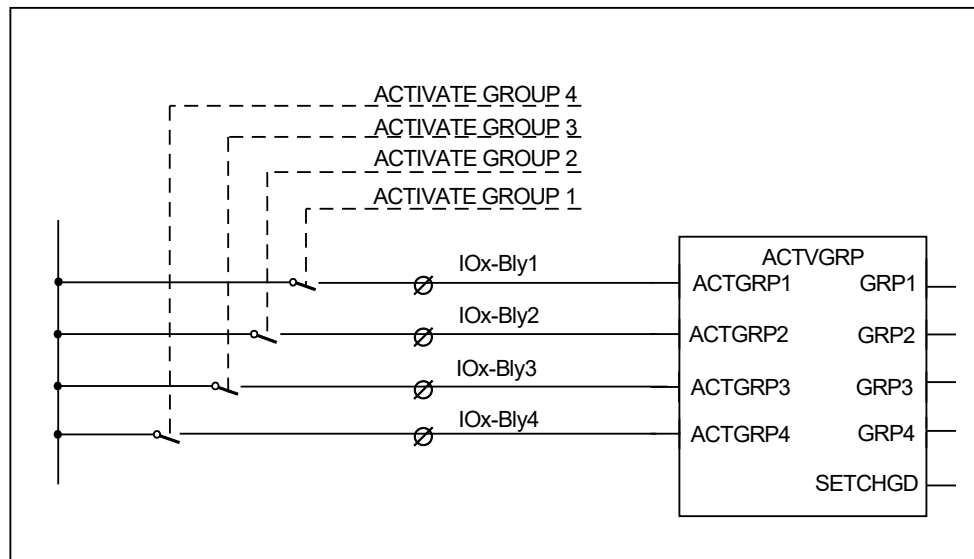
Switching to a different setting group takes effect immediately. There are two ways of activating a setting group:

1. Set the *ActiveSetGrp* parameter accordingly, either from local or from remote.
2. Activate the corresponding input of the ACTVGRP function block.

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. Four functional output signals are available for configuration purposes, so that information on the active setting group is always available.

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 ACTGRP4 and ACTGRP2 inputs are 1, setting group 2 will be the one activated.

Every time a setting is changed, the output signal SETCHGD is sending a pulse. Activating or deactivating test mode is made by changing a parameter, consequently this will also cause a pulse on the SETCHGD output.



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Figure 169: Connection of the function to external circuits

The above example also includes four binary output signals, for confirmation of which group 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 Test mode functionality TESTMODE is activated, all the functions in the IED are automatically blocked. Activated TESTMODE is indicating by a flashing yellow LED on the local HMI. It is then possible to unblock every function(s) individually from the local HMI to perform required tests.

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

Forcing of binary output signals is only possible when the IED is in test mode.

14.4.3 Function block

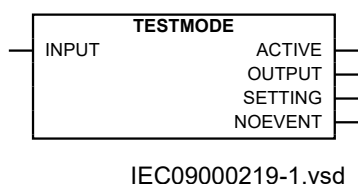


Figure 170: TESTMODE function block

14.4.4 Signals

Table 345: TESTMODE Input signals

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

Table 346: 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 347: 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

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

- configuration, activating the input SIGNAL on the function block TESTMODE.
- setting *TestMode* to *On* in the local HMI, under **Main menu /Tests /IED test mode / 1:TESTMODE**.

While the IED is in test mode, the output ACTIVE of the function block TESTMODE is activated. The outputs of the function block TESTMODE shows the cause of the “Test mode: being in *On*” state. If the input from the configuration (OUTPUT signal is activated) or setting from local HMI (SETTING signal 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, and returning to normal operation, these blockings are disabled and everything is set back to normal operation. All testing will be done with actually set and configured parameter 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 released function will return to blocked state if test mode is set to off.

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 set 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 functions includes the blocking from the 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 commissioning or maintenance test.

14.5 Analog signal processing for controlled switching application ANSGPROC

14.5.1 Identification

Table 348: Function description

Function description	IEC 61850 identification
Analog signal processing for controlled switching application	ANSGPROC

14.5.2 Functionality

To perform a controlled switching operation, signal plausibility, zero-crossing timestamps, half-cycle time and amplitude need to be evaluated, against which the optimal point-on-wave control must be achieved. This analog signal processing unit delivers the above requirements to be used by other functions in the product.

ANSGPROC can take VT connection types and connected phases as setting and provide outputs for both 1-phase and 3-phase voltage and current inputs. For 1-phase connection, it evaluates output of unavailable phases considering the system is balanced. It also helps in passing loading and grounding information to other functions including SSCPOW and ACBMSCBR.

14.5.3 Function block

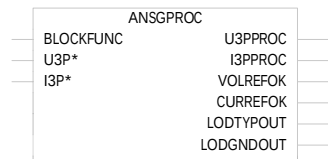


Figure 171: Analog Signal Processing (ANSGPROC) Function Block

* U3P and I3P are mandatory to connect in the application configuration.

14.5.4 Signals

Table 349: ANSGPROC Input signals

Name	Type	Default	Description
BLOCKFUNC	BOOLEAN	0	Block execution of this function and populate outputs with default values
U3P	GROUP SIGNAL	-	Three-phase voltage input
I3P	GROUP SIGNAL	-	Three-phase current input

Table 350: ANSGPROC Output signals

Name	Type	Description
U3PPROC	GROUP SIGNAL	Processed three-phase voltage signal
I3PPROC	GROUP SIGNAL	Processed three-phase current signal
VOLREFOK	BOOLEAN	Voltage signal is suitable as reference
CURREFOK	BOOLEAN	Current signal is suitable as reference
LODTYP0UT	INTEGER	Type of load for switching and monitoring operation
LODGND0UT	INTEGER	Type of grounding of load

14.5.5 Settings and parameters

Table 351: ANSGPROC Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
GlobalBaseSel	1 - 6	-	1	1	Selection of global base values group

Table 352: ANSGPROC Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
UConnType	Single phase star Three phase star Single phase delta Three phase delta	-	-	Single phase star	Connection type of reference voltage transformer
UConnPh	L1/L1-L2 L2/L2-L3 L3/L3-L1	-	-	L1/L1-L2	Connected phase(s) in case of single-phase voltage transformer selected in UConnType
UDead	5 - 80	%UB	1	20.00	Threshold level for valid reference voltage signal
IDead	5 - 80	%IB	1	20.00	Threshold level for valid reference current signal
LoadType	Capacitor Reactor Power transformer Line / Cable Coupled Reactor Coupled transformer	-	-	Capacitor	Type of load to be switched
Grounding	Star grounded Ungrounded/Delta Impedance grounded	-	-	Star grounded	Grounding of neutral point of load

Table 353: ANSGPROC Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
NumOfHalfCycle	2 - 16	-	2	10	Window size for averaging the half cycle time of reference signal

14.5.6 Monitored data

Table 354: ANSGPROC Monitored data

Name	Type	Values (Range)	Unit	Description
VOLREFOK	BOOLEAN	0=Below reference 1=Above reference	-	Voltage signal is suitable as reference
CURREFOK	BOOLEAN	0=Below reference 1=Above reference	-	Current signal is suitable as reference
LODTYPOUT	INTEGER	1=Capacitor 2=Reactor 3=Power transformer 4=Line / Cable 6=Coupled Reactor 7=Coupled transformer	-	Type of load for switching and monitoring operation
LODGNDOUT	INTEGER	0=Star grounded 1=Ungrounded/Delta 2=Impedance grounded	-	Type of grounding of load

14.5.7 Principle of operation

ANSGPROC receives voltage and current signals from SMAI (pre-processing) function blocks. From these signals, it extracts properties that are required for controlled switching (point-on-wave switching) and operations monitoring, and publishes them together with other relevant data.

14.5.7.1 Signal plausibility check

Both voltage and current signals are continuously validated to be healthy that is, suitable as reference for controlled switching. As soon as the RMS magnitude of voltage or current samples received by the function (through *U3P* or *I3P*) crosses a pre-defined threshold value or dead value (*Udead* or *IDead*), the source is considered healthy. If the RMS magnitude of the signal is less than the threshold, the signal cannot be used as a reference. The information is published on the **VOLREFOK** and **CURREFOK** outputs, wherein a value of TRUE (1) indicates healthy signal.

For a three-phase signal, the health of each phase is checked individually. Only if all phases are found healthy, the entire reference signal is declared healthy.

Table 355: Dead value settings

Setting name	Description
<i>UDead</i>	Threshold level for input source voltage signal in percent of <i>UBase</i> . If the voltage RMS is less than this threshold level, source voltage cannot be used as reference.
<i>IDead</i>	Threshold level for input current signal in percent of <i>IBase</i> . If the current RMS is less than this threshold level, load current cannot be used as reference.
<i>GlobalBaseSel</i>	Selection of GBASVAL function instance from which <i>UBase</i> and <i>IBase</i> are taken.



ANSGPROC expects that *UBase* and *IBase* in GBASVAL (selected by *GlobalBaseSel*) are set as rated phase-to-ground voltage and maximum steady-state current into the load, respectively. For controlled switching of transformers, transmission lines, or cables, the steady-state current shall be given as the nominal charging current, with no further load connected.

14.5.7.2 VT and CT configuration

The source voltage signals can be provided from single-phase or three-phase VTs, which measure either phase-to-ground or phase-to-phase voltages. The actual VT configuration is selected using the settings detailed in [Table 356](#).

Table 356: Reference voltage specification

Setting	Description
<i>UConnType</i>	Specifies the connection type of the source voltage transformer. It can be selected as: • One phase star – Any one phase-to-ground voltage signal is available • Three phase star – All three phase-to-ground voltage signals are available • One phase delta – Any one phase-to-phase voltage signal is available • Three phase delta – All three phase-to-phase voltage signals are available
<i>UConnPh</i>	When <i>UConnType</i> is selected as “One phase star” or “One phase delta”, the actually connected phase or phase-to-phase information has to be specified here from the options • “L1/L1-L2” when either L1-ground or L1-L2 voltage signal is connected to the first voltage input • “L2/L2-L3” when either L2-ground or L2-L3 voltage signal is connected to the first voltage input • “L3/L3-L1” when either L3-ground or L3-L1 voltage signal is connected to the first voltage input Selection in this setting is irrelevant if “Three phase star” or “Three phase delta” is selected for <i>UConnType</i> setting

When only one phase voltage is available, the setting *UConnPh* is used to specify the phase information that is connected. Selection of “L1/L1-L2” implies that L1 phase is connected if selection in *UConnType* is “One phase star”, or L1-L2 voltage is connected if selection in *UConnType* is “One phase delta”. The same is applicable for “L2/L2-L3” and “L3/L3-L1”.



When “One phase star” or “One phase delta” is being used, that voltage signal shall always be connected to the L1 voltage input of the IED irrespective of the phase/ phases that are acquired by the voltage transformer.



If the phase difference between system phases may significantly deviate from 120 degrees, set *UConnType* to “One phase star” or “One phase delta”.



There is no provision for single-phase current signal connection. A 3-phase CT must always be connected to the IED.

14.5.7.3 Evaluation of zero crossings, half-cycle times, amplitudes

When a signal is rated “healthy”, ANSGPROC continuously extracts zero crossings in each connected phase. Using linear interpolation, the time stamp of exact zero crossing point is calculated between the two consecutive samples of opposite polarity and stored in a cyclic list of zero crossings.

As soon as minimum two zero crossings are detected, the half cycle time is calculated as the difference between the latest two zero crossings. For the example of ZC_1 and ZC_2 in [Figure 172](#), the instantaneous half cycle time is calculated as:

$$\text{Instantaneous half cycle time} = ZC_2 - ZC_1$$

With each new zero crossing, the function updates its moving average of the last settable number of half-cycle times, which can be configured using the *NumOfHalfCycle* setting. This information is used for extrapolating zero crossings and evaluating frequency in the controlled switching algorithms.

For any reference source, the frequency and point-on-wave targets are ascertained by tracking the signal for a settable number of half cycles. The higher values of *NumOfHalfCycle* are used to provide more stable tracking. Conversely, if the system frequency is expected to change rapidly, a lower value of *NumOfHalfCycle* can be provided. However, in case of rapid changes in frequency, a low value of the parameter may lead to inaccurate targeting.



Point-on-wave switching is not suggested to be used on rapidly changing system conditions.

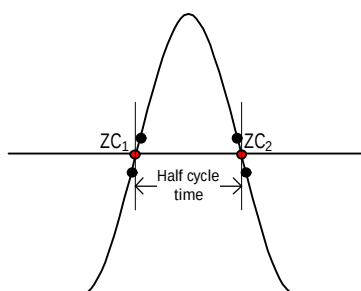


Figure 172: Interpolation of zero-crossings from adjacent samples, and half cycle time evaluation

ANSGPROC also calculates the amplitudes of the input signals. For current signals, the RMS value is multiplied by $\sqrt{2}$. For voltage signals, the phase-to-ground amplitude is obtained by multiplying the input RMS value by a factor taken from [Table 357](#), depending on the VT connection.

Table 357: 3-phase amplitude evaluation

VT connection	Voltage RMS multiplier
3 phase star	$\sqrt{2}$
1 phase star	$\sqrt{2}$
3 phase delta	$\sqrt{3/3}$
1 phase delta	$\sqrt{3/3}$



Zero-crossing, half-cycle and amplitude are always given as three phase output irrespective of VT connection types. For single phase connection, the above parameters are estimated for the unavailable phases assuming balanced power system.

The information is passed as group signals on the *U3PPROC* and *I3PPROC* outputs.

14.5.7.4 Load and Grounding Selection

In a controlled switching application, several functions require identical information on the type and configuration of the switched load. This information centrally resides in ANSGPROC, configurable through the *LoadType* and *Grounding* settings. From here, it is distributed to other functions through the **LODTYPEOUT** and **LOGNDOUT** outputs. The settings are described in [Table 358](#).

Table 358: Application selection

Setting name	Description
<i>LoadType</i>	This setting specifies the connected load. Available options are: • Capacitor • Reactor • Coupled reactor • Power transformer • Coupled transformer • Transmission line/power cable Refer to Table 359 for further selection of the load type for reactors and transformers.
<i>Grounding</i>	For all load types, this setting specifies the effective grounding of both system and load. Available options are: • Star grounded • Ungrounded / Delta • Impedance grounded (only for reactor and transformer load types) See Table 360 for details.

Table 359: Load type selection for reactors and transformers

Actual load type	Core configuration	Secondary/ Tertiary winding	LoadType in ANSGPROC
Reactor	Individual bank	n/a	Reactor
Reactor	Common core 4/5-limb	n/a	Reactor
Reactor	Common core 3-limb	n/a	Coupled Reactor
Transformer	Individual bank	No delta winding	Power transformer
Transformer	Common core 4/5-limb	No delta winding	Power transformer
Transformer	Common core 3-limb	No delta winding	Coupled transformer
Transformer	Individual bank	At least one winding is delta connected	Coupled transformer
Transformer	Common core 4/5-limb	At least one winding is delta connected	Coupled transformer
Transformer	Common core 3-limb	At least one winding is delta connected	Coupled transformer

Table 360: Grounding options

Source Grounding	Load connection (of primary winding for transformers)	Grounding in ANSGPROC
Ungrounded	any	Ungrounded/Delta
Solidly grounded	Star connected, solidly grounded (Yn)	Star grounded
Solidly grounded	Ungrounded star (Y) / Delta (Δ)	Ungrounded star / Delta
Solidly grounded	Star (Y) connected, grounded through neutral reactor or neutral resistor	Impedance grounded



For the purpose of controlled switching, “primary winding” of a transformer refers to the winding that is switched under point-on-wave control.

14.6 Change lock function CHNGLCK

14.6.1 Identification

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

14.6.2 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.

The change lock function activation is normally connected to a binary input.

When CHNGLCK has a logical one on its input, then all attempts to modify the IED configuration and setting will be denied and the message "Error: Changes blocked" will be displayed on the local HMI; 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 to the CHNGLCK input. If such a situation would occur in spite of these precautions, then please contact the local Hitachi Energy representative for remedial action.

14.6.3 Function block

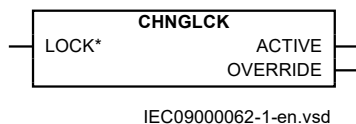


Figure 173: CHNGLCK function block

14.6.4 Signals

Table 361: CHNGLCK Input signals

Name	Type	Default	Description
LOCK	BOOLEAN	0	Activate change lock

Table 362: CHNGLCK Output signals

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

14.6.5 Settings

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

14.6.6 Operation principle

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

The function, when activated, prevents changes to application configuration and settings. However, it will still allow the following changes of the IED state that do 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:

Table 363: Change lock activation

LOCK input	Function
1	Change lock activated
0	Change lock deactivated

The change lock functionality can temporarily be disabled/overridden using the **Maintenance** menu. Go to **Maintenance menu /Recovery Menu(Password Protected) /Turn off Change-lock (Temporary)** to disable or override the functionality.

Turning off the change-lock overrides the change lock function until the next reboot of the IED. In this case, the change-lock function cannot be activated, which is indicated by the OVERRIDE output (value 1).

14.7 IED identifiers TERMINALID

14.7.1 Identification

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

14.7.2 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.

14.7.3 Settings

Table 364: *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
IEDMainFunType	0 - 255	-	1	0	IED main function type for IEC60870-5-103

14.8 Product information PRODINF

14.8.1 Identification

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

14.8.2 Functionality

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

- IEDProdType
- ProductVer
- ProductDef
- SerialNo
- OrderingNo
- ProductionDate

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

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

Table 365: *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

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
UnitNumber	0 - 99999	-	1	0	Unit number
IEDMainFunType	0 - 255	-	1	0	IED main function type for IEC60870-5-103
TechnicalKey	0 - 18	-	1	AA0J0Q0A0	Technical key

14.9 Primary system values PRIMVAL

14.9.1 Identification

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

14.9.2 Functionality

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

14.9.3 Settings

Table 366: 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

14.10 Signal matrix for analog inputs SMAI

14.10.1 Functionality

Signal matrix for analog inputs function (SMAI), also known as the preprocessor function, processes the analog signals connected to it and gives information about all aspects of the analog signals connected, like the RMS value, phase angle, frequency, harmonic content, sequence components and so on. This information is then used by the respective functions in ACT (for example protection, measurement or monitoring).

The SMAI function is used within PCM600 in direct relation with the Signal Matrix tool or the Application Configuration tool.

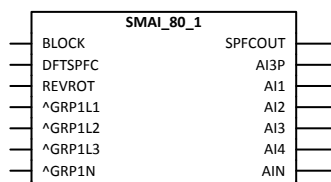


In the Switchsync PWC600 pre-configuration, all analog inputs to SMAI function blocks are routed through SRCSELECT function blocks. This is to enable selection of input signal sources either from TRM or IEC 61850-9-2(LE) merging units, through a parameter controlled by SST.

14.10.2 Identification

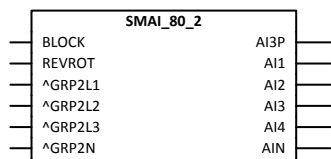
Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Signal matrix for analog inputs	SMAI_80_x	-	-

14.10.3 Function block



IEC09000139-2-en.vsd

Figure 174: SMAI_80_1 function block



IEC09000140-3-en.vsd

Figure 175: SMAI_80_2 to SMAI_80_12 function block

14.10.4 Signals

Table 367: SMAI_80_1 Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block group 1
DFTSPFC	REAL	80.0	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 368: SMAI_80_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

Table 369: SMAI_80_12 Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block group 12
REVROT	BOOLEAN	0	Reverse rotation group 12
GRP12L1	STRING	-	First analog input used for phase L1 or L1-L2 quantity
GRP12L2	STRING	-	Second analog input used for phase L2 or L2-L3 quantity
GRP12L3	STRING	-	Third analog input used for phase L3 or L3-L1 quantity
GRP12N	STRING	-	Fourth analog input used for residual or neutral quantity

Table 370: SMAI_80_12 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

14.10.5 Settings

Table 371: SMAI_80_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 372: SMAI_80_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

Table 373: SMAI_80_12 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 374: SMAI_80_12 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

14.10.6 Operation principle

Every SMAI can receive four analog signals (three phases and one neutral value), either voltage or current. The *AnalogInputType* setting should be set according to the input connected. The signal received by SMAI is processed internally to obtain 244 different electrical parameters, for example RMS value, peak-to-peak, frequency and so on. The activation of BLOCK input resets all outputs to 0.

SMAI_80 does all the calculation based on nominal 80 samples per line frequency period, this gives a sample frequency of 4 kHz at 50 Hz nominal line frequency and 4.8 kHz at 60 Hz nominal line frequency.

The output signals AI1...AI4 in SMAI_80_x function block are direct outputs of the connected input signals GRPxL1, GRPxL2, GRPxL3 and GRPxN. GRPxN is always the neutral current. If GRPxN is not connected, the output AI4 is zero. The AIN output is the calculated residual quantity, obtained as a sum of inputs GRPxL1, GRPxL2 and GRPxL3 but is equal to output AI4 if GRPxN is connected. The output signals AI1, AI2, AI3 and AIN are normally connected to the analog disturbance recorder.



The SMAI function block always calculates the residual quantities in case only the three phases (Ph-N) are connected (GRPxN input not used).

The output signal AI3P in the SMAI function block is a group output signal containing all processed electrical information from inputs GRPxL1, GRPxL2, GRPxL3 and GRPxN. Applications with a few exceptions shall always be connected to AI3P.

The input signal REVROT is used to reverse the phase order.

A few points need to be ensured for SMAI to process the analog signal correctly.

- It is not mandatory to connect all the inputs of SMAI function. However, it is very important that same set of three phase analog signals should be connected to one SMAI function.
- The sequence of input connected to SMAI function inputs GRPxL1, GRPxL2, GRPxL3 and GRPxN should normally represent phase L1, phase L2, phase L3 and neutral currents respectively.
- It is possible to connect analog signals available as *Ph-N* or *Ph-Ph* to SMAI. *ConnectionType* should be set according to the input connected.
- If the GRPxN input is not connected and all three phase-to-earth inputs are connected, SMAI calculates the neutral input on its own and it is available at the AI3P and AIN outputs. It is necessary that the *ConnectionType* should be set to *Ph-N*.
- If any two phase-to-earth inputs and neutral currents are connected, SMAI calculates the remaining third phase-to-neutral input on its own and it is available at the AI3P output. It is necessary that the *ConnectionType* should be set to *Ph-N*.
- If any two phase-to-phase inputs are connected, SMAI calculates the remaining third phase-to-phase input on its own. It is necessary that the *ConnectionType* should be set to *Ph-Ph*.
- All three inputs GRPxLx should be connected to SMAI for calculating sequence components for *ConnectionType* set to *Ph-N*.
- At least two inputs GRPxLx should be connected to SMAI for calculating the positive and negative sequence component for *ConnectionType* set to *Ph-Ph*. Calculation of zero sequence requires GRPxN input to be connected.
- Negation setting inverts (reverse) the polarity of the analog input signal.

Frequency adaptivity

SMAI function performs DFT calculations for obtaining various electrical parameters. DFT uses some reference frequency for performing calculations. For most of the cases, these calculations are done using a fixed DFT reference based on system frequency. However, if the frequency of the network is expected to vary more than 2 Hz from the nominal frequency, more accurate DFT results can be obtained if the adaptive DFT is used. This means that the frequency of the network is tracked and the DFT calculation is adapted according to that.

DFTRefExtOut and *DFTReference* need to be set appropriately for adaptive DFT calculations.

DFTRefExtOut: Setting valid only for the instance of function block SMAI_80_1. It decides the reference block for external output SPFCOUT.

DFTReference: Reference DFT for the block. This setting decides DFT reference for DFT calculations. *DFTReference* set to *InternalDFTRef* uses fixed DFT reference based on the set system frequency. *DFTReference* set to *DFTRefGrpX* uses DFT reference from the selected group block, when own group selected adaptive DFT reference will be used based on the calculated signal frequency from own group. *DFTReference* set to *External DFT Ref* will use reference based on input signal DFTSPFC.



Settings *DFTRefExtOut* and *DFTReference* shall be set to default value *InternalDFTRef* if no VT inputs are available. However, if it is necessary to use frequency adaptive DFT (*DFTReference* set to other than default, referring current measuring SMAI) when no voltages are available, note that the *MinValFreqMeas* setting is still set in reference to *UBase* (of the selected GBASVAL group). This means that the minimum level for the current amplitude is based on *UBase*. For example, if *UBase* is 20000, the resulting minimum amplitude for current is $20000 * 10\% = 2000$.

MinValFreqMeas: The minimum value of the voltage for which the frequency is calculated, expressed as percent of the voltage in the selected Global Base voltage group (*GlobalBaseSel*).

14.11 Summation block 3 phase 3PHSUM

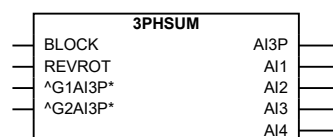
14.11.1 Identification

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

14.11.2 Functionality

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

14.11.3 Function block



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Figure 176: 3PHSUM function block

14.11.4 Signals

Table 375: 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 376: 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

14.11.5 Settings

Table 377: 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 378: 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

14.11.6 Operation principle

Summation block 3 phase 3PHSUM receives two groups of three-phase signals from Signal matrix for analog inputs (SMAI) functions. The outputs are a linear combination of the corresponding input signals, as per the *SummationType* setting.

The input signal REVROT is used to reverse the phase order of the output signal. *DFTReference* and *FreqMeasMinVal* should be set the same as in the source SMAI functions.

Activating the BLOCK input will force all outputs of the function to 0.

14.12 Selection of 3-phase signals 3PHSELECT

14.12.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Selection between two 3-phase analog signals	3PHSELECT	-	-

14.12.2 Functionality

The purpose of the 3PHSELECT function is to connect the receiver functions to one out of two three-phase analog signals. For example, in case of a tie-breaker application, where the connected load can be supplied by either of the two sources available (refer [Figure 177](#)), the tie-breaker should be controlled by the IED in such a way that it can switch between the two sources (Source 1/Feeder 1 and Source 2/Feeder 2) seen by the breaker as required by the user. The 3PHSELECT function allows selecting any of the available analog signals as reference signal or feedback signal without the need for external logic.

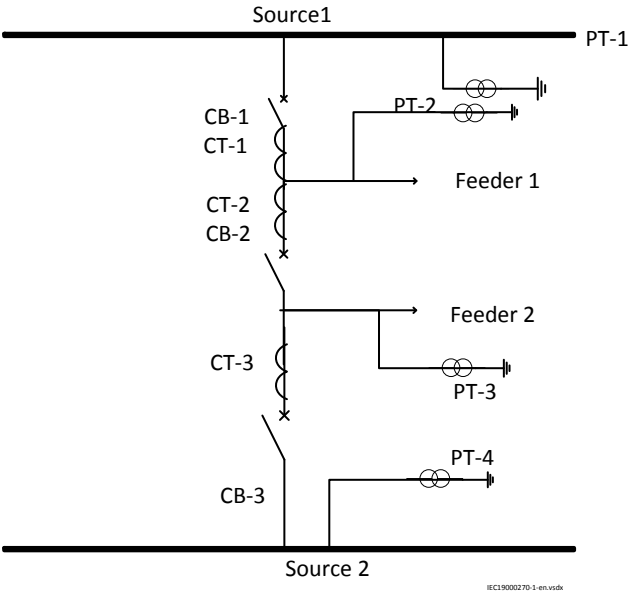


Figure 177: One-and-a-half breaker scheme in a substation

This function is specific to PWC600. It takes the instantaneous sample and RMS values from two 3-phase sources as inputs. Based on the source selector setting, it provides the same signals from the selected source as outputs to the receiving functions. The function also provides a blocking output, which can be used for blocking other functions while re-synchronizing to the selected source.

14.12.3 Function block

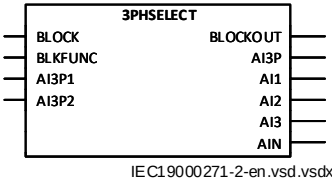


Figure 178: ACT view of 3PHSELECT function block

14.12.4 Signals

Table 379: 3PHSELECT Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block input for blocking binary outputs
BLKFUNC	BOOLEAN	0	Block the function from providing any outputs
AI3P1	GROUP SIGNAL	-	Group signal for input from Source 1
AI3P2	GROUP SIGNAL	-	Group signal for input from Source 2

Table 380: 3PHSELECT Output signals

Name	Type	Description
BLOCKOUT	BOOLEAN	Blocks the outputs defined by blockTime (ms) whenever the InputSelect setting is changed
AI3P	GROUP SIGNAL	Group signal for output from the selected source
AI1	GROUP SIGNAL	Phase L1 signal output from the selected source
AI2	GROUP SIGNAL	Phase L2 signal output from the selected source
AI3	GROUP SIGNAL	Phase L3 signal output from the selected source
AIN	GROUP SIGNAL	Neutral signal output from the selected source

14.12.5 Settings and parameters

Table 381: 3PHSELECT Non group settings (basic)

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

Table 382: 3PHSELECT Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
InputSelect	Source1 Source2	-	-	Source1	Selects group of input signals to be passed to outputs

Table 383: 3PHSELECT Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
BlockTime	60 - 1000	ms	1	60	Indicates change of input selection, to block receiver functions for blocktime(ms) while re-synchronizing

14.12.6 Operation principle

The purpose of the 3PHSELECT function is to connect the receiver functions to one out of the two three-phase analog signals. Specifically, the functionality is divided into the source selection logic and the blocking logic.

14.12.6.1 Switching between the sources (Source selection)

Referring [Figure 177](#), the 3-phase Source 1/Feeder 1 voltage (instantaneous sample and RMS values) can be fed to the function using grouped input AI3P1. Similarly, the Source 2/ Feeder 2 voltage (instantaneous sample and RMS values) can be fed to the function using grouped input AI3P2.

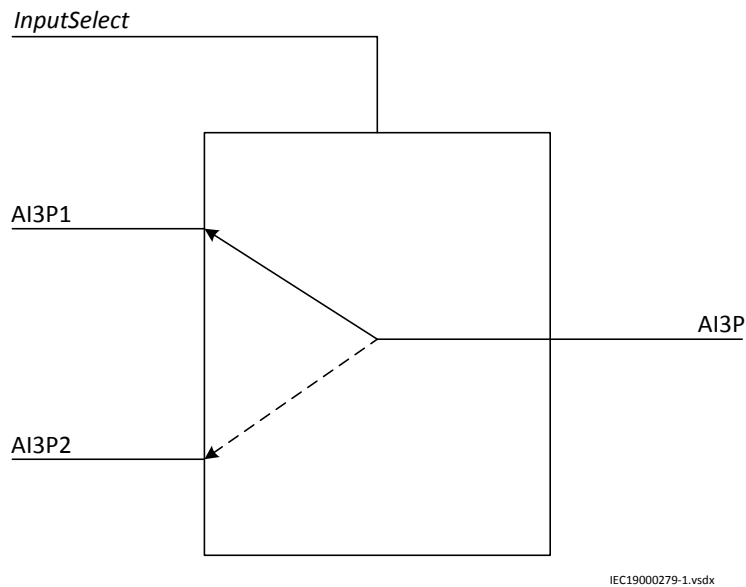


Figure 179: Source Selection Logic

As shown in [Figure 179](#), the setting *InputSelect* selects the analog signals from either AI3P1 or AI3P2 input groups to be propagated to the grouped output AI3P (multiplexer functionality). This output contains both the instantaneous samples and the RMS values of the selected input group. The outputs AI1, AI2, AI3 and AIN contain instantaneous samples of phase L1, phase L2, phase L3, and neutral, respectively, of the selected analog input signals group; for example, for direct connection to the disturbance recorder.

The 3PHSELECT function typically receives inputs from SMAI function block. When either of the inputs of the corresponding SMAI function block are not connected to an analog channel (either of the phases is left unconnected), the output of the corresponding unconnected phase is zero. When one or more inputs are unconnected, the 3PHSELECT function outputs the corresponding sample and RMS values as zero. When the selected input group is totally unconnected, the 3PHSELECT function sends the corresponding group outputs as zero.



The AI3P1/2 inputs of 3PHSELECT shall be connected only to SMAI, 3PHSUM, or TRAFOSWT functions. The AI3P output of 3PHSELECT shall be connected only to ANSGPROC, ACBMSCBR, or TRAFOSWT functions.

As *InputSelect* is setting-groups enabled, it can be changed dynamically during operation based on system conditions (for example, status of other switches in the substation). This is important, for example, in a 1½ breakers arrangement, where either side of the middle breaker is potentially the source side or the load side, to select the appropriate busbar voltage as reference signal.

14.12.6.2 Blocking logic

As the two input signal groups are not necessarily in sync with each other, the 3PHSELECT function provides the BLOCKOUT output, which is specifically intended to block other application functions during the time required for re-synchronizing to the respective source. This output goes high for a user-settable time-period (*BlockTime*) whenever the *InputSelect* setting is changed. If *InputSelect* is changed again before the *BlockTime* expires, BLOCKOUT is retriggered so that the output is high for *BlockTime* from the latest change of *InputSelect*.

The input BLKFUNC is used to block all the outputs of the function whenever it is set by the user. All analog outputs are forced to 0.0 values. The same result is achieved by setting *Operation* to “Off”.

The input BLOCK is specifically used to block only the binary output BLOCKOUT whenever set.

14.13 Global base values GBASVAL

14.13.1 Identification

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

14.13.2 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*, for selecting one out of the six sets of GBASVAL functions.

14.13.3 Settings

Table 384: GBASVAL Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
UBase	0.05 - 1500.00	kV	0.05	132.00	Global base voltage
IBase	1 - 50000	A	1	1000	Global base current
SBase	0.050 - 7500.000	MVA	0.001	229.000	Global base apparent power

14.14 Authority check ATHCHCK

14.14.1 Identification

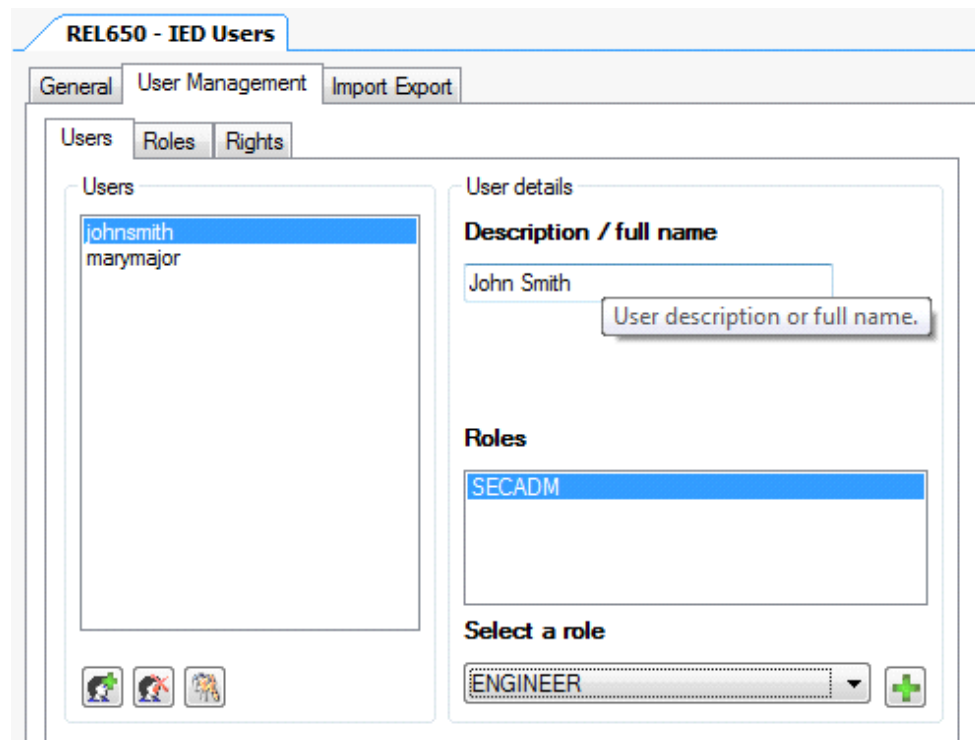
Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Authority check	ATHCHCK	-	-

14.14.2 Functionality

To safeguard the interests of our customers, both the IED and the tools that are accessing the IED are protected, by means of authorization handling. The authorization handling of the IED and the PCM600 is implemented at both access points to the IED:

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

The IED users can be created, deleted and edited only with PCM600 IED user management tool.



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Figure 180: PCM600 user management tool

14.14.3 Settings

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

14.14.4 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 given in [Table 385](#).

Table 385: Pre-defined user types

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 IED User Management 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. The maximum number of characters in a password is 12.



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

14.14.4.1 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 IED User Management.

Once a user is created and written to 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 / SCREEN:1**) elapses, the IED returns to 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 IED User Management and written to 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 opens.

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 entered (passwords are case sensitive) choose OK and press the  key again.

At successful Log on, the local HMI shows the new user name in the status bar 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 Log on has failed, an "Error Access Denied" message opens. 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 and PCM600. However, other users are still permitted to log in during this period.

14.15 Authority management AUTHMAN

14.15.1 Identification

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

14.15.2 Functionality

This function controls the options shown in the maintenance menu. It also controls the maintenance menu log on time out.

14.15.3 Settings

Table 386: AUTHMAN Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
MaintMenuDisAuth	Disable Enable	-	-	Enable	In maintenance menu, disable authority selection is shown
AuthTimeout	600 - 3600	s	600	600	Authority blocking timeout

14.16 FTP access with password FTPACCS

14.16.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
FTP access with SSL	FTPACCS	-	-

14.16.2 Functionality

The FTP Client defaults to the best possible security mode when trying to negotiate with SSL.

The automatic negotiation mode acts on port number and server features. It tries to immediately activate implicit SSL if the specified port is 990. If the specified port is any other, it tries to negotiate with explicit SSL via AUTH SSL/TLS.

Using FTP without SSL encryption gives the FTP client reduced capabilities. This mode is only for accessing disturbance recorder data from the IED.



If normal FTP is required to read out disturbance recordings, create a specific account for this purpose with rights only to do File transfer. The password of this user will be exposed in clear text on the wire.

14.16.3 Settings

Table 387: FTPACCS Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
PortSelection	None Front LAN1 Front+LAN1	-	-	Front+LAN1	Port selection for communication
TCPPortFTP	1 - 65535	-	1	21	TCP port for FTP and FTP with Explicit SSL

14.17 Authority status ATHSTAT

14.17.1 Identification

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

14.17.2 Functionality

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

User denied attempt to log-on and user successful log-on are reported.

14.17.3 Function block

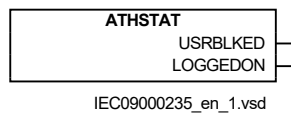


Figure 181: ATHSTAT function block

14.17.4 Signals

Table 388: 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

14.17.5 Settings

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

14.17.6 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.

14.18 Denial of service

14.18.1 Functionality

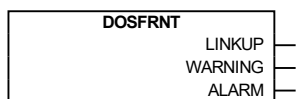
The Denial of service functions (DOSLAN1 and DOSFRNT) are designed to limit overload on the IED produced by heavy Ethernet network traffic. The communication facilities must not be allowed to compromise the primary functionality of the device. All inbound network traffic will be quota controlled so that too heavy network loads can be controlled. Heavy network load might for instance be the result of malfunctioning equipment connected to the network.

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

14.18.2.1 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	-	-

14.18.2.2 Function block



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Figure 182: DOSFRNT function block

14.18.2.3 Signals

Table 389: 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

14.18.2.4 Settings

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

14.18.2.5 Monitored data

Table 390: DOSFRNT Monitored data

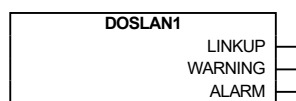
Name	Type	Values (Range)	Unit	Description
State	INTEGER	0=Off 1=Normal 2=Throttle 3=DiscardLow 4=DiscardAll 5=StopPoll	-	Frame rate control state
Quota	INTEGER	-	%	Quota level in percent 0-100
IPPackRecNorm	INTEGER	-	-	Number of IP packets received in normal mode
IPPackRecPoll	INTEGER	-	-	Number of IP 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

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

14.18.3.1 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	-	-

14.18.3.2 Function block



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Figure 183: DOSLAN1 function block

14.18.3.3 Signals

Table 391: 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

14.18.3.4 Settings

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

14.18.3.5 Monitored data

Table 392: 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
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

14.18.4 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

14.19 Source selection SRCSELECT

14.19.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Source selection between transformer module and merging unit	SrcSelect	-	-

14.19.2 Functionality

Switchsync PWC600 is supplied with a pre-configuration that can be customized to most applications by settings entered in Switchsync Setting Tool (SST). The SRCSELECT function allows selecting the source of an analog (voltage or current) signal from TRM (hardware based) or MU (software based)

by settings. Flexibility of selection of the input source from all the MUs (that is, four MUs) and TRM (that is, two TRMs) sources modeled as three-phase + neutral inputs eliminates the need for modifications in ACT or SMT. A SRCSELECT function block is placed between TRM or MU outputs and SMAI inputs.

There are eight sets of input available in the function. Each set is modeled as the three-phase + neutral input. For each MU, the function has five binary status inputs. The selection needs to be done for the status signals of MU from which the data is subscribed. TRM signals can be connected to any of the eight input phase groups.

14.19.3 Function block

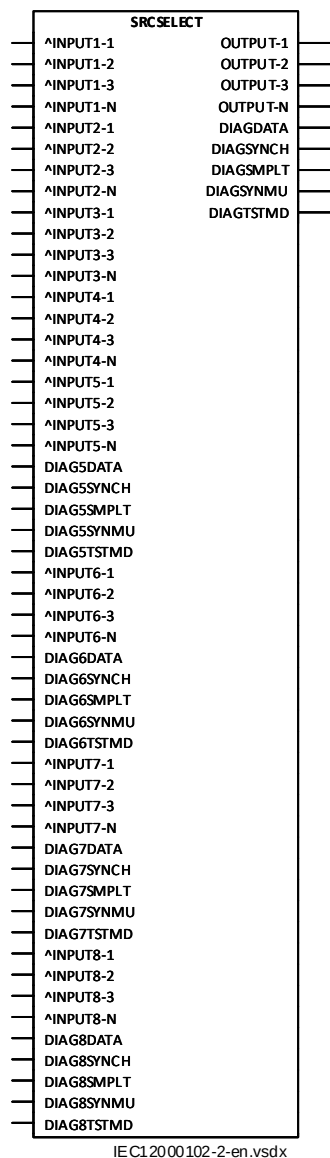


Figure 184: Function block

14.19.4 Signals

Table 393: SRCSELECT Input signals

Name	Type	Default	Description
INPUT1-1	STRING	0	First analog input used for phase L1 or L1-L2 quantity of INPUT1
INPUT1-2	STRING	0	Second analog input used for phase L2 or L2-L3 quantity of INPUT1
INPUT1-3	STRING	0	Third analog input used for phase L3 or L3-L1 quantity of INPUT1
INPUT1-N	STRING	0	Fourth analog input used for residual or neutral quantity of INPUT1
INPUT2-1	STRING	0	First analog input used for phase L1 or L1-L2 quantity of INPUT2
INPUT2-2	STRING	0	Second analog input used for phase L2 or L2-L3 quantity of INPUT2
INPUT2-3	STRING	0	Third analog input used for phase L3 or L3-L1 quantity of INPUT2
INPUT2-N	STRING	0	Fourth analog input used for residual or neutral quantity of INPUT2
INPUT3-1	STRING	0	First analog input used for phase L1 or L1-L2 quantity of INPUT3
INPUT3-2	STRING	0	Second analog input used for phase L2 or L2-L3 quantity of INPUT3
INPUT3-3	STRING	0	Third analog input used for phase L3 or L3-L1 quantity of INPUT3
INPUT3-N	STRING	0	Fourth analog input used for residual or neutral quantity of INPUT3
INPUT4-1	STRING	0	First analog input used for phase L1 or L1-L2 quantity of INPUT4
INPUT4-2	STRING	0	Second analog input used for phase L2 or L2-L3 quantity of INPUT4
INPUT4-3	STRING	0	Third analog input used for phase L3 or L3-L1 quantity of INPUT4
INPUT4-N	STRING	0	Fourth analog input used for residual or neutral quantity of INPUT4
INPUT5-1	STRING	0	First analog input used for phase L1 or L1-L2(not in case of MU) quantity of INPUT5
INPUT5-2	STRING	0	Second analog input used for phase L2 or L2-L3(not in case of MU) quantity of INPUT5
INPUT5-3	STRING	0	Third analog input used for phase L3 or L3-L1(not in case of MU) quantity of INPUT5
INPUT5-N	STRING	0	Fourth analog input used for residual or neutral quantity of INPUT5
DIAG5DATA	BOOLEAN	0	Serious data loss from MU over INPUT5 group
DIAG5SYNCH	BOOLEAN	0	MU clock not synced to same clock as IED over INPUT5 group
DIAG5SMPLT	BOOLEAN	0	Sample lost; Current sample estimated for MU over INPUT5 group
DIAG5SYNMU	BOOLEAN	0	SmpSynch flag in frame for MU not ok over INPUT5 group
DIAG5TSTMD	BOOLEAN	0	Used channel from MU is in testmode over INPUT5 group
INPUT6-1	STRING	0	First analog input used for phase L1 or L1-L2(not in case of MU) quantity of INPUT6
INPUT6-2	STRING	0	Second analog input used for phase L2 or L2-L3(not in case of MU) quantity of INPUT6
INPUT6-3	STRING	0	Third analog input used for phase L3 or L3-L1(not in case of MU) quantity of INPUT6
Table continues on next page			

Name	Type	Default	Description
INPUT6-N	STRING	0	Fourth analog input used for residual or neutral quantity of INPUT6
DIAG6DATA	BOOLEAN	0	Serious data loss from MU over INPUT6 group
DIAG6SYNCH	BOOLEAN	0	MU clock not synced to same clock as IED over INPUT6 group
DIAG6SMPLT	BOOLEAN	0	Sample lost; Current sample estimated for MU over INPUT6 group
DIAG6SYNMU	BOOLEAN	0	smpSynch flag in frame for MU not ok over INPUT6 group
DIAG6TSTMD	BOOLEAN	0	Used channel from MU is in testmode over INPUT6 group
INPUT7-1	STRING	0	First analog input used for phase L1 or L1-L2(not in case of MU) quantity of INPUT7
INPUT7-2	STRING	0	Second analog input used for phase L2 or L2-L3(not in case of MU) quantity of INPUT7
INPUT7-3	STRING	0	Third analog input used for phase L3 or L3-L1(not in case of MU) quantity of INPUT7
INPUT7-N	STRING	0	Fourth analog input used for residual or neutral quantity of INPUT7
DIAG7DATA	BOOLEAN	0	Serious data loss from MU over INPUT7 group.
DIAG7SYNCH	BOOLEAN	0	MU clock not synced to same clock as IED over INPUT7 group
DIAG7SMPLT	BOOLEAN	0	Sample lost; Current sample estimated for MU over INPUT7 group
DIAG7SYNMU	BOOLEAN	0	smpSynch flag in frame for MU not ok over INPUT7 group
DIAG7TSTMD	BOOLEAN	0	Used channel from MU is in testmode over INPUT7 group
INPUT8-1	STRING	0	First analog input used for phase L1 or L1-L2(not in case of MU) quantity of INPUT8
INPUT8-2	STRING	0	Second analog input used for phase L2 or L2-L3(not in case of MU) quantity of INPUT8
INPUT8-3	STRING	0	Third analog input used for phase L3 or L3-L1(not in case of MU) quantity of INPUT8
INPUT8-N	STRING	0	Fourth analog input used for residual or neutral quantity of INPUT8
DIAG8DATA	BOOLEAN	0	Serious data loss from MU over INPUT8 group.
DIAG8SYNCH	BOOLEAN	0	MU clock not synced to same clock as IED over INPUT8 group
DIAG8SMPLT	BOOLEAN	0	Sample lost; Current sample estimated for MU over INPUT8 group
DIAG8SYNMU	BOOLEAN	0	smpSynch flag in frame for MU not ok over INPUT8 group
DIAG8TSTMD	BOOLEAN	0	Used channel from MU is in testmode over INPUT8 group

Table 394: SRCSELECT Output signals

Name	Type	Description
OUTPUT-1	STRING	Selected Output -1
OUTPUT-2	STRING	Selected Output -2
OUTPUT-3	STRING	Selected Output -3
OUTPUT-N	STRING	Selected Output -N
DIAGDATA	BOOLEAN	Serious data loss from selected MU
DIAGSYNCH	BOOLEAN	Selected MU clock not synced to same clock as IED
Table continues on next page		

Name	Type	Description
DIAGSMPLT	BOOLEAN	Sample lost; Current sample estimated for selected MU
DIAGSYNMU	BOOLEAN	smpSynch flag in frame for selected MU not ok
DIAGTSTMD	BOOLEAN	Used channel from selected MU is in testmode

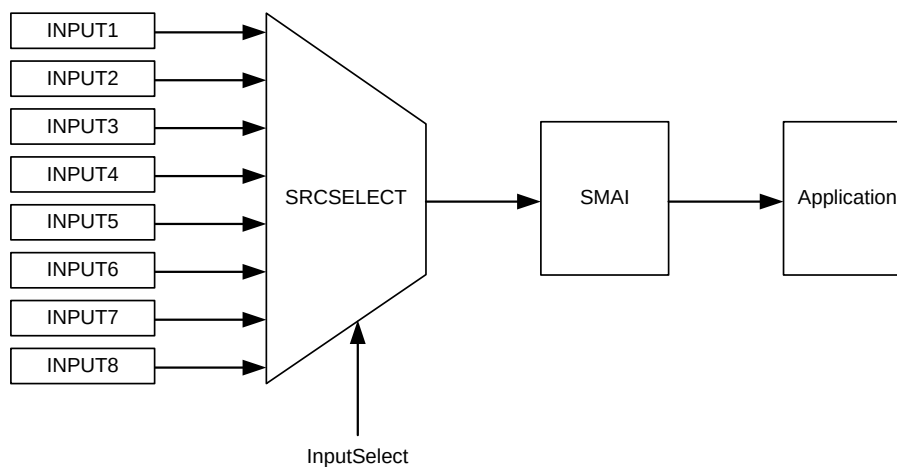
14.19.5 Settings

Table 395: SRCSELECT Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
InputSelect	INPUT1 INPUT2 INPUT3 INPUT4 INPUT5 INPUT6 INPUT7 INPUT8	-	-	INPUT1	Input group selection to output

14.19.6 Operation principle

The source selector function is a multiplexer, where the output is selected from one of the eight input phase group with a setting. It selects one of the analog input groups and forwards the selected input group to the pre-processing component connected to its output. A group of transformer module channels or merging unit channels can be connected to the source selector as the input source.



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Figure 185: Source selector application

[Figure 185](#) depicts the source selector embedded in an application. When *InputSelect* is set to "INPUT1", the INPUT1 channel link strings are passed to the pre-processing component, and so forth. Based on that link, the pre-processing component fetches the data from the particular channel.

The IED supports four IEC 61850-9-2(LE) merging unit streams, wherein each stream has four sets of current and voltage signals. In a hybrid configuration, the current and voltage can be either from a conventional CT/VT (connection through TRM) or through the IEC 61850-9-2(LE) MU. The eight input groups are provided per instance for the selection, out of which the last four input groups can be connected to the merging unit signals, as there are diagnostic status signals that need to be selected and provided as an output from the function.

The input groups are named INPUT1-x to INPUT8-x and each group supports four analog inputs. INPUT5-x to INPUT8-x additionally support the diagnostic binary status signals from a merging unit (see description of MU_4I_4U). If any of INPUT1 through INPUT4 is selected, the diagnostic outputs assume default value 0.

14.20 Web server WEBSERVER

14.20.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Web server	WEBSERVER	-	-

14.20.2 Functionality

Web server function is used for configuring the access to the IED through the web interface (WHMI) using a web browser.

14.20.3 Settings

Table 396: WEBSERVER Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation On/Off
WriteMode	Writing disabled Writing enabled	-	-	Writing disabled	Writing of settings enabled
SessionTimeout	2 - 60	Min	1	3	Session timeout
HTTPSPortNumber	1 - 65535	-	1	443	Port number for https request
MaxUsers	1 - 4	-	1	2	Maximum concurrent users

Table 397: WEBSERVER Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
Port	None Front Rear All	-	-	All	Select network port

14.20.4 Operation principle

For accessing the IED using a web browser, WEBSERVER works as an interface function to accept requests and send data. The actual webpages to be displayed are defined by HTML files stored in the IED. WEBSERVER interacts with the authority system in the IED to validate user permissions.

Access to the IED from a web browser can be disabled by setting Operation to “Off”.

It is possible to change IED parameters and settings through Web HMI. This feature can be disabled by setting *WriteMode* to “Writing disabled”.

From a security point of view, it is desirable to terminate a browser session if the user has been idle for some duration. This duration can be set by *SessionTimeout*.

The IED has two physical ports through which it can be accessed using web browser. Allowed access can be configured using the Port setting. The options are described in the table below.

Port option	Description
None	Web access is disabled
Front	Web access is enabled only through the front port
Rear	Web access is enabled only through the rear port
All	Web access is enabled through both front and rear ports

Refer to the Web HMI section in the User manual for additional information on WHMI.

Section 15 IED physical connections

All terminals of a PWC600 device are shown in the connection diagram.

15.1 Protective earth connections

The IED shall be earthed with a 16.0 mm² flat copper cable.



The earth lead should be as short as possible, less than 1500 mm. Additional length is required for door mounting.

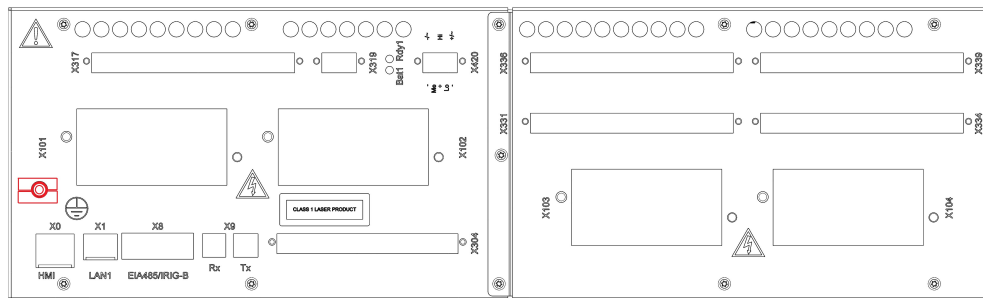


Figure 186: The protective earth pin is located to the left of connector X101 on the 3U full 19" case

15.2 Inputs

15.2.1 Measuring inputs

Each terminal for CTs/VTs is dimensioned for one 0.5...6.0 mm² (AWG 20...10) wire or for two wires of maximum 2.5 mm² (AWG 13).

Table 398: Assignment of conventional CT and VT inputs in pre-configuration

Connector	Pin	Signal	Description	Software signal
X101	1	I L1 N	L1 phase current	TRM_2.CH1(I)
X101	2	I L1 L		
X101	3	I L2 N	L2 phase current	TRM_2.CH2(I)
X101	4	I L2 L		
X101	5	I L3 N	L3 phase current	TRM_2.CH3(I)
X101	6	I L3 L		
X101	7	-	Not used	TRM_2.CH4(I)
X101	8	-		
X101	9	V1 L1 N	Source voltage L1 / L1-L2 / only available single phase	TRM_2.CH5(U)
X101	10	V1 L1 L		
X102	1	V1 L2 N	Source voltage L2 / L2-L3	TRM_2.CH6(U)
X102	2	V1 L2 L		

Table continues on next page

Connector	Pin	Signal	Description	Software signal
X102	3	V1 L3 N	Source voltage L3 / L3-L1	TRM_2.CH7(U)
X102	4	V1 L3 L		
X102	5	V2 L1 N	Load voltage L1 (mandatory for power transformer with residual flux estimation in PWC600-HT; otherwise optional but recommended where available)	TRM_2.CH8(U)
X102	6	V2 L1 L		
X102	7	V2 L2 N	Load voltage L2 (mandatory for power transformer with residual flux estimation in PWC600-HT; otherwise optional but recommended where available)	TRM_2.CH9(U)
X102	8	V2 L2 L		
X102	9	V2 L3 N	Load voltage L3 (mandatory for power transformer with residual flux estimation in PWC600-HT; otherwise optional but recommended where available)	TRM_2.CH10(U)
X102	10	V2 L3 L		



A single-phase reference VT shall always be connected to terminals X101:9-10, regardless which system phase(s) it measures. If it does not measure L1 then the application configuration should be adjusted for proper recording and display of the signals (see [Section](#)).

To avoid mismatch between CT and VT connections the connectors are mechanically encoded and cannot be inserted in the wrong location.

15.2.2 Auxiliary supply voltage input

The auxiliary voltage of the IED is connected to terminals X420-1 and X420-2/3 by one 0.5...2.5 mm² (AWG 20...13) wire or by two 0.5...1.0 mm² (AWG 20...17) wires. The terminals used depend on the power supply module. The connector is delivered with the device.

The permitted auxiliary voltage range of the IED is marked on the identification sticker on the IED's enclosure.

Table 399: Auxiliary supply voltage input on PSM for 48...125 V DC

Connector	Pin	Description	PCM600 Info	
			Hardware module	Hardware channel
X420	1	-Input	PSM_102	BATTAMPL
X420	2	+ Input	PSM_102	BATTAMPL

Table 400: Auxiliary supply voltage input on PSM for 110...250 V DC or 100...240 V AC

Connector	Pin	Description	PCM600 Info	
			Hardware module	Hardware channel
X420	1	-Input	PSM_102	BATTAMPL
X420	3	+ Input	PSM_102	BATTAMPL

The BATTAMPL analog input gives the actual value of the supply voltage on the input terminals.

The two LEDs next to X420 indicate the following conditions:

- Bat1 = input voltage (e.g. station battery) is within the expected range.
- Rdy1 = output voltage of internal power supply is within the expected range (no IED internal short circuit or overvoltage).

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 connector terminal is connected with one 0.5...2.5 mm² (AWG 20...13) wire or with two 0.5...1.0 mm² (AWG 20...17) wires.

Table 401: Circuit breaker auxiliary switch position inputs

Connector	Pin	Signal	Description	Software signal
X324	1	L1 NO/52a -	UB-	PIO_3.PBI4
X324	2	L1 NO/52a +	L1 auxiliary contact NO (52a), the other pole of which is connected to UB+	
X324	3	L2 NO/52a -	UB-	PIO_3.PBI5
X324	4	L2 NO/52a +	L2 auxiliary contact NO (52a), the other pole of which is connected to UB+	
X324	5	L3 NO/52a -	UB-	PIO_3.PBI6
X324	6	L3 NO/52a +	L3 auxiliary contact NO (52a), the other pole of which is connected to UB+	
X324	7	L1 NC/52b -	UB-	PIO_3.PBI7
X324	8	L1 NC/52b +	L1 auxiliary contact NC (52b), the other pole of which is connected to UB+	
X324	9	L2 NC/52b -	UB-	PIO_3.PBI8
X324	10	L2 NC/52b +	L2 auxiliary contact NC (52b), the other pole of which is connected to UB+	
X324	11	L3 NC/52b -	UB-	PIO_3.PBI9
X324	12	L3 NC/52b +	L3 auxiliary contact NC (52b), the other pole of which is connected to UB+	
X324	13	L1 prim -	UB-	PIO_3.PBI10
X324	14	L1 prim +	L1 primary contact (make available on terminal; only used during commissioning)	
X324	15	L2 prim -	UB-	PIO_3.PBI11
X324	16	L2 prim +	L2 primary contact (make available on terminal; only used during commissioning)	
X324	17	L3 prim -	UB-	PIO_3.PBI12
X324	18	L3 prim +	L3 primary contact (make available on terminal; only used during commissioning)	

Table 402: Recommended shunt resistor ratings for precision binary inputs

Cable length	110...127 V supply	220...250 V supply
Up to 30 m	100 kΩ, 0.5 W	100 kΩ, 2 W
Up to 150 m	33 kΩ, 2 W	33 kΩ, 5 W
Up to 300 m	15 kΩ, 3 W	15 kΩ, 15 W
Above 300 m	4.7 kΩ, 10 W	4.7 kΩ, 30 W

Table 403: Inputs for close/open commands and CB drive energy level

Connector	Pin	Signal	Description	Software signal
X329	1	Close in -	Close command input from bay control	BIO_4.BI1
X329	2	Close in +		
X329	4	Open/Trip in -	Open and Trip command inputs from bay control or protection (common terminal)	*
X329	5	Open in +	Open command input from bay control	BIO_4.BI2
X329	6	Trip in +	Trip command input from protection	BIO_4.BI3
X329	8	L1 Spr -	L1 spring charge level (common terminal)	*
X329	9	L1 Spr OCObk +	L1 spring charge level: OCO blocked	BIO_4.BI4
X329	10	L1 Spr CObk +	L1 spring charge level: CO blocked	BIO_4.BI5
X329	12	L2 Spr -	L2 spring charge level (common terminal)	*
X329	13	L2 Spr OCObk +	L2 spring charge level: OCO blocked	BIO_4.BI6
X329	14	L2 Spr CObk +	L2 spring charge level: CO blocked	BIO_4.BI7
X329	16	L3 Spr -	L3 spring charge level (common terminal)	*
X329	17	L3 Spr OCObk +	L3 spring charge level: OCO blocked	BIO_4.BI8
X329	18	L3 Spr CObk +	L3 spring charge level: CO blocked	BIO_4.BI9
X321	13	LED Rst -	Reset latched status LEDs	PIO_3.PBI1
X321	14	LED Rst +		
X321	15	PBI2 -	Spare precision input 2	PIO_3.PBI2
X321	16	PBI2 +		
X321	17	PBI3-	Spare precision input 3	PIO_3.PBI3
X321	18	PBI3 +		
* No separate software designation, as this is the common terminal for the next two signals.				



Binary inputs for spring charge level are intended for circuit breakers in which the drive energy and the operating capability can differ with the position of the main storage element (spring). This occurs in spring-hydraulic drives such as Hitachi Energy models HMB/HMC. The spring charge information is used for compensation of operating times and for reporting the CB's operating capability. However, if the breaker is not used for fast reclosing and if the spring is always fully charged prior to each operation, these inputs need not be connected. Similarly, these inputs are not used with drives in which the spring is always fully charged by design.

15.2.4 Precision binary inputs

The precision binary inputs are used for accurate detection of status changes of main or auxiliary contacts in the circuit breaker.

Connectors are delivered with the device. Each connector terminal is connected with one 0.5...2.5 mm² (AWG 20...13) wire or with two 0.5...1.0 mm² (AWG 20...17) wires.

Table 404: Precision binary inputs on PIO

Connector	Pin	Description	PCM600 Info	
			Hardware module	Hardware channel
X321	13	– for precision input 1		
X321	14	Precision binary input 1 +	PIO_3	PBI1
X321	15	– for precision input 2		
X321	16	Precision binary input 2 +	PIO_3	PBI2
X321	17	– for precision input 3		
X321	18	Precision binary input 3 +	PIO_3	PBI3
X324	1	– for precision input 4		
X324	2	Precision binary input 4 +	PIO_3	PBI4
X324	3	– for precision input 5		
X324	4	Precision binary input 5 +	PIO_3	PBI5
X324	5	– for precision input 6		
X324	6	Precision binary input 6 +	PIO_3	PBI6
X324	7	– for precision input 7		
X324	8	Precision binary input 7 +	PIO_3	PBI7
X324	9	– for precision input 8		
X324	10	Precision binary input 8 +	PIO_3	PBI8
X324	11	– for precision input 9		
X324	12	Precision binary input 9 +	PIO_3	PBI9
X324	13	– for precision input 10		
X324	14	Precision binary input 10 +	PIO_3	PBI10
X324	15	– for precision input 11		
X324	16	Precision binary input 11 +	PIO_3	PBI11
X324	17	– for precision input 12		
X324	18	Precision binary input 12 +	PIO_3	PBI12

15.3 Binary outputs

The precision binary outputs are used for time-synchronized energization of the circuit breaker Close and Trip coils. These outputs are normally open.

Each connector terminal is connected with one one 0.5...2.5 mm² (AWG 20...13) wire or with two 0.5...1.0 mm² (AWG 20...17) wires.

Table 405: Open and close command outputs

Connector	Pin	Signal	Description	Software signal
X321	1	L1 Close -	Controlled close command output L1	PIO_3.PBO1
X321	2	L1 Close +		
X321	3	L2 Close -	Controlled close command output L2	PIO_3.PBO2
X321	4	L2 Close +		
X321	5	L3 Close -	Controlled close command output L3	PIO_3.PBO3
X321	6	L3 Close +		
X321	7	L1 Open -	Controlled open command output L1	PIO_3.PBO4
X321	8	L1 Open +		
X321	9	L2 Open -	Controlled open command output L2	PIO_3.PBO5
X321	10	L2 Open +		
X321	11	L3 Open -	Controlled open command output L3	PIO_3.PBO6
X321	12	L3 Open +		

15.3.1 Outputs for controlling and signaling

Signal output contacts are used for signalling alarms and warning conditions. See [Section](#) for details on each output signal.

Outputs designated “PO” are power output contacts designed for controlling switchgear. Three of the power outputs on the power supply module (PSM) feature additional circuitry for trip circuit supervision.



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.

Connectors are delivered with the device. Each connector terminal is connected with one 0.5...2.5 mm² (AWG 20...13) wire or with two 0.5...1.0 mm² (AWG 20...17) wires.

Table 406: Power outputs on PSM (not used in PWC600 pre-configuration)

Connector	Pin	Description	PCM600 Info	
			Hardware module	Hardware channel
		Power output 1, normally open (TCS)		
X317	1 2	– +	PSM_102	BO1_PO_TCS
		Power output 2, normally open (TCS)		
X317	3 4	– +	PSM_102	BO2_PO_TCS

Table continues on next page

Connector	Pin	Description	PCM600 Info	
			Hardware module	Hardware channel
		Power output 3, normally open (TCS)		
X317	5 6	– +	PSM_102	BO3_PO_TCS
X317	7 8	Power output 4, normally open	PSM_102	BO4_PO
X317	9 10	Power output 5, normally open	PSM_102	BO5_PO
X317	11 12	Power output 6, normally open	PSM_102	BO6_PO

Table 407: Power outputs on BIO (not used in PWC600 pre-configuration)

Connector	Pin	Description	PCM600 Info	
			Hardware module	Hardware channel
X326	1 2	Power output 1, normally open	BIO_4	BO1_PO
X326	3 4	Power output 2, normally open	BIO_4	BO2_PO
X326	5 6	Power output 3, normally open	BIO_4	BO3_PO

15.3.2 Outputs for signaling

Outputs designated “SO” are relay contacts designed for indicating configurable conditions in the application.

Connectors are delivered with the device. Each connector terminal is connected with one 0.5...2.5 mm² (AWG 20...13) wire or with two 0.5...1.0 mm² (AWG 20...17) wires.

Table 408: Signaling outputs on PSM

Connector	Pin	Description	PCM600 Info	
			Hardware module	Hardware channel
X317	13 14	Signal output 1, normally open	PSM_102	BO7_SO
X317	15 16	Signal output 2, normally open	PSM_102	BO8_SO
X317	17 18	Signal output 3, normally open	PSM_102	BO9_SO

Table 409: Signaling outputs on BIO

Connector	Pin	Description	PCM600 Info	
			Hardware module	Hardware channel
X326	7 8	Signal output 1, normally open	BIO_4	BO4_SO
X326	9 10	Signal output 2, normally open	BIO_4	BO5_SO
X326	11 12	Signal output 3, normally open	BIO_4	BO6_SO
X326	13	Signal output 4, normally open	BIO_4	BO7_SO

Table continues on next page

Connector	Pin	Description	PCM600 Info	
			Hardware module	Hardware channel
X326	14	Signal output 5, normally open	BIO_4	BO8_SO
X326	15	Signal outputs 4-5, 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		

15.3.3 IRF

The IRF (internal relay fault) 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.

The connector is delivered with the device. Each connector terminal is connected with one 0.5...2.5 mm² (AWG 20...13) wire or with two 0.5...1.0 mm² (AWG 20...17) wires.

Table 410: IRF contact on PSM

Connector	Pin	Description
X319	1	Closed: no IRF, and U _{aux} connected
X319	2	Closed: IRF, or U _{aux} disconnected
X319	3	IRF, common

15.4 Communication interfaces

The IED's LHMI is provided with an RJ-45 connector. This interface is intended for temporarily connecting a PC, for interrogation, configuration, and setting.

Station bus and process bus communication runs on the communication module via the optical interfaces (LC Ethernet connectors) on the rear panel. If both buses are used, the process bus shall run as a separate network from the station bus to prevent interference of control data with the sampled values stream.

The rear connector X8 (EIA-485/IRIG-B) provides time synchronization via low-voltage galvanic interface. Other communication functions via the EIA-485 serial port are not supported in Switchsync PWC600.

The HMI connector X0 and the serial interface X9 are not used in Switchsync PWC600.

15.4.1 Ethernet RJ-45 front port

The IED's LHMI is provided with an RJ-45 connector designed for Ethernet point-to-point use. This interface is intended 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 DHCP server is enabled in the IED. The DHCP server inside the IED can be activated for the front interface only.

Usually this port is used only for temporary connection, thus no permanent wiring is required. Events, setting values and all input data such as operation records and waveform 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
- WHMI

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 with RJ-45 connector is used with the front port.

15.4.2 Station communication rear port

The IED's communication module is provided with an optical LC connector, X1/LAN1 A, designed for Ethernet station bus communication. A second identical connector, X2/LAN1 B, can optionally be used for redundant communication via PRP.

The default IP address of the IED through the rear Ethernet port is 192.168.1.10. The communication speed is 100 Mbps for the 100BASE-FX LC interface.

Table 411: Station bus

Connector	Pin	Signals	Description
X1	All	LAN1 A	Station bus
X2	All	LAN1 B	Redundant station bus, optional

For specification of the optical fibers to be used, see [Section 17.8](#).

15.4.3 Optical serial rear connection

The optical serial communication port (X9) is not used in Switchsync PWC600.



Always keep the factory supplied cap on the Tx output of port X9, to prevent exposure to laser radiation.

15.4.4 EIA-485 serial rear connection

The communication module follows the EIA-485 standard and is intended to be used in multi-point communication.

Table 412: EIA-485 and IRIG-B connections

Connector	Pin	Signals	Description
X8	1	RS485_GNDC	RS485 ground through capacitance
X8	2	RS485_RXTERM	Termination for RS485 receiver
X8	3	RS485_RX +	RS485 receiver
X8	4	RS485_TXTERM	Termination for RS485 transmitter
X8	5	RS485_SIGGND	Signal ground for RS485
X8	6	IRIG-B -	Time synchronization input
Table continues on next page			

Connector	Pin	Signals	Description
X8	7	IRIG-B_GNDC	IRIG-B ground through capacitance
X8	8	RS485_GND	RS485 ground
X8	9	RS485_RX -	RS485 receiver
X8	10	RS485_TX +	RS485 transmitter
X8	11	RS485_TX -	RS485 transmitter
X8	12	RS485_SIGGND	Signal ground for RS485
X8	13	IRIG-B +	Time synchronization input
X8	14	IRIG-B_GND	IRIG-B ground



EIA-485 communication is not enabled in this product.

15.4.5 Process bus rear connection

Switchsync PWC600 can receive digital sampled values (voltage and/or current) via IEC 61850-9-2(LE) process bus at its X3/LAN2 A interface. Up to four logical merging units can be connected, which are distinguished by their sampled values ID (sVID). The specifications of X3 are identical to X1 and X2.

Hardware synchronization of the sampled values is achieved by a 1PPS signal received on optical input X10. Time synchronization via SNTP or IRIG-B cannot be used for this purpose.



If the 9-2 process values to Switchsync PWC600 originate from two or more separate physical merging units, they should be synchronized to the same master. Otherwise, occasional communication interruptions may occur.

Table 413: Process bus

Connector	Pin	Signals	Description
X3	All	9-2LE	Process bus: sampled values from one or more merging units compliant to IEC 61850-9-2 (LE)

Table 414: Optical 1PPS signal

Connector	Pin	Signals	Description
X10	Rx	1PPS	Optical 1PPS signal from time synchronization master

For specification of the optical fibers to be used, see [Section 17.8](#).

15.4.6 Communication interfaces and protocols

Table 415: Supported station communication interfaces and protocols

Protocol	Ethernet
	100BASE-FX LC
IEC 61850-8-1	•
HTTPS	•
• = Supported	

15.5 Connection diagrams

The connection diagrams are delivered on the IED Connect USB stick as part of the product delivery. They can be accessed through the IED's context menu (item **Documentation**), or directly on the USB stick.

The latest versions of the connection diagrams can be downloaded from the [product webpage](#).

Section 16 Labels

16.1 Labels on IED

Front view of IED

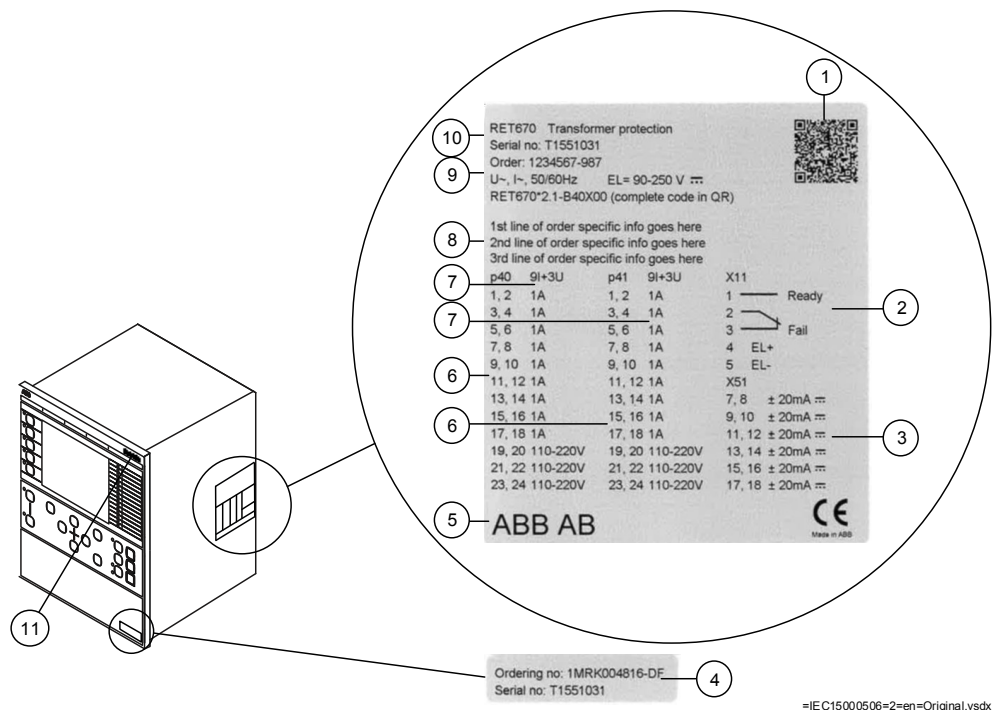


Figure 187: Example of IED label

- | | |
|----|---|
| 1 | QR-code containing the complete ordering code 2 |
| 2 | Power supply module (PSM) |
| 3 | mA input module (MIM) |
| 4 | Ordering and serial number |
| 5 | Manufacturer |
| 6 | Transformer designations |
| 7 | Transformer input module, rated currents and voltages |
| 8 | Optional, customer specific information |
| 9 | Order number, dc supply voltage and rated frequency |
| 10 | Product type, description and serial number |
| 11 | Product type |

=IEC15000506=2=en=Original.vsd

Rear view of IED

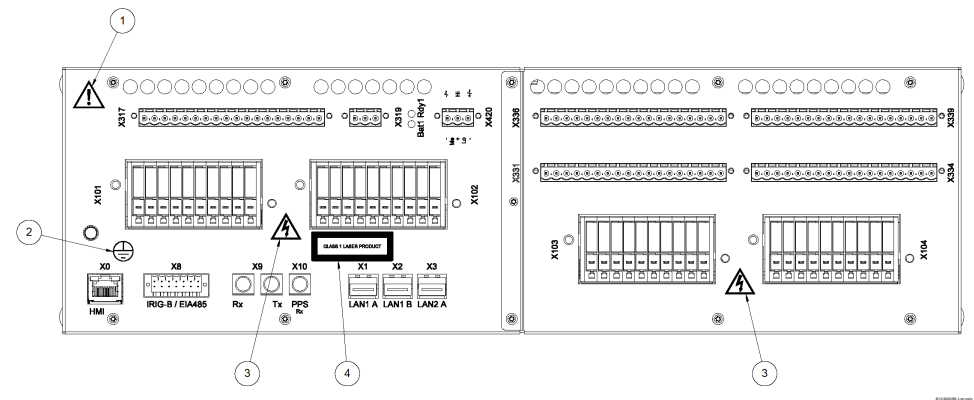


Figure 188: Example of IED labels on rear panel

- 1 Caution label
- 2 Earthing
- 3 Warning label
- 4 Class 1 laser product label



It is used when an optical SFP or an MR/LR LDCM is configured in the product.

Section 17 Technical data

17.1 Dimensions

Table 416: Dimensions of the IED - 3U full 19" rack

Description	Value
Width	444 mm (17.48 inches)
Height	132 mm (5.20 inches), 3U
Depth	249.5 mm (9.82 inches)
Weight box	10 kg (<22.04 lbs)

17.2 Power supply

Table 417: Power supply

Description	600PSM02	600PSM03
$U_{aux,nominal}$	48, 60, 110, 125 V DC	110, 125, 220, 250 V DC
$U_{aux,variation}$	80...120% of U_n (38.4...150 V DC)	80...120% of U_n (88...300 V DC)
Maximum load on auxiliary voltage supply	35 W for DC	
Ripple in the DC auxiliary voltage	Max 15% of the DC value (at frequency of 100 and 120 Hz)	
Maximum interruption time in the auxiliary DC voltage without resetting the IED	50 ms at U_{aux}	
Resolution of the voltage measurement in PSM module	1 bit represents 1 V (+/- 1 VDC)	1 bit represents 2 V (+/- 1 VDC)

17.3 Energizing inputs

17.4 Measuring inputs

Table 418: Measuring inputs

Description	Value
Frequency	
Rated frequency f_r	50 or 60 Hz
Operating range	$f_r \pm 10\%$
Sampling frequency	4000 S/s at 50 Hz 4800 S/s at 60 Hz
Current inputs	
Rated current I_r	1 or 5 A ¹⁾
Operating range	0 – 500 A
Table continues on next page	

Description	Value
Thermal withstand	500 A for 1 s *) 100 A for 10 s 40 A for 1 min 20 A continuously
Dynamic withstand	1250 A one half wave
Burden	< 10 mVA at $I_r = 1$ A < 200 mVA at $I_r = 5$ A
*) max. 350 A for 1 s when COMBITEST test switch is included.	
Voltage inputs **)	
Rated voltage U_r	100 or 220 V
Operating range	0 – 420 V
Thermal withstand	450 V for 10 s 420 V continuously
Burden	< 50 mVA at 100 V < 200 mVA at 220 V
**) all values for individual voltage inputs	
Note! All current and voltage data are specified as RMS values at rated frequency	

1) Phase currents or residual current

17.5 Binary inputs

Table 419: 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	<0.38 W
Threshold voltage	15...221 V DC (parametrizable in the range in steps of 1% of the rated voltage)

Table 420: Precision binary inputs

Description	Value
Operating range	Maximum input voltage 300 V DC
Rated voltage	33...288 V DC
Current drain	0...0.5 mA
Power consumption/input	<0.15 W
Threshold voltage	15...221 V DC (parametrizable in the range in steps of 1% of the rated voltage)

17.6 Signal outputs

Table 421: Signal outputs and IRF output

Description	Value
Rated voltage	250 V AC/DC
Continuous contact carry	5 A
Make and carry for 3.0 s	10 A
Make and carry 0.5 s	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

17.7 Power outputs

Table 422: Power output relays without TCS function (not used in default pre-configuration)

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

Table 423: Power output relays with TCS function (not used in default pre-configuration)

Description	Value
Rated voltage	250 V 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
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

Table 424: Precision binary outputs

Description	Value
Rated switching voltage	33...288 V DC
Continuous carry (resistive)	0.5 A DC
DC make and carry ton <1 s (single shot, toff >600 s) L/R <10 ms Usw ≤50 V	10 A DC
Table continues on next page	

Description	Value
DC make and carry ton <1 s (single shot, toff >600 s) L/R <10 ms Usw >150 V	6 A DC
Impedance in On state	≤0.5 Ω
Impedance in Off state	≥100 kΩ

17.8 Data communication interfaces

Table 425: Ethernet interfaces

Ethernet interface	Protocol	Cable	Data transfer rate
100BASE-TX (front port)	TCP/IP	CAT 5 S/FTP or better	100 MBit/s
100BASE-FX (rear Ethernet ports)	TCP/IP	Fibre-optic cable with LC connector	100 MBit/s

Table 426: Fibre-optic communication links

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 427: Supported station communication interfaces and protocols

Protocol	Ethernet
	100BASE-FX LC
IEC 61850-8-1	•
HTTPS	•
• = Supported	

Table 428: X8/IRIG-B and EIA-485 interface

Type	Protocol	Cable
Tension clamp connection	IRIG-B	Shielded twisted pair cable Recommended: CAT 5, Belden RS-485 (9841- 9844) or Alpha Wire (Alpha 6222-6230)
Tension clamp connection	DNP3.0 (not used in Switchsync PWC600)	Shielded twisted pair cable Recommended: DESCAFLEX RD-H(ST)H-2x2x0.22mm ² , Belden 9729, Belden 9829

Table 429: IRIG-B

Type	Value	Accuracy
Input impedance	430 Ohm	-
Minimum input voltage HIGH	4.3 V	-
Maximum input voltage LOW	0.8 V	-
Supported IRIG-B types	001...007	-

Table 430: EIA-485 interface

Type	Value	Conditions
Minimum differential driver output voltage	1.5 V	–
Maximum output current	60 mA	-
Minimum differential receiver input voltage	0.2 V	-
Supported bit rates	300, 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200	-
Maximum number of IEDs supported on the same bus	32	-
Max. cable length	925 m (3000 ft)	Cable: AWG24 or better, stub lines shall be avoided

Table 431: Optical serial port (X9) and PPS synchronization input (X10)

Wave length	Fibre type	Connector	Permitted path attenuation ¹⁾
820 nm	MM 62,5/125 µm glass fibre core	ST	6.8 dB (approx. 1700 m length with 4 dB/km fibre attenuation)
820 nm	MM 50/125 µm glass fibre core	ST	2.4 dB (approx. 600 m length with 4 dB/km fibre attenuation)

1) Maximum allowed attenuation caused by fibre

17.9 Enclosure class

Table 432: Degree of protection of rack-mounted IED

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

Table 433: Degree of protection of the LHMI

Description	Value
Front and side	IP40

17.10 Ingress protection

Table 434: Ingress protection

Description	Value
IED front	IP 54
IED rear	IP 20
IED sides	IP 40
IED top	IP 40
IED bottom	IP 20

17.11 Environmental conditions and tests

Table 435: Environmental conditions

Description	Value
Operating temperature range	-25...+55°C (continuous)
Short-time service temperature range	-40...+70°C (<16h) Note: Degradation in MTBF and HMI performance outside the temperature range of -25...+55°C
Relative humidity	<93%, non-condensing
Altitude	up to 2000 m
Transport and storage temperature range	-40...+85°C

Table 436: Environmental tests

Description	Type test value	Reference
Cold tests operation	96 h at -25°C 16 h at -40°C	IEC 60068-2-1 ANSI C37.90-2005 (chapter 4)
storage	96 h at -40°C	
Dry heat tests operation	16 h at +70°C	IEC 60068-2-2 ANSI C37.90-2005 (chapter 4)
storage	96 h at +85°C	
Damp heat tests steady state	240 h at +40°C humidity 93%	IEC 60068-2-78
cyclic	6 cycles at +25 to +55°C humidity 93...95%	IEC 60068-2-30

17.12 Electromagnetic compatibility tests

Table 437: Electromagnetic compatibility tests

Description	Type test value	Reference
100 kHz and 1 MHz burst disturbance test		IEC 61000-4-18, level 3 IEC 60255-22-1 ANSI C37.90.1-2012
• Common mode	2.5 kV	
• Differential mode	2.5 kV	
Electrostatic discharge test		IEC 61000-4-2, level 4 IEC 60255-22-2 ANSI C37.90.3-2001
• Contact discharge	8 kV	
• Air discharge	15 kV	
Radio frequency interference tests		
• Conducted, common mode	10 V (emf), f=150 kHz...80 MHz	IEC 61000-4-6, level 3 IEC 60255-22-6

Table continues on next page

Description	Type test value	Reference
Radiated, amplitude-modulated	20 V/m (rms), f=80...1000 MHz and f=1.4...2.7 GHz	IEC 61000-4-3, level 3 IEC 60255-22-3 ANSI C37.90.2-2004
Fast transient disturbance tests		IEC 61000-4-4 IEC 60255-22-4, class A ANSI C37.90.1-2012
- Communication ports - Other ports	4 kV 4 kV	
Surge immunity test		IEC 61000-4-5 IEC 60255-22-5
- Communication ports - Other ports - Power supply	1 kV line-to-earth 2 kV line-to-earth, 1 kV line-to-line 4 kV line-to-earth, 2 kV line-to-line	
Power frequency (50 Hz) magnetic field		IEC 61000-4-8, level 5
3 s - Continuous	1000 A/m 100 A/m	
Pulse magnetic field immunity test	1000 A/m	IEC 61000-4-9, level 5
Damped oscillatory magnetic field	100 A/m, 100 kHz and 1 MHz	IEC 61000-4-10, level 5
Power frequency immunity test		IEC 60255-22-7, class A IEC 61000-4-16
- Common mode - Differential mode	300 V rms 150 V rms	
Voltage dips and short interruptions on DC power supply	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
Voltage dips and interruptions on AC power supply	Dips: 40% 10/12 cycles at 50/60 Hz 70% 25/30 cycles at 50/60 Hz Interruptions: 0...50 ms: No restart 0...∞ s: Correct behaviour at power down	IEC 60255-11 IEC 61000-4-11
Electromagnetic emission tests		EN 55011, class A IEC 60255-25 ANSI C63.4, FCC
Conducted, RF-emission (mains terminal) 0.15...0.50 MHz	<79 dB(μV) quasi peak <66 dB(μV) average	

Table continues on next page

Description	Type test value	Reference
0.5...30 MHz	<73 dB(μV) quasi peak <60 dB(μV) average	
• Radiated RF-emission, IEC		
30...230 MHz	<40 dB(μV/m) quasi peak, measured at 10 m distance	
230...1000 MHz	<47 dB(μV/m) quasi peak, measured at 10 m distance	

17.13 Insulation tests

Table 438: Insulation tests

Description	Type test value	Reference
Dielectric tests:		IEC 60255-5 ANSI C37.90-2005
• Test voltage	2 kV, 50 Hz, 1 min 1 kV, 50 Hz, 1 min, communication	
Impulse voltage test:		IEC 60255-5 ANSI C37.90-2005
• 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	
Insulation resistance measurements		IEC 60255-5 ANSI C37.90-2005
• Isolation resistance	>100 MΩ, 500 V DC	
Protective bonding resistance		IEC 60255-27
• Resistance	<0.1 Ω (60 s)	

17.14 Mechanical tests

Table 439: Mechanical tests

Description	Reference	Requirement
Vibration response tests (sinusoidal)	IEC 60255-21-1	Class 1
Vibration endurance test	IEC 60255-21-1	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

17.15 Product safety

Table 440: Product safety

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

17.16 EMC compliance

Table 441: EMC compliance

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

Section 18

Glossary



Names of function blocks, IEC 61850 logical nodes, data objects, data attributes etc. are not listed here. Refer to the respective section of this document or to the relevant part of the standard.

AC	Alternating current
ACT	Application configuration tool within PCM600
ACSI	Abstract communication service interface, as defined in IEC 61850-7-2
A/D converter	Analog-to-digital converter
AI	Analog input
ANSI	American National Standards Institute
AP	Access point for digital communication
AR	Autoreclosing
AWG	American Wire Gauge standard
BI	Binary input
BIO	Binary input/output module
BO	Binary output
BRCB	Buffered report control block
BS	British Standards
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
CDC	Common data class
CET	Central European Time zone
CID	Configured IED description file as per IEC 61850-6
Class C	Protection Current Transformer class as per IEEE/ ANSI
CMT	Communication Management tool in PCM600
CO cycle	Close-open cycle
COM	Communication module
COMTRADE	Standard format according to IEC 60255-24
CPU	Central processing unit
CRC	Cyclic redundancy check
CSV	Comma-separated values
CT	Current transformer
CVT	Capacitive voltage transformer
DA	Data attribute
DARPA	Defense Advanced Research Projects Agency (The US developer of the TCP/IP protocol etc.)

DC	Direct current
DHCP	Dynamic Host Configuration Protocol
DI	Digital input
DNP	Distributed Network Protocol as per IEEE Std 1815-2012
DO	Data object
DR	Disturbance recorder
DRAM	Dynamic random access memory
DSP	Digital signal processor
DST	Daylight Saving Time
DTT	Data type template section in the SCL description file of a station or IED
DVD	Digital versatile disc
EHV	Extra high voltage
EIA	Electronic Industries Association
EMC	Electromagnetic compatibility
EMI	Electromagnetic interference
EN	European standard
ESD	Electrostatic discharge
FAT	Factory Acceptance Test
FC	Function constraint
FB	Function block in the IED
GDE	Graphical display editor within PCM600
GIS	Gas-insulated switchgear
GoCB	GOOSE control block
GOOSE	Generic object-oriented substation event
GPS	Global positioning system
GSAL	Generic security application
GSE	Generic substation event
HMI	Human-machine interface
HSAR	High speed autoreclosing
HTTPS	Hypertext transfer protocol secure
HV	High-voltage
HVDC	High-voltage direct current
HW	Hardware
ICD	IED capability description file as per IEC 61850-6
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
IEC 61850-8-1	Communication protocol standard for station bus
IEC 61850-9-2(LE)	Communication protocol standard for sampled values
IEEE	Institute of Electrical and Electronics Engineers

IEEE 802.12	A network technology standard that provides 100 Mbps/s on twisted-pair or optical fiber cable
IEEE 1686	Standard for Substation Intelligent Electronic Devices (IEDs) Cyber Security Capabilities
IED	Intelligent electronic device
IID	Instantiated IED Description as per IEC 61850-6
Instance	When several occurrences of the same function are available in the IED, they are referred to as instances of that function. One instance of a function is identical to another of the same kind but has a different number in the IED user interfaces. The word "instance" is sometimes defined as an item of information that is representative of a type. In the same way an instance of a function in the IED is representative of a type of function.
IP	1. Internet protocol. The network layer for the TCP/IP protocol suite widely used on Ethernet networks. IP is a connectionless, best-effort packet-switching protocol. It provides packet routing, fragmentation and reassembly through the data link layer. 2. Ingression protection, according to IEC standard
IP 20	Ingression protection, according to IEC standard, level 20
IP 40	Ingression protection, according to IEC standard, level 40
IP 54	Ingression protection, according to IEC standard, level 54
IRF	Internal relay fault
IRIG-B	InterRange Instrumentation Group Time code format B, standard 200
ITU	International Telecommunications Union
ISO	International Organization for Standardization
LAN	Local area network
LCD	Liquid crystal display
LD	Logical device in IEC 61850
LED	Light-emitting diode
LHMI	Local human-machine interface
LN	Logical node in IEC 61850
MCB	Miniature circuit breaker
MICS	Model implementation conformance statement, for IEC 61850
MMS	Manufacturing Message Specification
MU	Merging unit
MVB	Multifunction vehicle bus. Standardized serial bus originally developed for use in trains.
NC	Normally closed auxiliary contact
NCC	National Control Centre
NCIT	Non-conventional instrument transformer
NO	Normally open auxiliary contact
OCO cycle	Open-close-open cycle
PBI	Precision Binary Input for accurate detection of contact changeover
PBO	Precision Binary Output for time-controlled release of a circuit breaker pole
PC	Personal computer

PCM	Pulse code modulation
PCM600	Protection and control IED manager
PICS	Protocol implementation conformance statement, for IEC 61850
PIO	Precision input/output module
PIXIT	Protocol implementation extra information for testing, for IEC 61850
PoW	Point on wave
PPS, 1PPS	One pulse per second, time synchronization interface
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
PWC	Point-on-wave controller
RBAC	Role-based access control (role-based security)
RISC	Reduced instruction set computer
RJ-45	Registered jack 45, commonly used as plug connector for electrical Ethernet
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
Rx	Receive line
SA	Substation Automation
SBO	Select-before-operate
SCADA	Supervision, control and data acquisition
SCD	System configuration description file as per IEC 61850-6
SCL	System configuration language in IEC 61850
SCS	Station control system
SCT	System configuration tool according to standard IEC 61850
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.
SPO	Single-pole operated (circuit breaker), i.e. one drive for each pole.
SST	Switchsync Setting Tool within PCM600
Starpoint	Neutral point of transformer or generator
SVC	Static VAr compensation
SW	Software
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.
TICS	Tissue implementation conformance statement, for IEC 61850
TPO	Three-pole operated (circuit breaker), i.e. one drive for three poles
TPZ, TPY, TPX, TPS	Current transformer class according to IEC
TRM	Transformer module
TRV	Transient recovery voltage
Tx	Transmit line
UAC	User Account Control in Microsoft Windows operating systems
UCA	Utility Communication Architecture forum
UDP/IP	User Datagram Protocol over Internet Protocol
UHV	Ultra high voltage
UMT	User management tool
Unicode	Universal standard for text encoding
URCB	Unbuffered report control block
UTC	Coordinated Universal Time. A coordinated time scale, maintained by the Bureau International des Poids et Mesures (BIPM), which forms the basis of a coordinated dissemination of standard frequencies and time signals. UTC is derived from International Atomic Time (TAI) by the addition of a whole number of "leap seconds" to synchronize it with Universal Time 1 (UT1), thus allowing for the eccentricity of the Earth's orbit, the rotational axis tilt (23.5 degrees), but still showing the Earth's irregular rotation, on which UT1 is based. The Coordinated Universal Time is expressed using a 24-hour clock, and uses the Gregorian calendar. It is used for aeroplane and ship navigation, where it is also sometimes known by the military name, "Zulu time." "Zulu" in the phonetic alphabet stands for "Z", which stands for longitude zero.
VT	Voltage transformer
WAN	Wide area network
WHMI	Web human-machine interface
XML	Extensible markup language

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